



Investigations into the management of the darkling beetle

**A report for the Rural Industries Research
and Development Corporation**

by TA Lambkin

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Foreword

The darkling beetle, *Alphitobius diaperinus* (Panzer) is a common cosmopolitan insect pest of poultry houses, in particular broiler sheds and egg barns, and is capable of transmitting a large number of poultry diseases and parasites. In recent years the poultry industries have been concerned about increasing beetle numbers in broiler sheds and the pest's potential to breach farm biosecurity. In spite of the occurrence of the pest on almost every Australian poultry farm, no previous Australian research has been done to determine the pest's status, abundance, behaviour, disease association and insecticide resistance.

In 1998 this research project commenced to investigate the pest status and control of *A. diaperinus* in Australian broiler and egg barn systems, with a view to ultimately developing strategies for inclusion in a future integrated pest management system. These investigations have included a scientific literature review on darkling beetle research, the development of a beetle culture method, and an insecticide resistance testing method and a survey of local beetle populations for insecticide resistance.

This publication reports on findings resulting from these investigations and highlights the need for a strategic management plan for *A. diaperinus* in Australian poultry systems and in particular in broiler sheds. The development of such a plan will require a better understanding of the pest's ecology and insecticide resistance, and of the variables that control pest numbers within broiler sheds.

This project was funded from industry revenue which is matched by funds provided by the Federal Government.

This report is a new addition to RIRDC's diverse range of over 700 research publications and forms part of our Chicken Meat/Eggs R&D programs. It aims to report on a survey of insecticide resistance of the darkling beetle in broiler shed houses and in deep litter egg production systems in south east Queensland, and deliver an improvement in the understanding of the ecology of the pest.

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Peter Core
Managing Director
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Executive Summary

The darkling beetle, *Alphitobius diaperinus* (Panzer) is a common cosmopolitan insect pest of poultry houses, in particular broiler sheds and egg barns, and is capable of transmitting a large number of poultry diseases and parasites. In recent years industries have been concerned over increasing beetle numbers in broiler sheds and the pest's potential to breach farm biosecurity. In spite of the occurrence of the pest on almost every Australian poultry farm, no previous Australian research has been undertaken to determine the pest's behaviour and its insecticide resistance status. The researchers commenced investigation of these two areas of study in 1998, in particular to develop a better understanding of the ecology of the pest, and to determine if resistance to fenitrothion (Folithion®) and cyfluthrin (Tugon®) has developed in pest populations. Insecticide resistance in the pest was believed to be highly likely because of the long-term and frequent use of fenitrothion by industry, and because of continued control failures.

The main objectives of this research were to review the relevant literature pertaining to *A. diaperinus* research and thereby develop an improved understanding of the ecology of the pest, and also to develop an insecticide resistance testing method for *A. diaperinus*. These two objectives enabled a survey to be undertaken in southeast Queensland of broiler shed and egg barn beetle populations, and the subsequent testing of these populations for insecticide resistance.

The scientific literature review and project field studies have indicated that the pest's ability to avoid contact with insecticides contributes to *A. diaperinus* control failures. This behaviour, together with predominantly clay-floors in most broiler sheds contributes to problems with control after clean-outs, as many individuals stay concealed in the floor and do not receive a lethal dose of insecticide. The development of a laboratory culture method has provided adequate numbers of test insects. Problems with the culture method have arisen during the latter part of the project due to mite infestations, and these have hindered the availability of insects for testing.

The development of fenitrothion and cyfluthrin resistance testing methods was successful. Test results showed that insects from SEQ broiler shed systems have strong fenitrothion resistance and some cyfluthrin resistance, and preliminary results indicate that populations of *A. diaperinus* from some production areas, for example Tamworth & the Atherton Tableland have quite weak fenitrothion resistance. Insecticide resistance levels in insects from other intensive livestock systems including egg barns were generally weaker, and all levels of resistance were directly related to duration and/or frequency of insecticide use. Insecticide resistance may not be the major factor that determines beetle population sizes in broiler sheds. There was no relationship between anecdotal estimates of broiler shed beetle numbers and fenitrothion and cyfluthrin resistance levels, ie- population sizes of insects in different broiler sheds, with similar levels of insecticide resistance, can be very different. Results of testing *A. diaperinus* from the only SEQ egg barn show that the insects were still susceptible to fenitrothion and a rotation of fenitrothion and cyfluthrin may be used on alternate clean outs. Whether these egg barn results are typical for all is not known. For broiler sheds in general it is suggested that the application of cyfluthrin be reduced to every second clean out (part or full) or just used over the summer period. This may delay the development of stronger resistance. Preliminary results for the broiler shed production areas of Tamworth & Atherton Tableland indicate that fenitrothion may be included with cyfluthrin in an insecticide rotation.

In summary, as development of strong insecticide resistance in all areas is inevitable given time, a closer examination is needed of the other major factors that control population sizes in broiler sheds. When this is known, studies of currently registered insecticides, alternative control strategies and the interaction of both may be properly evaluated.

1. Introduction

Background to project

The darkling beetle, *Alphitobius diaperinus* (Panzer) is a common cosmopolitan insect pest of poultry houses, in particular broiler sheds. All stages of the pest can act either as reservoirs or external carriers of eight serious avian/poultry diseases including Newcastle and Mareks disease, and fowl pox, and can also act as intermediate hosts for tapeworms and protozoans. The species is believed to have originated in the tropical east African region. It occurs naturally in bird and bat nests where it feeds on droppings and animal parts such as feathers and carcasses. Because of its natural association with animals, in particular birds, this tropical species is well suited to the warm humid conditions that occur in heated or insulated poultry and other intensive livestock houses. The beetle is also known to be a pest of animal feeds within these systems.

The high risk of poultry disease transfer due to beetle infestations increases the likelihood of transfer of food borne diseases into competitively marketed safe chicken products. Despite the occurrence of the pest on almost every Australian poultry farm, no previous Australian research has been done to determine the pest's status, abundance, behaviour, disease association, insecticide resistance and control.

In recent years Australian industries have been concerned over increasing beetle numbers in broiler sheds, and the pest's potential to breach farm biosecurity as a consequence of their high numbers. Traditionally, *A. diaperinus* in Australian broiler sheds and egg barns has been controlled by regular applications of fenitrothion to the floors of the sheds. The apparent lack of control of pest populations in broiler sheds of late has challenged the industry to question the efficacy of fenitrothion applications and ask whether this lack of control is due in some part to fenitrothion resistance. Even though pest numbers that occur in deep litter egg barns are normally lower than those that occur in broiler sheds (for reasons not fully understood as yet), the pest and its associated disease transfer are still of concern to the egg barn industry.

Objectives

In 1998 the author commenced research to investigate the pest status and control of *A. diaperinus* in Australian broiler shed and egg barn systems. The key objectives of the research were:

- to review the relevant literature pertaining to *A. diaperinus* research and thereby develop an improved understanding of the ecology of the pest.
- to develop a laboratory culture method and an insecticide resistance testing method for *A. diaperinus* and subsequently survey broiler shed and egg barn pest populations in south east Queensland for insecticide resistance.

2. Methodology

Reviewing relevant scientific literature

Relevant published literature on the bionomics and pest status of *A. diaperinus* in relation to chicken production was reviewed. Relevant articles were retrieved using two library reference data base systems (CAB & AGRICOLA), and extracting citations directly from journals. By reviewing the relevant literature pertaining to *A. diaperinus* in this way, an increased knowledge of and an improved understanding of the ecology of the pest were developed. A bibliographic document was developed that enables the reader to retrieve titles, authors, abstracts and full reference data for scientific papers dealing with relevant areas of *A. diaperinus* research.

Developing a culture method

The development of an effective laboratory culture method for *A. diaperinus* provided a ready supply of adult insects for laboratory insecticide testing. Despite having reviewed published information dealing with *A. diaperinus* research, no published laboratory culture method for this species was found. Therefore a variety of methods and potential culture media for culturing this species were trialed. As a result a laboratory culture method for *A. diaperinus* was developed.

Developing an insecticide resistance test

An insecticide resistance testing method is a useful tool for identifying and characterising insecticide resistance in insect populations. Insecticide resistance testing methods are used widely in many integrated insect pest management systems to monitor the development, levels and distribution of insecticide resistance in pest systems.

A review of the literature indicated that some research had been done in testing for *A. diaperinus* insecticide resistance (Spencer & Jespersen 1998, Vaughan & Turner 1984, Wakefield & Cogan 1990, 1992). Wakefield & Cogan (1990) initially used the FAO recommended impregnated filter-paper method (FAO 1974) to test adults of *A. diaperinus* with malathion and iodofenphos. After this they trialed a topical dosing method with both chemicals and subsequently chose the former method as the most suitable but reported that satisfactory probability mortality curves for resistant populations were difficult to obtain. Vaughan & Turner (1984) used the topical dosing method for a range of insecticides and published suitable dose-response curves for beetle mortality. Recently however, Spencer & Jespersen (1998) in Denmark reported using the FAO testing method to test *A. diaperinus* against a variety of insecticides but their methodology and results are yet to be published.

Assessing baseline biological responses to insecticides

Prior to the laboratory insecticide resistance testing of *A. diaperinus*, laboratory cultured and field collected insects of a caged layer population were tested with fenitrothion, and the log dose/probit mortality curves for each were compared. This comparison was done to determine if there were any difference between laboratory cultured insects and insects collected directly from the field in their basic biological response to insecticides. Also the mean weights of 100 susceptible and resistant insects were compared to determine if there was any correlation between resistance or susceptibility and insect body weight.

Fenitrothion and cyfluthrin resistance tests

The FAO recommended and topical dosing methods were trialed against fenitrothion using local populations of field collected and laboratory cultured *A. diaperinus* adults. The topical

dosing method was chosen as the most suitable for fenitrothion because the analyses of data using this method provided better probit mortality curves and consequently this method was then optimised for testing with fenitrothion. The same method was chosen as the most suitable to trial for cyfluthrin resistance testing, although some of the dosing and assessment criteria required optimisation.

Full assay responses for a reference insecticide-susceptible population and for suspect resistant populations

A population of *A. diaperinus* that had never been exposed to insecticide was collected from a piggery in Nobby, south east Queensland. These insects were cultured in the laboratory and used to determine the baseline response of an insecticide-susceptible population. The results of multiple concentration assays for this population and a number of broiler shed populations (fenitrothion n=7, cyfluthrin n=4) suspected to be resistant were fitted to log dose/probit mortality curves and LD₅, LD₅₀, LD₉₅ and LD₉₉ values were estimated by probit analysis. Control mortality was accounted for using Abbott's formula.

Determination of a discriminating dose for fenitrothion

By comparing the analyses of the insecticide-susceptible population to the broiler shed populations, a single insecticide concentration (called a discriminating dose) was devised for fenitrothion that would discriminate between susceptible and resistant insects. That is, beetles that survived this discriminating dose were classed as resistant. The discriminating dose also provided a rough estimate of resistance levels. As only preliminary results were obtained for multiple concentration assays with cyfluthrin, a discriminating dose was not developed.

Surveying beetle populations for insecticide resistance

Sampling and testing beetle populations

A. diaperinus were collected from poultry houses by sieving litter or manure through 2.8 and 2mm screens and then put into laboratory culture. Insecticide resistance testing of *A. diaperinus* using topical dosing required a minimum of 500 beetles for a discriminating dose test, but for full log dose/probit mortality curves, up to 4000 were required. Collection of field insects in these numbers was quite often not possible, so laboratory culturing of some field populations was required. The collecting of beetles was preferably done just prior to clean out times after the litter had been piled overnight, as beetles migrate to and can congregate in large numbers on the tops of the piles. When collected in this manner, insects were kept for seven days in the laboratory to ensure that they were of a minimum age to test. Populations were collected from broiler sheds in southeast and northern Queensland, and Tamworth and Byron Bay in New South Wales. Insects were also collected from the only egg barn in southeast Queensland (at Beerburrum). These populations were tested with the discriminating dose and the percent mortality results for each population were compared.

3. Detailed results and discussion

Review of relevant scientific literature

The reviewing of published scientific literature in reference to *A. diaperinus* has been completed and has provided a good understanding of the biology, ecology and bionomics of the pest. The results of this review have been incorporated into a bibliography document. This bibliography is intended as a reference tool for current and future research workers of *A. diaperinus*. It outlines full reference retrieval information, including abstracts where available for each scientific article, and it groups articles into specific areas of research; namely biology and behaviour, insecticide and non-insecticide control, and disease associations. The bibliography has been restricted to include only scientific journal and conference proceedings' articles. Poultry magazines and similar industry publications' articles have not been included, as most have originated from earlier scientific publications. This document is included as an appendix following this annual report.

Development of a culture method

The culture method that was developed at first provided a constant and adequate supply of beetles for laboratory testing, but during the latter six months of the project infestations of predatory mites in the cultures caused major reductions in *A. diaperinus* progeny. Consequently, the insecticide resistance of some *A. diaperinus* populations was not adequately analysed and only provisional results were obtained for these populations. Hygiene strategies for reducing mites in the *A. diaperinus* cultures were put into place before the completion of the project to ensure that adequate numbers of test insects would be available for any subsequent project work.

A summary of this culture method is as follows:

- Incubation conditions for the entire culturing method are 30°C and 55% relative humidity.
- 100 beetles are placed into a vented plastic culture box (18.5 x 25.5 x 8.5cm) containing 1 kg of medium.
- This medium consists of by weight: 76% pollard, 17% chicken feed pellets and 7% non-fermenting yeast.
- Two apple halves are placed on the top of the media to provide moisture to beetles while ovipositing, and for developing progeny.
- The 100 beetles are kept in the culture box for a 4-day oviposition period and then removed.
- Culture boxes are incubated, and at five weeks after the start of the culture procedure, a piece of high-density foam (17 x 24 x 2cm) is placed in the bottom of the container under the media. This acts as a substrate for final instar larvae to burrow into and pupate in.

At the seventh week emergence of beetle progeny is complete ie between 700 and 1000 beetles emerge per culture box.

Development of an insecticide resistance test

Assessment of baseline biological responses to insecticides

Prior to the major work of conducting full dose-response assays and determining discriminating doses, preliminary tests were done to determine:

1. Whether field collected and laboratory cultured insects were equivalent in their response to insecticides? Full dose-response assays were performed on *A. diaperinus* individuals (n=5334) collected from a layer cage system at Kingsthorpe, Queensland. Progeny of the same insects cultured in the laboratory were tested (n=3862) [age 1-2 weeks] in the same

fashion and both response data were compared (Table 1). The values at the LD₅₀ and LD₉₉ mortality levels for both types were not significantly different, but the 95% fiducial limits were more variable (a broader range) for the field-tested insects than for the laboratory cohorts. This difference could be indicative of a number of biological variables inherent to testing field-collected insects. These variables may be related to the age of the insects, and their general health (eg previous starvation, dehydration or high-density effects). As the LD₅₀ and LD₉₉ mortality values for both were not significantly different despite the variable fiducial limits, it was decided that either field or lab cultured insects could be used for testing with a minimum of 400 insects per dose (500 for the discriminating dose). As a precaution, field-collected insects were not tested for at least one week after collection to ensure all insects were of a minimum age, and were allowed to feed and hydrate prior to being tested.

2. Whether there is any correlation between insect body weight and resistance or susceptibility? The mean weight (100 insects) of susceptible insects was compared with mean weights (100 insects) of two highly resistant populations and also of a population with very low resistance (Kingsthorpe). The results of this comparison are included in Table 1, and indicate that there was no correlation between insect body weight and insecticide resistance or susceptibility.

Fenitrothion resistance test

The methodology is as follows:

- Because variability in response to fenitrothion occurs amongst individuals within beetle populations, a minimum number of 400 insects are treated at each test dose.
- Because of time and facility constraints the maximum number of beetles tested on any day was 1400 (ie. 200 per dose).
- Adult beetles are removed from the culture media and counted into 30mL plastic cups and 2 small pieces of damp sponge (1cm square) are placed in each cup.
- Beetles from each cup are placed into a chilled evacuated dish (4 x 4 x 1.5 cm).
- When beetle movement has ceased small numbers are transferred to a glass sheet where they are turned with ventral side up.
- Using a special micro-applicator instrument individual adult beetles are topically dosed onto their ventral surface with 1 µL (one thousandth of a mL) of fenitrothion in technical grade acetone.
- Beetles are returned to the plastic cup and placed in front of a fan to facilitate evaporation of the acetone
- After dosing, beetles dosed at each insecticide concentration are placed in separate glass jars (100 insects per jar), containing kibbled wheat with two small pieces of damp sponge (3cm square) and incubated at 25°C, 55% relative humidity.
- Beetle mortality is assessed 72 hours after dosing. Beetles are removed from the jars and allowed to walk across a large filter paper under a bright light.
- After one minute they are assessed and the individuals that walk in a coordinated manner are assessed as alive.

Cyfluthrin resistance test

The cyfluthrin resistance test is as for fenitrothion but with the following differences:

- After dosing, beetles are placed in separate glass jars with only one piece of damp sponge (3cm square)[because beetles are only in jars for 24 hours for this test].
- Beetle mortality is assessed 24 hours after dosing.
- There is no time limit for beetle assessment.
- Beetles that show no signs of being affected (ie walk straight in a forward motion using all six legs without jerky movements), are assessed as alive and all others are classed as dead.

Full dose-response assays for fenitrothion

Full dose-response assay data generated from probit analyses of the insecticide-susceptible population from a piggery at Nobby and seven broiler shed populations previously exposed to fenitrothion from southeast Queensland are presented in Table 1. A mean value for the log dose/probit mortality curves (using LD₅, LD₉₅ values) from fenitrothion for the seven broiler shed populations for fenitrothion and the susceptible population curve were plotted (Figure 1). These two curves were displaced markedly and were quite steep, indicating that the broiler shed populations had significant resistance to fenitrothion and were very homogeneous in their response to the chemical. A mean resistance factor of 21 was measured at the LD₅₀ level for fenitrothion, by comparing the susceptible population to the mean resistant population at the LD₅₀ levels (Table 1).

Determination of discriminating dose for fenitrothion

From the analyses of these two curves (Figure 1) and the full dose response data (Table 1) a discriminating dose value of 0.15% fenitrothion was chosen. The likelihood of assessing a susceptible insect as resistant using this value was very low as it was above the 95% fiducial limit for the LD₉₉ mortality level for the susceptible population.

Full dose-response assays for cyfluthrin

A mean value for the log dose/probit mortality curves (using LD₅, LD₉₅ values) for four broiler shed populations for cyfluthrin and the susceptible population curve were also plotted (Figure 2). The cyfluthrin curve was not displaced as much from the susceptible curve as the fenitrothion curve, and it was not as steep. This indicated that the four broiler shed populations were more heterogeneous in their response to cyfluthrin, with relatively low resistance. Despite cyfluthrin only being used for approximately two years in broiler shed systems already there is a mean resistance factor of 3.5 for broiler shed populations at the LD₅₀ level. A discriminating dose for cyfluthrin was not determined as only four full dose-response assays were completed, and only preliminary cyfluthrin response data for the susceptible population was generated.

Survey of beetle populations for insecticide resistance

A total of 18 broiler sheds, one egg barn and two layer cage farm populations of *A. diaperinus* were tested for resistance to fenitrothion. These were mainly from southeast Queensland, but some were also from northern Queensland and northern New South Wales. Results indicating percent survival after testing these populations with the fenitrothion discriminating dose are presented in Table 2. Also included in Table 2 are anecdotal records of duration and frequency of fenitrothion use at each location. In general, the existence of and level of fenitrothion resistance in all samples collected was related to duration of fenitrothion use.

Southeast Queensland broiler sheds

Beetle numbers in southeast Queensland broiler sheds are generally high but some low levels do exist. The broiler shed populations in southeast Queensland have generally high levels of resistance to fenitrothion with survival at the discriminating dose ranging from 36.9-100%. For each of these broiler sheds fenitrothion has been applied at every clean out (partial or full) for varying lengths of time ranging from 1.5 to 20 years. Even though the broiler shed at Allenvue only had fenitrothion applied for one and a half years, *A. diaperinus* from this farm were still highly resistant to fenitrothion. The close proximity of this farm to other older broiler shed systems could explain the occurrence of the resistant Allenvue population.

South east Queensland egg barn

Beetles from an egg barn system at Beerburum did not have high resistance despite annual use of fenitrothion for the last 16-18 years.

North Queensland broiler sheds

Northern Queensland farms were all situated on the Atherton Tableland and all were approximately five years old, and had varying numbers of beetles ie very high to almost none. Of the two populations tested from this area both had high beetle numbers and both were susceptible to fenitrothion (0 & 9.2% survival at the discriminating dose). These farms had only been using fenitrothion for four years and only at every second clean out, and the isolation of the area may not have allowed the immigration of resistant phenotypes.

Northern New South wales broiler sheds

The populations tested from two broiler sheds in the Tamworth area were also quite susceptible with one farm having never used fenitrothion and another with only intermittent use of the chemical for 20 years. If these records of fenitrothion use are correct then infrequent use of the chemical for a long period of time on this farm had not caused significant fenitrothion resistance. Both farms had relatively low numbers of beetles compared to some southeast Queensland broiler sheds.

Susceptible populations

Two susceptible populations were obtained from a piggery at Nobby and a layer cage system at Edmonton that had never been exposed to insecticides and results showed that they were susceptible to fenitrothion (Tables 1 & 2). Of particular interest is the organic layer cage population from Kingsthorpe that has not been exposed to fenitrothion for at least 15 years, but despite that still retained some resistance to the chemical.

4. Implications and recommendations

Insecticide application

In general, research results indicate that high levels of fenitrothion resistance were common in broiler sheds in southeast Queensland while much lower levels of resistance occurred in other production areas, for example Tamworth and the Atherton Tableland. In all cases fenitrothion resistance is related to the application frequency of, or the duration of use of, fenitrothion, or both of these combined. The poultry industry's replacement of fenitrothion with cyfluthrin (Tugon[®]) is questionable and most likely not sustainable for any long-term control of *A. diaperinus*. Chemical resistance in many insect pest species is known to develop faster for the pyrethroid group of insecticides (eg cyfluthrin) than for the organophosphate group (eg fenitrothion) (Daly and Murray 1988). Furthermore, insects that have developed resistance to one group of chemicals are likely to be 'repeat offenders' and may readily develop cross-resistance to other chemical groups. Evidence that low level resistance to cyfluthrin has already been detected despite the introduction of this chemical less than two years ago supports this hypothesis.

A. diaperinus from the only southeast Queensland egg barn at Beerburrum showed low fenitrothion resistance and whether this egg barn is typical of all, is not known. For broiler sheds in general it is suggested that the application of cyfluthrin may be reduced to every second clean out (part or full) or used only over the summer period when insect activity and reproduction is at their highest. This may delay the development of stronger cyfluthrin resistance. Preliminary results for the broiler shed production areas of Tamworth & Atherton Tableland indicate that fenitrothion may be included with cyfluthrin in an insecticide rotation. A rotation of fenitrothion and cyfluthrin applications for egg barns may assist in maintaining low resistant levels. The need to vary insecticide application regimes for different geographical areas as suggested above is strong evidence to support the concept that a single management strategy is not suitable for the management of this pest on a national basis.

Understanding other factors controlling beetle numbers

The scientific literature review and project field studies have indicated that the pest's ability to avoid contact with insecticides contributes to *A. diaperinus* control failures. This behaviour, together with predominantly clay floors in most broiler sheds contributes to problems with control after clean-outs, as many individuals stay concealed in the floor and do not receive a lethal dose of insecticide. Therefore insecticide resistance may not be a major factor that determines beetle population sizes in broiler sheds. Evidence to support this statement is that there appears to be no relationship between anecdotal estimates of broiler shed beetle numbers, and fenitrothion and cyfluthrin resistance levels, ie- population sizes of insects in different broiler sheds with similar levels of insecticide resistance can be very different.

In summary, as development of strong insecticide resistance in all areas is inevitable given time, a closer examination is needed of other major factors that control population sizes in broiler sheds. When this is known, studies of currently registered insecticides and the efficacy of their applications, alternative control strategies and the interaction of both may be properly evaluated.

The recommendations that have emanated from this research offer considerable savings to industry. These savings will result from the reduction of the number of applications of cyfluthrin and the consequent extension of the life of the chemical, and the incorporation of fenitrothion into an insecticide rotation regime for some geographical areas.

5. Tables and Figures

Table 1. Responses of *A. diaperinus* when topically dosed with fenitrothion and cyfluthrin - an insecticide susceptible population (Nobby) and 8 resistant populations (p = ex piggery, b = ex broiler shed, c = ex caged layer)

Location - production system	Total number tested (n)	Mean weight of 100 <i>A. diaperinus</i> (g)	LD ₅₀ (95% limits)	LD ₉₉ (95% limits)	Slope
Fenitrothion					
Nobby – p	5273	0.69	0.014 (0.013-0.016)	0.096 (0.074-0.14)	2.8 (±0.24)
Anstead (Farm 1) – b	4150	-	0.12 (0.12-0.13)	0.76 (0.66-0.91)	2.8 (±0.18)
Redlands - b	5159	1.5	0.14 (0.11-0.17)	2.9 (2.4-3.8)	3.0 (±0.24)
Anstead (Farm 2) – b	6927	1.6	0.37 (0.34-0.41)	2.8 (2.2-3.7)	2.6 (±0.20)
Logan Village – b	5056	-	0.32 (0.29-0.35)	2.6 (2.1-3.4)	2.6 (±0.17)
Allenview – b	3200	1.7	0.34 (0.31-0.36)	2.8 (2.3-3.4)	2.6 (±0.14)
Beerwah - b	4355	1.5	0.67 (0.55-0.81)	7.2 (4.7-13)	2.2 (±0.24)
Glasshouse Mtns – b	4882	-	0.13 (0.12-0.14)	2.0 (1.8-2.4)	2.0 (±0.065)
Kingsthorpe (field collected insects) – c	5334	2.0	0.035 (0.030-0.040)	0.32 (0.25-0.46)	2.4 (±0.19)
Kingsthorpe (lab cultured insects) – c	3862	-	0.024 (0.021-0.027)	0.14 (0.11-0.19)	3.0 (±0.29)
Cyfluthrin					
Nobby – p	503*	0.69	0.000075 (0.00067-0.00083)	0.00030 (0.00024-0.00040)	3.9 (±0.44)
Anstead (Farm 2) – b	3969	1.6	0.00027 (0.00022-0.00033)	0.0020 (0.0013-0.0039)	2.9 (±0.62)
Logan Village –b	3993	-	0.00031 (0.00028-0.00034)	0.0011 (0.00092-0.0014)	4.1 (±1.1)
Allenview – b	4020	1.7	0.00052 (0.00040-0.00067)	0.0044 (0.0027-0.0097)	3.4 (±0.90)
Beerwah – b	4775	1.5	0.00091 (0.00072-0.0012)	0.0048 (0.0031-0.010)	4.1 (±3.0)
Glasshouse Mtns - b	4244	-	0.00030 (0.00027-0.00034)	0.0015 (0.0011-0.0021)	3.6 (±0.68)

* preliminary results

Table 2. Resistance survey results—Comparison of fenitrothion application to survival of *A. diaperinus* populations at the discriminating dose (p = ex piggery, b = ex broiler shed, c = ex caged layer, e = ex egg barn)

Location - production system	Fenitrothion use		Percent survival at the discriminating dose
	Duration (years)	Frequency	
South East Queensland			
Nobby - p	0	nil	0
Kingsthorpe –c	Not for 15 years	?	4
Beerburum – e	16-18	annual	17
Allenvie –b	1.5	every cleanout	81
Glasshouse Mtns – b	2.5	every cleanout	48
Anstead (Farm 2) – b	8-20	every cleanout	37
Munruban –b	12	every cleanout	92
Beerwah -b	16-18	every cleanout	89
Jimboomba (Farm 1) - b	18	every cleanout	100
Redlands - b	20	every cleanout	96
Anstead (Farm 1) –b	20	every cleanout	98
Wamuran - b	20	every cleanout	92
Redland Bay – b	20	every cleanout	96
Buccan – b	20	every cleanout	83
Park Ridge – b	20	every cleanout	100
Logan Village - b	?	every cleanout	85
Jimboomba (Farm 2) - b	?	every cleanout	91
North Queensland			
Mutchilba – b	4	every 2 nd cleanout	0*
Mareeba – b	4	every 2 nd cleanout	9*
Cairns – c	0	nil	0
Northern New South Wales			
Tamworth (Farm 1) – b	0	nil	10
Tamworth (Farm 2) - b	20	intermittent	10

*Preliminary results only

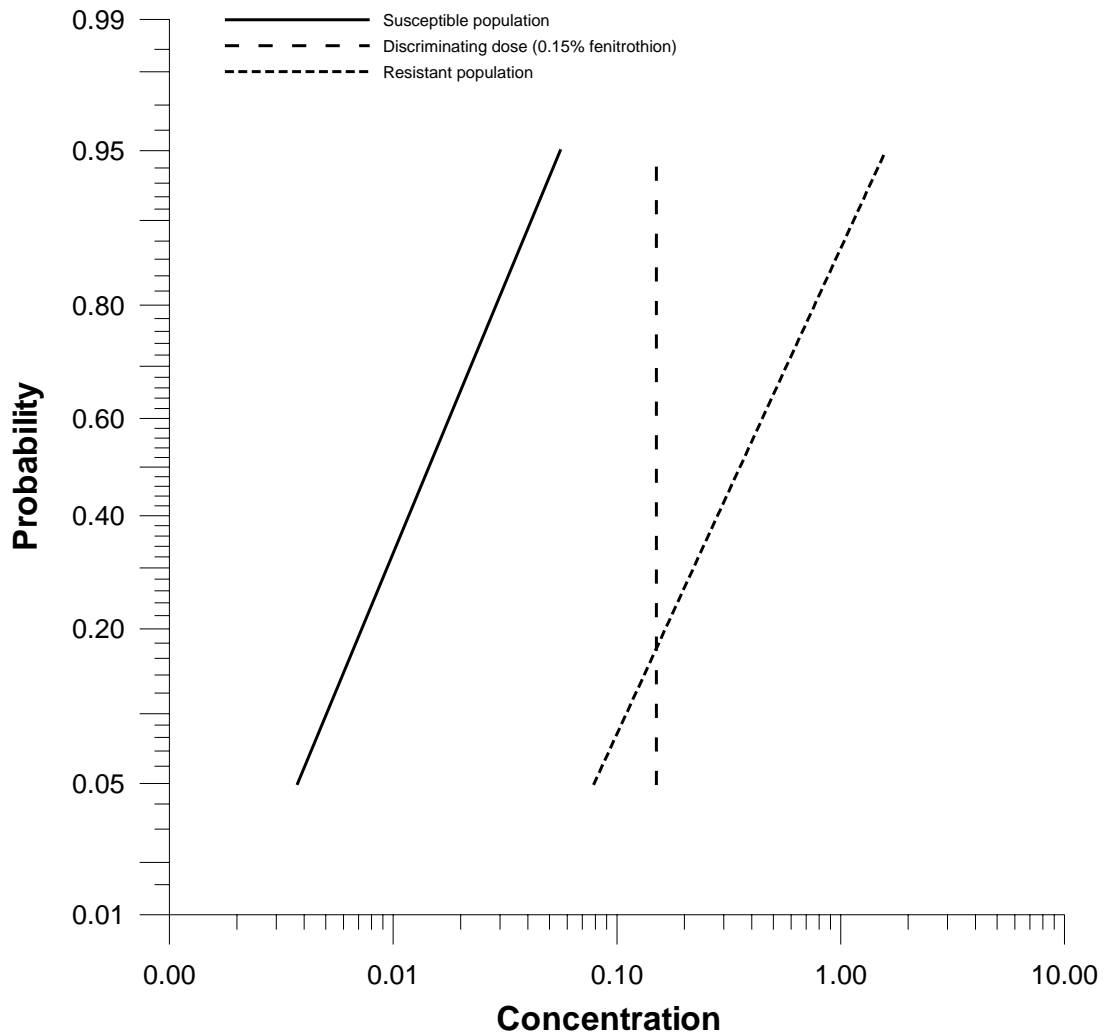


Figure 1. Log dose/probit mortality curves for a susceptible *Alphitobius diaperinus* population (Nobby) and a mean for seven resistant populations from SEQ - topically dosed with fenitrothion.

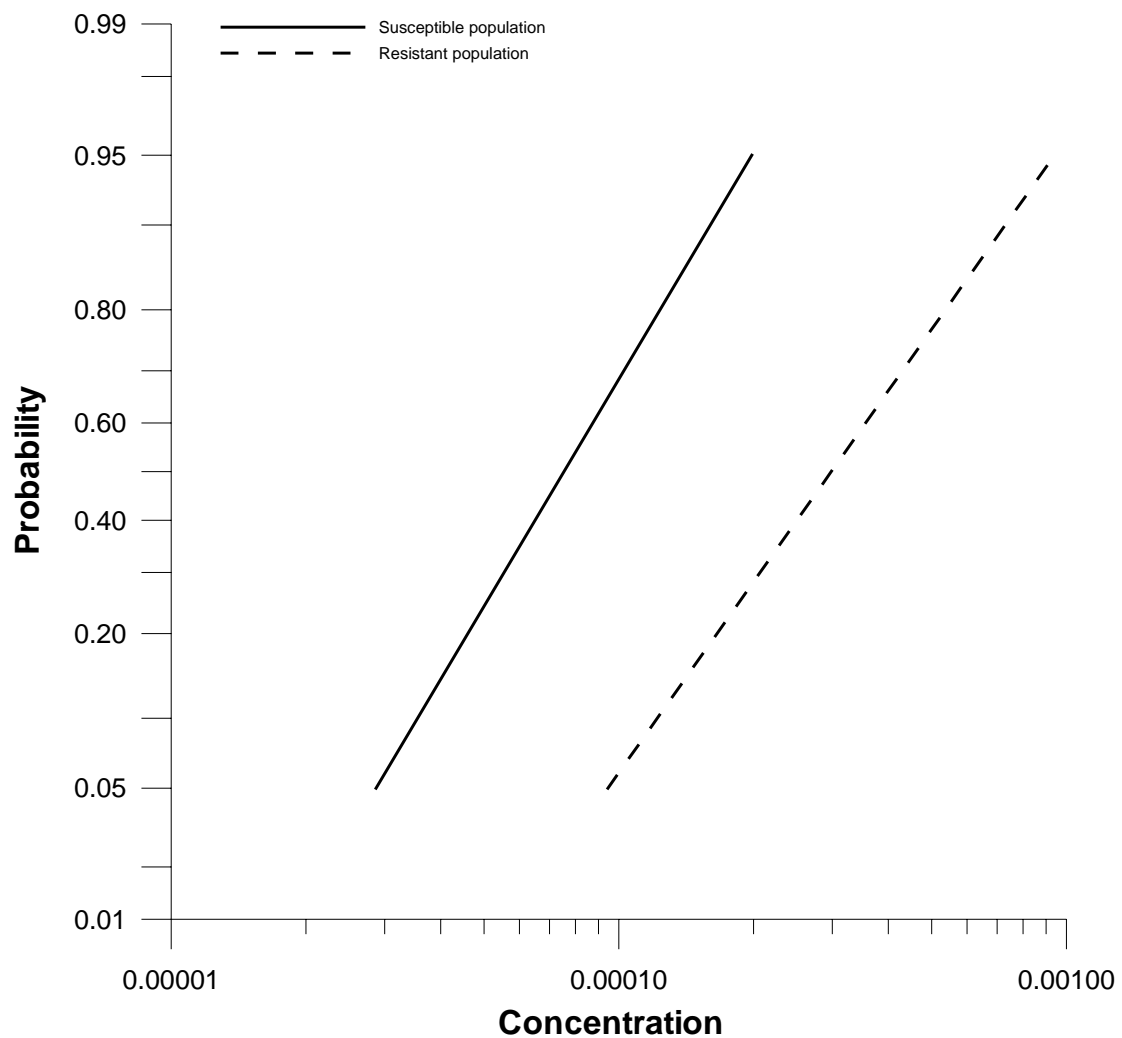


Figure 2. Log dose/probit mortality curves for a susceptible *Alphitobius diaperinus* population (Nobby) and a mean for six resistant populations from SEQ - topically dosed with cyfluthrin.

6. References

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7. Appendix

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Introduction

The darkling beetle, *Alphitobius diaperinus* (Panzer) is a common cosmopolitan insect pest of poultry houses, in particular broilers and egg barns. The species is believed to have originated in the tropical East African region. It occurs naturally in bird and bat nests where it feeds on droppings and animal parts such as feathers and carcasses. Because of its natural association with animals, in particular birds, this tropical species is well suited to the warm humid conditions that occur in heated or insulated poultry and other intensive livestock houses. The beetle is also known to be a pest of animal feeds within these systems. In spite of the occurrence of the pest on almost every Australian poultry farm, no Australian research has been done to determine the pest's status, abundance, behaviour, disease association and insecticide resistance.

In 1998 the authors commenced research to investigate the pest status and control of *A. diaperinus* in Australian broiler and egg barn systems, with a view to ultimately develop strategies for inclusion into a future integrated pest management system for the pest. These investigations commenced with the development of an insecticide resistance testing method, determining insecticide resistance in beetle populations from regional Queensland, Australia, and completing a bibliography of *A. diaperinus* research. This bibliography is presented here and is intended as a reference tool for current and future research workers of *A. diaperinus*. It outlines full reference retrieval information, including abstracts when available, for each scientific article, and group articles into specific areas of research; namely biology and behaviour, insecticide and non-insecticide control, and disease associations. The bibliography has been restricted to include only scientific journal and conference proceedings' articles. Poultry magazines and similar industry publications' articles have not been included in this publication as most have originated from earlier scientific publications.

BIBLIOGRAPHY

SECTION 1. ALL ARTICLES (BY AUTHOR/S)

ALICATA J.E.. 1945. **The value of crude naphthalene in controlling the beetle, *Alphitobius diaperinus*.** *Hawaii Agricultural Experiment Station Report 1943-1944*, 106–107.

Abstract

No abstract available

Key Subject

non insecticide control

ANDERSON JR & POORBAUGH JK. 1964. **Biological control possibility for houseflies.** *California Agriculture* **9**, 2–4.

Abstract

One phase of integrated fly control studies on poultry ranches in northern California involves research on several natural enemies of the house fly, *Musca domestica* L., the little house fly, *Fannia canicularis* (L.), and other nuisance flies. The black garbage fly, *Ophyra leucostoma* (Wied.), is one promising, and otherwise harmless, biological control agent. Its predaceous larvae kill and feed on house fly maggots and other fly larvae which commonly inhabit chicken droppings. Recent studies have shown that one *Ophyra* larvae during its development may kill from 2 to 20 *M. domestica* maggots per day.

Key Subject

biology & behaviour

APUYA LC, STRINGHAM SM, ARENDS JJ & BROOKS WM. 1994. **Prevalence of protozoan infections in darkling beetles from poultry houses in North Carolina.** *Journal of Invertebrate Pathology* **63**, 255–259.

Abstract

A study was conducted from November 1990 to February 1992 on the prevalence of protozoan infections in *Alphitobius diaperinus*, from turkey and broiler houses in the southeastern, northeastern and central Piedmont regions of North Carolina, USA. Beetles were commonly infected with the eugregarine *Gregarina alphitobii*, an undescribed species of *Gregarina* (Eugregarinorida, Gregarinidae) and the neogregarine *Farinocystis tribolii* (Neogregarinorida, Lipotrophidae). Both eugregarine and neogregarine parasites were present throughout the sampling period. A decreased trend in percentage infection by eugregarines in beetles from broiler houses was observed through time, while percentage infection in turkey houses showed a variable trend. Percentage neogregarine infection exhibited a variable trend with a significant difference in the overall rate of infection in the 2 types of production houses. Neogregarine infection was higher in the broiler houses than in turkey houses. Both adult and larval stages of the beetle were infected with the gregarines, with higher levels of infection observed in the larval stages. Mixed infections with both types of gregarines were highest in the smallest larvae.

Key Subject

non insecticide control

ARENDS JJ. 1991. **External parasites and poultry pests.** In Calnek BW, Barnes HJ, Beard CW, Reid WM, Yoder HW Jnr (eds.), *Diseases of Poultry*. 9th ed. Iowa State University Press, Ames, IA: 702–730

Abstract

No abstract available

Key Subject

disease association

ARENDS JJ & STRINGHAM SM. 1989. **Poultry Pest Management.** North Carolina Cooperative Extension Service, College of Agriculture and Life Sciences, North Carolina State University.

Abstract

No abstract available

Key Subject

non insecticide control

ARMITAGE DM. 1985. **Environment and deep-pit poultry houses: survey of air and manure temperatures in British houses.** *British Poultry Science* **26**, 275–280.

Abstract

1. In order to investigate factors which influence the development of insect infestations in poultry manure, air and manure temperatures in 5 deep-pit poultry houses were measured over a period of at least one year. 2. When the external temperature was below 10°C the air temperature in the cage and pit area dropped below the favoured temperature of 20°C. During winter, therefore, temperatures in some houses were often close to the lower limit for fly development. 3. Maximum temperatures of nearly 45°C were recorded in some manure heaps, whilst others at the same point in the manure cycle were 10°C lower. It was believed that the difference was due to the variation in the height of the manure pile, which in turn was determined by the cage stacking arrangements. 4. This difference could affect the rate of increase of predatory mites and beetles, so the design of the house may determine the type and extent of infestation.

Key Subject

biology & behaviour

ARMITAGE DM. 1986. **Population changes of four species of insects (Col. & Dipt.) in three deep pit poultry houses.** *Entomologist's Monthly Magazine* **122**, 1460–1463.

Abstract

No abstract available

Key Subject

biology & behaviour; insecticide control

ARSHAD M, JAN GA & KHATTACK A. 1984. **Insect fauna of birds' nests of N.W.F.P.** *Bulletin of Zoology Pakistan* **2**, 1–7.

Abstract

The nests of 11 species of bird, including pigeons, were examined for insects in a survey conducted in the North West Frontier Province of Pakistan. More than 25 species of insects were recorded, including the thysanuran *Lepisma saccharina*, the collembolan *Lepidocyrtus cyaneus*, the psocopteran *Liposcelis divinatorius*, the dermestids *Anthrenus flavipes*, *A. coloratus* and *Attagenus piceus* (*A. unicolor*), the bostrichid *Rhyzopertha dominica*, the silvanid *Oryzaephilus surinamensis*, the tenebrionids *Tribolium castaneum* and *Alphitobius diaperinus*, the bruchid *Bruchus chinensis* (*Callosobruchus chinensis*), the curculionid *Hypera variabilis* (*H. postica*), the cimicids *Cimex lectularius* and *C. macrocephalus* (*C. hemipterus*), fleas and biting lice. Many of these insects are pests of households and stored products.

Key Subjects

biology & behaviour

AVANCINI RMP & UETA MT. 1990. **Manure breeding insects (Diptera and Coleoptera) responsible for cestoidosis in caged layer hens.** *Journal of Applied Entomology* **110**, 307–312.

Abstract

The role of insects in the life cycle of cestode parasites of caged layer hens was studied in Campinas, Brazil. Of forty-one 81 week old Hyline birds necropsied, 15 were negative for cestodes, 17 were positive for *Raillietina laticanalis*, and 9 were positive for both *R. laticanalis* and *Hoanotaenia Infundibulum*. Of 1462 individuals of *Dermestes ater* collected from poultry droppings under the hen cages and examined for parasites, 702 (48%) were found harbouring *C. infundibulum* and *R. laticanalis*, and 1030 individuals of *Musca domestica* examined, 165 (16%) harboured *C. infundibulum* (only). *Stomoxys calcitrans*, *Muscina stabulans*, *Chrysomya putoria*, *C. megacephala*, *Alphitobius diaperinus*, a histerid and *Trox* sp. were not found to harbour cysticercoids, although 12 of 243 individuals of another species of histerid, 4 of 131 of a third species of histerid and 3 of 108 of a staphylinid did (for these cysticercoid-positive insects, the number of cysticercoids per insect was one, except for an individual staphylinid which harboured 4).

Key Subjects

disease association

AXTELL RC. 1985. **Arthropod pests of poultry.** In *Livestock Entomology*. : 269–295.

Abstract

No abstract available

Key Subjects

biology & behaviour

AXTELL RC & ARENDS JJ. 1990. **Ecology and management of arthropod pests of poultry.** *Annual Review of Entomology* **35**, 101–126.

Abstract

The major arthropod pest problems in modern integrated poultry production are reviewed. Pests discussed are ectoparasites (*Ornithonyssus sylvii*, *Menacanthus stramineus*, *Dermanyssus gallinae* and *Cimex lectularius*) and habitat pests (*Alphitobius diaperinus*, *Dermestes maculatus*, and filth flies

(*Musca domestica*, *Fannia* spp., *Ophyra* (Hydrotaea) spp., *Muscina stabulans*, *Stomoxys calcitrans* and *Hermetia illucens*)). Sections are given on: ectoparasite management; stress caused to poultry by ectoparasites; housing and production systems; fly predators, parasites and pathogens; and fly management.

Key Subjects

biology & behaviour

BAGGESEN DL, OLSEN JE & BISGAARD M. 1992. **Plasmid profiles and phage types of *Salmonella typhimurium* isolated from successive flocks of chickens on three parent stock farms.** *Avian Pathology* **21**, 569–579.

Abstract

S. typhimurium (387 strains) obtained from successive generations of parent stock originating from 3 different rearing farms in Denmark were characterized by phage typing and plasmid profiling; 76 strains representing dominant types were selected for restriction enzyme analysis and colony hybridization. The main phage of each of the 3 farms was 110. Plasmid profiling, however, allowed further subtyping. All but 3 isolates carried the serotype-specific virulence-associated plasmid. Restriction enzyme analysis showed variations in this plasmid as well as the presence of co-migrating plasmids of the same size. At each locality one or more clonal lines of *S. typhimurium* were reisolated from successive generations, indicating that the infections were persistent. Although house construction, sanitation and disinfection procedures, and precautionary measures in general were improved significantly during the observation period, infection with *S. typhimurium* was not eliminated until eradication of the beetle *Alphitobius diaperinus* was complete.

Key Subjects

disease association

BALA P, KAUR D, LIPA JJ & BHAGAT RC. 1990. ***Gregarina alphitobii* sp. n. and *Mattesia alphitobii* sp. n., parasitizing *Alphitobius diaperinus* Panz (Tenebrionidae, Coleoptera).** *Acta Protozoologica* **29**, 245–256.

Abstract

Gregarina alphitobii sp. nov., and *Mattesia alphitobii* sp. nov., parasitizing natural and laboratory populations of *Alphitobius diaperinus* Panz. in Africa (Nigeria), Europe (France, Poland, Germany), North America (USA) and Asia (India, Tonga Island) are described. *G. alphitobii* sp. nov. which is found in the mid and hindgut, is similar to *Gregarina cuneata* but differs from it in having a narrower protomerite and deutomerite and smaller cysts. *M. alphitobii* sp. nov., which infects the midgut and fat body of *A. diaperinus*, can be characterized by the size and shape of spore, prominence of polar protuberances, and the presence of polar plugs and two annular ridges. The life histories of both species is described. Some data on prevalence and distribution are also presented.

Key Subjects

non insecticide control

BARKE HE & DAVIS R. 1967. **Sexual dimorphism in the lesser mealworm, *Alphitobius diaperinus***

(Panz.). *Journal of the Georgia Entomological Society* 2, 119–121.

Abstract

In recent years, for several reasons, there had been increased interest in the lesser mealworm, *Alphitobius diaperinus* (Panz.). Back and Cotton (1962) listed the lesser mealworm as a pest of moldy or poor quality grain storehouses. Discovery that certain poultry diseases (Avian leukosis, Salmonellosis) might be transmitted by the lesser mealworm (Gould and Moses (1951), MacCreary and Catts (1954), Harding and Bissell (1958), Lancaster and Simco (1967)) has resulted in expanded research on the biology of this beetle and its potential role as a vector of other poultry diseases. Further interest arises from the realization the *Alphitobius* is an excellent subject for basic research investigations in entomology and ecology because of its adaptability to laboratory culture. One difficulty standing in the way of its convenient use as an experimental laboratory animal, however, has been the lack of an easy method of sexing the beetles. This paper presents such a method.

Key Subjects

biology & behaviour

BARKE HE & DAVIS R. 1967. **Notes on the biology of the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae).** *Journal of the Georgia Entomological Society* 4, 46–49.

Abstract

The life cycle of the lesser mealworm, *Alphitobius diaperinus* (Panz.), was completed in 60–85 days at 21°C in the laboratory. Oviposition occurred readily in rolled or folded back paper. Relative humidities of 70, 80 and 90% had little effect on the duration of the egg stage or the per cent of hatch. Application of Dyar's law indicated six to nine larval instars.

Key Subjects

BIOLOGY

BATTU GS & DHALIWAL GS. 1975. **On the activity of certain spider predators against stored grain insect pests.** *Current Science* 44, 893–894.

Abstract

In the light of evidence of predation on certain stored-product insects by spiders in India, adults and juveniles of *Artema atlanta* Walck., *Marpissa* sp., *Oecobius* sp., *O. putus* Cambridge, *Selenops agumbensis* Tikader and *Uloborus dandolius* Tikader collected from rural wheat stores near Ludhiana in July and August 1974 were starved and then offered adults or larvae of *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.), *Tribolium castaneum* (Hbst.) and *Alphitobius* sp. as prey in the laboratory, observations on insect mortality were made every 24h and the results are presented in a table. All 6 spider species preyed actively on the grain pests, and their methods of feeding are described. The preferred prey, against which all the spiders were very efficient, was the larvae of *T. castaneum*; *Artema atlanta* was equally effective against *S. oryzae*, and *Selenops agumbensis* against *R. dominica*.

Key Subjects

non insecticide control

BELLINI R & MAINI S. 1989. **The seasonal presence and activity of parasitoids (Hymenoptera: Pteromalidae) of synanthropic Diptera in animal housing in Romagna.** *Bollettino dell' Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna* 43, 217–222.

Abstract

The parasitoids of synanthropic filth flies were monitored in 4 animal houses (poultry houses, one dairy and one pig house) in farms in Forlì province, Romagna, Italy, in June–November 1987. A total of 30 251 naturally-occurring dipteran pupae were collected from the manure in the animal houses, a further 16 417 pupae of laboratory-bred *Musca domestica* were introduced into the houses. The fly population in the animal houses was monitored weekly by sticky traps. *Ophyra aenescens* (*Hydrotaea aenescens*) was the commonest filth fly in poultry housing, *M. domestica* in pig housing and *Stomoxys calcitrans* in dairy housing. All dipteran pupae were collected weekly and a total of 8201 parasitoids emerged from the collected pupae. The following parasitoids were found: *Spalangia cameroni* (51.16% of the total), *Muscidifurax raptor* (20.83%), *S. endius* (16.37%), *S. nigroaenea* (11.44%) and *Pachycrepoideus vindemiae* (0.20%). The percentage of parasitism was higher in wild than in introduced pupae, with *S. endius* and *S. nigroaenea* in particular showing preference for wild pupae. The beetles *Alphitobius diaperinus* and *Carcinops pumilio* were found in high density in poultry manure.

Key Subjects

biology & behaviour

BERTI FILHO E, COSTA VA & AAGEESEN TL. 1989. **Occurrence of natural enemies of *Musca domestica* L. (Diptera: Muscidae) in poultry areas of Bastos, State of Sao Paulo, Brazil.** *Revista de Agricultura (Piracicaba)* 64, 98.

Abstract

To determine the natural enemies of *M. domestica* present in the poultry housing in the Bastos region, San Paulo state, Brazil, samples of poultry droppings and housefly pupae were collected. The following natural enemies were recorded: the predators *Acritus analis*, *Aleochara puberula*, *Carcinops troglodytes*, *Euspilotus arrogans*, *Hister* sp. and *Philonthus sordidus* (Coleoptera); the competitors *Alphitobius diaperinus* (Coleoptera) and *Hermetia illucens* (Diptera); and the parasitoids *Muscidifurax uniraptor*, *Pachycrepoideus vindemiae*, *Spalangia cameroni*, *S. endius* and *S. gemina* (Hymenoptera: Pteromalidae).

Key Subjects

biology & behaviour

BHATTACHARYYA S. 1995. **Coleopteran insects in the nests of birds in West Bengal.** *Environment and Ecology* 13, 629–632.

Abstract

In 1984–85, the beetles associated with nests of *Streptopelia chinensis*, *Acridotheres tritis*, *Sturnus contra*, *Corvus splendens*, *Pycnonotus cafer*, *Prinia socialis*, *Ploceus philippinus* and *Passer domesticus* in 8 districts of West Bengal, India, were collected and identified. The nest environment played a part in regular beetle population density. 13 species

representing 10 genera in 6 families (Dermestidae, Ptinidae, Bostrychidae, Nitidulidae, Tenebrionidae and Bruchidae) were found, mostly known as stored products pests, and were new records as birds' nests inhabitants.

Key Subjects

biology & behaviour

BLAHUTIAK A. 1970. **Comparison of the effectiveness of five insecticides for control of *Alphitobius diaperinus***. *Academia de Ciencias de Cuba Instituto de Biología* **20**, 17.

Abstract

Fosfotion (an insecticide made in Czechoslovakia) proved to be the most efficient, compared to four other insecticides, in laboratory experiments on the beetle *Alphitobius diaperinus* Panzer, by the topical method of application. Results were the best for Fosfotion not only according to toxicity on the beetles tested, but also for its tolerance regarding warm blooded vertebrates, which makes it usable also in the semioperative test for the control of intermediary hosts of the nematode *Subulura suctorica* (Molin, 1860). Two of the other insecticides (Soldep and Lindano), less efficient than Fosfotion but with higher toxicity on warm blooded vertebrates, are also suitable for semioperative trials. DDT and Aldrin proved less suitable: DDT, for its lower toxicity on the beetles tested; Aldrin' for its higher toxicity on hens and other warm blooded vertebrates.

Key Subjects

insecticide control

BONIN W. 1977. **The results of laboratory investigations on the effectiveness of the insecticide heptenophos - from the point of view of the possibility of its use as a compound against ectoparasites in veterinary medicine**. *Berliner und Muenchener Tieraerztliche Wochenschrift* **90**, 34–37.

Abstract

The results are presented of laboratory toxicity tests of heptenophos against 7 species of arthropods that are (mainly) ectoparasites of domestic animals and man. Against *C(imex) lectularius* L. and (in brackets) *D(ermanussus) gallinae* (Deg.), the LC50 (expressed as a percentage) was 5.3×10^{-3} (5.0×10^{-6}), as compared with 3.2×10^{-2} (1.3×10^{-4}) for trichlorphon, 3.8×10^{-2} (1.3×10^{-3}) for carbaryl and 6.2×10^{-2} (1.3×10^{-2}) for bromocyclen. The lethal times and residual action are given, together with further results with various insecticides are acaricides for comparison with heptenophos against *M(elophagus) ovinus* (L.), *L(ucilia) cuprina* (Wied.), *A(lphitobius) diaperinus* (Panz.), *Ps(oroptes) cuniculi* (Delafond) and *A(mblyomma) hebraeum* Koch. Heptenophos was strongly insecticidal and acaricidal, had an extremely rapid action and short residual effect, and was effective as a vapor.

Key Subjects

insecticide control

BRENDALL MTO. 1975. **Key to species of the genus *Alphitobius* (Stephens), (Coleoptera: Tenebrionidae)**. *Proceedings of the Royal Entomological Society of London* **5**, 14–15.

Abstract

No abstract available

Key Subjects

biology & behaviour

BYNG AJ. 1962. **A study of the fauna of poultry deep litter**. *Agricultural Science* **60**, 251–257.

Abstract

No abstract available

Key Subjects

biology & behaviour

CASTRILLO LA et al. 1998. **Differentiation of *Beauveria bassiana* isolates from the darkling beetle, *Alphitobius diaperinus*, using isozyme and RAPD analyses**. *Journal of Invertebrate Pathology* **72**, 190–196.

Abstract

No abstract available

Key Subjects

disease association

CHAIX MO. 1980. **The disinsection of rearing premises**. *Phytoma* **314**, 18–20.

Abstract

The injuriousness and control of arthropods in premises for rearing domestic animals, especially cattle, pigs and poultry in France, are reviewed. Special attention is paid to flies as vectors of disease, flies and fleas causing reductions in production of milk and eggs, respectively, and the infestation of feed by stored-product pests. *Alphitobius diaperinus* (Panz.) has caused important damage to insulating structures made of polystyrene and related materials in the past 2 years, especially where stock is reared on an industrial scale. Good agricultural practice, including maintaining atmospheric conditions unsuitable for pests, eliminating cover where they can breed, and the use of netting over windows, are recommended, and a list of 12 insecticides that can be used is given.

Key Subjects

biology & behaviour; insecticide control

CHATTERJEE NB & GANGOPADHYAY AK. 1988. **Environmental cues in monthly egg laying and hatching of lesser mealworm *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae)**. *Proceedings of the Zoological Society* **40**, 13–18.

Abstract

Environmental temperature and relative humidity play important roles in regulating laying and hatching of eggs of *Alphitobius diaperinus*, a stored product pest. During winter the rates of egg laying and hatching significantly decrease, and in summer and monsoon these increase. Continuous egg laying and hatching behaviour may be associated with uninterrupted vitellogenesis. Ecological plasticity in the reproductive behaviour of *A. diaperinus* is partly due to temperature and humidity responsiveness of the adult beetle population.

Key Subjects

biology & behaviour

COGAN P, WEBB D & WAKEFIELD M. 1996. **A comparison of four residual insecticides for the**

- control of the lesser mealworm beetle (*Alphitobius diaperinus* Panzer) in turkey broiler houses in the UK.** *International Pest Control* March/April, 52–55.
- Abstract**
Residual applications of iodofenphos SC, fenitrothion WP, permethrin WP and azamethiphos WP were evaluated for the control of *Alphitobius diaperinus* (the lesser mealworm or darkling beetle) in earth floored turkey broiler units. Single applications of either iodofenphos SC, fenitrothion WP or permethrin WP were found to be ineffective, but azamethiphos WP was found to be effective over the stocking period of four months. A total of only four beetles found during the four months of the final stocking cycle throughout the five sheds treated with azamethiphos WP. This may be compared with the shed treatment with iodofenphos SC where more than 3300 *A. diaperinus* were found in the samples of litter in the final population assessment. The level of control of *A. diaperinus* was not significantly improved by a supplementary application of dichlorvos as a space spray after treatment with a residual insecticide, before restocking with birds. Bioassays showed that azamethiphos was the most persistent of the insecticides used and was effective at even high summer temperatures. Persistence of iodofenphos deposits indicated that survival of *A. diaperinus* was most likely to be due to resistance and not poor treatment or insecticide breakdown.
- Key Subjects**
biology & behaviour; disease association; insecticide control
- CONWAY JA. 1973. **The micro-fauna of Californian-system poultry houses in Britain.** *British Poultry Science* **14**, 213–216.
- Abstract**
No abstract available
- Key Subjects**
biology & behaviour
- CRAWFORD PJ, BROOKS WM & ARENDS JJ. 1998. **Efficacy of field-isolated strains of *Beauveria bassiana* (Moniliales: Moniliaceae) as microbial control agents of the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **91**, 1295–1301.
- Abstract**
Two field isolates (NC2 and NC3) of *B. bassiana* were evaluated as microbial control agents of *Alphitobius diaperinus* in a bioassay system incorporating physical characteristics of commercial poultry houses. Both isolates produced >90% mortality in new litter against larval *A. diaperinus* at the highest application rate (2.37×10^{11} conidia per square metre) 2 wk after application. Neither isolate achieved as high a rate of mortality in used litter. Adult *A. diaperinus* were less susceptible than larvae to these isolates. At the highest application rate (2.37×10^{11} conidia per square metre), isolate NC2 conidia achieved 60% mortality of adults in new litter and 33% mortality in old litter. The same concentration of isolate NC3 conidia produced 68 and 33% mortality in new and used litter, respectively.
- Key Subjects**
non insecticide control
- CROOK PG, NOVAK JA & SPILMAN TJ. 1980. **The lesser mealworm, *Alphitobius diaperinus*, in the scrotum of *Rattus norvegicus*, with notes on other vertebrate associations (Coleoptera, Tenebrionidae; Rodentia, Muridae) Philippines.** *Coleopterists Bulletin* **34**, 393–396.
- Abstract**
Larvae and adults of *A. diaperinus* bored into and lived in the scrotum of *R. norvegicus* on Negros Is., Philippines. The lesser mealworm, sometimes associated with bats, poultry and other birds, and several vertebrates.
- Key Subjects**
biology & behaviour
- DALE PS, HAYES JC & JOHANNESSON J. 1976. **New records of plant pests in New Zealand.** *New Zealand Journal of Agricultural Research* **19**, 265–269.
- Abstract**
The arthropods reported from New Zealand for the first time are *Coccus longulus* (Dgl.) (*Lecanium longulum*), which was found on papyrus leaves (*Cyperus papyrus*) at Auckland in 1973; *Aleyrodes proletella* (L.), on cabbage in Auckland in 1975; *Prays nephelomina* Meyr., on lemon flowers at Tauranga in 1975; *Phyllocoptruta oleivora* (Ashm.), on grapefruit in Auckland in 1975; and *Tarsonemus waitei* Banks, on glasshouse tomatoes at Whangarei in 1974. Pests are also recorded from 12 new food-plants, and it is reported that *Alphitobius diaperinus* (Panz.) has several times been observed destroying polystyrene wall insulation in poultry broiler houses in New Zealand.
- Key Subjects**
biology & behaviour
- DASS R, AGARUAL RA & PAUL AUN. 1984. **Feeding potential and biology of lesser mealworm *Alphitobius diaperinus* (Panz.) (Col., Tenebrionidae), preying on *Corcyra cephalonica* St. (Lep., Pyralidae).** *Zeitschrift fuer Angewandte Entomologie* **98**, 444–447.
- Abstract**
The grubs and adults of the lesser mealworm, *Alphitobius diaperinus* (Panz.) were found gregariously feeding on the eggs and larvae of *Corcyra cephalonica* St. for the first time in India. The development period from egg to adult was completed in 70 to 89 days at $27 \pm 1^\circ\text{C}$ and $65 \pm 5\%$ R.H. The mean egg, larval and pupal periods were 6.6, 68.8 and 8.4 days, respectively. The longevity of most of the beetles was between 14 and 16 months and they laid fertile eggs ranging between 1059 to 1874 per female. Some of the beetles are found to survive beyond 16 months and lay very few eggs. The beetle remained active in the laboratory throughout the year with a peak during summer season.
- Key Subjects**
biology & behaviour; non insecticide control
- DAVIES R & WRAY C. 1995. **Contribution of the lesser mealworm beetle (*Alphitobius diaperinus*) to carriage of *Salmonella enteritis* in poultry.** *Veterinary Record* **137**, 407–408.

Abstract

None of the 20 live *Alphitobius* beetles fed fish meal contaminated with 103 to 104 *S. enteritis* per gram for 6 days, experimentally, were found to have surface contamination with *Salmonella* and *Salmonella* could not be cultured from the beetles after they had been killed and macerated. Environmental surface swabs, mice *Mus musculus domesticus* and *Alphitobius* beetles collected from 2 broiler breeder units which had contained *S. enteritis* infected flocks were cultured for *Salmonella*. *S. enteritis* was present in 22% of the swabs and 48.6% of mice PM but none of the 500 beetles examined were positive. The results suggest that *Alphitobius* beetles may be relatively resistant to *Salmonella* colonization and infected mice and environmental contamination are likely to be a greater hazard

Key Subjects

disease association

DAVILA M, REBOLLO M & TELLEZ G. 1996. **The importance of the beetle *Alphitobius diaperinus* in poultry litter as a vector of *Salmonella* sp. and *Escherichia coli* in poultry farms in Mexico.** *Proceedings of the Western Poultry Disease Conference 45th*, 291–293.

Abstract

The purpose of this work was to evaluate the presence of *A. diaperinus* in poultry litter by monitoring several areas within the Mexican Republic. Ten sample collections from different farms with the problem were performed in the States of Coahuila, Mexico, Yucatan, Jalisco, Morelos, Queretaro and Mexico City with the purpose of isolating *Salmonella* sp. and *E. coli* from this black beetle. These farms had not necessarily presented salmonella problems in the past. Results from bacteriological tests indicated that 21.42% isolated were positive to *Salmonella* sp. and 28.57% were positive to *E. coli*.

Key Subjects

disease association

DE LAS CASAS E, POMEROY BS & HAREIN PK. 1968. **Infection and quantitative recovery of *Salmonella typhimurium* and *Escherichia coli* from within the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **47**, 1871–1875.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

DE LAS CASAS E, HAREIN PK, DESHMUKH DR & POMEROY BS. 1973. **The relationship between the lesser mealworm and avian viruses. I. Reovirus 24.** *Environmental Entomology* **2**, 1043–1047.

Abstract

Reovirus 24 survived in *Alphitobius diaperinus* for at least 9 days when fed infected choriollantoic membrane for 2 days, followed by a 9 day starvation period; the titre decreased with time. The virus also survived the metamorphosis of the insect, but the concentration of the virus in newly emerged adults was relatively low. Artificially infected mealworms successfully contaminated a mixture of poultry litter,

food and faeces, and this mixture remained contaminated for 7 days; excrement of the infected mealworms was the major source of contamination for at least 3 days. When uninfected mealworms were exposed to the infected mixture of litter, food and faeces, the virus was recovered from the insects following the first day of feeding, but the virus titre within the adults never increased in spite of its high concentration in the infected medium; reovirus 24 could not be detected in these insects 5 days after exposure. In general, the lesser mealworm is a relatively inefficient carrier of reovirus 24, even when exposed to highly infected sources.

Key Subjects

disease association

DE LAS CASA E, HAREIN PK, DESHMUKH DR & POMEROY BS. 1976. **Relationship between the lesser mealworm, fowl pox and Newcastle disease virus in poultry.** *Journal of Economic Entomology* **69**, 775–779.

Abstract

Alphitobius diaperinus (Panzer) was investigated under laboratory conditions to determine its importance as a potential carrier of 2 avian viruses. The lesser mealworm, exposed to a medium contaminated with the fowl pox virus, ingested the virus within the 1st 6h but retained it less than 7 days. Artificially infected lesser mealworms transferred fowl pox virus through their excrement into a noncontaminated medium within the 1st 6h. The virus failed to multiply inside the lesser mealworms. All attempts to recover the Newcastle disease virus from the lesser mealworm were unsuccessful with the exception of adult beetles fed on highly infected chorioallantoic membranes. The toxicity of a bacterial-free suspension of the lesser mealworm on the Newcastle disease virus was demonstrated.

Key Subjects

disease association

DE LAS CASAS E, HARIEN PK & POMEROY BS. 1972. **Bacteria and fungi within the lesser mealworm collected from poultry brooder houses.** *Entomops* **1**, 27–30.

Abstract

During 1968 and 1969, adult *A. diaperinus* were collected from turkey brooder houses in Minnesota, Wisconsin and S. Dakota, USA, and were analyzed for bacteria and fungi. The animals were surface disinfected, macerated and cultured on different media, the choice depending on the experimental objectives. A wide range in the number of micro-organisms was found within individual animals. Some harboured several thousand colonies, whereas others were comparatively clean. *Micrococcus* spp, *Streptococcus* spp and the *Bacillus subtilis* group were the most common gram-positive bacteria. Emphasis was given to gram-negative bacteria, especially those belonging to the enterobacteriaceae group. *Escherichia intermedia* was isolated from a relatively high percentage. *Salmonella saint-paul* occurred only in 3% of the *A. diaperinus*, such animals coming from only a single locality. *Aspergillus flavus* was the dominant fungus, an average of 25% being positive. Other spp of

Aspergillus, *Penicillium* spp and *Candida* spp were also present, but in relatively low numbers.

Key Subjects

disease association

DE LAS CASAS E, HAREIN PK, YORK MD & POMEROY BS. 1974. *Escherichia coli* serotypes isolated from within the lesser mealworm and evaluated for virulence. *Annals of the Entomological Society of America* **67**, 967–970.

Abstract

Differences in virulence of strains of *Escherichia coli* isolated from the lesser mealworm, *Alphitobius diaperinus* (Panz.), were demonstrated in embryonating chicken eggs by the use of the allantoic route of inoculation. The ability of certain strains to kill a percentage of the inoculated eggs showed a reproducible pattern from the individual strains. Thus, grouping of strains into arbitrary categories of virulence (high, medium, low and avirulent) according to the percentage of embryos killed seems feasible and comparable to similar experiments carried out with strains isolated from man and animals. The disease producing ability strains of *E. coli* appears to be reduced when recovered from within the mealworm. It is likely that these insects are an abnormal host for those strains of *E. coli* that are adapted and pathogenic to warm blooded animals.

Key Subjects

disease association

DE LAS CASA E, POMEROY BS & HAREIN PK. 1968. Infection and quantitative recovery of *Salmonella typhimurium* and *Escherichia coli* from within the lesser mealworm, *Alphitobius diaperinus* (Panzer). *Poultry Science* **47**, 1871–1875.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

DEMILO AB, MILLER RW, BORDAS B, REDFERN RE & MILLS G JNR. 1995. Larvicidal effects of benzoylphenylureas against the lesser mealworm (Coleoptera: Tenebrionidae): quantitative structure-activity relationships. *Journal of Entomological Science* **30**, 324–332.

Abstract

Larvicidal activity of a congeneric set of *N*-2-halo- (and 2,6-dihalo) benzoyl-*N'*-phenylureas was determined in *in vivo* tests and *Alphitobius diaperinus*. Substituent modifications were made in both the benzoyl and anilide portions of the molecule. Linear regression analysis was used to derive quantitative structure-activity relationships (QSAR) from LC50 and LC99 values and a series of physicochemical substituent parameters. The analysis resulted in 2 significant single parameter regression equations selecting Hammett σ constant as the only relevant chemical descriptor and rejecting the other descriptors as insignificant. Penfluron and 2,6-difluoro-*N*-[[[4-(trifluoro-methoxy)phenyl]amino]carbonyl]benzamide were

potent larvicides in these tests and exceeded the effectiveness of diflubenzuron and triflumuron.

Key Subjects

insecticide control

DE SANTIS L, LOIACONO MS & COSCARON M DEL C. 1987. **Parasitoids and predator insects.** In Brenner RR and de la Merced Stoka A (eds.) *Chagas' disease vectors*. Volume 1. Taxonomic, ecological, and epidemiological aspects. CRC Press, Inc., Florida: 21–39.

Abstract

This review of the insect predators and parasitoids of Triatominae gives a list of known natural enemies arranged by order and family, together with notes on the following species and assessments of their potential value as biological control agents: Mantidae; *Clerada apicicornis* (Lygaeidae); *Apiomerus*, *Cosmoclopius*, *Daraxa*, *Graptocleptes*, *Microtomus*, *Opisthacidi*, *Rasahus*, *Reduvius*, *Zelurus* and other species of Reduviidae; Coleoptera (including *Alphitobius diaperinus*); *Sarcodexia sternodontes* (Sarcophagidae); *Eciton* and *Pheidole megacephala* (Formicidae); *Oolathron mireyae* (Aphelinidae); *Anastatus excavatus*, *A. catamarcensis*, *A. coreophagus* and *A. charitos* (Eupelmidae); *Ooencyrtus venatorius* (Encyrtidae); *Gryon triatomae*, *G. linschostei*, *Telenomus capito*, *T. costalimai* and *T. fariai* (including *T. f. fariai* and *T. f. rabinovichii*) (Scelionidae).

Key Subjects

biology & behaviour

DESPINS JL. 1987. **Investigations of the destructive behavior, and methods for control of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Dissertation Abstracts International* **48**, 334-B.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

DESPINS JL & AXTELL RC. 1995. **Feeding behavior and growth of turkey poult fed larvae of the darkling beetle, *Alphitobius diaperinus*.** *Poultry Science* **73**, 1526–1533.

Abstract

Experiments were conducted to determine the effect of feeding larvae of the darkling beetle (lesser mealworm), *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), to turkey poults on poult growth and of beak trimming on poult feeding on the larvae. Young turkey poults readily fed on the larvae and exhibited reduced growth in the absence of other feed. Poults 3 to 5d old restricted to a diet of only larvae consumed 259 ± 99 (\pm SD) larvae per poult per day and their body weights were significantly lower (mean(x) = 30g) at the end of the 3d than for poults on starter feed during the same time. After return to starter feed for 16d after feeding on larvae for 3d, the poults did not compensate for the weight loss although weight gains were normal. Poults from 2 through 10d of age were given a choice between starter turkey feed and darkling beetle larvae. The numbers of larvae consumed per poult per day were: 174 ± 8 for days 2 to 4, 221 ± 3 for days 5 to 7,

and 189 ± 80 for days 8 to 10. There were no significant differences between the body weight of poult feeding on larvae and starter feed compared with that of poult consuming feed only. In the presence of larvae, the mean feed consumption per poult was lower than for poult provided with only starter feed. The beetle larvae were 68% crude protein and 21% fat (DM basis) and had higher amounts of 18 amino acids than the starter feed. Poult that were beak trimmed consumed only about one-third as many larvae as poult with intact beaks. Poult (1 to 3d old) with intact beaks consumed 169 ± 20 larvae per poult per day; poult with trimmed beaks consumed 58 ± 23 larvae per poult per day.

Key Subjects

biology & behaviour

DESPINS JL, AXTELL RC, RIVES DV, GUY JS & FICKEN MD. 1994. **Transmission of enteric pathogens of turkeys by darkling beetle larva (*Alphitobius diaperinus*)**. *Journal of Applied Poultry Research* **3**, 61–65.

Abstract

Larvae of the darkling beetle (lesser mealworm) were exposed to turkey feces from an enteritis-affected flock and determined to contain turkey enterovirus and rotavirus. Growth depression and increased mortality were observed in turkey poult, which fed on the exposed larvae. Exposed larvae, which had been surface-sterilised also, produced clinical signs of enteritis after consumption by the poult, indicating that pathogens were able to survive within the larvae. This experiment demonstrated the capacity of the larva of the darkling beetle to serve as a mechanical vector for enteric pathogens of turkeys.

Key Subjects

disease association

DESPINS JL, TURNER EC JNR & PFEIFFER DG. 1991. **Evaluation of methods to protect poultry house insulation by lesser mealworm (Coleoptera: Tenebrionidae)**. *Journal of Agricultural Entomology* **8**, 209–217.

Abstract

Insecticide sprays and paint barriers applied to the surface of extruded polystyrene, and different types of insulation, were evaluated for prevention of lesser mealworm, *Alphitobius diaperinus* (Panzer), infestations. In a laboratory study, tetrachlorvinphos 50 WP and pirimiphos-methyl 7E on extruded polystyrene produced > 90% mortality in larval and adult lesser mealworm populations 71 wk after application. These insecticide spray treatments, however, were not effective under conditions found in the manure pit of a high rise cage layer house. Our field study showed that Styrofoam BB and Ethafoam 220, were resistant to lesser mealworm infestations. Super IQ paint, a latex paint impregnated with chlorpyrifos, was also effective in protecting extruded polystyrene from infestations under field conditions.

Key Subjects

biology & behaviour; insecticide control

DESPINS JL, TURNER EC JNR & RUSZLER PL. 1987. **Construction profiles of high rise caged layer houses in association with insulation damage caused by the lesser mealworm,**

Alphitobius diaperinus (Panzer) in Virginia. *Poultry Science* **66**, 243–250.

Abstract

The relationship between types of construction of high rise caged layer houses and insulation damage produced by the lesser mealworm, *Alphitobius diaperinus* (Panzer), was examined. There were no infestations in polyurethane insulation that had heavy weight paper glued to the surface of the insulation and installed with tape to seal off the seam between insulation boards. High rise houses with pit walls constructed of concrete block had lower insulation infestations than houses with wooden walls forming the pits. Houses that had pit wall foundations built of both types of materials had intermediate lesser mealworm infestations. Houses with the support structure set on top of the concrete block pit wall had lower infestations than houses where the support structure was set directly into the earth. There was a reduced gradient of damage with height of insulation above the pit; insulation installed in the pit was the most severely infested. Extruded polystyrene insulation exposed to 10 years or more of lesser mealworm infestation suffered a substantial loss of volume in the corner area of the insulation panels, resulting in a 9.1 to 30.8% reduction from an original volume of 84 838 cm³. Additionally, there was a significant reduction in R-value of infested insulation.

Key Subjects

biology & behaviour

DESPINS JL, TURNER EC JNR & RUSZLER PL. 1989. **Effects of poultry manure moisture and poultry house construction materials on the movements of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), a structural insect pest in high rise caged layer houses**. *Poultry Science* **68**, 1326–1331.

Abstract

Observations were made on the effect of manure moisture and method of construction of the manure pit walls on the dispersal behaviour of larvae and adults of *A. diaperinus* in high rise caged layer chicken houses. Larvae preferred to remain in manure habitats with 30 and 40% moisture; dispersal from the manure increased significantly at 50 or 60% moisture. Adults were more active than larvae in manure at 30 and 40% moisture, with dispersal rates increasing significantly as the moisture levels rose. Larvae could climb a significantly greater distance up a vertical wooden surface than up a vertical concrete block surface. This indicated that high rise chicken houses built with wooden pit walls and support beams that are set directly into the ground are predisposed to greater levels of insulation damage than houses built with concrete block foundations.

Key Subjects

biology & behaviour

DESPINS JL, VAUGHAN JA & TURNER EC JR. 1988. **Role of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), as a predator of the house fly, *Musca domestica* L. (Diptera: Muscidae), in poultry houses**. *The Coleopterists Bulletin* **42**, 211–216.

Abstract

The role of the lesser mealworm, *Alphitobius diaperinus* (Panzer), as a predator of house fly *Musca domestica* L., maggots and pupa in poultry houses is discussed. Late instar larval and adult *A. diaperinus* fed on house fly maggots when isolated together in glass vials. Lesser mealworm adults and middle instar larvae significantly reduced house fly emergence from apparatus which simulated the manure pit environment of the a high rise caged layer egg house.

Key Subjects

biology & behaviour

DUFOUR L, SANDER JE, WYATT RD, ROWLAND GN & PAGE RK. 1992.

Experimental exposure of broiler chickens to boric acid to assess clinical signs and lesions of toxicosis. *Avian Diseases* **36**, 1007–1011.

Abstract

The safety of using orthoboric acid in poultry houses to control darkling beetles (*Alphitobius diaperinus*) was assessed. One-day-old broiler chicks were housed on litter treated with 0, 0.9, 3.6 or 7.2 kg of boric acid per 9.3 m² of floor space. After 15 days, average body weights were 340.7, 278.1 and 213.2g for chickens exposed to 0, 3.6 and 7.2kg boric acid/9.3 m², respectively. Feed conversion was 1.68 and 2.29 in chickens exposed to 0 and 7.2 kg boric acid/9.3 m². In a second experiment, after birds ingested feed treated with 2500 and 5000 ppm (mg/kg) of boric acid for 2 weeks, body weights were 254.8 and 149.6g, respectively. The chickens in the control group weighed an average of 285.0g. The 5000 ppm treatment group had a feed conversion of 1.70 compared with 1.45 in the controls. A dose-related feathering abnormality was evident in treated chickens. No significant histopathological changes were observed. Survival, weight gain, and feed conversion were not adversely affected in broilers as a result of exposure to litter treated with boric acid at the recommended levels of 0.4-0.9 kg/9.3 m².

Key Subjects

non insecticide control

EDWARDS JP & ABRAHAM L. 1985. **Laboratory evaluation of two insect juvenile hormone analogues against *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **21**, 189–194.

Abstract

The insect juvenile hormone analogues methoprene and fenoxycarb have been tested against larval stages of the lesser mealworm, *Alphitobius diaperinus*. Methoprene completely prevented the formation of adult insects at a concentration of 5.0 ppm in food medium. The same effect was achieved with only 0.05 ppm fenoxycarb. There was no evidence that sub-lethal levels of methoprene decreased the fecundity of insects that successfully completed adult development. The results of these laboratory tests are discussed in relation to the potential use of these compounds for control of *A. diaperinus* in intensive poultry production units.

Key Subjects

biology & behaviour; insecticide control

EIDSON CS, SCHMITTLE DC, LAI JB & GOODE RB. 1965. **The role of the darkling beetle, *Alphitobius diaperinus* in the transmission of acute leucosis in chickens.** *Poultry Science* **44**, 1366–1367.

Abstract

No abstract available

Key Subjects

disease association

EIDSON CS, SCHMITTLE SC, GOODE RB & LAL JB. 1966. **Induction of leukosis tumors with the beetle *Alphitobius diaperinus*.** *American Journal of Veterinary Research* **37**, 1053–1057.

Abstract

Chickens dead of leukosis had larvae and adults of the beetle *Alphitobius diaperinus* in the subcutis. Poultry litter from a poultry house, where there was an increasing incidence of leukosis, was found teeming with the beetles. A prepared suspension of larvae or adult beetles collected from the litter was injected into susceptible day-old chicks either orally or intra-abdominally and resulted in leukosis tumor development in 25 to 83% of the chicks by 4 weeks of age; uninoculated controls were negative. Chicks placed on used litter with beetles also developed tumors. Treatment of the external surface of the beetles with bichloride of mercury did not appreciably diminish the oncogenic properties; on the other hand, sterilization (by autoclaving) of beetles prior to processing in activated the tumor-producing properties.

Key Subjects

disease association

ELOWNI EE & ELBIHARI S. 1979. **Natural and experimental infection of the beetle *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) with *Choanotaenia infundibulum* and other chicken tapeworms.** *Veterinary Science Communications* **3**, 171–173.

Abstract

Naturally occurring cysticeroids of *Choanotaenia infundibulum* were recovered by dissection from 78 out of 542 adults of *Alphitobius diaperinus* (Panz.) collected from 2 poultry farms in Khartoum, Sudan. Larvae were also found to be infected, but only at the rate of 0.75%. Experimental infection of healthy adults confirmed the suitability of this species as an intermediate host for *C. infundibulum*, but 4 other species of tapeworms affecting poultry failed to develop in *A. diaperinus*. This is the first record of *A. diaperinus* as an intermediate host for *C. infundibulum*.

Key Subjects

disease association

ERICHSEN LD. 1996. **Behaviour and population dynamics of litter beetles in broiler houses.** *Danish Pest Infestation Laboratory Annual Report*, 64–65.

Abstract

A master's degree project on the population dynamics and behaviour of four species of beetles (*Alphitobius diaperinus*, *Typhaea stercorea*, *Ahasverus advena* and *Carcinops pumilio*) in a broiler farm started in

September 1996, and is planned to end in the winter of 1997. In the autumn of 1995, a Danish farmer reported to the Danish Pest Infestation Laboratory that he had an unusually high number of beetles in his farm and that he also had salmonella-infested poultry. To obtain additional proof of a possible link between salmonella and beetle presence, a few simple experiments were carried. The results indicate that salmonella could be transferred from beetles to a previously clean stock of poultry. To control the beetles, different traditional pesticides and methods have been used. However, further knowledge on population dynamics and behaviour of the beetles is important for a satisfactory control of the beetles. I have found no references to field studies of these beetles in chicken poultry farming, but all four species have been well examined in laboratory trials since they are all common pest in stored products worldwide. This project examines population increase, development rates, flight activity and habitat preferences in the farm for all four species mentioned above. The investigation was carried out as a field study in two six-week periods. A new trap design was used in the experiment and was therefore tested. All experiments were carried out in a Danish broiler farm on Funen. The preliminary results indicate that the population increase is in accordance with results obtained in laboratory experiments described in literature. However, *T. stercorea* and *Ahasverus advena*, which were expected to manage two generations, only managed one, as did *A. diaperinus* and *C. pumilio*. After each six-week period the houses were cleaned very thoroughly, so when a new test period started, the beetles had to resettle the houses and it seems that they never reached an equilibrium before the houses were cleaned again. There was a very clear difference in flight activity of the two species that were observed flying (*Ahasverus advena* and *T. stercorea*). Another observation was that *T. stercorea* seems to prefer more humid surroundings, which is only natural since it is considered to be a fungus eater. All species of beetles were contagiously distributed in the house.

Key Subjects

biology & behaviour; disease association

ERICHSEN LD & JESPERSEN JB. 1997.

Behaviour and population dynamics of litter beetles in broiler houses. *Danish Pest Infestation Laboratory Annual Report*, 71.

Abstract

A master's degree project on the population dynamics and behaviour of litter beetles (specifically *Alphitobius diaperinus*, *Typhaea stercorea* and *Ahasverus advena*) in a broiler farm was initiated in September 1996, and is planned to end mid-1998. All of these species are common pests in stored products worldwide and have therefore been extensively studied in laboratory trials. However, little or no work has been carried out on the field biology of these beetles in chicken production facilities. This project examined population increase, development rates, flight activity and habitat preferences in a commercial broiler facility for the beetle species mentioned above. The investigation was carried out as a field study in two six-week periods. A new trap design was used in the experiment and was therefore tested as part of the

study. All experiments were carried out on a Danish broiler farm on Funen. The development times from egg to adult emergence of *T. stercorea*, *A. diaperinus* and *A. advena* were estimated to be approximately three weeks, four weeks and five to six weeks, respectively. All three species were therefore only able to complete one generation within one chicken rearing period of six weeks. *T. stercorea* and *A. advena* were observed to leave the litter shortly after adult emergence. All three species had a distinct preference for a particular environment and the distribution of the two large fungus feeders, *T. stercorea* and *A. advena*, was closely correlated in all samples. *A. advena* was the only beetle to fly in significant numbers. Tube traps were well suited for monitoring the activity of adult *T. stercorea*, *A. advena* and *A. diaperinus* adult and larvae in the litter. Bait bags were well suited for monitoring of the activity of *T. stercorea* and *A. advena* on the walls. A full description of the investigation is now being published as a master's thesis by L.D. Erichsen; the results will later be published as a formal paper.

Key Subjects

biology & behaviour

ESPAIN L & JURASEK V. 1971. **First finding of the cysticeroids of *Raillietina* (S.) *cesticillus* (Molin, 1858) in the beetles *Carcinops troglodytes*, Paykull (Histeridae) under natural poultry-rearing conditions.** *Revista Cubana de Ciencias Veterinarias* 2, 217–222.

Abstract

A list is given of some 100 species of Coleoptera previously recorded as intermediate hosts of the Cestode *Raillietina cesticillus*, and the finding in Cuba of cysticeroids of *R. cesticillus* in the Histerid *Carcinops troglodytes* (Payk.) for the first time is recorded. Examples of *C. troglodytes* were collected from fowl houses at a farm in the Havana area, and on examination 4 out of 160 were found to contain a single cysticeroid. As beetles are plentiful and could be eaten in large numbers by the fowls, it is concluded that they could be responsible for infecting them with *R. cesticillus* and should be considered as intermediate hosts under normal conditions of poultry keeping in Cuba, together with *Dermestes ater* Deg., the chief vector there, and *Alphitobius diaperinus* (Panz.).

Key Subjects

disease association

EUGENIO C, DE LAS CASAS E, HAREIN PK & MIROCHA CJ. 1970. **Detection of the mycotoxin F-2 in the confused flour beetle and the lesser mealworm.** *Journal of Economic Entomology* 63, 412–415.

Abstract

The mycotoxin, F-2, produced by *Fusarium roseum* var. *graminearum* was ingested and retained by *T. confusum* and *A. diaperinus*. F-2 persisted in the animals through metamorphosis and was detected after starvation and death. The amount of F-2 recovered increased with increasing F-2 concentrations in the culture media.

Key Subjects

disease association

FALOMO AA. 1987. **The pheromone biology of the lesser mealworm, *Alphitobius diaperinus* (Panzer), (Coleoptera: Tenebrionidae).** Thesis, University of Wisconsin, Madison, USA.

Abstract

No abstract available

Key Subjects

biology & behaviour

FERNANDES MA, SANTOS MAS & LOMONACO C. 1995. **Occurrence of arthropods in accumulated manure in a poultry house.** *Anais da Sociedade Entomologica do Brasil* **24**, 649–654.

Abstract

The arthropod fauna of manure in a poultry house near Uberlandia, Minas Gerais State, Brazil, was studied monthly from October 1992 to August 1993. The manure was allowed to accumulate during this time and no insecticides were used to control flies. The most abundant species were and unidentified drosophilid fly (18 823 individuals collected during the study period, representing 66.65% of all the insects collected), *Chrysomya putoria* (5818, 20.60%) and *Musca domestica* (3251, 11.51%). Other arthropods, which occurred frequently, included several predators on the immature stages of Diptera, including the beetle *Carcinops* sp. (573 individuals), and unidentified dermapteran (943) and the mite *Macrocheles* sp. (672). Other fairly common species included the beetles *Alphitobius diaperinus* (1713) and *Tribolium confusum* (652), and a species of Pseudoscorpion (248). Most species showed monthly variations in frequency which were not correlated with temperature, rainfall or relative humidity.

Key Subjects

biology & behaviour

GANGOPADYAY AK & CHATTERJEE NB. 1989. **Effect of temperature and moisture content of the stored rice grain on the egg laying, hatching and post-embryonic development of the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Indian Agriculturist* **33**, 115–124.

Abstract

Investigation was carried out to observe the effect of grain moisture (18.5% - 23.5%), grain temperature (29°C - 35°C) and starch content of the Patnai variety of rice grain (85%) on daily laying, egg hatch and postembryonic development of *Alphitobius diaperinus* in the laboratory during the month of August when maximal climatic factors prevailed. The percentage of each egg hatch, 68.2 to 77.0, was noted after 72 hours of incubation. The total larval period covered 26.45 ± 0.23 days for six larval instars and the last three stadia are considered as the grand period of growth. Pupal period continued for 5 days. Adult females started laying rhythmically from seventh day onwards after emergence. A maximum of 264 and 52 eggs were laid during the month under review and in 24 hours period respectively.

Key Subjects

biology & behaviour

GAUTAM RD. 1989. **Exploration of the lesser mealworm for the control of storage insects together with its stages and effect on seed**

viability. *Agricultural Situation in India* **64**, 487–489.

Abstract

The potential of the tenebrionid *Alphitobius diaperinus* as a biological control agent for stored products pests was studied in the laboratory at 27°C and 65% RH. Normal development of larvae occurred on either composite feed or with eggs and larvae of the pyralid *Corcyra cephalonica*. An average of 948.6 eggs were laid by females with *C. cephalonica* compared to 638.2 eggs with composite feed. The larval period was 64.91 and 65.23 days on eggs of *C. cephalonica* and composite feed, resp. Larvae did not develop on whole wheat or sorghum grains or broken or powered sorghum. The germination of wheat grains, which were infested for 45 days by adults of *A. diaperinus*, declined from 99.80% to 79.80, 27.20 and 11.40% after 21, 45 and 90 days storage, resp. Larvae and adults of *A. diaperinus* fed most voraciously on eggs of the gelechiid *Sitotroga cerealella* (25 eggs/day), followed by eggs of the tenebrionid *Tribolium castaneum* and the bruchids *Callosobruchus chinensis*, *C. maculatus* and *C. analis* (14, 6, 5 and 7 eggs/day). Adults also preyed on larvae of *S. cerealella*, *T. castaneum* and the anobiid *Lasioderma serricorne*.

Key Subjects

biology & behaviour

GEDEN CJ. 1990. **Coleopteran and acarine predators of house fly immatures in poultry production systems.** In Rutz DA and Patterson RS (eds.) *Biocontrol of arthropods affecting livestock and poultry*. Westview Press, Inc., Colorado: 177–200.

Abstract

A general account is given of the beneficial arthropod predators of the eggs or larvae of *Musca domestica* and other Muscidae in poultry manure, dealing particularly with (1) predator species composition and succession patterns, (2) *Alphitobius diaperinus*, more a pest than beneficial under current poultry management systems, (3) *Carcinops pumilio* and (4) *Macrocheles muscaedomesticae*. Ecological considerations, attack rates and finally prospects for use in management programs are discussed. In conclusion, it is pointed out that the manure arthropod community is too complex for easy manipulation and that predator conservation is generally more practical than augmentation at present. Future research should address the problems of quantifying the ecological parameters necessary for predator establishment and efficacy, and to develop cost effective rearing methods for these beneficial predators.

Key Subjects

biology & behaviour

GEDEN CJ, ARENDS JJ & AXTELL RC. 1987. **Field trials of *Steinernema feltiae* (Nematoda: Steinernematidae) for control of *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) in commercial broiler and turkey houses.** *Journal of Economic Entomology* **80**, 136–141.

Abstract

Infective juveniles of the All strain of *Steinernema feltiae* (*Neoaplectana feltiae*) were applied at a rate of 100 000/m² to the soil floors of 1 broiler and 2 turkey

houses in North Carolina with known recent histories of infestation with *Alphitobius diaperinus*. After the addition of fresh litter and new flocks of birds, beetle populations increased more slowly in treated than in untreated houses. Soil samples were bioassayed biweekly for the presence of nematodes by adding beetle larvae. Nematodes persisted (63-87% beetle mortality) for 7 weeks after treatment on 2 of the farms; on the 3rd farm, beetle mortality was <50% at 3 weeks after treatment. When soil in plastic containers was treated a varying nematode rates and held for 6 months in a poultry house, beetle mortality ranged from 0 (103 nematodes/m²) to 48.2% (106 nematodes/m²).

Key Subjects

non insecticide control

GEDEN CJ, ARENDS JJ, RUTZ DA & STEINKRAUS DC. 1998. **Laboratory evaluation of *Beauveria bassiana* (Moniliales: Moniliaceae) against the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae), in poultry litter, soil, and a pupal trap.** *Biological Control* **13**, 71–77.

Abstract

The virulence of 4 strains of *Beauveria bassiana* was tested against larvae of *Alphitobius diaperinus* using contact bioassays, treated litter and treated soil in the laboratory at 26°C, LD 16:8 and 60-70% RH. The relative susceptibility of different stages of tenebrionids to *B. bassiana* was also determined and a trap for infecting mature larvae was tested. Five- and 10-day-old larvae were highly susceptible to the WV strain of *B. bassiana* with LC50s of 1.73×10^2 and 2.49×10^2 conidia/ml, respectively. The LC50s for adults and 15-day-old larvae were 1.94×10^5 and 1.01×10^4 , respectively. Two *A. diaperinus*-derived strains of *B. bassiana* (WV and NC) were more virulent for larvae and adults than house fly-derived strains (HF88 and HF89) in forced-contact bioassays. Strain HF88 caused higher larval mortality than WV and NC in poultry litter, but adult mortality in litter never exceeded 20% with HF88. In soil bioassays, strain WV and NC gave 90-100% control of prepupae when conidia were applied in starch dust to the soil surface at 2.5×10^{11} conidia/m². Both WV and NC strains killed 100% of larvae that were exposed to treated pupation traps at 4×10^5 conidia/cm².

Key Subjects

non insecticide control

GEDEN CJ & AXTELL RC. 1987. **Factors affecting climbing and tunneling behaviour of the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **80**, 1197–1204.

Abstract

The propensity of late instar *Alphitobius diaperinus* (Panzer) for climbing and tunneling was evaluated with larvae at several densities in chambers containing poultry litter, both with and without a base of clay soil as a pupation site, and an elevated section of polystyrene insulation. In chambers with soil, no climbing or tunneling was observed until larval density reached 500 larvae per chamber; at this higher density the amount of damage caused by individual larvae was low (0.3-0.5 holes per tunnel). When

soil was lacking, 36% of the larvae climbed at the lowest density treatment (10 larvae per chamber); the number of tunnelers increased with increasing density to a maximum of 60 immatures per section of insulation, although the proportion of climbing larvae stabilized at ca. 6% at the higher density treatments. Larvae in chambers without soil caused ca. 4-fold as much damage at higher density (two holes per tunnel) than at lower densities (ca. 0.5 holes per climber). Mortality among nonclimbing larvae increased with density, and was much higher in chambers without soil than in chambers with soil at all densities. Trapping and observations of the beetles in a poultry house during a 24-h period demonstrated that the climbing population was composed almost solely of the late instars and adults. Early and late instars were present in comparable numbers in the nonclimbing population in the litter. Larvae climbed almost exclusively during the night, and this activity was maximal between 2000 and 2400 hours EST. Adults displayed broader peaks of activity, but also climbed primarily during periods of darkness.

Key Subjects

biology & behaviour

GEDEN CJ & AXTELL RC. 1988. **Effect of temperature on nematode (*Steinernema feltiae* (Nematoda: Steinernematidae)) Treatment of soil for control of lesser mealworm (Coleoptera: Tenebrionidae) in turkey houses.** *Journal of Economic Entomology* **81**, 800–803.

Abstract

In North Carolina, infective juveniles of *Steinernema feltiae* (*Neoaplectana carpocapsae*) (All stain) were applied at the rate of 106 per m² to the soil floors of 2 turkey houses with small populations of *Alphitobius diaperinus*; a 3rd house was left untreated. The overall mean air temperature during the 9 weeks after treatment was 26.4°C. Soil bioassays indicated that nematodes were present in treated soil at 3 weeks but not at 5, 7 or 9 weeks after treatment. Larval or adult beetle population densities in the treated houses did not significantly compared with the control house. When nematodes were applied to soil and then assayed for survival after being held in the laboratory at 4 different temperatures, none survived beyond 2 weeks after treatment in soil held at temperatures >24°C. Nematodes were still detected at 9 weeks after treatment in soil held at 20 and 24°C.

Key Subjects

biology & behaviour; non insecticide control

GEDEN CJ, AXTELL RC & BROOKS WM. 1985. **Susceptibility of the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) to the entomogenous nematodes *Steinernema feltiae*, *S. glaseri* (Steinernematidae) and *Heterorhabditis heliothidis* (Heterorhabditidae).** *Journal of Entomological Science* **20**, 331–339.

Abstract

The pathogenicity of *Steinernema feltiae* (*Neoaplectana carpocapsae*), *S. glaseri* (*N. glaseri*) and *Heterorhabditis heliothidis* to early-instar larvae, late-instar larvae, pupae and adults of the tenebrionid *Alphitobius diaperinus* were evaluated under different habitat conditions in the laboratory in North Carolina.

When kept in petri dishes with nematode-treated filter paper, all stages of the beetle were highly susceptible to attack by *N. carpocapsae*, the LD50s ranging from 9 to 56 nematodes/host. Early-instar larvae (LD50 = 26) and pupae (LD50 = 36) were most susceptible than late-instar larvae (LD50 = 1971) and adults (LD50 = 724) to *H. heliothidis*. Only adult beetles (LD50 = 714) were susceptible to *N. glaseri*. Late-instar beetle larvae were more susceptible to *N. carpocapsae* in rearing medium (LD50 = 24), broiler litter (LD50 = 258) and poultry faeces (LD50 = 212) than to *H. heliothidis*, which caused <50% mortality at all dose rates in these substrates. Adults were less susceptible than larvae in these substrates, and mortality only exceeded 50% in litter treated with *N. carpocapsae* (LD50 = 971). Late-instar larvae were highly susceptible to both *N. carpocapsae* and *H. heliothidis* in sandy loam and clay soils, the LD50s ranging from 1 to 14 nematodes/larva. Pupal mortality was higher in sandy loam (the LD50s for *N. carpocapsae* and *H. heliothidis* being 46 and 444, respectively) than in clay soil (95 and 5796, respectively).

Key Subjects

non insecticide control

GEDEN CJ, EDWARDS TD, ARENDS JJ & AXTELL RC. 1987. **Efficacies of mixtures of disinfectants and insecticides.** *Poultry Science* **66**, 659–665.

Abstract

Efficacies of mixtures of diluted commercial formulations of selected insecticides and disinfectants were evaluated. Insecticides tested included representative pyrethroids (fenvalerate (Ectrin WDL and WD) and permethrin (Ectiban EC), organophosphates (dichlorvos (Vapona EC), tetrachlorvinphos (Rabon WP) and dichlorvos/tetrachlorvinphos (Ra Vap EC), and carbamate (carbaryl (Sevin S)). Disinfectants tested included representatives of cresylic acid (Biolene), cresylic acid/phenol (BioGuard X-185), phenol (1-Stroke Environ), quaternary ammonium (BioGuard S-3 and PFP-4), quaternary ammonium/formalin (DC & R), and formalin classes of disinfectants. Mixtures were tested for toxicity to two target insects (*Musca domestica* on plywood, *Alphitobius diaperinus* in litter) and two bacteria (*Pseudomonas aeruginosa* and *Staphylococcus aureus*). Of 56 mixtures evaluated, 24 showed reduced insecticidal toxicity and 35 showed reduced bactericidal activity compared with insecticides or disinfectants alone.

Key Subjects

insecticide control

GEISSLER H & KOSTERS J. 1972. **Hygienic significance of the lesser mealworm beetle (*Alphitobius diaperinus* Panz.) in broiler production.** *Deutsche Tierärztliche Wochenschrift* **79**, 178–181.

Abstract

Adult beetles and larvae about to pupate were fed *S. thompson* culture. Infection was demonstrated in the adult beetles for up to 15 days and in newly emerged beetles infected as larvae. It is considered that the presence of these insects in a chicken house could cause various bacterial and viral infections in

successive batches of birds. Exposure to cold (-5 deg C) is the best method of control.

Key Subjects

disease association

GEISSLER H & KOSTERS J. 1978. **The significance of lesser mealworm infestations in poultry meat production.** *Deutsche Tierärzteblatt* **79**, 177–204.

Abstract

No abstract available

Key Subjects

biology & behaviour

GERSDORF E. 1969. **The cereal mildew beetle (*Alphitobius diaperinus* PZ. Ten.) in cockerel-fattening units.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **42**, 153–155.

Abstract

The author describes the way in which intensive rearing units for male chicks are used in northern Germany, many being built over pig- or cattle-fattening units in order to utilize the heat; insect or mite infestations can occur if there is any space between the ceiling of the lower unit and the floor of the upper unit, in which spilt chick food and other litter can accumulate. The chickens become full-grown in six weeks and are reared at such a density that cleaning or spraying the floor is possible only in the intervals between broods. Among the insects present (most of which are harmless to the chicks), *Alphitobius diaperinus* (Panz.) has been reported in large numbers in some units, taking eight weeks to develop at about 22°C. Insects in the containers of mixed cereal feed or exposed on the floor of the upper unit are eaten by the chickens, and beetles hide mainly in the litter between the floors, passing right through to the lower unit when the upper unit is emptied and cleaned and the temperature falls at the end of a chick-rearing cycle. *A. diaperinus* can not develop for long in clean meal or other dry cereal food, unless this becomes damp and mouldy from spilt drinking water or chicken droppings on the floor of the rearing unit. The source of the infestations is not known, since the beetle cannot survive in the normal climatic conditions of northern Germany and has not been found in chick food before it reaches the rearing unit. It is suggested that adult may move from unit to unit on warm summer days, but in fact little spread occurs and large populations tend to build up in a few isolated units. Chemical control is not feasible unless rearing cycles can be arranged so as to allow both upper and lower units to be empty at the same time, but infestation can be reduced by filling holes or cracks in the upper floor and the space between the upper floor and the lower ceiling. At present, the beetle cannot be considered a pest of the chick food in the feeding containers, and it sometimes provides the birds with supplementary protein.

Key Subjects

biology & behaviour; non insecticide control

GIGA DP. 1987. **Evaluation of the insect growth regulators cyromazine and diflubenzuron as surface sprays and feed additives for controlling houseflies *Musca domestica* (L.) in**

- chicken manure.** *International Pest Control* **29**, 66–69.
- Abstract**
Cyromazine or diflubenzuron were added as surface sprays or admixes to poultry food to determine their efficacy in controlling populations of *Musca domestica* breeding in poultry droppings in Zimbabwe. Cyromazine was mixed with the food as Larvadex 0.3% premix at 1.5 g a.i. or sprayed on the surface as Neporex 2% WSG at 5.0 g a.i./m². Diflubenzuron was added to the feed as Dimilin 25% WP at 5.0 g a.i. or sprayed on the food at 1.0 g a.i./m². Both growth regulators were equally effective in controlling breeding flies. Significant differences in the number of flies which emerged and in the ratio of normal to abnormal pupae were found between the 2 methods of application; admixes were more effective than surface sprays. Populations of the tenebrionid *Alphitobius diaperinus*, which lived in the manure in great numbers, were unaffected by either chemical.
- Key Subjects**
insecticide control
- GOGOI AR & CHAUDHURI RP. 1982. **Contribution to the fowl cestodes *Raillietina tetragona*, *Raillietina echinobothrida* and *Raillietina cesticillus*.** *Indian Journal of Animal Sciences* **52**, 246–253.
- Abstract**
In Assam, India, 8933 ants from 8 species and 1383 beetles from 3 species were examined for cysticercoids. *Raillietina tetragona* was recovered from 1.6% of 1331 *Tetramorium tortosum*, 0.4% of 536 *T. rothneyi*, 0.3% of 4238 *T. simillimum* and 1.4% of 2809 *Phidole* sp. *R. echinobothrida* was recovered from 8%, 14.9%, 5.0% and 0.1%, respectively. Mixed infections occurred in 3.9%, 0, 0.09% and 0.03%. The number of cysts/ant ranged from one to 27. *R. cesticillus* only was recovered from 7.6% of 707 *Tribolium confusum*, and *Hymenolepis minutissima* only from 1.1% of 557 *Alphitobius diaperinus*. The prevalence of *Raillietina* spp. increased during the monsoon months. Infected ants were fed to White Leghorn chicks and the prepatent periods of *R. tetragona*, *R. echinobothrida* and *R. cesticillus* were 13, 14 and 13 days, respectively. *Tetramorium rothneyi* and *A. diaperinus* represent new host records.
- Key Subjects**
disease association
- GOODWIN MA & WALTMAN WD. 1996. **Transmission of *Eimeria*, viruses, and bacteria to chicks: darkling beetles *Alphitobius diaperinus* as vectors of pathogens.** *Journal of Applied Poultry Research* **5**, 51–55.
- Abstract**
Darkling beetle homogenates (DBH) were prepared from beetles collected from chicken houses on 7 farms. DBH were shown to contain many infectious organisms including bacteria (eg., *Salmonella*, viruses (eg., reovirus) and *Eimeria*. It is concluded that darkling beetles serve as vectors for common avian pathogens.
- Key Subjects**
disease association
- GORDH G & WILLS L. 1989. **Anatomical notes on *Uropoda* sp., a phoretic mite infesting dung-inhabiting beetles in southern California (Acari: Uropodidae; Coleoptera: Tenebrionidae, Histeridae).** *Pan Pacific Entomologist* **65**, 410–413.
- Abstract**
The morphology of the anal pedicel of *Uropoda* sp. is described. The deutonymph of this species is phoretic on adults of the tenebrionid *Alphitobius diaperinus* and the histerid *Dendrophilus punctatus* in poultry manure.
- Key Subjects**
biology & behaviour
- GOULD GE & MOSES HE. 1951. **Lesser mealworm infestation in a brooder house.** *Journal of Economic Entomology* **44**, 265.
- Abstract**
No abstract available
- Key Subjects**
biology & behaviour
- GREEN DB. 1979. **Predatory beetles in Lancashire deep-pit poultry houses.** *Entomologist's Monthly Magazine* **114**, 16.
- Abstract**
No abstract available
- Key Subjects**
biology & behaviour
- GREEN DB. 1980. **The fauna of a Lancashire deep-pit poultry house.** *Entomologist's Monthly Magazine* **116**, 13–15.
- Abstract**
No abstract available
- Key Subjects**
biology & behaviour
- GREEN DB. 1982. **The fauna and environment of two Lancashire deep-pit poultry houses.** *Ministry of Agriculture, Fisheries and Food Poultry* **140**, 15–32.
- Abstract**
Between 1976 and 1980, the fauna at two Lancashire deep-pit poultry houses was studied and temperature and relative humidity measurements were made. Some sixty-nine species of arthropods were identified, many previously unrecorded from this environment in the UK. The most abundant species at both sites were *Carcinops pumilio*, *Alphitobius diaperinus*, *Dermestes maculatus*, *Musca domestica*, *Leptocera* sp and Acarina, particularly *Caloglyphus berlesei*. The most diverse fauna was found at the end of the 13–15 months' egg laying period, by which time the depth of the manure was about one metre. Predatory beetles were numerous, including four species of Histeridae, two species of Cleridae and several species of Staphylinidae. These and other predators such as *Ophyra* sp and *Macrocheles muscaedomesticae* are important components of the fauna because of predation on pest species of flies such as *Musca domestica*, which develops rapidly in the constant warmth of deep-pit poultry houses. Only the fly *Leptocera* sp and the predatory beetle *Carcinops pumilio* were collected from manure depths greater than 25 cms and all the recorded species were found

within 10 cms of the surface of the droppings. In future faunal studies of this type, manure sampling can be confined to the surface layers of droppings, but this should be combined with detailed visual examination of the pit fauna. Many of the species have been recorded in birds' nests, notable exceptions being species, such as *Tribolium confusum* and *Gnatocerus cornutus*, normally found in association with stored foodstuffs. The fauna is also comparable with that occurring at USA poultry farms, where many similar faunal studies of this type have been carried out.

Key Subjects

biology & behaviour

GREEN M. 1980. *Alphitobius viator* Mulsant & Godart in stored products and its identification (Coleoptera: Tenebrionidae). *Journal of Stored Products Research* **16**, 67–70.

Abstract

Records of *Alphitobius viator* Muls. & Godt. on stored products in the UK, France and Africa are reviewed. The species is redescribed, and an illustrated key is presented for distinguishing it from the other stored-product species *A. diaperinus* (Panz.) and *A. laevigatus* (F.). In addition, characters for distinguishing it from *A. rufus* Ardoyn, a very similar species that is not found on stored products, are noted.

Key Subjects

biology & behaviour

HALSTEAD DGH. 1975. **Changes in the status of insect pests in storage and domestic habitats.** *Proceedings of the First International Working Conference on Stored Product Entomology*, 142–153.

Abstract

Changes in the status of some storage and household insect pests that have occurred in Europe (especially Britain and Denmark) during the past 30 years are reviewed, mainly from the literature. In Britain, *Trogoderma granarium* Everts, which used to be an important pest in maltings, has become relatively insignificant, giving way to *Oryzaephilus surinamensis* (L.), which has also superseded *Sitophilus granarius* (L.) as the major pest of grain in farm stores. *Alphitobius diaperinus* (Panz.) has become widespread in intensive poultry-breeding units in Britain and elsewhere. The storage pest *O. surinamensis* and *Tribolium destructor* Uytt. have become common in Danish houses and *O. mercator* (Fauv.) in Canadian ones. *Dermestes peruvianus* Lap. and *D. haemorrhoidalis* Kust. have become important in town houses (especially tall apartment blocks) in Britain and Denmark. *Tineola bisselliella* (Humm.) is no longer a significant pest of clothes in Europe and has been superseded by *Anthrenus* and *Attagenus* spp.; *A. pellio* (L.) and *Anthrenus verbasci* (L.) are the most important pests of woollen textiles in Britain, but in Sweden, *Attagenus pellio* has been largely replaced by *A. fasciatus* (Thnb.), a tropical species, and in Copenhagen and Moscow, dwellings have recently been invaded by the African *A. smirnovi* Zhantiev. *Anthrenus sarnicus* Mroczkowski has become established in houses in London and *A. coloratus* Rtt. in apartments in the United States. In storage habitats in Britain, changes in pest status

appear to be related to changes in agricultural practice including control measures. In domestic habitats in Europe, central heating has enabled certain storage pests to become established in houses and may be responsible for the increased importance of beetle pests of textiles.

Key Subjects

biology & behaviour

HARDING WL & BISSELL TL. 1958. **Lesser mealworm in a brooder house.** *Journal of Economic Entomology* **51**, 112.

Abstract

The lesser mealworm *Alphitobius diaperinus* (Panz.) (Tenebrionidae) is known as a pest of cereal products and grain that are in poor condition. It is cosmopolitan in distribution being commonly found in flour mill basements in damp or musty flour or grain (U.S. Dept. Agric., 1953). The paper reports an unusual outbreak of lesser mealworms in the corn cob litter of a brooder house on the Eastern Shore of Maryland during which larvae were observed to bore into and apparently feed on the flesh and internal organs of moribund and dead baby chicks. Results of limited control experiments against lesser mealworm adults and larvae in corn cob litter are also presented.

Key Subjects

biology & behaviour; insecticide control

HAREIN PK, DE LAS CASAS E, LARSEN CT & POMEROY BS. 1972. **Microbial relationship between the lesser mealworm and its associated environment in a turkey brooder house.** *Environmental Entomology* **1**, 189–194.

Abstract

Insect, litter and dust samples were collected weekly and cultured on different media in order to identify bacteria and fungi and estimate relative levels of microbiological contamination. The number of bacteria and fungi increased during the 13 week sampling period, the amount of increase depending on the type of sample. Surface and sub-surface litter became heavily contaminated with bacteria, both having similar bacterial counts. The total number of bacteria in the dust was less than in the litter. *A. diaperinus* carried the least. However, a greater percentage of the surface disinfected animals were contaminated with *Escherichia coli* (bacteria) than any other type of sample, and they represented the largest number of the different isolates identified. *A. diaperinus* was also the first type sample found to be positive for *Salmonella* spp (bacteria). Sub-surface litter and dust had the greatest amount of fungi, surface litter was second, while *A. diaperinus* had the least.

Key Subjects

disease association

HAREIN PK, DE LAS CASAS E, POMEROY BS & YORK MD. 1970. **Salmonella spp. and serotypes of Escherichia coli isolated from the lesser mealworm collected in poultry brooder houses.** *Journal of Economic Entomology* **63**, 80–82.

Abstract

Adult *Alphitobius diaperinus* (Panzer) were collected from the litter of poultry brooder houses in 1967 and

1968. One thousand of the lesser mealworms were individually surface disinfected, macerated, and cultured in thioglycolate enrichment broth at 37°C and streaked on eosin methylene blue agar or brilliant green agar plates for detection of *Escherichia coli* (Migula) Castellani & Chalmers and *Salmonella* spp., respectively. Five species of *Salmonella* found within the lesser mealworms were identified as *S. heidelberg* Kauffman, *S. worthington* Edwards and Bruner, *S. saint paul* Kauffmann, *S. typhimurium* var. copenhagen Kauffmann, and *S. chester* Kauffmann and Tesdal. Forty-eight serotypes of *E. coli* were recovered from within 251 lesser mealworms. Twenty-six of these serotypes are known pathogens for man or animals.

Key Subjects

disease association

HARRIS F. 1966. **Observations of the lesser mealworm *Alphitobius diaperinus* (Panz.).** *Journal of the Georgia Entomological Society* **1**, 17–18.

Abstract

The distribution of the lesser mealworm, *Alphitobius diaperinus* (Panz.), and its abundance in poultry houses are discussed. A review of the food habits of this beetle with additional observations on their carnivorous habits is presented.

Key Subjects

biology & behaviour

HEALY WM. 1985. **Turkey poult feeding activity, invertebrate abundance, and vegetation structure.** *Journal of Wildlife Management* **45**, 466–470.

Abstract

No abstract available

Key Subjects

biology & behaviour

HEIMBUCHER J & KUTZER E. 1979. **Lesser mealworm (*Alphitobius diaperinus*) in poultry farms.** *Wien Tierärztliche Monatsschrift* **66**, 334–337.

Abstract

Studies are carried out on the occurrence of *Alphitobius diaperinus* (Panz.), a possible intermediate host of fowl helminths, on a poultry farm in Austria. The insect occurred in large numbers, the conditions of modern fowl houses being ideal for its development and multiplication. A spray containing 2% chlorpyrifos (Gesektin K) was effective against the pest in empty fowlhouses while in inhabited fowlhouses a spray containing a mixture of permethrin and pyrethrum (Permanent) was successfully applied. Both preparations had residual activity. In the inhabited fowlhouses, sprays containing 0.5% fenvalerate (Sumifly), 2% fenchlorphos (Nankor) or an organophosphorus compound in combination with pyrethrum (Lysozid S) (5%) were less effective; in addition, the latter should be used cautiously on poultry farms.

Key Subjects

insecticide control

HEWLETT PS. 1958. **Secondary sexual characters in *Alphitobius laevigatus* (F.) and *A. diaperinus***

(Panz.) (Col., Tenebrionidae). *Entomologist's Monthly Magazine* **94**, 144.

Abstract

No abstract available

Key Subjects

biology & behaviour

HICKS EA. 1959. **Check-list and bibliography on the occurrence of insects in birds' nests.** The Iowa State College Press, Iowa.

Abstract

No abstract available

Key Subjects

biology & behaviour

HULLEY PE & PFLEIDERER M. 1988. **The Coleoptera in poultry manure - potential predators of house flies, *Musca domestica* Linnaeus (Diptera: Muscidae).** *Journal of the Entomological Society of Southern Africa* **51**, 17–29.

Abstract

Twenty-three species representing 12 families of beetles were collected from poultry manure in the eastern Cape of South Africa. The most numerous species was *Carcinops troglodytes*; 5 species were uncommon. Seasonal variation in numbers of the numerous species (*C. troglodytes*, *Cercyon quiquillus*, *Dactylosternum abdominale*, *Philonthus* sp., *Aleochara* sp., *Oxytelus* sp., *Phacophallus* sp., an unidentified merophysiid, *Gnathocerus cornutus*, *Palorus subdepressus* and *Alphitobius diaperinus*) is described. Laboratory feeding preference of selected species (*D. abdominale*, *C. dimidiatus*, *Carcionops troglodytes*, *A. diaperinus*, *Saprinus* sp., *Philonthus* sp., *Aleochara* sp., *Oxytelus* sp., *Dermestes maculatus*, *Monotoma* spp., *Euxestus phalacroides* and *Euxestoxenus* sp.), given a choice of potential foods, was determined. The results indicated that beetles are important in natural control of houseflies. The importance of management practices that keep the manure dry and favour predators and parasitoids is emphasized.

Key Subjects

biology & behaviour

ICHINOSE T, SHIBAZAKI S & OHTA M. 1980. **Studies on the biology and mode of infestation of the tenebrionid beetle, *Alphitobius diaperinus* Panzer, harmful to broiler-chicken houses.** *Japanese Journal of Applied Entomology and Zoology* **24**, 167–174.

Abstract

The development of *A. diaperinus* was promoted by high temperature and high population density, but was inhibited at a temperature of 15°C in every developmental stage. Three-day exposure of eggs at 7°C gave only 2% hatching. Water deficiency also prevented breeding. The relationship between activity and temperature was consistent with that of the developmental velocity and the temperature, with maximum values at 35°C. Only old-age larvae bored into various adiabatic materials, while younger ones and adults did not, and they failed to survive on these materials. Some coatings of the materials prevented boring. These results indicate that damage is caused merely by the requirements of a pupation site by the

mature larvae and that the thermal, moist and trophic conditions in broiler-houses are conducive to the development and multiplication of the insect.

Key Subjects

biology & behaviour

JACOBS-REITSMA WF, GIESSEN AW, VAN DE BOULDER NM & MULDER RWAW. 1995.

Epidemiology of *Campylobacter* spp. at two Dutch broiler farms. *Epidemiology and Infection* **114**, 413–421.

Abstract

Broiler flocks on 2 Dutch poultry farms were screened weekly for the presence of *Campylobacter* in fresh caecal droppings during 8 consecutive production cycles. Hatchery and fresh litter samples were taken at the start of each new cycle. Water, feed, insects, and faeces of domestic animals, present on the farms were also included in the sampling. Flocks became colonized with *Campylobacter* at about 3–4 weeks of age with isolation percentage of 100%, and stayed colonized up to slaughter. A similar pattern of serotypes was found within the various broiler houses on one farm during on production cycle. New flocks generally showed a new pattern of serotypes. Most serotypes isolated from the laying hens, pigs, sheep and cattle were different from those isolated from the broilers at the same time. Serotypes from darkling beetles (*Alphitobius diaperinus*) inside the broiler houses were identical to ones isolated from the broilers. No *Campylobacter* was isolated from any of the hatchery water, feed or fresh litter samples. Conclusive evidence of transmission routes was not found, but results suggest horizontal transmission from the environment.

Key Subjects

disease association

JERRARD PC & WILDEY KB. 1980. **Beetle plague from deep pit muck spreading.** *Poultry World* **131**, 20–21.

Abstract

The poultry droppings in deep-pit units in Britain commonly harbour 3 species of beetle, *Alphitobius diaperinus* (Panz.), *Dermestes maculatus* Deg. and *Carcinops pumilio* (Erichs.). Very brief notes are given on the appearance of the adults and in 2 cases the larvae, of these species and on their habits. By their activity, they help to dry the manure and reduce fly infestation, but if the manure is spread on fields in warm weather, massive infestations of beetles can occur in nearby dwellings. A case of such an occurrence in southern England is described. Spraying the outside walls of the houses of a height of 1m and the ground around for the same distance with a 2% solution of idofenphos at 5 litres/100m² killed many beetles, but in spite of this and the use of aerosols indoors, the problem persisted because of reinvasion on warm days when the beetles were more active and flew in.

Key Subjects

biology & behaviour; insecticide control

JESPERSEN JB. 1996. **Litter beetles as disease reservoirs.** *Danish Pest Infestation Laboratory Annual Report*, 63–64.

Abstract

In broiler houses, litter beetles, in particular the lesser mealworm *Alphitobius diaperinus* and the hairy fungus beetle *Typhaea stercorea*, are found very frequently. The beetles are difficult to control chemically, and as the development time is rather short, they often constitute a pest problem. In addition they are potential transmitters of disease agents; for salmonella bacteria it has been shown that both species of beetles might be infected or surface-contaminated by salmonella bacteria. The Ministry of Food, Agriculture and Fisheries therefore has supported a project with the following specific objectives 1) to investigate the occurrence, biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project is a collaborative project involving in Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (Project coordinator), as well as many veterinarians and poultrymeat farmers.

Key Subjects

biology & behaviour; disease association

JESPERSEN JB & LAURIDSEN MK. 1997. **Chemical control of litter beetles in a parent flock farm.** *Danish Pest Infestation Laboratory Annual Report*, 74–75.

Abstract

The lesser mealworm *Alphitobius diaperinus* (together with certain other beetle species) is a problem in the egg production houses of parent flock farms, which produce eggs for broiler production. The problems are mainly related to the damage that the beetles cause to the insulation of the houses and the potential of the beetles to act as reservoirs for pathogens, in particular salmonella. A field test was carried out to evaluate the efficacy of treatments made with Baycidal WP 25 alone or in combination with Baythion-EC or Solfac WP 10 to control litter beetles (in particular *A. diaperinus*) in such parent flocks. The active ingredients in Baycidal WP 25, Baythion-EC, and Solfac WP 10 are triflumuron, phoxim and cyfluthrin, respectively. The test was carried out in a parent flock in South Jutland and ran from February 1997 until January 1998. The farm comprises eight houses, separated by a feed alley. One week before new hens were introduced, two of the houses were sprayed with Baythion-EC, while two other houses were sprayed with Solfac WP 10. In both cases the treatment involved spraying the walls up to one metre above ground level, and spraying the floor up to one metre from the walls. These four houses, together with two further houses, were treated with Baycidal WP 25 treatments involved topical application to the manure heaps under the slats. Two houses were left as untreated controls. The efficacy of the treatments was monitored every two weeks by the placement of 10 tube traps in each house between one and three days on the top of the manure, out of reach of the hens. All the treatment strategies successfully controlled *A. diaperinus* in the six treated poultry houses, whereas in the two untreated control houses

the numbers of *A. diaperinus* increased steadily during the period.

Key Subjects

insecticide control

KARTMEN L, TANADA Y, HOLDAWAY FG & ALICATA JE. 1950. **Laboratory tests to determine the efficiency of certain insecticides in the control of arthropods inhabiting poultry manure.** *Poultry Science* **29**, 336–346.

Abstract

No abstract available

Key Subjects

insecticide control

KARUNAMOORTHY G, CHELLAPPA DJ & ANANDAN R. 1994. **The life history of *Subulura brumpti* in the beetle *Alphitobius diaperinus*.** *Indian Veterinary Journal* **71**, 12–15.

Abstract

Thirty-nine of 86 *Alphitobius diaperinus* collected from deep litter houses in the Namakkal area of Tamil Nadu, India, were found to be naturally infected with *Subulura brumpti*, with 1-5 encysted larvae in each infected beetle. The life cycle of the nematode was established by experimental infection of beetles and fowls. Adult worms were removed from the caeca of infected birds and their eggs mixed with poultry mash and fed to beetles from deep litter houses with no history of *S. brumpti* infection. L2 were observed in beetles 8 days pi and encysted infective L3 appeared 12-16 days pi. Eggs appeared in the droppings of previously uninfected fowls 30-35 days after they were fed with infected *A. diaperinus*.

Key Subjects

disease association

KASZAB Z. 1980. **Contributions to the knowledge of the tenebrionids of North Vietnam (Coleoptera).** *Annales Historico Naturales Musei Nationalis Hungarici* **72**, 169–221.

Abstract

The author presents faunistic data for many species of Tenebrionidae collected in North Vietnam; the species previously mentioned in the Review include *Mesomorphus villiger* (Blanch.), *Tribolium castaneum* (Hbst.), *Alphitobius diaperinus* (Panz.) and *A. laevigatus* (F.). In addition, descriptions are given of many new species and subspecies of the family collected in the country.

Key Subjects

biology & behaviour

KEIFER HH. 1935. **The black fungus beetle and lesser mealworm.** *Bulletin - Department of Agriculture* **24**, 316.

Abstract

No abstract available

Key Subjects

biology & behaviour

KELEYNIKOVA SI. 1970. **Darkling beetle larvae of Palearctic tribes of the subfamily Tentyriinae (Coleoptera, Tenebrionidae).** *Entomology Revue* **49**, 245–253.

Abstract

No abstract available

Key Subjects

biology & behaviour

KELEYNIKOVA SI. 1976. **Darkling beetle (Coleoptera, Tenebrionidae) larvae of the tribe Steosini.** *Entomology Revue* **55**, 71–74.

Abstract

No abstract available

Key Subjects

biology & behaviour

KHAN BA, DAY PA, GOONEWARDENE LA, ZUIDHOF MJ & HAWKINS G. 1998. **Efficacy of tetrachlorvinphos insecticide dust against darkling beetles in commercial broiler chicken barns.** *Canadian Journal of Animal Science* **78**, 723–725.

Abstract

Residual application of tetrachlorvinphos dust (Debantic 50WP) was evaluated against *Alphitobius diaperinus* in commercial broiler chicken barns. The dust formulation was applied using an electrostatic duster after clean out of old litter at the start of a new broiler cycle. Tetrachlorvinphos dust provided adequate control of beetle larvae and adults up to 5 weeks. 1 application is adequate for 1 commercial broiler chicken production cycle only.

Key Subjects

insecticide control

KOMAREK S. 1988. **The glossy black cereal mould beetle (*Alphitobius diaperinus* Panzer), a little-known stored product pest.** *Pflanzenschutz Wein* **1**, 3–4.

Abstract

The tenebrionid *Alphitobius diaperinus*, a sporadic pest of stored products in Central Europe, was found recently in large numbers in a storeroom of a zoological garden in Austria. Notes are provided on the biology, injuriousness and control of this beetle, which can harbour pathogens (such as *Salmonella* and *Escherichia coli*) of poultry.

Key Subjects

biology & behaviour, disease association; insecticide control

KOZLOV VI. 1970. **The tenebrionid *Alphitobius diaperinus*, a predator of *Dermanyssus gallinae*.** *Parazitologiya* **4**, 363–364.

Abstract

Observations made in 1967-1969 in chicken farms of the Krasnoyarsk area showed that (a) *A. diaperinus* was commonly found in long established sites of occurrence of *D. gallinae* and (b) that numbers of nymphs and adults of *D. gallinae* were 90-95% lower in such areas. Laboratory tests established that *A. diaperinus* is a predator on all stages of *D. gallinae*, including the eggs. Each *A. diaperinus* took up to 10 *D. gallinae* adults, with most predatory activity at 20-24 °C and 50-60% r.h. *A. diaperinus* has hitherto been known principally as a stored-products pest.

Key Subjects

biology & behaviour

KUMAR P. 1986. **Flesh eating behaviour of *Alphitobius diaperinus* Panz. (Tenebrionidae);**

Coleoptera). *Indian Journal of Entomology* **48**, 113–115.

Abstract

Larvae and adults of *A. diaperinus* were fed in poultry houses in Aligarh District, Kerala, India, feeding on feathers, excreta and spilt poultry meal. When attacking feathers the adult beetles preferred the margins but the larvae would even enter the quill and cause much greater damage. Adult beetles also bit through the skin at the base of the chickens' claws where they fed on the exuding blood. Most serious, however, was that the larva and adult beetles could kill newly hatched chicks. This was demonstrated experimentally by confining single chicks in wooden roosting cages each with 350 larvae and 150 adults of *A. diaperinus*. The larvae appeared to be more capable at penetrating the chick's skin and were more voracious feeders on flesh than adults. By 12 days of age the chick's skin had evidently become sufficiently tough to prevent penetration.

Key Subjects

biology & behaviour

LAMBKIN TA. 1998. **Controlling black beetles (*Alphitobius diaperinus* (Panzer), Coleoptera: Tenebrionidae) in chicken sheds.** In *Proceedings 1998 Poultry Industry Exchange Surfers Paradise 19-21 April 1998*, 33–37.

Abstract

The black or darkling beetle (*Alphitobius diaperinus* (Panzer)), which is of tropical origin, is a serious, cosmopolitan insect pest of chicken houses. Losses to production are indirect and result from the transmission of poultry disease, downgrading of bird feed quality, bird ingestion of large quantities of beetle larvae, damage to shed insulation and the high cost of pesticide applications. The duration of the pest's life cycle is dependent on temperature and humidity. As a result, beetle populations in chicken sheds tend to be localized around areas of high temperature and moisture. In very dry chicken sheds, the beetle will eat dead birds and at night, bit sleeping live birds. *A. diaperinus*, which is omnivorous and active in low light conditions is also an active flier and can readily infest new areas. Control of the pest traditionally has been by the use of chemicals and now insecticide resistant populations of the pests have been reported. Hygiene is an important component of pest control, which incorporates proper shed cleanouts and disposal of manure litter. Indications are that in Australia, control of *A. diaperinus* is becoming increasingly difficult and there is a need to adopt and integrated pest management system for the beetle which would encompass an insecticide resistance management strategy.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN T & CAMERON MC. 1999. **Darkling beetle control – Current difficulties and future prospects.** *The Eleventh Australian Poultry & Feed Convention Proceedings*, 184–192.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus*

transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, as pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN TA & CAMERON MC. 2000. **Darkling beetle control in Australian broilers – a new direction.** *Proceedings 2000 Poultry Information Exchange*, 97–102.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, a pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated pest management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LANCASTER JL & SIMCO JS. 1967. **Biology of the lesser mealworm, a suspected reservoir of avian leucosis.** *Arkansas Experiment Station* **159**, 1–12.

Abstract

Attention has been drawn to the lesser mealworm, *Alphitobius diaperinus* (Panzer) by a recent report that it was capable of transmitting acute leucosis, an infectious agent producing tumors in broilers. This report created a flurry of excitement and worry throughout the major poultry production area in the South. The objectives of thesis study were develop a method for culturing the insect, to determine its life cycle, to survey for its frequency of occurrence in broiler houses, and to attempt transmission by the beetles of the infectious agent.

Key Subjects

biology & behaviour; disease association

LANCASTER JL, SIMCO JS & EVERETT R. 1969.

Pre-treated rice hull for the control of the lesser mealworm. *Report Series, Arkansas Agricultural Experiment Station* **174**, 14pp.

Abstract

Infestations of *Alphitobius diaperinus* (Panz.) in poultry houses may give rise to a serious problem because the larvae transmit the virus of fowl leucosis (cf. RAE/B 59, 338, etc.). In tests in Arkansas, Coumaphos, Dursban, fenclorophos (ronnel), malathion, carbaryl and Mobam (benzo(b)thien-4-yl methylcarbamate) were evaluated for the control of the beetle. The insecticides were applied to rice husks, a material frequently used as poultry litter, in the form of dusts and emulsifiable concentrates mixed with water and with oil. After treatment, the rice husks were stored in bags for various periods or used in poultry pens for eight weeks, and samples were tested at weekly intervals by placing them in containers, adding adults and larvae of *A. diaperinus* and recording mortalities after 72h. In tests of the rice husks used in poultry pens, material containing about 0.17% Dursban caused 100% mortality for eight weeks, that containing fenclorophos at 0.17% was equally effective for three weeks, that containing Dursban at 0.125% was nearly as effective for three weeks and those containing the other insecticides at 0.07-0.18% were effective for 1-2 weeks. When stored, the treated rice husks remained effective for longer periods. No residues of Dursban were detected in the skin, muscle or liver and not more than 0.02 ppm in the fat of fowls kept for eight weeks on rice husks containing 0.125% Dursban. It is considered that complete elimination of the beetle from poultry houses may be possible by use of litter treated with 0.25% Dursban and that a high degree of effectiveness can be expected from treatment with carbaryl, coumaphos or malathion.

Key Subjects

insecticide control

LEGNER EF & OLTON GS. 1968. **The biological method and integrated control of house and stable flies in California.** *California Agriculture* **22**, 1-4.

Abstract

Full utilization of the biological method in fly control requires the preservation of existing predatory and parasitic enemies in animal dung. The use of residual poisons to control adult flies did not interfere with natural enemy complexes in these tests. Alternating the removal deposits, and abstaining from chemical treatment of manure were essential procedures in maintaining largest populations of predators and parasites.

Key Subjects

biology & behaviour

LEGNER EF & OLTON GS. 1970. **Worldwide survey and comparison of adult predator and scavenger insect populations associated with domestic animal manure where livestock is artificially congregated.** *Hilgardia* **40**, 225-266.

Abstract

The following is virtually the authors' synopsis. The predatory and scavenger insects found associated with the developmental stages of Muscoid Diptera

breeding in the manure that accumulates in dairies, poultry houses, and similar places are listed and their frequency and distribution are compared for the summer and winter seasons of the major climatic areas in the south-western United States. Insects were also identified under somewhat more limited conditions in the Neotropical, Palaearctic, Ethiopian, and Australasian regions. The Holarctic and Australian collections were similar, although the latter lacked many species. Collections made in the Ethiopian and Neotropical regions were not similar. Further search in these latter two regions might uncover additional predatory species for introduction elsewhere. Climatic similarity between the areas of origin and release appears to be necessary for the successful establishment of any new species. The principal predators found were in the families Labiduridae, Histeridae and Staphylinidae, although other families predominated in certain areas. Although only two California predators, *Philonthus longicornis* Steph. and *P. rectangulus* Sharp, were common in both the Ethiopian and Neotropical regions, the Californian and the Neotropical regions had nine species in common. The distribution of scavengers was similar. The principal predators noted for their wide distribution and high relative abundance were *Carcinops* ?, *Alphitobius diaperinus* (Panz.) and *Aphodius lividus* (Ol.). The fauna in cattle droppings in the field was sparse, but the species found were similar to those in the accumulated manure.

Key Subjects

biology & behaviour

LEGNER EF, OLTON GS, EASTWOOD RE & DIETRICK EJ. 1975. **Seasonal density, distribution and interactions of predatory and scavenger arthropods in accumulating poultry wastes in coastal and interior southern California.** *Entomophaga* **20**, 269-283.

Abstract

Seasonal predatory and scavenger arthropod densities were studied at interior and coastal southern California poultry ranches. Though some seasonal population clumping occurred with some species, the distribution of predators and scavengers was fairly uniform within each ranch. Correlation analyses of key predators in the *Histeridae*, *Staphylinidae*, *Hydrophilidae* and *Dermaptora* with the potential hosts, *Musca domestica* L., *Tinea fuscipunctella* HAWORTH, and *Fannia* spp. suggested that predator activity was seasonally influenced. Possible periodic avoidance of a particular host's habitat was detected as significant negative correlations. The data tend to support the importance of different species of predators in different seasons and the need for natural enemy complexes rather than single species for biological control.

Key Subjects

biology & behaviour

LE TORCH JM. 1979. **A new pest of rearing buildings (*Alphitobius diaperinus* in pigsties, Brittany).** *Phytoma* **308**, 31-33.

Abstract

In their search for pupation sites, larvae of *Alphitobius diaperinus* (Panz.) caused considerable damage to expanded polystyrene partitions and other structures

in piggeries in Brittany, France, in the autumn of 1977. Methods for control and prevention of damage, including interfacing with the conditions.

Key Subjects

biology & behaviour

LE TORCH JM. 1983. **Laboratory study of the susceptibility to carbon dioxide and nitrogen of several species of stored product insects with a view to the disinfection of stores.** *Agronomie* 3, 399–406.

Abstract

Studies were made on the tolerance of several insect pests of stored products to exposure to carbon dioxide or nitrogen gas. The experiments were carried out in a controlled environment chamber in a set of small exposure cells containing the batches of insects, exposed to continuous flow of the inert gas or air (control). The reactions of seven species: *Trogoderma granarium* Everts, *Carpophilus ligneus* Murr., *Alphitobius diaperinus* Panz., *Tenebrio molitor* L., *Tribolium confusum* Duv., *Anagasta kuehniella* Zell. and *Plodia interpunctella* Hubn. were observed at different development instars at temperatures of 15, 18 and 25°C and 85% RH. The exposure time needed to kill 99% of the population was generally estimated by regression after probit transformation of the mortality rate. The curves showed both gases to have effective killing action: 6 of the species withstood less than 10 days of exposure at all temperatures for all stages except eggs. Only the larvae of the khapra beetle, *Trogoderma granarium*, survived more than 25 days with nitrogen and nearly 17 days with carbon dioxide. Some variation was observed with species, stages and temperatures. In some cases, the 2 gases did not have the same effect, particularly at the lowest temperature: carbon dioxide was more efficient than nitrogen for *T. granarium*, *C. ligneus*, *A. diaperinus*, *T. molitor* and less efficient for *T. confusum*, *A. kuehniella*, *P. interpunctella*. Keeping stored products under an inert atmosphere could be used, like fumigation, as a disinfection process, with practicable exposure times.

Key Subjects

non insecticide control

LE TORCH JM & LETENNEUR R. 1983. **Laboratory tests of resistance of different thermic insulators to perforation by the tenebrionid, *Alphitobius diaperinus* Panzer (Col. Tenebrionidae).** *Comptes Rendus des Seances de l'Academie d'Agriculture de France* 69, 188–200.

Abstract

Alphitobius diaperinus (Panz.), a stored product pest that also attacks rotten wood, was recently found in expanded polystyrene used as insulating material in the construction of pig and poultry houses in commercial rearing units in France. The mature larvae bored into the polystyrene to pupate. Laboratory tests with panels of 7 different materials used for this purpose showed that none was resistant and that all were similarly affected as regards numbers of holes, weight losses, number of insects harboured and insect mortality rates.

Key Subjects

biology & behaviour

LOHREN U. 1972. **The effect of different insecticides on the corn mould beetle (*Alphitobius diaperinus*).** *Deutsche Tierärztliche Wochenschrift* 79, 504–506.

Abstract

Results are given of studies on the control of the Tenebrionid *Alphitobius diaperinus* (Panz.), a tropical species that has been introduced into poultry houses in Germany with imported feeding stuff and become a severe pest. It is particularly favored by underground heating. It is known to transmit various pathogens of fowls (cf. RAE/B 60, 1535, etc.), including the virus of Marek's disease (an acute form of leucosis (57, 260)) and also some helminths (59, 1955, etc.). In laboratory tests in which adult beetle were topically treated with various insecticides in acetone solution, the LD95 of fenchlorphos (Gesektin K) in mg/beetle was 0.21 (cf. 57, 794; 59, 338), as compared with 0.6 for malathion (cf. 61, 1313), 4.2 for chlordane and 9.2 for diazinon. When exposed to concentrated serial solutions in petrie dishes, all beetles were killed by 0.1% fenchlorphos, but this concentration of propoxur killed only 5%. In tests of the duration of effectiveness and possible repellent effect on various surfaces, fenchlorphos was still giving 90% kill after 20 weeks among beetles exposed to treated concrete in a petrie dish in which they could avoid the treated surface. Diazinon gave 90% kill for 7 weeks. On all other surfaces tested, fenchlorphos was effective for about three times as long as diazinon. It was particularly effective on alkaline surfaces. To test the effectiveness of fenchlorphos as a mist, 100 beetles were exposed for 6h in each of four pails containing a layer of filter paper or crumpled filter paper or 5 cm fresh or old litter. At the end of exposure and (in brackets) after 24h, 20(89), 14(35), 5(22) and 3(18) of the beetles in the four pails were dead. All were dead after 48h. Slabs of various materials were also placed in different positions in a room before it was treated and exposed to the action of the mist for 24h. their toxicity was then evaluated. Kill was less on perpendicular than on horizontal surfaces. A concentration of 5-15 ml/m³ is considered sufficient, and it is recommended that a film should be left on the floor and in places where the beetles are likely to congregate. A field test of fenchlorphos was made in the Weser-Ems region, where *A. diaperinus* was increasing in spite of careful cleaning and treatment of poultry houses with broad-spectrum disinfectants before new stock was introduced, and spraying with BHC (HCH) had effected only a limited improvement. One section of a heavily infested farm was sprayed with a 0.5% solution of fenchlorphos and a second and part of a third with 1% solution; the rest of the third farm and a forth farm remained untreated. No beetles were seen after the treatment in the sprayed sections, whereas the others remained heavily infested. The treated farms remained free of infestation during an observed period of four months. Fenchlorphos has medium toxicity for mammals and birds (an LD50 for fowls of 36 mg/kg, a compared with 8.4 for diazinon and 50 for DDT). It is concluded that it provides a contact, stomach and respiratory insecticide that is better than any hithero described in ease of use and effectiveness against *A. diaperinus*.

Key Subjects

insecticide control

LOMONACO C & PRADO AP. 1994. **Community structure, population dynamics and natural enemies of the dipteran fauna of caged poultry.** *Anais da Sociedade Entomologica do Brasil* **23**, 71–80.

Abstract

Musca domestica (91.82%) and *Chrysomya putoria* (6.47%) were the most abundant of 23 species of Diptera recorded on a poultry farm near Uberlandia, Minas Gerais, Brazil, from August 1989 to October 1990. Populations of both dominant species showed marked seasonal variation, which was attributed to temperature changes during the year. The dipteran community structure showed a log-normal distribution, with the dominance of a few species. 27 species of arthropods were found in the poultry litter and 12 of these were considered to be natural enemies of Diptera; the most frequent were the Coleoptera *Dermestes ater* and *Alphitobius diaperinus*, and the Acari *Macrocheles muscaedomesticae*, *M. merdarius* and *Caloglyphus berlesei*.

Key Subjects

biology & behaviour

LORENZO P. 1990. **Application of 60Co gamma radiation to control insects in stored rice. Part IV. *Lasioderma serricorne* (Anobiidae: Coleoptera), *Alphitobius diaperinus* and *Tenebrionido* sp. (Tenebrionidae: Coleoptera).** *Ciencia y Tecnica en la Agricultura (Arroz)* **13**, 1–2, 67–76.

Abstract

The effects of 60Co gamma radiation from 0.2 to 1.0 kGy on *Lasioderma serricorne*, *Alphitobius diaperinus* and *Tenebrionido* sp. were investigated. A dose of 0.6 kGy effectively controlled these pests in stored rice.

Key Subjects

non insecticide control

MACCREARY D & CATTS EP. 1954. **Ectoparasites of Delaware poultry including a study of litter fauna.** *University of Delaware Agricultural Experimental Station Bulletin* **307**, 17–22.

Abstract

No abstract available

Key Subjects

biology & behaviour

MATHUR N, KHERA S & SHARMA N. 1994. **A study of infectivity and propagation of *Steinernema feltiae* on some insect pests.** *Journal of Parasitology and Applied Animal Biology* **3**, 47–53.

Abstract

Laboratory inoculation of last-instar larvae of *Pieris brassicae*, *Alphitobius diaperinus*, *Oryzaephilus mercator* and adults of *O. meractor* with *S. feltiae* (N-25 strain) was carried out to study the infectivity of this nematode after inoculation with 500, 1000 and 200 infective juveniles/ml/insect. It was found that the body weight of inoculated insects decreased steadily on each of the 5 successive days measured,

but the time taken to kill the various insects varied. The infectivity of *S. feltiae* varied with the size of the inoculum, and with increasing density of insects inoculated with 1000 juvenile *S. feltiae*, the number of infected insects and number of invading nematodes per insect decreased. The number of nematodes recovered per insect varied considerably among the different insect species and according to the inoculum size.

Key Subjects

disease association

MCALLISTER JC. 1993. **Determination of the potential of lesser mealworms, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae), to transmit poultry pathogens.** *Ph.D. Dissertation, University of Arkansas*.

Abstract

No abstract available

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD, NEWBERRY LA & SKEELS JK. 1995. **Isolation of infectious bursal disease virus from the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **74**, 45–49.

Abstract

Infectious bursal disease (IBDV) is an acute, highly contagious viral disease of young chickens. The relationship between the lesser mealworm, *Alphitobius diaperinus*, and IBDV was investigated. 60 adult lesser mealworms and 60 larvae were placed in sterile petrie dishes and starved for 24 hours, after which time they were provided with 1g of ground commercial chicken feed inoculated with IBDV for 24 hours. Adult and larvae mealworms were removed 1, 5, 10 and 15 days after exposure to the virus and the presence of IBDV tested for. The virus was undetected after 24 hours in beetle larvae. IBDV was present in adult lesser mealworm blood, all regions of the digestive tract and on the mouthparts 24 hours after exposure. Foregut samples from day 10 contaminated IBDV but other tissues sampled at this time were negative for virus. It is concluded that the lesser mealworm is capable of serving as a reservoir for IBDV.

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD & SKEELES JK. 1994. **Reservoir competence of the lesser mealworm (Coleoptera: Tenebrionidae) for *Salmonella typhimurium* (Eubacteriales: Enterobacteriaceae).** *Journal of Medical Entomology* **31**, 369–372.

Abstract

The reservoir competence of *Alphitobius diaperinus* is reported for *S. typhimurium* relative to broiler chicken production. *S. typhimurium* was isolated from faeces of the adult beetles at least 28 days after feeding for 24 hours on 1g of chicken feed (containing corn and soybean meal) inoculated with 3x10⁸ bacteria/ml. All larvae fed *S. typhimurium* ceased voiding the bacteria in their faeces before pupal moult, except one. One beetle continued to void *S. typhimurium* after it emerged as an adult, providing evidence that

transstadial transmission of *S. typhimurium* may occur. The bacteria were found both on the external body surface and inside the body of surface-sterilized adults and larvae during 16 days exposure. *Salmonella*-positive cloacal swabs were obtained from 1-day-old broiler chicks within 24h after eating 1 infected lesser mealworm adult or larvae.

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD, SKEELES JK, NEWBERRY LA & GBUR EE. 1996. **Reservoir competence of *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) for *Escherichia coli* (Eubacteriales: Enterobacteriaceae).** *Journal of Medical Entomology* **33**, 983–987.

Abstract

Larval and adult lesser mealworms, *Alphitobius diaperinus* (Panzer), were found to harbor a Congo red-binding strain of *Escherichia coli* (Migula) Castellani & Chalmers both on the external surface of their body and internally for 12d. Thereafter, *E. coli* was not detected, even though the beetles were exposed continually to a food source inoculated with the bacteria. Lesser mealworm larvae and adults discharge *E. coli* bacteria in their feces for up to 6 and 10 d, respectively. However, bacteria were no longer detected in their feces after larvae under went a single molt to the next larval stage. This indicated there was no transstadial transmission of this strain of *E. coli*. Consumed infected larvae were found to cause 1-d-old chicks to have positive cloacal swabs for Congo red-binding *E. coli* than consumed infected adults. The data indicated that the lesser mealworm may play a role in the direct transmission of *E. coli* and contribute to the spread of this bacteria in broiler production systems. This may be achieved by beetles being directly consumed by chickens or indirectly by spread of the bacteria throughout the broiler house by lesser mealworm feces.

Key Subjects

disease association

MEIK J. 1980. **A comparative study of the toxicity of seven contact insecticides against a field strain of *Alphitobius diaperinus*.** M.A.F.F. *Internal Report*.

Abstract

No abstract available

Key Subjects

insecticide control

MEKADA H, IMAEDA N, SHIGEZUMI S & EBISAWA S. 1983. **Control of *Alphitobius diaperinus* by polyurethane boards impregnated some insecticides.** *Japanese Poultry Science* **20**, 149–157.

Abstract

No abstract available

Key Subjects

insecticide control

MEKADA H, IMAEDA N & UMEDA K. 1984. **Effect of insecticide-impregnated insulation board on growth of chicks and vaporizing rate of the insecticide.** *Japanese Poultry Science* **21**, 330–332.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

MILLER RW & REDFERN RE. 1988. **Feed additives for control of lesser mealworm (Coleoptera: Tenebrionidae) in poultry broiler houses.** *Journal of Economic Entomology* **81**, 1137–1139.

Abstract

In laboratory tests, lesser mealworm, *Alphitobius diaperinus* (Panzer), larvae were fed chicken rations containing one of six benzoylphenylurea compounds, thuringiensin, cyromazine, or ivermectin. The more active compounds were incorporated into the feed of broiler chicks housed in small pens to which adult lesser mealworms had been introduced. After 8 wk, essentially no lesser mealworm larvae could be found in the pens to which penfluron; 2,6-difluoro-N-[[[4-(trifluoromethoxy)phenyl]amino]carbonyl]benzamide; N-[[[3,5-dichloro-4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]phenyl]amino]carbonyl]-2,6-difluorobenzamide; N-[[[3,5-dichloro-4-(1,1,2,2-tetrafluoroethoxy)phenyl]amino]carbonyl]-2,6-difluorobenzamide; or ivermectin had been added to the feed at a level of ≤ 2.5 ppm.

Key Subjects

insecticide control

MILLER RW. 1990. **Use of ivermectin to control the lesser mealworm (Coleoptera: Tenebrionidae) in a simulated poultry broiler house.** *Poultry Science* **69**, 1281–1284.

Abstract

Broiler chickens were fed ivermectin (Ivomec) at a level of 2 p.p.m. for 5 weeks to determine its efficacy against *Alphitobius diaperinus*. This treatment essentially eliminated beetle larvae; no ivermectin residues were found in the livers of the treated chickens, even without a withdrawal period. However, the feeding of ivermectin may reduce body weights, body weight gain and feed efficacy at older ages.

Key Subjects

insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1974. **Flies and other insects in poultry houses.** *Ministry of Agriculture, Fisheries and Food leaflet* **537**, 6pp.

Abstract

Fannia canicularis (L.) is the main pest found in poultry houses causing complaints from householders. *Musca domestica* L. and *Muscina stabulans* (Fall.) are often serious pests also. The life cycle and breeding habits of *F. canicularis* are described, and methods for its control and the control of other flies and preventive measures are noted. The habits and control of various beetles (particularly *Alphitobius diaperinus* (Panz.)), mites, moths and other flies found in poultry house litter are also briefly mentioned.

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1980. **Insects in poultry houses.** Leaflet 537, 8 pp.

Abstract

In the UK, pest problems encountered in poultry houses are related to the type of house and frequency of droppings removal. In laying houses where droppings are removed by conveyor belt every 3 to 4 days and in deep-litter houses for broilers where the litter is replaced every 8 to 10 weeks, serious infestations are unlikely to develop. However, in deep-pit houses where droppings are allowed to accumulate for up to 14 months and in deep-litter houses where litter is not replaced frequently, insect pest problems may occur. The first insects to appear in new droppings are usually *Leptocera* spp. and *Sciara* spp. At a later stage, *Musca domestica* L., *Fannia canicularis* (L.) and *Muscina stabulans* (Fall.) may colonise the droppings. Occasionally, the predatory fly *Ophyra capensis* (Wied.) may also occur. A wide range of insect species can breed in poultry droppings. After a few weeks, predatory beetles such as *Carcinops pumilio* (Erichs.) and staphylinids may be found and, as the droppings become drier, other beetles occur, including *Alphitobius diaperinus* (Panz.), which is common in deep-pit houses. *Dermestes* spp. may be present in very large numbers in deep-pit houses. Moths are also common in poultry houses where the larvae are usually found living in the droppings or in residues of very dry material. Although the commonest is *Endorsis sarcitrella* (L.), *Niditinea fuscipunctella* (Haw.) may occur in large numbers on dry droppings. *Ephesia kuehniella* Zell. may be found in and around feed hoppers and *Pyrallis farinalis* (L.) has been found in several deep-pit houses. In this revised leaflet, information is presented on the biology, morphology, injuriousness and control of these insects.

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1983. **Poultry house insulation.** Ministry of Agriculture, Fisheries and Food leaflet 637, 6pp.

Abstract

In a section on insects and vermin in this revised leaflet on poultry house insulation in the UK, it is reported that larvae of *Alphitobius diaperinus* (Panz.) and *Dermestes maculatus* Deg. are sometimes responsible for the deterioration of polystyrene and ureaformaldehyde insulations.

Key Subjects

biology & behaviour

MISHCHENKO AA & MASHKEI IA. 1987. **Harmful beetles (Coleoptera) - inhabitants of livestock premises.** Veterinariya Kiev 62, 68–71.

Abstract

Details are given of the species and life stages of the beetles collected in pig, cattle and poultry quarters in the Ukraine, USSR, during 1979–85. The presence of *Alphitobius diaperinus* and dermestids was considered particularly important as they can transmit disease to livestock.

Key Subjects

biology & behaviour; disease association

MOYA A, FLORES R & OVIES D. 1977. **On the epizootiology of heteroxenous helminths of the hen (*Gallus gallus forma domestica*) in Cuba.** Revista Cubana de Ciencias Veterinarias 8, 25–29.

Abstract

A group of 15 four-week-old Plymouth Rock chicks was fed 100 *Dermestes ater* beetles during 4 consecutive days and killed 75 days later. Autopsy of 13 birds showed 6 infected with *Raillietina cesticillus*, 4 with *Choanotaenia infundibulum*, 5 with *Tropisurus confusus*, 3 with *Chelospirura hamulosa* and 5 with *Subulura suctoria*; the mean intensity of infection was about one to 5 worms. Another 15 chicks were fed with 100 *Alphitobius diaperinus* during 3 consecutive days. At autopsy, 7 were found to be infected with *S. suctoria* (mean intensity, 6 worms). Another 15 were fed with 100 *Musca domestica* during 2 days. At autopsy of 14, one was infected with 2 *R. cesticillus*. A control group, not fed with arthropods, showed no worms.

Key Subjects

disease association

NEMESERI L & GESZTESSY T. 1973. **Mass incidence and control of *Alphitobius diaperinus* on poultry farms.** Magyar Allatorvosok Lapja 28, 335–338.

Abstract

Alphitobius diaperinus (Panz.) has been found on poultry farms in all parts of Hungary. Notes are given on the morphology and ecology of the Tenebrionid, which likes warm dark moist places and occurs mainly in the litter beneath water and feed troughs. It does not seem to play a part in the spread of coccidiosis or Ascarid infections among poultry. The larvae and adults can be destroyed by application of a 2% trichlorphon (cf. RAE/B 62, 380). In winter, it is recommended that poultry houses should be kept cool for 5 days as a control measure. Paper bags instead of gunnysacks should be used to distribute the poultry food in order to prevent the spread of the beetle.

Key Subjects

biology & behaviour; insecticide control

O'CONNOR JP. 1987. ***Alphitobius diaperinus* (Panzer) (Col., Tenebrionidae) damaging polystyrene insulation in an Irish piggery.** Entomologist's Monthly Magazine 123, 1472–1475.

Abstract

In September 1983, a large sample of extruded polystyrene slab that was riddled with large (4 mm and above) and small (about 2 mm) holes was received for diagnosis of the damage. The material came from an intensive pig farm in the Irish Republic, where it was being used for insulating animal housing. Since the damage was extensive, the pigs were suffering from draughty and cold conditions. The large holes were found to have been caused by *Alphitobius diaperinus* and the small ones by *Gnatocerus cornutus*.

Key Subjects

biology & behaviour

OHIO STATE UNIVERSITY. 1987. **Pesticides for poultry and poultry buildings.** *Ohio Cooperative Extension Service*, 12.

Abstract

No abstract available

Key Subjects

insecticide control

OVIES D & BIROVA V. 1976. **Epizootiology of *Subulura suctoria* in Cuba.** *Revista Cubana de Ciencias Veterinarias* 3, 71–79.

Abstract

Subulura suctoria is widely distributed among poultry in Cuba. It is present throughout the year but with seasonal variations. The intermediate coleopteran host, *Alphitobius diaperinus*, occurs in most poultry establishments. In the present work, 358 White Leghorn chickens were autopsied at the rate of 30/month, and 1000 *A. diaperinus* were examined. About 77% of the chickens were infected with a mean number of 21.6 worms/bird. The maximum infection rate occurred in February and the minimum in August. In the beetles, the maximum rate occurred in October to December, preceding the maximum in the chickens. It is recommended that measures to control the beetles should be intensified during October to December and that anthelmintic treatment should be given to the birds in December and January.

Key Subjects

disease association

PAJANI HR & GILL KM. 1974. **Effect of light on the pests of stored products.** *Bulletin of Grain Technology* 12, 151–153.

Abstract

Behaviour of insects towards light is rather well known and is mainly of two types i.e., they may be positively phototrophic or negatively phototrophic. Except for the general observations on the common species, orientation of different species to sources of light have not been studied in detail. During investigations on the biology of important pests of stored grains in the last two years, certain interesting observations relating to their reaction to light have come to our notice, which are described in the present communication.

Key Subjects

biology & behaviour

PFEIFFER DG. 1978. **The coleoptera of poultry houses in North Carolina.** MS Thesis, North Carolina State University, Raleigh, NC.

Abstract

No abstract available

Key Subjects

biology & behaviour

PFEIFFER DG & AXTELL RC. 1980. **Coleoptera of poultry manure in caged layer houses in North Carolina.** *Environmental Entomology* 9, 21–28.

Abstract

At least 120 species of Coleoptera were recovered from poultry manure in narrow, wide-span, and high-rise types of caged-layer poultry houses in the Mountains, Piedmont, and Coastal Plain regions of North Carolina. *Carcinops pumilio* (Erichson) and *Alphitobius diaperinus* (Panzer) were consistently the

most abundant species in all 3 regions, followed by *Gnathoncus nanus* (Scriba) and the *Aleocharinae* (Staphylinidae). According to 5 indices of diversity, the Piedmont ranked 1st in overall diversity, species richness and equitability, followed by the Coastal Plain, and thirdly, by the Mountains. Narrow and high-rise house types were compared for adult and larval *C. pumilio* and *A. diaperinus*. The larval population peak for *A. diaperinus* occurred significantly earlier in the high-rise than in the narrow houses, however, the narrow houses had significantly higher beetle diversity. A qualitative examination of overwintering forms showed that most species overwintered primarily, but not exclusively, as adults.

Key Subjects

biology & behaviour

PILETSKIS SA. 1984. **Three species of Coleoptera new to the Lithuanian SSR, found in 1982–1984.** *Novye I Redkie Dlia Litovskoi SSR Vidy Nasekomykh Soobshcheniia I Opisaniia*, 19–22.

Abstract

The 3 species mentioned in this paper that were recorded as new to the Lithuanian SSR, USSR, in 1982–84 are the tenebrionid *Alphitobius diaperinus*, the nitidulid *Carpophilus hemipterus* and the dermestid *Trogoderma versicolor*.

Key Subjects

biology & behaviour

POSPISIL J. 1973. **Tests of olfactory repellents against *Alphitobius diaperinus* Panzer (Scarabaeidae) and *Dermestes maculatus* DeGeer (Dermestidae) (Col.).** *Regulation of Insect Reproduction – Program & Abstracts – International Conference – Institute of Entomology Czechoslovak Academy of Sciences* 112, 1–10.

Abstract

Menthol, thymol and paradichlorobencene were tested on *A. diaperinus*, and they and naphthalene on *D. maculatus*. *A. diaperinus* were repelled by thymol and by high concentrations of paradichlorobencene; menthol was only slightly repellent. *D. maculatus* was repelled by thymol; menthol and naphthalene showed some repellent action, while paradichlorobencene was relatively ineffective. *D. maculatus* lost its sensitivity to repellents when exposed to them for long periods.

Key Subjects

insecticide control

PREISS FJ, DAVIDSON JA. 1970. **Characters for separating late stage larvae, pupae, and adults of *Alphitobius diaperinus* and *Alphitobius laevigatus* (Coleoptera: Tenebrionidae).** *Annals of the Entomological Society of America* 63, 807–809.

Abstract

The urogomphus, epipharynx, 4th abdominal pupal segment and adult pronotum are illustrated. The structural differences used to distinguish late-stage larvae, pupae, and adults of *A. diaperinus* and *A. laevigatus* are discussed.

Key Subjects

biology & behaviour

PREISS FJ & DAVIDSON JA. 1971. **Adult longevity, pre oviposition and fecundity of *Alphitobius diaperinus* in the laboratory (Coleoptera: Tenebrionidae).** *Journal of the Georgia Entomological Society* **6**, 105–109.

Abstract

A semi-synthetic medium was developed on which *A. diaperinus* could be easily reared and maintained in the laboratory. Adult longevity is probably over 400 days. The average pre-oviposition period was 12.7 days (range 4–30 days). The females laid an average of 3.5 eggs per day. One female deposited 2684 apparently viable eggs during the study.

Key Subjects

biology & behaviour

PROPP GD & MORGAN PB. 1985. **Mortality of eggs and first-stage larvae of the house fly, *Musca domestica* L. (Diptera: Muscidae), in poultry manure.** *Journal of the Kansas Entomological Society* **58**, 442–445.

Abstract

The activity of predators and scavengers found in accumulated poultry droppings in Florida resulted in up to 97% reduction of eggs and larvae of *Musca domestica* recovered from artificially infested containers. The most abundant predators were the histriid *Carcinops pumilio*, the formicid *Solenopsis invicta*, the labidurid *Euborellia annulipes* and unidentified staphylinids, macrochelid mites and pseudoscorpions, and the most abundant scavenger was the tenebrionid *Alphitobius diaperinus* (which, while probably not a direct predator of *M. domestica*, appeared to have an adverse effect on the muscid larvae in the droppings). These results suggest that competitors, scavengers and generalist predators may be as important as parasites in reducing the numbers of *M. domestica*.

Key Subjects

biology & behaviour

REMUS B, BAUSCHKE K, VOGEL K & BAHR I. 1983. **The importance and control of the lesser mealworm (*Alphitobius diaperinus*) in industrial broiler rearing premises.** *Monatshefte fuer Veterinaermedizin* **38**, 358.

Abstract

Observations carried out in broiler rearing premises in the German Democratic Republic indicated that *Alphitobius diaperinus* (Panz.), and important pest of stored products, could also play an important role as a vector of microorganisms pathogenic to poultry. Brief notes on the biology of the insects are given. Since only part of the pest population can be eradicated by insecticides in the premises, other measures should be developed which take account of behavioural characteristics, such as behaviour-regulating effect of pheromones.

Key Subjects

biology & behaviour; insecticide control

REYNA PS, MCDUGALD LR & MATHIS GF. 1983. **Survival of coccidia in poultry litter and reservoirs of infection.** *Avian Diseases* **27**, 464–473.

Abstract

The survival of coccidia was studied in poultry litter, soil and invertebrate animals. The populations of coccidia in litter were recorded during broiler growout in 16 broiler houses and in floor-pen trials involving anticoccidial drugs. The viability of oocysts declined rapidly in poultry litter regardless of species; it was retained best in 40% moisture of 4 deg C, regardless of the carrier. In four floor-pen experiments designed to study the efficacy of anticoccidial drugs, the oocyst counts correlated in general with lesion sources and performance, indicating the oocyst counts might be useful along with other parameters to judge the effectiveness of drugs. Coccidia were transmitted to susceptible chicks by feeding them beetles (*Alphitobius diaperinus*), flies, or house dust from poultry houses. More carrier samples were positive during warmer months. Oocyst counts in litter of commercial poultry houses were very low during the first or last weeks of broiler growout but were high during the normal 3 to 6 week stress period. These results confirm that poor survival of a few oocysts in poultry litter and suggest that carryover from one flock to the next on the survival of a few oocysts in dust or arthropod vectors

Key Subjects

disease association

RUEDA LM & AXTELL RC. 1996. **Temperature-dependent development and survival of the lesser mealworm, *Alphitobius diaperinus*.** *Medical and Veterinary Entomology* **10**, 80–86.

Abstract

Development, growth and survival of *A. diaperinus* were determined at 6 constant temperatures. No egg hatch or larval development occurred at 17°C. At temperatures of 20, 25, 30, 35 and 38°C the median development time (days), respectively, were for eggs (13.4, 6.0, 4.4, 2.6 and 2.6), larvae (133.0, 46.0, 26.2, 22.4 and 23.9), pupae (17.0, 8.0, 5.5, 4.0 and 4.1), and from oviposition to adult emergence (164.4, 60.2, 37.9, 29.0 and 30.8). The Sharpe and DeMichele (1977) (Journal of Theoretical Biology, 64: 649–670) model was used to describe the temperature-dependent development. The mean egg survival (Hatching) ranged from 61–86%, with lowest hatch at 20°C. Survival of the larvae and pupae ranged from 32–73% and from 85–95%, respectively, with lowest survival at 20°C. Pupae had significantly lower weights at 35°C and adults at 38°C than at the other temperatures. Female pupae (20 mg) and female adults (16 mg) were significantly heavier than male pupae (17 mg) and male adults (13 mg). Adults (0.5–9 months old) laid 4–7 eggs per female per day at 25°C.

Key Subjects

biology & behaviour

RUEDA LM, OSAWARU SO, GEORGI LL & HARRISON RE. 1993. **Natural occurrence of entomogenous nematodes in Tennessee nursery soils.** *Journal of Nematology* **25**, 181–188.

Abstract

To isolate potential insect biocontrol agents, entomogenous nematodes were surveyed in Tennessee plant nurseries in 1991. Soil samples from 113 nursery sites were baited with greater wax moth

(*Galleria mellonella*) larvae, house cricket (*Acheta domestica*) adults, lesser mealworm (*Alphitobius diaperinus*) adults, and house fly (*Musca domestica*) larvae. *Heterorhabditis bacteriophora* and *Steinernema carpocapsae* were each recovered from 17 soil samples. *Heterorhabditis bacteriophora* was more common in habitats with crape myrtle (*Lagerstroemia indica*) and Chinese juniper (*Juniperus chinensis*) than other nursery plants, and *S. carpocapsae* was more frequently recovered from habitats with juniper and Southern magnolia (*Magnolia grandiflora*). Bulk density, electrical conductivity, organic matter, pH, temperature, and moisture content of the entomogenous-nematode positive soil samples were compared. Other nematode genera recovered with insect baits included *Rhabditis* sp., *Pelodera* sp., *Cryptaphelenchoides* sp., and *Mesodiplogaster* sp., which was recovered from a greater percentage of soil samples than the other 5 genera.

Key Subjects

non insecticide control

SAFRIT RD & AXTELL RC. 1984. **Evaluations of sampling methods for darkling beetles (*Alphitobius diaperinus*) in the litter of turkey and broiler houses.** *Poultry Science* **63**, 2368–2375.

Abstract

Materials placed on the litter in turkey and broiler houses in North Carolina were evaluated as sampling devices for the larvae and adults of *Alphitobius diaperinus*. Insects harboured in, on and between pieces of the materials were counted after exposure for 1 week. Pan traps consisting of 2 stacked pieces of 1.3 cm thick foil covered polyisocyanurate insulation (Celotex) placed under a protective metal pan stacked to the litter surface was a more effective sampling device than pan traps using thicker (5 cm) Celotex, 3.8 cm thick polystyrene (Styrofoam) or 2 stacked pieces of wood. A tube trap consisting of rolled fluted corrugated cardboard inserted in a section of poly(vinyl chloride) pipe was as effective a sampling device as the 2 pieces of Celotex in a pan trap and was more convenient to use. Six pieces of corrugated cardboard stacked under a pan caught larger numbers of beetle larvae and adults but was awkward to handle and impractical. Placement of sampling devices in the major subhabitats (open centre, near walls, near feeders and near waterers) in turkey and broiler houses affected catches of beetle larvae and adults. The open centre area was satisfactory and most convenient.

Key Subjects

biology & behaviour

SALIN C, VERNON P & VANNIER G. 1998. **The super-cooling and high temperature stupor points of the adult lesser mealworm *Alphitobius diaperinus* (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **34**, 385–394.

Abstract

Potential thermobiological limits in adult *Alphitobius diaperinus* were assessed during winter by measuring individual super-cooling points (SCP) and thermostupor points (TSP). Two experimental

conditions were tested: SCP and TSP measured at 100% relative humidity (RH); and SCP with specimens which survive the TSP at 0% RH. The absolute temperature range compatible with life between the two limits SCP and TSP, termed thermobiological span (TBS), was calculated in both conditions. The potential adaptive capacity to withstand cooling and overheating was: at 100% RH, mean TSP=46.7°C (SD± 0.67); mean SCP=-9.4°C (SD±/-1.81); absolute TBS=56.1°C; at 0% RH, mean TSP=47.4°C (SD±/-0.61); mean SCP=-12.3°C (SD± 2.5); mean TBS=59.7°C (SD±2.43). The TSP at 0% RH was reached with a loss of 3.84% in fresh weight vs. 1.15% at 100% RH. The difference in the SCP (females = 2.1°C; males = 5.4°C) obtained in dry or moist conditions could also be explained by the influence of the heat shock preceding the SCP measured at 0% RH. A decrease of water content may increase the osmolarity of the body fluid and thus the supercooling capacity and could be an adaptation to avoid freezing. Supercooling capacity allows adults to survive in areas where freezing temperatures may occur in poultry houses and more specially during the winter litter removals when adults beetles migrate and overwinter in the soil floor or in the insulation materials of the building walls. The heat tolerance capacity is mainly ruled by the physiological and behavioural adaptations of this species. It is concluded that the adult population of *A. diaperinus* could be controlled by increasing the temperature above 48°C.

Key Subjects

biology & behaviour; non insecticide control

SAMISH M & ARGAMANN O. 1991. ***Alphitobius diaperinus* beetles, a pest in poultry houses.** *Hassadeh* **72**, 387–389.

Abstract

This article reviews the biology and damages of the lesser mealworm (darkling beetle, *Alphitobius diaperinus*) with special reference to the status of this beetle in Israel. The four species of the genus *Alphitobius* found in Israel are: *A. diaperinus*, *A. laevigatus*, *A. ruficolor* and *A. viator*. The lesser mealworm which was first recorded in Israel in 1953 is the only serious pest of poultry from this genus in the country. The structural damage due to this beetle, its potential role as reservoir of pathogens, its direct damage to the birds and their feed, their nuisance to people, their life cycle and the problems encountered during their control are discussed.

Key Subjects

biology & behaviour; insecticide control

SARIN K. 1972. **On food utilization and nutrients by *Alphitobius diaperinus* (Panz).** *Zoologische Jahrbuecher Abteilung fuer Allgemeine Zoologie und Physiologie der Tiere* **76**, 408–415.

Abstract

7th instar larvae were fed on broken wheat (*Triticum*) grains or starved in individual glass vials for 7 days. The food utilization (percentage assimilation) was 81% for protein, 24.5% for carbohydrate, 38% for fats, and 25.6% for minerals.

Key Subjects

biology & behaviour

SARIN K. 1978. **Population variation of *Alphitobius diaperinus* (Panz.) during a year.** *Indian Journal of Entomology* **40**, 358–359.

Abstract

No abstract available

Key Subjects

biology & behaviour

SARIN K. 1980. **On population variation of a stored product pest *Alphitobius diaperinus* (Panz) during a year.** *Pestology* **4**, 30–31.

Abstract

Population variation of a stored product pest *Alphitobius diaperinus* (Panz) during a year at environmental temperature and humidity was studied. Adult population reached its peak in late August whereas the larvae showed maximum density in May. There was complete absence in larval population in the months of December to March. Temperature preferred by both the instars was 26 to 40 °C. Adults increased only when r.h. was 90% whereas the larval population increased even at 50-60% r.h.

Key Subjects

biology & behaviour

SARIN K, et al. 1973. **Effect of temperature and relative humidity on the development and mortality of *Alphitobius diaperinus* (Panz), a stored product pest.** *Folia Biologica (Cracow)* **21**, 223–228.

Abstract

A very few workers have worked out the life development of *Alphitobius diaperinus* but at entirely different temperatures. The literature completely lacks information on the effect of temperature and relative humidity on this beetle. The present work determines and confirms the range of humidity and temperature which is most favourable for the development of this beetle. Complete development is recorded at 30°C 33°C and 90% RH. At a higher temperature of 35°C to 37°C more time is required to complete the life development. At the lower temperature of 15°C there is no development. A high RH of 90% is required to complete the life development whereas at low RH (50%) the development is incomplete.

Key Subjects

biology & behaviour

SARIN K & SAXENA SC. 1975. **Food preference and site of damage to preferred products by *Alphitobius diaperinus* Panz.** *Bulletin of Grain Technology* **13**, 50–51.

Abstract

It is concluded from investigations in the laboratory in India with eight types of grains and pulses (wheat, curd (*Phaseolus mungo*), gram (*Cicer arietinum*), cowpea (*Vigna unguiculata*), groundnut, maize, barley and rice) that the larvae of *Alphitobius diaperinus* (Panz.) preferred wheat to the others, and that the adults preferred cowpea. Development did not take place on gram, groundnut or maize. In investigations on the site of damage to wheat, rice and cowpea, 59-77% of the damaged grains were attacked at the germ end.

Key Subjects

biology & behaviour

SAXENA SC & SARIN K. 1972. **Relative toxicity of some common insecticides to the adults of *Alphitobius diaperinus* (Panz.).** *Indian Journal of Entomology* **34**, 349–351.

Abstract

In laboratory tests in India on the contact toxicity of five commonly used insecticides to adults of *Alphitobius diaperinus* (Panz.), a pest of stored food-stuffs, the LC50's calculated from mortality percentages 48h after a direct spray application showed that mevinphos was the most toxic material, followed by fenitrothion, pyrethrins (Pyrethrum), gamma BHC (lindane) and *p,p'*-DDT.

Key Subjects

insecticide control

SCARBOROUGH A. 1988. **How to deal with darkling beetles.** *Broiler Industry*, 48–49.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

SCHMITTLE SC, 1966. **Leukosis - new or changed disease?** *Poultry Tribune* **72**, 32–34.

Abstract

No abstract available

Key Subjects

disease association

SCHMITZ VM & WOHLGEMUTH R. 1988. **Investigations on mass increase and behaviour of *Alphitobius diaperinus* Panz. (Coleoptera, Tenebrionidae) in poultry houses as a basis for directed control in practice.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **61**, 108–114.

Abstract

A correlation was found between successive generations of *Alphitobius diaperinus* and the rhythm of rearing broilers and cleaning the poultry houses in Berlin. In the litter, many larvae of the tenebrionid, in various instars, were found. The larvae began to leave the litter and search for pupation and hiding sites in the walls of the building about 13 days before rearing of the broilers was completed. The tenebrionids remained in these hiding places until cleaning of the houses was completed. When the houses were prepared with new litter, and higher temperatures for rearing the chickens were maintained, the beetles and larvae left their hiding places and reinfested the new litter. The possibility of using temperature barriers to prevent the pests from migrating from their hiding places was investigated, and it was found that larvae and adults rarely crossed barriers with a temperature exceeding 45°C.

Key Subjects

biology & behaviour; non insecticide control

SCHROECKENSTEIN DC, MEIER-DAVIS S, GRAZIANO FM, FALOMO A & BUSH RK. 1988. **Occupational sensitivity to *Alphitobius diaperinus*.** *Journal of Allergy and Clinical Immunology* **82**, 1081–1088.

Abstract

Alphitobius diaperinus is an important beetle in the grain and poultry industries. We evaluated three

individuals with work related symptoms of asthma, rhinitis, conjunctivitis, urticaria, and angioedema on exposure to the insects. Prick skin tests with extracts prepared from the larval, pupal, and adult life stages were positive in all three patients. Specific IgE antibodies to these extracts were demonstrated by RAST or radioimmunoassay. RAST and radioimmunoassay inhibition confirmed the specificity of IgE binding and further demonstrated immunologic cross reactivity between the three life stages. Peripheral blood leukocytes from two of the individuals demonstrated significant histamine release when they were compared with cells from nonexposed atopic and normal control subjects. The proteins in the extracts; however, the patterns of separation were different for each life stage. After immunoblotting and autoradiography, IgE binding proteins were recognised by sera from all three individuals in the larval extract at 90 kilodaltons (kd), in the pupal extract at 90, 64 and 38 kd, and in the adult extract at 84 kd. Additionally, several other proteins were identified as being allergenic in some of the patients. We conclude that these three patients developed IgE mediated sensitivity to *A. diaperinus* antigens as the result of occupational exposure. To our knowledge, this is the first description of sensitivity to this grain beetle.

Key Subjects

disease association

SCHULTKA H, BETKE P & STUBGEN H. 1984.

Device to generate insecticide-aerosol-air mixtures in broiler houses for controlling the lesser mealworm (*Alphitobius diaperinus*).

Monatshfte fuer Veterinaermedizin **39**, 561–562.

Abstract

Described in this paper is a technology for the control of *Alphitobius diaperinus*, Panzer 1797, on broiler production units, with due consideration being given to biological attitudes. The beetle can be controlled right into the wall insulation in the service period by preheating of the hall temperature between 32°C and 37°C and application of insecticide aerosol mixture in hot-air flow with temperatures between 50°C and 60°C, using Py-ULV 78 or Delicia-Milon aerosol. The population can thus be reduced to levels below the damage threshold.

Key Subjects

insecticide control

SHALABY FM, REFAII AH, MICHAEL SA, BISHARA SI, NAZMI NH & MOSTAFA MA. 1979.

The role of dung beetles in the epidemiology of helminth parasites of animals in Egypt. *Journal of the Egyptian Society of Parasitology* **9**, 339–348.

Abstract

Twelve species of scarabaeid and one tenebrionid beetle were captured from various semidesert or desert areas in Egypt where they were abundant around dung. They were kept in the laboratory for various periods before being dissected. Guinea pigs, rabbits and dogs were inoculated with encysted larvae that were recovered. It was evident that 75.4 to 100% of *Scarabaeus puncticolis*, 80% of *S. sacer*, 60% of *S. cornifrons*, 85% of *Bubas bubalus* and 17.35% of *Onitis alexis* were harbouring encysted larvae of

Spirocerca lupi in the coelomic cavity. *B. bulbulus* also harboured another unidentified nematode species. *Aphodius lividus*, *A. nitidulus*, *A. contractus*, *Corpis hispanus*, *Heliocopris gigas*, *H. isidis*, *Oniticellus pallens* and *Alphitobius diaperinus* were all free of encysted larvae, but some carried free-living nematode larvae or suspected parasites. Puppies inoculated with larvae from *S. puncticolis*, *S. sacer* or *S. cornifrons* developed nodules on the aorta; each nodule contained a *Spirocerca lupi* larva. Inoculated guinea pigs and rabbits did not become infected.

Key Subjects

disease association

SILBERMANN MS & SCHMITTLE SC. 1967.

Chemical control of the lesser mealworm, *Alphitobius diaperinus* (Panz.), (Coleoptera: Tenebrionidae). *Journal of the Georgia Entomological Society* **2**, 1–8.

Abstract

Various compounds were evaluated in the laboratory and field to determine their efficacy in controlling the adult beetle, *Alphitobius diaperinus* (Panz.), in poultry houses. Dimethoate, ronnel, Dursban, and carbaryl, all give satisfactory results within three days after treatment. Eidson et al., (1966), showed that the lesser mealworm, *Alphitobius diaperinus* (Panz.) was capable of inducing acute leukosis (Marek's disease) in chickens. Almost all poultry houses in Georgia visited by the authors harbored this insect. Eidson (1965) found the beetle in New York and Maine, while one of the authors found it in Minnesota in 1966. We have received specimens of *A. diaperinus* from Maryland, Missouri, North Carolina and South Carolina. The prevalence of this insect and its relationship to leukosis has led to these studies on the evaluation of various chemical controls in the laboratory and in the field.

Key Subjects

insecticide control

SILFVERBURG H. 1979. *Alphitobius diaperinus* (Panz.) (Tenebrionidae) established in Finland.

Notulae Entomologicae **59**, 171.

Abstract

No abstract available

Key Subjects

biology & behaviour

SIMCO JS, EVERETT R & LANCASTER JL JNR.

1966. **Preliminary studies on control of lesser mealworm in broiler houses.** *Arkansas Farm Research* **15**, 8.

Abstract

No abstract available

Key Subjects

insecticide control

SKEWES PA & MONROE JL. 1991. **The effects of darkling beetles (*Alphitobius diaperinus*) on broiler performance.** *Poultry Science* **70**, 1034–1036.

Abstract

Six polyvinylchlorine pipe darkling beetle traps were placed in 20 commercial broiler production facilities, and the relative level of beetle infestation was determined from weekly sampling during a 4-wk

period. The average number of beetles found at each facility was compared with following production parameters: mortality, feed conversion, condemnation rate, and production cost. In the 20 commercial broiler flocks evaluated, the level of darkling beetles within the facility was not related to any of the production parameters measured.

Key Subjects

Biology & behaviour; disease association

SMITH LB. 1975. **Occurrence of the depressed flour beetle, *Palorus subdepressus* (Coleoptera: Tenebrionidae), in Canada.** *Canadian Entomologist* **107**, 109.

Abstract

Palorus subdepressus (Woll.) was recorded for the first time in Canada in April 1974, when it occurred in residues of coarsely ground feed in pigsties in southern Manitoba. Adults and larvae were found in a heated area of a pen for young piglets where the temperature was maintained probably higher than 25 deg C and would permit the development of all stages (cf. RAE/A 55, 1646). The Tenebrionid was probably introduced in maize imported from the Great Plains area of the United States for the use in preparation of animal feed. As it does not survive the winter in southern England, it is unlikely to become established in unheated granaries in Canada, but it may do so in heated buildings or in heated grain or grain products. Other arthropods present in the feed residues included adults of *Cryptolestes pusillus* (Schönh.) and adults and larvae of *Alphitobius diaperinus* (Panz.) and *Dermestes lardarius* L.

Key Subjects

biology & behaviour

SNEDEKER C, WILLS FK & MOULTHROP IM. 1966. **Some studies on the infectious Bursal agent.** *Avian Diseases* **11**, 519–528.

Abstract

No abstract available

Key Subjects

disease association

SPENCER A & JESPERSEN JB. 1997. **Litter beetles as disease reservoirs.** *Danish Pest Infestation Laboratory Annual Report*, 70.

Abstract

Litter beetles, in particular the lesser mealworm *Alphitobius diaperinus*, the hairy fungus beetle *Typhaea stercorea* and foreign grain beetle *Ahasverus advena* are commonly found in broiler houses. These beetles are difficult to control chemically, and as their developmental time is rather short, they often constitute a pest problem. In addition they are potential transmitters of disease agents; for salmonella bacteria it has been shown that these species can be infected or surface-contaminated by salmonella bacteria. The Ministry of Food, Agriculture and Fisheries has therefore supported a project with the following specific objectives: 1) to investigate the occurrence, biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project involves collaboration

between the Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (Project co-ordinator), as well as many veterinarians and poultry meat farmers. The project was established in 1996, and by now samples of beetles have been collected and analysed for the presence of *Salmonella* and *Campylobacter* from a number of sites across Denmark. This work will continue in 1998. A survey of the distribution and extent of beetle infestation and a study of insecticide resistance are also planned for 1998.

Key Subjects

disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.

Litter beetles. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

The litter beetles, *Alphitobius diaperinus* (the lesser mealworm), *Typhaea stercorea* (the hairy fungus beetle), *Ahasverus advena* (the foreign grain beetle) and *Carcinops pumilio* are commonly found in Danish poultry houses. These beetles are difficult to control and often constitute a pest problem. In addition they are potential transmitters of human and avian disease. In 1996 the Ministry of Food, Agriculture and Fisheries supported a three year project with the following specific objectives: 1) to investigate the occurrence biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project involves collaboration between the Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (project co-ordinator), and many veterinarians and poultry meat farmers. The project will conclude in 1999, but has already achieved most of its objectives. The principal findings made so far are detailed below.

Key Subjects

biology & behaviour; disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.

The role of litter beetles in the transmission of disease. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

Fourteen broiler houses were non-randomly selected based on their salmonella infection status. Nine were persistently contaminated with salmonella while the remaining five were salmonella negative. In each house, beetles collected from two consecutive flocks and during the empty period between these flocks were monitored for the presence of salmonella and *Campylobacter*. Beetles sampled during production were shown to be able to harbor salmonella and/or *Campylobacter*, confirming earlier studies Denmark and elsewhere. More significantly however, in one house, beetles collected during the empty period were also found to be salmonella positive. This demonstrates the potential for litter beetles to transfer infections between successive flocks. However, our results also suggest that salmonella from beetles may not always be transmitted to the chickens and that beetles living in infested houses can remain free of

infection. All cases of *Campylobacter* positive beetles samples were detected in connection with a positive chicken flock. In no case was *Campylobacter* isolated from beetles taken from an empty house. This work was carried out in collaboration with M. N. Skov, L. Petersen and M. Madsen of the Danish Veterinary Laboratory, Århus. The findings will shortly be submitted for publication. All bacterial analysis was carried out by collaborators at DVL, Århus.

Key Subjects

disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.

A survey of litter beetles in Danish broiler houses. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

Samples were collected from 16 beetle infested broiler houses using two trap types. Wall-traps consisting of netting bags containing boiled wheat suspended against the outer wall out of reach of chickens were found to be effective in collecting the fungus feeding species *Typhaea sterocera* and *Ahasverus advena*. Floor-traps made from sections of PVC pipe perforated with 4 mm holes, stoppered at each end and placed half-filled with chicken feed within the litter, were effective in collecting *Alphitobius diaperinus* and also collected *Carcinops pumilio*. Five of each trap types were placed in each broiler house for one week immediately prior to slaughter. The traps were then returned to the laboratory where the beetles were speciated and counted. *A. diaperinus* was the most prevalent species and was found in all the houses surveyed. *T. sterocera* and *A. advena* were also common and were found in large numbers in many houses. No other beetle species were identified.

Key Subjects

biology & behaviour

SPENCER A & BRØCHNER JESPERSEN J. 1998.

Insecticide use and resistance in beetles infesting broiler houses in Denmark. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

A survey of Danish broiler producers was conducted by way of detailed questionnaire to ascertain the prevalence of litter beetle infestation, and the control measures used to manage them. A total of 177 questionnaires were returned completed and are included in our analysis. This represents approximately 54% of Denmark's broiler producers. Almost 60% of those responding reported litter beetle infestation. Of these 76% used insecticidal treatments. A wide variety of insecticides were used, with organophosphates being the most popular one. In spite of the persistence of most infestations, all but one of the respondents reported good or moderately good effect from insecticidal treatment. However, in visits to infested farms soon after treatment we have often found large numbers of apparently unaffected beetles. We are therefore currently carrying out a survey of insecticide resistance on litter beetles collected from infested farms. This study involves a range of insecticides including organophosphates,

carbamates and pyrethroids. We plan to report on our findings in 1999.

Key Subjects

insecticide control

SPILMAN TJ. 1968. **Minutes of meeting: the lesser mealworm, *Alphitobius diaperinus*.** In *Proceedings of the Entomological Society of Washington* **70**, 294–295.

Abstract

No abstract available

Key Subjects

biology & behaviour

STAFFORD KC III & COLLISON CH. 1987.

Manure pit temperatures and relative humidity of Pennsylvania high-rise poultry houses and their relationship to arthropod population development. *Poultry Science* **66**, 1603–1611.

Abstract

No abstract available

Key Subjects

biology & behaviour

STAFFORD KC III, COLLISON CH, BURG JG & CLOUD JA. 1988. **Distribution and monitoring lesser mealworms, hide beetles, and other fauna in high-rise caged-layer poultry houses.** *Journal of Agricultural Entomology* **5**, 89–101.

Abstract

The distribution of *Alphitobius diaperinus*, *Dermestes maculatus* and several fly predators were determined from cross-sectional and surface sampling of manure cones within environmentally controlled high-rise, caged-layer poultry houses. Most of the adults and larvae of *A. diaperinus* were recovered from the lower-outer regions of the manure cone and the aisle between manure rows. Most of the fly predators, *Carcinops pumilio*, *Macrocheles muscaedomesticae* and an uropodid mite, were recovered at the crest and top side of the manure surface. The Arends tube trap, consisting of rolled, corrugated cardboard inserted into a length of polyvinyl chloride pipe, was evaluated as a monitoring technique for the tenebrionid and dermestid. Significantly greater numbers of adult tenebrionids and dermestids and larval tenebrionids were recovered from traps placed on the top of the manure cone (P,0.05) than 3 other positions within the manure pit (floor, post and wall ledge). Manure tube trap sample sizes for monitoring tenebrionid densities at 5 levels of reliability were calculated. Recovery of *C. pumilio* and *L. campestris* in the traps suggested population trends of other fauna could also be monitored with the tube trap.

Key Subjects

biology & behaviour

STEELMAN D. 1996. **Darkling beetles are costly pests.** *Poultry Digest* **55**, 22–23.

Abstract

Alphitobius diaperinus as a pest of poultry housing is discussed under the following headings: beetle life cycle; determining populations; economic impact; salmonellae; infectious bursal disease; turkey enteritis; method of control.

Key Subjects

biology & behaviour; disease association

STEENBERG T & JESPERSEN JB. 1996.

Entomopathogenic fungi for control of litter beetles. *Danish Pest Infestation Laboratory Annual Report*, 65.

Abstract

A survey was conducted of the natural occurrence of entomopathogenic fungi in populations of litter beetles in poultry houses, primarily the lesser mealworm (Darkling beetle) *Alphitobius diaperinus*. Samples of litter were collected from broiler houses and chicken manure was samples from manure pits in different types of houses with egg-laying hens. A total of 45 locations were sampled. In locations with no or very darkling beetles present (N=18), litter or manure was baited with larvae of *A. diaperinus* produced at our rearing unit. After 4 days, the larvae were recovered and incubated for a week in order to detect entomopathogenic fungi or other groups of entomopathogens. Entomopathogenic fungi were found in 5 locations but in very low frequencies of occurrence. In *A. diaperinus*, *Beauveria bassiana*, *Metarhizium anisopliae* and *Paecilomyces farinosus* were recorded. These fungi were isolated from other species of litter inhabiting beetle as well. In addition, *Verticillium lecanii* was isolated from a larva of the histeroid predator *Carcinops pumilio*. Bait larvae detected the bacterium *Serratia marcescens* as well as nematodes, possibly entomoparasitic species, at three locations. In conclusion, fungal species that are currently used as microbial control agents against agricultural pests in crops are present in poultry houses, albeit in low amounts. Epizootic development of the disease does not seem common under Danish conditions. Preliminary bioassays showed that larvae of *A. diaperinus* are distinctly more susceptible to fungal infection compared to adults. 142 strains, representing 7 fungal species were tested against larvae and 86 strains were infective.

Key Subjects

non insecticide control

STEENBERG T & JESPERSEN JB. 1997.

Entomopathogenic fungi for control of litter beetles. *Danish Pest Infestation Laboratory Annual Report*, 72–73.

Abstract

In 1996 a survey was conducted of the natural occurrence of entomopathogenic fungi in litter beetles. Beetles from only five locations (N=45) were infected by entomopathogenic fungi, and the fungus prevalence was low not only for the lesser mealworm (*Alphitobius diaperinus*) but also for other potential beetle pests in poultry farms (*Typhaea stercorea*, *Ahasverus advena*). However, despite the limited natural occurrence of entomopathogenic fungi, a previous screening showed that larvae of the lesser mealworm (*Alphitobius diaperinus*) were susceptible to strains of most species of hyphomycetes tested (*Beauveria bassiana*, *B. brongniartii*, *Paecilomyces farinosus*, *P. fumosoroseus*, *Metarhizium anisopliae*, *Verticillium lecanii*, *Acremonium* sp. and *Fusarium* sp.). Tests with *B. bassiana*, *M. anisopliae* and *P. fumosoroseus* confirmed earlier observations that larvae and pupae were much more susceptible to

infection than adults. Bioassays, in which insects were immersed in aqueous spore suspensions, showed that it was possible to select fungal strains that were not only highly pathogenic to larvae but also showed relatively high pathogenicity against adult beetles. These strains will be tested in cage experiments to evaluate their potential for spread in populations of the lesser mealworm.

Key Subjects

non insecticide control

STEENBERG T & BRØCHNER JESPERSEN J.

1998. **Entomopathogenic fungi for control of litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

This was the final year of the project, aimed at evaluating the potential of entomopathogenic fungi for the control of the lesser mealworm in poultry houses. In the laboratory we have selected a number of fungal isolates with high pathogenicity to larvae or adult beetles. The field efficacy of these isolates should be tested in the future. Planned experiments with application of fungus in bait stations were abandoned, as initial experiments showed that it was very difficult to attract the pest into the bait stations when placed under realistic conditions, i.e. in substrates providing alternative hiding places for larvae and adults. During 24 hours 5–10% of late instar larvae would enter the bait stations, and the experiments indicated that the larvae were attracted to the stations primarily because they provided a hiding place, while the food provided (boiled wheat kernels or solid substrate consisting of corn flour, wheat bran, dry yeast, water and agar) was not very attractive. It should be evaluated whether the selected fungal isolates can control the lesser mealworm by spreading in the population after 5–10% have been inoculated in bait stations. Furthermore, other food sources should be evaluated as baits.

Key Subjects

biology & behaviour; non insecticide control

STEINKRAUS DC & CROSS EA. 1993.

Description of life history of *Acarophenax mahunkai*, n. sp. (Acari, Tarsonemina: Acarophenacidae), an egg parasite of the lesser mealworm (Coleoptera: Tenebrionidae). *Annals of the Entomological Society of America* **86**, 239–249.

Abstract

A new species of mite, *Acarophenax mahunkai* Steinkraus & Cross, n. sp., was discovered parasitizing eggs of the lesser mealworm, *Alphitobius diaperinus* (Panzer), a serious cosmopolitan poultry pest. *Acarophenax mahunkai* is an obligate, apparently host-specific parasitoid that kills the egg upon which it feeds. Therefore, it may help control the lesser mealworm. The systematics and biology of *A. mahunkai* are presented here. In the laboratory, 51.0% of lesser mealworm egg masses were parasitized by one or more female mites. Male mites were not parasitic and had poor locomotory abilities. Significantly fewer lesser mealworm eggs hatched (23.9% egg hatch) in parasitized egg masses than in unparasitized egg masses (72.7%). Mite sex ratios were highly skewed, with means of 27.2 ± 3.9 females

and 1.7 ± 0.2 male offspring produced per gravid mite. Physogastric female mites parasitizing lesser mealworm eggs gave birth to fertile adult females. The developmental time of the mites (3-5 d) was faster than that of lesser mealworm eggs (5-7 d).

Key Subjects

biology & behaviour; non insecticide control

STEINKRAUS DC, GEDEN CG & BROOKS WM. 1992. **Discovery of the neogregarine *Farinocystis tribolii* and an eugregarine in lesser mealworm.** *Journal of Invertebrate Pathology* **59**, 203–205.

Abstract

Larvae and adults of *Alphitobius diaperinus* were collected from poultry litter on poultry farms in Arkansas, North Carolina and New York. Various tissues were examined for spores of neogregarines and microsporidia. *Farinocystis tribolii* and an apparently undescribed eugregarine were found in all areas. *F. tribolii* occurred with a frequency ranging from 44.4% of field collected larvae from Arkansas to more than 90% in laboratory reared colonies. The severity of the infections in moribund larvae ranged from 5×10^4 to 1.6×10^6 oocysts/larva. Eugregarine gamonts occurred in 52% of larvae in Arkansas.

Key Subjects

non insecticide control

STEINKRAUS DC, GEDEN CJ & RUTZ DA. 1991. **Susceptibility of lesser mealworm (Coleoptera: Tenebrionidae) to *Beauveria bassiana* (Moniliales: Moniliaceae): effects of host stage, substrate, formulation, and host passage.** *Journal of Medical Entomology* **28**, 314–321.

Abstract

Mature larvae of *Alphitobius diaperinus* were susceptible to infection with *B. bassiana* when larvae were shaken with conidia in an aqueous suspension or in a starch dust. Approximately 98 and 60% larval mortality rates were observed 2 weeks after exposure to suspensions containing 5×10^7 conidia per ml of aqueous suspension or 2.5×10^8 conidia per g of dust, respectively. Substantially lower larval infection rates (<30% mortality at all doses) were observed when aqueous suspensions of conidia (high rate of 5×10^7 conidia) were applied to 250 cm³ of used poultry litter containing beetle larvae; dust-treated litter resulted in mortality similar to forced-contact assays. Mortality was higher when larvae were exposed to extruded polystyrene insulation treated at 7.3×10^6 conidia/cm² than when larvae were exposed to weathered plywood treated at the same rate. The fungus used in the tests was originally isolated from and subsequently produced in adult houseflies (*Musca domestica*); a single passage through mature *A. diaperinus* larvae resulted in a substantial increase in virulence for *A. diaperinus* larvae. Mortality among adult beetles was low (<27%) in all assays.

Key Subjects

non insecticide control

STUKE P & KALENTA EF. 1970. **The role of the beetle *Alphitobius diaperinus* for spreading of infectious bronchitis of chicks.** *Deutsche Tierärztliche Wochenschrift* **77**, 38–41.

Abstract

No abstract available

Key Subjects

disease association

SWATONEK F. 1970. **On the biology of the lesser mealworm beetle (*Alphitobius diaperinus*).** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **43**, 101–104.

Abstract

It is reported that large numbers of *Alphitobius diaperinus* (Panz.) developed in a fowlhouse near Vienna (cf. also RAE/A 60,4526), so that control measures became necessary. The house was cleared, thoroughly cleaned out and then sprayed with gamma BHC (lindane), care being taken to treat the cracks and gaps between the concrete floor and the structural woodwork. One day after treatment, the dead beetles numbered 34/m². The Tenebrionid may have been introduced with the feed. Studies showed that the beetle can reproduce only in conditions of high temperature and high humidity, and there appears to be no possibility that it will become a serious pest in the field in Europe.

Key Subjects

biology & behaviour; insecticide control

TABASSUM R, NAQVI SNH, JAHAN M, NURULAIN SM, KHAN MF & AZMI MA. 1998. **Determination of the toxicities of fenpropathrin (pyrethroid) and neem formulation (RB-a + PBO + Tx-100) against *Alphitobius diaperinus* adults and their effects on transaminases.** *Turkish Journal of Zoology* **22**, 319–322.

Abstract

The toxicity of a neem formulation (RB-a plus piperonyl butoxide plus Triton X 100) and fenpropathrin (Danitol) to adults of *Alphitobius diaperinus* was determined in the laboratory at 30+/-2°C and 60+/-5% RH. A 117.8 ug/cm² dose of neem formulation caused 70% mortality, while a 1.96 ug/cm² dose of fenpropathrin caused 88% mortality. The LD50 of fenpropathrin WS 0.2749 ug/cm², and that of the neem formulation was 58.92 ug/cm². Fenpropathrin-treated *Alphitobius diaperinus* adults showed inhibitions of 44.66 and 45.91% of GPT (alanine aminotransferase) and GOT (aspartate aminotransferase) activity, respectively. In insects treated with neem formulation, these activities were inhibited by 52.48 and 12.15%, respectively.

Key Subjects

insecticide control

TEN HAKEN EH. 1981. **Assessment of seven insecticides for the control of the lesser mealworm *Alphitobius diaperinus* in poultry houses.** *M.A.F.F. Internal Report*.

Abstract

No abstract available

Key Subjects

Insecticide control

THOMPSON P. 1966. **Arthropods from the nests of house sparrows.** In *Proceedings of the Entomological Society of Washington* 44–48.

Abstract

No abstract available

Key Subjects

biology & behaviour

TOYOSHIMA K, BANBA H & KAMIYA M. 1996.

Control of *Alphitobius diaperinus* Panzer in chicken houses. I. Sensitivity to insecticides of adult. *Research Bulletin of the Aichi-ken Agricultural Research Center* **28**, 363–367.

Abstract

Experiments were conducted to control *A. diaperinus* in high floor chicken houses. The sensitivity of adults to insecticides was examined by filter paper and spray methods. Using the filter paper method, the adult was sensitive to naled, metriphosphate (trichlorfon), carbaryl, fenitrothion + permethrin, and fenitrothion + resmethrin with piperonyl butoxide. From the results, the authors consider that sprinkling these insecticides on the droppings surface would be effective in controlling the insect pest in spring, autumn and winter. With the spray method, the adult was sensitive to cyfluthrin, permethrin, naled, fenitrothion + permethrin, and fenitrothion + resmethrin with piperonyl butoxide. The authors thought it would be effective to spray these insecticides in poultry houses in summer.

Key Subjects

insecticide control

TURNER EC JNR. 1986. **Structural and litter pests.** *Poultry Science* **65**, 644–648.

Abstract

The importance of rodents and Coleoptera as structural pests of poultry houses, particularly in Virginia, is discussed. The pests include mice (*Mus musculus*), rats (*Rattus norvegicus* and *R. rattus*, *Dermestes lardarius*, *D. maculatus* and the tenebrionid *Alphitobius diaperinus*, of which mice and the tenebrionid are the most important. These pests are destructive to the fibreglass and polystyrene insulation in structural walls, causing serious losses. Brodifacoum, bromadiolone and difenacoum are recommended for controlling rodents including those resistant to anticoagulant rodenticides. Studies have shown that an increase in manure moisture was an important factor causing increased dispersion and migration of adults of *A. diaperinus* into the insulation of the houses. Larvae were more able to crawl up vertical pit walls constructed of wood than those made of cinder blocks, thus allowing easier access to insulation. Chlorpyrifos, permethrin, stirofos (tetrachlorvinphos) and carbaryl were toxic to both larvae and adults. Several new formulations of expanded polystyrene foam insulation were more resistant to beetle damage than untreated polystyrene insulation.

Key Subjects

biology & behaviour; insecticide control

UCHIDA A. 1980. **Studies on the life cycle of a cestode parasitic in the small intestine of Japanese quail.** *Bulletin of the Azabu University* **1**, 61–73.

Abstract

Various insects were collected from the rearing rooms of Japanese quails and examined for cysticercoids of

Metroliasthes coturnix. 5 species of beetles (*Dermestes maculatus*, *D. ater*, *Alphitobius diaperinus*, *Tenebrioides mauritanicus* and *T. obscurus*) were infected. *D. maculatus* was the most numerous beetle and the most commonly infected. At 30 deg C cysticercoids matured in the beetles in 12 days, and in quails development took 7 to 12 days

Key Subjects

disease association

UNKNOWN. 1990. **Darkling beetle control.** *Broiler Industry*, 40–42.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association; insecticide control

VAUGHAN JA & TURNER EC. 1982. **Studies of the infestation into polystyrene insulation by the lesser mealworm, a common inhabitant of deep-pit caged layer houses.** *Virginia Journal of Science* **33**, 91.

Abstract

No abstract available

Key Subjects

biology & behaviour

VAUGHAN JA & TURNER EC JNR. 1984. **Residual and topical toxicity of various insecticides to the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **77**, 216–220.

Abstract

Experiments were conducted to determine the relative toxicities of seven insecticides to adult and late instar lesser mealworms and to compare the residual activity of permethrin and carbaryl on polystyrene and unpainted plywood. In the residual activity tests, insecticide performance was altered by differences in formulation, surface type, and life stage of the insect. Wettable powder formulations were more effective on polystyrene than were emulsifiable concentrate formulations. Residual activity of permethrin and carbaryl was longer and more effective on polystyrene surfaces than on unpainted plywood. Tetrachlorvinphos WP (0.50% AI) gave excellent control on both surfaces. In the topical application experiments, permethrin, famphur, and tetrachlorvinphos, carbaryl, and propoxur were more toxic to late instars than to adults. The reverse was true for malathion. Protection administered to polystyrene insulation by surface sprays may be nullified by the burrowing habits of the insects. Toxicity profiles of different mealworm populations may depend on different spray regimes within poultry houses.

Key Subjects

insecticide control

VAUGHAN JA, TURNER EC JNR & RUSZLER PL. 1984. **Infestation and damage of poultry house insulation by the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **63**, 1094–1100.

Abstract

The phenologic events occurring in various types of insulation during infestation by *A. diaperinus* were studied under laboratory conditions. Late instar larval *A. diaperinus* initiated tunneling behavior into polystyrene insulation. No oviposition occurred within the tunnels. Few middle instar larvae were present in the polystyrene. All lifestages of *A. diaperinus* invaded exposed fibreglass, but invading late instar larvae did not pupate successfully. Polystyrene seemed to be preferred by late instar larvae over polyurethane for pupation sites, but polyurethane was favored over polystyrene by oviposition beetles. The insulative capacity of polystyrene was reduced as a result of lesser mealworm infestation.

Key Subjects

biology & behaviour

VICTOR JR & OGONOR PS. 1987. **Humidity reactions in the two species of tenebrionid beetles infesting poultry and food storage houses in Nigeria.** *Revue de Zoologie Africaine* **101**, 423–430.

Abstract

The reactions to humidity of two species of tenebrionid beetles, *Alphitobius diaperinus* (Panzer) and *Alphitobius laevigatus* (Fabricius) co-existing in the poultry and food storage houses of Nigeria were investigated. The adults of both species showed preferences for dry conditions and the most preferred humidity was 20% R.H. The eighth instar larvae of *A. diaperinus* showed preferences for dry conditions similar to those exhibited by the adults of both species, while the eighth instar larvae of *A. laevigatus* showed preferences for wet conditions preferring the highest humidity offered. The hygroreceptors responsible for the response to humidity by the adults of both species seem to be located in the proximal half of the antennae. The role of humidity as a factor in the ecology of these congeneric species of insects pests is discussed.

Key Subjects

biology & behaviour

VORIS JC, MEYER JA, PFOST R & WOODBURY R. 1994. **Temperature affects lesser mealworm populations in turkey brooder houses.** *California Agriculture* **48**, 18–21.

Abstract

The lesser mealworm beetle is a serious pest in turkey brooder houses. It tunnels into the building walls and insulation, and serves as a vector of poultry disease and an intermediate host of parasites. This research shows that population growth is encouraged by certain temperatures and by certain industry practices, but more research is needed to evaluate the population dynamics of the lesser mealworm, particularly its response to varying temperatures.

Key Subjects

biology & behaviour

WAKEFIELD ME & COGAN PM. 1992. **Laboratory study of resistance to iodofenphos and malathion in *Alphitobius diaperinus*.** *Central Science Laboratory Report* **42**, 19.

Abstract

Alphitobius diaperinus is considered a major pest in poultry houses because of its disease carrying capability and the damage it causes to insulation materials. Failure of treatments to control *Alphitobius diaperinus* in a turkey broiler house led to a laboratory investigation to determine whether this population was resistant to current M.A.F.F. approved insecticides. This investigation led to the determination of tentative discriminating doses of 0.5% for iodofenphos and 0.25% for malathion using the F.A.O. recommended filter paper method. Other methods for the production of probit response lines were also investigated.

Key Subjects

insecticide control

WAKEFIELD ME & COGAN PM. 1990. **Resistance to iodofenphos and malathion in the lesser mealworm *Alphitobius diaperinus*.** In *Proceedings 5th International Working Conference of Stored Protection, Bordeaux 1990*, 1065–1074.

Abstract

Alphitobius diaperinus is a major pest in poultry houses due to the damage that it causes to insulation material and to its disease carrying capability. Recently, treatment failures for *Alphitobius diaperinus* have been reported and an investigation was undertaken to determine whether these populations were resistant to the insecticide approved by M.A.F.F. for fabric treatments. Using a method based on the FAO recommended filter paper method for stored product beetles, tentative discriminating doses for iodofenphos and malathion were determined as 0.5% and 0.25% respectively. Using these discriminating doses it was found that almost half of the field populations tested were resistant to one or both of the insecticides. These findings have serious implications for both the feed milling and poultry industries.

Key Subjects

insecticide control

WALLACE MMH, WINKS RG & VOESTERMENS J. 1985. **The use of a beetle, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) for the biological control of poultry dung in high-rise layer houses.** *Journal of the Australian Institute of Agricultural Science* **51**, 214–219.

Abstract

The lesser mealworm, *Alphitobius diaperinus* (Panzer), is commonly found in poultry houses and often considered a pest. A situation is described in which it has been encouraged to build up large populations in the dung of high-rise layer houses and now plays an important role in drying out the moist dung. As a result, the dung is rendered unfavorable for fly breeding, and is easy to remove.

Key Subjects

biology & behaviour; insecticide control

WEAVER JE. 1996. **The lesser mealworm, *Alphitobius diaperinus*: Field trials for control in a broiler house with insect growth regulators**

and pyrethroids. *Journal of Agricultural Entomology* **13**, 93–97.

Abstract

Two trials were conducted under field conditions for control of the lesser mealworm, *Alphitobius diaperinus* (Panzer), in a broiler grow-out house. Larvae were controlled with treatments applied after litter cleanout and either before the addition of the new litter or to the surface of the new litter. Three benzoylurea insect growth regulators (IGRs) and two pyrethroids provided 95%-100% control of larvae through a 42 d grow-out period. The IGRs hexafluron, triflumuron and UC84572 were equally as effective in controlling larvae as the two pyrethroids, cyfluthrin and permethrin. The pyrethroids greatly reduced the adult beetle population within 7d posttreatment and held the population at low levels through the 42 d study; control of adults with the IGRs was not comparable. Numbers of adults were lower in most IGR treatments but in general not significantly different than untreated controls. Adult migration from untreated areas could have influenced these results.

Key Subjects

biology & behaviour; insecticide control

WILDEY KB. 1983. **Insect pests in animal houses - current control developments.** *In Proceedings of the 6th British Pest Control Conference*, 11pp.

Abstract

Recent developments in the control of insect pests in intensive animal housing units in the United Kingdom are reviewed and discussed with reference to the increase in pest problems resulting from increased intensification, the main pests (flies (including *Musca domestica* and *Fannia canicularis*), beetles (including *Dermestes maculatus* and *Alphitobius diaperinus*), the lepidopterous *Niditinea fuscipunctella* and *Endrosis sarcitrella*, *Ceratophyllus gallinae* and *Pyemotes* spp.); control difficulties; measures currently in use (application of diflubenzuron and other insect growth regulators as larvicides, use of baits based on insecticides, and entomopathogenic nematodes against flies, and conventional residual surface treatments and use of physical barriers against beetles).

Key Subjects

biology & behaviour; insecticide control

WILLS LE & MULLENS BA. 1991. **Vertical distribution of dipterous larvae and predatory arthropods in accumulated caged layer poultry manure in southern California.** *Journal of Agricultural Entomology* **8**, 59–66.

Abstract

Vertical distribution of filth fly larvae (*Musca domestica*, *Muscina stabulans*, *Ophyra aenescens* [*Hydrotaea aenescens*], *Fannia canicularis*, *F. femoralis*), predaceous Coleoptera (Histeridae, Staphylinidae), Anthocoridae, Pseudoscorpionidae, and predaceous Acarina (Macrochelidae, Uropodidae) were determined in accumulated caged layer poultry manure. Three zones in the manure cones (top, middle, and bottom) were sampled every 2 weeks at each of the 3 facilities over 5-17 months. Most taxa preferred certain zones. Arthropods found most commonly in the top zone (fresh manure deposition)

including fly larvae and *Macrocheles muscaedomesticae*. Adult *Carcinops pumilio*, adult *Philonthus* spp., staphylinidae larvae, and the mite *Fuscuropoda vegetans* were found most often in the top and middle zones. Adult *Gnathonchus rotundatus* (= *G. nanus* of some authors), anthocorids and pseudoscorpions were found mostly in the middle and bottom zones, while *Dendrophilus punctatus*, Aleocharinae and *Alphitobius diaperinus* were found most often in the bottom (driest) zone. Histerid larvae were widely distributed among the zones. Based on spatial overlap, the predaceous mites, *C. pumilio*, and *Philonthus* spp. would be expected to be primary predators on fly immatures.

Key Subjects

biology & behaviour

WILSON TH & MINER FD. 1969. **Influence of temperature on development of the lesser mealworm *Alphitobius diaperinus*.** *Journal of the Kansas Entomological Society* **42**, 294–303.

Abstract

The lesser mealworm, *Alphitobius diaperinus* (Panzer), was reared on ground wheat at constant temperatures of 50, 60, 70, 80, 90 and 100oF (+/- 2oF). From 8 to 11 larva instars were found, depending partly on temperature. The optimum temperature for development from egg to adult appeared to be 90oF, with a mean development time of 45.6 +/- 0.65 days. Most stages developed slightly faster and no larvae survived beyond the first instar at this temperature. More larvae were produced in cultures of adults when the rearing medium was held at 90oF and approximately 15% moisture than at any other combination of temperature and moisture. A sex ratio of 1:2.25, males to females, was obtained in laboratory rearing. Adults of both sexes were found to possess a pair of fleshy scent glands which produced a secretion causing sexual excitement among adult mealworms.

Key Subjects

biology & behaviour

WILSON DD, SCHMIDTMANN ET, RICHARD RD, LEHMAN RD, ST GEORGE TD & BLOK J. 1986. **Isolation of avian influenza from insects.** *Arbovirus research in Australia*, 221–226.

Abstract

During an outbreak of avian influenzavirus in poultry flocks in Pennsylvania in 1983-84, the virus was isolated from pools of the following insect species as follows: 25 of 72 adults of *Musca domestica*, 9 of 23 adults of *Ophyra aenescens* (*Hydrotaea aenescens*), 9 of 25 adults of *Coproica hirtula*, 1 of 51 adults of *Alphitobius diaperinus*, and 1 of 26 larvae of *Dermestes maculatus*.

Key Subjects

Disease association

WOHLGEMUTH R. 1989. **Control of mealworm (*Alphitobius diaperinus* Panz.) in poultry housing.** *In World Association of Veterinary Food Hygienists Proceedings of the Xth Jubilee International Symposium*, 18–20.

Abstract

The use of barrier systems for the control of larvae and adults of *A. diaperinus* in poultry housing is described.

Key Subjects

non insecticide control

YAGI A & RAZIG MTA. 1972. *Alphitobius diaperinus* (Panzer) (Coleoptera, Tenebrionidae) in pigeon houses in the Sudan. *Current Science*, Sept 5 41 642–643, 717.

Abstract

No abstract available

Key Subjects

biology & behaviour

YOSHIDA T. 1975. Rearing twelve coleopterous species and one psocid infesting cereal products on milk powder. *Journal of the Food Hygienic Society of Japan* 16, 80–84.

Abstract

Rearing experiments were carried out in Japan at 30 deg C and 70-80% R.H. with 12 species of Coleoptera and 1 psocid normally associated with stored grain on five types of milk powder sold commercially. Details of the compositions of these powders and of the results of the experiments are shown in tables. *Tribolium castaneum* (Hbst.), *Cryptolestes pusillus* (Schonh.), *T. confusum* Duv., *Oryzaephilus mercator* (Fauv.) and *O. surinamensis* (L.) developed well and produced numerous progeny; for *Lasioderma serricorne* (F.), *Gnathocerus cornutus* (F.), *Palorus subdepressus* (Woll.), *P. ratzeburgi* (Wissm), *Alphitobius diaperinus* (Panz.) and *Liposcelis bostrychophilus* Badonnel, milk powder proved a poor diet and only permitted only limited growth and adult emergence. *Stegobium paniceum* (L.) and *Latheticus oryzae* Waterh. did not survive to the pupal stage. The addition of water to the milk powder was not essential for growth but increased the rate of reproduction in some of the species.

Key Subjects

biology & behaviour

ZAEDDE IHM & IGNATOWICZ S. 1994. Mortality of larvae and adults of the lesser mealworm *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), caused by gamma radiation. *Annals of Warsaw Agricultural University SGGW AR, Veterinary Medicine* 18, 131–140.

Abstract

The post-radiation mortality of *Alphitobius diaperinus* was positively related to the radiation dosage. Adults of the pest showed a 2 week latent period before any significant increase in mortality occurred. Larvae were more susceptible to gamma radiation than adults, but were found to more sensitive to irradiation than larvae of other tenebrionids. Doses higher than 1.0 kGy are recommended for irradiation of animal feed infested by *A. diaperinus*.

Key Subjects

non insecticide control

SECTION 2. BIOLOGY AND BEHAVIOUR ARTICLES (BY AUTHOR/S)

ANDERSON JR & POORBAUGH JK. 1964. **Biological control possibility for houseflies.** *California Agriculture* **9**, 2–4.

Abstract

One phase of integrated fly control studies on poultry ranches in northern California involves research on several natural enemies of the house fly, *Musca domestica* L., the little house fly, *Fannia canicularis* (L.), and other nuisance flies. The black garbage fly, *Ophyra leucostoma* (Wied.), is one promising, and otherwise harmless, biological control agent. It predaceous larvae kill and feed on house fly maggots and other fly larvae which commonly inhabit chicken droppings. Recent studies have shown that one *Ophyra* larvae during its development may kill from 2 to 20 *M. domestica* maggots per day.

Key Subjects

biology & behaviour

ARMITAGE DM. 1985. **Environment and deep-pit poultry houses: survey of air and manure temperatures in British houses.** *British Poultry Science* **26**, 275–280.

Abstract

1. In order investigate factors which influence the development of insect infestations in poultry manure, air and manure temperatures in 5 deep-pit poultry houses were measured over a period of at least one year. 2. When the external temperature was below 10°C the air temperature in the cage and pit area dropped below the favored temperature of 20°C. During winter, therefore, temperatures in some houses were often close to the lower limit for fly development. 3. Maximum temperatures of nearly 45°C were recorded in some manure heaps, whilst others at the same point in the manure cycle were 10°C lower. It was believed that the difference was due to the variation in the height of the manure pile, which in turn was determined by the cage stacking arrangements. 4. This difference could affect the rate of increase of predatory mites and beetles, so the design of the house may determine the type and extent of infestation.

Key Subjects

biology & behaviour

ARMITAGE DM. 1986. **Population changes of four species of insects (Col. & Dipt.) in three deep pit poultry houses.** *Entomologist's Monthly Magazine* **122**, 1460–1463.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

ARSHAD M, JAN GA & KHATTACK A. 1984. **Insect fauna of birds' nests of N.W.F.P.** *Bulletin of Zoology Pakistan* **2**, 1–7.

Abstract

The nests of 11 species of bird, including pigeons, were examined for insects in a survey conducted in the North West Frontier Province of Pakistan. More

than 25 species of insects were recorded, including the thysanuran *Lepisma saccharina*, the collembolan *Lepidocyrtus cyaneus*, the psocopteran *Liposcelis divinatorius*, the dermestids *Anthrenus flavipes*, *A. coloratus* and *Attagenus piceus* (*A. unicolor*), the bostrichid *Rhyzopertha dominica*, the silvanid *Oryzaephilus suranamensis*, the tenebrionids *Tribolium castaneum* and *Alphitobius diaperinus*, the bruchid *Bruchus chinensis* (*Callosobruchus chinensis*), the curculionid *Hypera variabilis* (*H. postica*), the cimicids *Cimex lectularius* and *C. macrocephalus* (*C. hemipterus*), fleas and biting lice. Many of these insects are pests of households and stored products.

Key Subjects

biology & behaviour

AXTELL RC. 1985. **Arthropod pests of poultry.** In *Livestock Entomology*. 269–295.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

AXTELL RC & ARENDS JJ. 1990. **Ecology and management of arthropod pests of poultry.** *Annual Review of Entomology* **35**, 101–126.

Abstract

The major arthropod pest problems in modern integrated poultry production are reviewed. Pests discussed are ectoparasites (*Ornithonyssus sylviarum*, *Menacanthus stramineus*, *Dermanyssus gallinae* and *Cimex lectularius*) and habitat pests (*Alphitobius diaperinus*, *Dermestes maculatus*, and filth flies (*Musca domestica*, *Fannia* spp., *Ophyra* (Hydrotaea) spp., *Muscina stabulans*, *Stomoxys calcitrans* and *Hermetia illucens*)). Sections are given on: ectoparasite management; stress caused to poultry by ectoparasites; housing and production systems; fly predators, parasites and pathogens; and fly management.

Key Subjects

biology & behaviour

BARKE HE & DAVIS R. 1967. **Sexual dimorphism in the lesser mealworm, *Alphitobius diaperinus* (Panz.).** *Journal of the Georgia Entomological Society* **2**, 119–121.

Abstract

In recent years, for several reasons, there had been increased interest in the lesser mealworm, *Alphitobius diaperinus* (Panz.). Back and Cotton (1962) listed the lesser mealworm as a pest of moldy or poor quality grain storehouses. Discovery that certain poultry diseases (Avian leukosis, Salmonellosis) might be transmitted by the lesser mealworm (Gould and Moses (1951), MacCreary and Catts (1954), Harding and Bissell (1958), Lancaster and Simco (1967)) has resulted in expanded research on the biology of this beetle and its potential role as a vector of other poultry diseases. Further interest arises from the realization the *Alphitobius* is an excellent subject for

basic research investigations in entomology and ecology because of its adaptability to laboratory culture. One difficulty standing in the way of its convenient use as an experimental laboratory animal, however, has been the lack of an easy method of sexing the beetles. This paper presents such a method.

Key Subjects

biology & behaviour

BARKE HE & DAVIS R. 1967. **Notes on the biology of the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae).** *Journal of the Georgia Entomological Society* **4**, 46–49.

Abstract

The life cycle of the lesser mealworm, *Alphitobius diaperinus* (Panz.), was completed in 60–85 days at 21°C in the laboratory. Oviposition occurred readily in rolled or folded back paper. Relative humidities of 70, 80 and 90% had little effect on the duration of the egg stage or the per cent of hatch. Application of Dyar's law indicated six to nine larval instars.

Key Subjects

biology & behaviour

BELLINI R & MAINI S. 1989. **The seasonal presence and activity of parasitoids (Hymenoptera: Pteromalidae) of synanthropic Diptera in animal housing in Romagna.** *Bollettino dell' Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna* **43**, 217–222.

Abstract

The parasitoids of synanthropic filth flies were monitored in 4 animal houses (poultry houses, one dairy and one pig house) in farms in Forlì province, Romagna, Italy, in June–November 1987. A total of 30 251 naturally-occurring dipteran pupae were collected from the manure in the animal houses, a further 16 417 pupae of laboratory-bred *Musca domestica* were introduced into the houses. The fly population in the animal houses was monitored weekly by sticky traps. *Ophyra aenescens* (*Hydrotaea aenescens*) was the commonest filth fly in poultry housing, *M. domestica* in pig housing and *Stomoxys calcitrans* in dairy housing. All dipteran pupae were collected weekly and a total of 8201 parasitoids emerged from the collected pupae. The following parasitoids were found: *Spalangia cameroni* (51.16% of the total), *Muscidifurax raptor* (20.83%), *S. endius* (16.37%), *S. nigroaenea* (11.44%) and *Pachycrepoides vindemiae* (0.20%). The percentage of parasitism was higher in wild than in introduced pupae, with *S. endius* and *S. nigroaenea* in particular showing preference for wild pupae. The beetles *Alphitobius diaperinus* and *Carcinops pumilio* were found in high density in poultry manure.

Key Subjects

biology & behaviour

BERTI FILHO E, COSTA VA & AAGEESEN TL. 1989. **Occurrence of natural enemies of *Musca domestica* L. (Diptera: Muscidae) in poultry areas of Bastos, State of Sao Paulo, Brazil.** *Revista de Agricultura (Piracicaba)* **64**, 98.

Abstract

To determine the natural enemies of *M. domestica* present in the poultry housing in the Bastos region, San Paulo state, Brazil, samples of poultry droppings and housefly pupae were collected. The following natural enemies were recorded: the predators *Acritus analis*, *Aleochara puberula*, *Carcinops troglodytes*, *Euspilotes arrogans*, *Hister* sp. and *Philonthus sordidus* (Coleoptera); the competitors *Alphitobius diaperinus* (Coleoptera) and *Hermetia illucens* (Diptera); and the parasitoids *Muscidifurax uniraptor*, *Pachycrepoides vindemiae*, *Spalangia cameroni*, *S. endius* and *S. gemina* (Hymenoptera: Pteromalidae).

Key Subjects

biology & behaviour

BHATTACHARYYA S. 1995. **Coleopteran insects in the nests of birds in West Bengal.** *Environment and Ecology* **13**, 629–632.

Abstract

In 1984–85, the beetles associated with nests of *Streptopelia chinensis*, *Acridotheres tritis*, *Sturnus contra*, *Corvus splendens*, *Pycnonotus cafer*, *Prinia socialis*, *Ploceus philippinus* and *Passer domesticus* in 8 districts of West Bengal, India, were collected and identified. The nest environment played a part in regular beetle population density. 13 species representing 10 genera in 6 families (Dermestidae, Ptinidae, Bostrychidae, Nitidulidae, Tenebrionidae and Bruchidae) were found, mostly known as stored products pests, and were new records as birds' nests inhabitants.

Key Subjects

biology & behaviour

BRENDALL MTO. 1975. **Key to species of the genus *Alphitobius* (Stephens), (Coleoptera: Tenebrionidae).** *Proceedings of the Royal Entomological Society of London* **5**, 14–15.

Abstract

No abstract available

Key Subjects

biology & behaviour

BYNG AJ. 1962. **A study of the fauna of poultry deep litter.** *Agricultural Science* **60**, 251–257.

Abstract

No abstract available

Key Subjects

biology & behaviour

CHAIX MO. 1980. **The disinsection of rearing premises.** *Phytoma* **314**, 18–20.

Abstract

The injuriousness and control of arthropods in premises for rearing domestic animals, especially cattle, pigs and poultry in France, are reviewed. Special attention is paid to flies as vectors of disease, flies and fleas causing reductions in production of milk and eggs, respectively, and the infestation of feed by stored-product pests. *Alphitobius diaperinus* (Panz.) has caused important damage to insulating structures made of polystyrene and related materials in the past 2 years, especially where stock is reared on an industrial scale. Good agricultural practice, including maintaining atmospheric conditions unsuitable for pests, eliminating cover where they can

breed, and the use of netting over windows, are recommended, and a list of 12 insecticides that can be used is given.

Key Subjects

biology & behaviour; insecticide control

CHATTERJEE NB & GANGOPADHYAY AK. 1988. **Environmental cues in monthly egg laying and hatching of lesser mealworm *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Proceedings of the Zoological Society* **40**, 13–18.

Abstract

Environmental temperature and relative humidity play important roles in regulating laying and hatching of eggs of *Alphitobius diaperinus*, a stored product pest. During winter the rates of egg laying and hatching significantly decrease, and in summer and monsoon these increase. Continuous egg laying and hatching behaviour may be associated with uninterrupted vitellogenesis. Ecological plasticity in the reproductive behaviour of *A. diaperinus* is partly due to temperature and humidity responsiveness of the adult beetle population.

Key Subjects

biology & behaviour

COGAN P, WEBB D & WAKEFIELD M. 1996. **A comparison of four residual insecticides for the control of the lesser mealworm beetle (*Alphitobius diaperinus* Panzer) in turkey broiler houses in the UK.** *International Pest Control March/April*, 52–55.

Abstract

Residual applications of iodofenphos SC, fenitrothion WP, permethrin WP and azamethiphos WP were evaluated for the control of *Alphitobius diaperinus* (the lesser mealworm or darkling beetle) in earth floored turkey broiler units. Single applications of either iodofenphos SC, fenitrothion WP or permethrin WP were found to be ineffective, but azamethiphos WP was found to be effective over the stocking period of four months. A total of only four beetles found during the four months of the final stocking cycle throughout the five sheds treated with azamethiphos WP. This may be compared with the shed treatment with iodofenphos SC where more than 3300 *A. diaperinus* were found in the samples of litter in the final population assessment. The level of control of *A. diaperinus* was not significantly improved by a supplementary application of dichlorvos as a space spray after treatment with a residual insecticide, before restocking with birds. Bioassays showed that azamethiphos was the most persistent of the insecticides used and was effective at even high summer temperatures. Persistence of iodofenphos deposits indicated that survival of *A. diaperinus* was most likely to be due to resistance and not poor treatment or insecticide breakdown.

Key Subjects

biology & behaviour; disease association; insecticide control

CONWAY JA. 1973. **The micro-fauna of Californian-system poultry houses in Britain.** *British Poultry Science* **14**, 213–216.

Abstract

No abstract available

Key Subjects

biology & behaviour

CROOK PG, NOVAK JA & SPILMAN TJ. 1980.

The lesser mealworm, *Alphitobius diaperinus*, in the scrotum of *Rattus norvegicus*, with notes on other vertebrate associations (Coleoptera, Tenebrionidae; Rodentia, Muridae) Philippines. *Coleopterists Bulletin* **34**, 393–396.

Abstract

Larvae and adults of *A. diaperinus* bored into and lived in the scrotum of *R. norvegicus* on Negros Is., Philippines. The lesser mealworm, sometimes associated with bats, poultry and other birds, and several vertebrates.

Key Subjects

biology & behaviour

DALE PS, HAYES JC & JOHANNESSON J. 1976.

New records of plant pests in New Zealand. *New Zealand Journal of Agricultural Research* **19**, 265–269.

Abstract

The arthropods reported from New Zealand for the first time are *Coccus longulus* (Dgl.) (*Lecanium longulum*), which was found on papyrus leaves (*Cyperus papyrus*) at Auckland in 1973; *Aleyrodes proletella* (L.), on cabbage in Auckland in 1975; *Prays nephelomina* Meyr., on lemon flowers at Tauranga in 1975; *Phyllocoptruta oleivora* (Ashm.), on grapefruit in Auckland in 1975; and *Tarsonemus waitei* Banks, on glasshouse tomatoes at Whangarei in 1974. Pests are also recorded from 12 new food-plants, and it is reported that *Alphitobius diaperinus* (Panz.) has several times been observed destroying polystyrene wall insulation in poultry broiler houses in New Zealand.

Key Subjects

biology & behaviour

DASS R, AGARUAL RA & PAUL AUN. 1984.

Feeding potential and biology of lesser mealworm *Alphitobius diaperinus* (Panz.) (Col., Tenebrionidae), preying on *Corcyra cephalonica* St. (Lep., Pyralidae). *Zeitschrift fuer Angewandte Entomologie* **98**, 444–447.

Abstract

The grubs and adults of the lesser mealworm, *Alphitobius diaperinus* (Panz.) were found gregariously feeding on the eggs and larvae of *Corcyra cephalonica* St. for the first time in India. The development period from egg to adult was completed in 70 to 89 days at 27±1°C and 65±5% R.H. The mean egg, larval and pupal periods were 6.6, 68.8 and 8.4 days, respectively. The longevity of most of the beetles was between 14 and 16 months and they laid fertile eggs ranging between 1059 to 1874 per female. Some of the beetles are found to survive beyond 16 months and lay very few eggs. The beetle remained active in the laboratory throughout the year with a peak during summer season.

Key Subjects

biology & behaviour; non insecticide control

DE LAS CASAS E, POMEROY BS & HAREIN PK. 1968. **Infection and quantitative recovery of *Salmonella typhimurium* and *Escherichia coli* from within the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **47**, 1871–1875.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

DE SANTIS L, LOIACONO MS & COSCARON M DEL C. 1987. **Parasitoids and predator insects.** In Brenner RR and de la Merced Stoka A (eds.) *Chagas' disease vectors. Volume 1. Taxonomic, ecological, and epidemiological aspects.* CRC Press, Inc., Florida: 21–39.

Abstract

This review of the insect predators and parasitoids of Triatominae gives a list of known natural enemies arranged by order and family, together with notes on the following species and assessments of their potential value as biological control agents: Mantidae; *Clerada apicicornis* (Lygaeidae); *Apiomerus*, *Cosmoclopius*, *Daraxa*, *Graptocleptes*, *Microtomus*, *Opisthacidius*, *Rasahus*, *Reduvius*, *Zelurus* and other species of Reduviidae; Coleoptera (including *Alphitobius diaperinus*); *Sarcodexia sternodotes* (Sacrophagidae); *Eciton* and *Pheidole megacephala* (Formicidae); *Oolathron mireyae* (Aphelinidae); *Anastatus excavatus*, *A. catamarcensis*, *A. coreophagus* and *A. charitos* (Eupelmidae); *Ooencyrtus venatorius* (Encyrtidae); *Gryon triatoma*, *G. linschostei*, *Telenomus capito*, *T. costalimai* and *T. fariai* (including *T. f. fariai* and *T. f. rabinovichi*) (Scelionidae).

Key Subjects

biology & behaviour

DESPINS JL. 1987. **Investigations of the destructive behavior, and methods for control of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Dissertation Abstracts International* **48**, 334-B.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

DESPINS JL & AXTELL RC. 1995. **Feeding behavior and growth of turkey poult fed larvae of the darkling beetle, *Alphitobius diaperinus*.** *Poultry Science* **73**, 1526–1533.

Abstract

Experiments were conducted to determine the effect of feeding larvae of the darkling beetle (lesser mealworm), *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), to turkey poult on poult growth and of beak trimming on poult feeding on the larvae. Young turkey poult readily fed on the larvae and exhibited reduced growth in the absence of other feed. Poult 3 to 5d old restricted to a diet of only larvae consumed 259 ± 99 (\pm SD) larvae per poult per day and their body weights were significantly lower (mean (\bar{x}) = 30g) at the end of the 3d than for poult on starter feed during the same time. After return to starter feed for 16d after feeding

on larvae for 3d, the poult did not compensate for the weight loss although weight gains were normal. Poult from 2 through 10d of age were given a choice between starter turkey feed and darkling beetle larvae. The numbers of larvae consumed per poult per day were: 174 ± 8 for days 2 to 4, 221 ± 3 for days 5 to 7, and 189 ± 80 for days 8 to 10. There were no significant differences between the body weight of poult feeding on larvae and starter feed compared with that of poult consuming feed only. In the presence of larvae, the mean feed consumption per poult was lower than for poult provided with only starter feed. The beetle larvae were 68% crude protein and 21% fat (DM basis) and had higher amounts of 18 amino acids than the starter feed. Poult that were beak trimmed consumed only about one-third as many larvae as poult with intact beaks. Poult (1 to 3d old) with intact beaks consumed 169 ± 20 larvae per poult per day; poult with trimmed beaks consumed 58 ± 23 larvae per poult per day.

Key Subjects

biology & behaviour

DESPINS JL, TURNER EC JNR & PFEIFFER DG. 1991. **Evaluation of methods to protect poultry house insulation by lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Agricultural Entomology* **8**, 209–217.

Abstract

Insecticide sprays and paint barriers applied to the surface of extruded polystyrene, and different types of insulation, were evaluated for prevention of lesser mealworm, *Alphitobius diaperinus* (Panzer), infestations. In a laboratory study, tetrachlorvinphos 50 WP and pirimiphos-methyl 7E on extruded polystyrene produced > 90% mortality in larval and adult lesser mealworm populations 71 wk after application. These insecticide spray treatments, however, were not effective under conditions found in the manure pit of a high rise cage layer house. Our field study showed that Styrofoam BB and Ethafoam 220, were resistant to lesser mealworm infestations. Super IQ paint, a latex paint impregnated with chlorpyrifos, was also effective in protecting extruded polystyrene from infestations under field conditions.

Key Subjects

biology & behaviour; insecticide control

DESPINS JL, TURNER EC JNR & RUSZLER PL. 1987. **Construction profiles of high rise caged layer houses in association with insulation damage caused by the lesser mealworm, *Alphitobius diaperinus* (Panzer) in Virginia.** *Poultry Science* **66**, 243–250.

Abstract

The relationship between types of construction of high rise caged layer houses and insulation damage produced by the lesser mealworm, *Alphitobius diaperinus* (Panzer), was examined. There were no infestations in polyurethane insulation that had heavy weight paper glued to the surface of the insulation and installed with tape to seal off the seam between insulation boards. High rise houses with pit walls constructed of concrete block had lower insulation infestations than houses with wooden walls forming the pits. Houses that had pit wall foundations built of both types of materials had intermediate lesser

mealworm infestations. Houses with the support structure set on top of the concrete block pit wall had lower infestations than houses where the support structure was set directly into the earth. There was a reduced gradient of damage with height of insulation above the pit; insulation installed in the pit was the most severely infested. Extruded polystyrene insulation exposed to 10 years or more of lesser mealworm infestation suffered a substantial loss of volume in the corner area of the insulation panels, resulting in a 9.1 to 30.8% reduction from an original volume of 84 838 cm³. Additionally, there was a significant reduction in R-value of infested insulation.

Key Subjects

biology & behaviour

DESPINS JL, TURNER EC JNR & RUSZLER PL. 1989. **Effects of poultry manure moisture and poultry house construction materials on the movements of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), a structural insect pest in high rise caged layer houses.** *Poultry Science* **68**, 1326–1331.

Abstract

Observations were made on the effect of manure moisture and method of construction of the manure pit walls on the dispersal behaviour of larvae and adults of *A. diaperinus* in high rise caged layer chicken houses. Larvae preferred to remain in manure habitats with 30 and 40% moisture; dispersal from the manure increased significantly at 50 or 60% moisture. Adults were more active than larvae in manure at 30 and 40% moisture, with dispersal rates increasing significantly as the moisture levels rose. Larvae could climb a significantly greater distance up a vertical wooden surface than up a vertical concrete block surface. This indicated that high rise chicken houses built with wooden pit walls and support beams that are set directly into the ground are predisposed to greater levels of insulation damage than houses built with concrete block foundations.

Key Subjects

biology & behaviour

DESPINS JL, VAUGHAN JA & TURNER EC JR. 1988. **Role of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), as a predator of the house fly, *Musca domestica* L. (Diptera: Muscidae) in poultry houses.** *The Coleopterists Bulletin* **42**, 211–216.

Abstract

The role of the lesser mealworm, *Alphitobius diaperinus* (Panzer), as a predator of house fly *Musca domestica* L., maggots and pupa in poultry houses is discussed. Late instar larval and adult *A. diaperinus* fed on house fly maggots when isolated together in glass vials. Lesser mealworm adults and middle instar larvae significantly reduced house fly emergence from apparatus which simulated the manure pit environment of the a high rise caged layer egg house.

Key Subjects

biology & behaviour

EDWARDS JP & ABRAHAM L. 1985. **Laboratory evaluation of two insect juvenile hormone analogues against *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **21**, 189–194.

Abstract

The insect juvenile hormone analogues methoprene and fenoxycarb have been tested against larval stages of the lesser mealworm, *Alphitobius diaperinus*. Methoprene completely prevented the formation of adult insects at a concentration of 5.0 ppm in food medium. The same effect was achieved with only 0.05 ppm fenoxycarb. There was no evidence that sub-lethal levels of methoprene decreased the fecundity of insects that successfully completed adult development. The results of these laboratory tests are discussed in relation to the potential use of these compounds for control of *A. diaperinus* in intensive poultry production units.

Key Subjects

biology & behaviour; insecticide control

ERICHSEN LD. 1996. **Behaviour and population dynamics of litter beetles in broiler houses.** *Danish Pest Infestation Laboratory Annual Report*, 64–65.

Abstract

A master's degree project on the population dynamics and behaviour of four species of beetles (*Alphitobius diaperinus*, *Typhaea stercorea*, *Ahasverus advena* and *Carcinops pumilio*) in a broiler farm started in September 1996, and is planned to end in the winter of 1997. In the autumn of 1995, a Danish farmer reported to the Danish Pest Infestation Laboratory that he had an unusually high number of beetles in his farm and that he also had salmonella-infested poultry. To obtain additional proof of a possible link between salmonella and beetle presence, a few simple experiments were carried. The results indicate that salmonella could be transferred from beetles to a previously clean stock of poultry. To control the beetles, different traditional pesticides and methods have been used. However, further knowledge on population dynamics and behaviour of the beetles is important for a satisfactory control of the beetles. I have found no references to field studies of these beetles in chicken poultry farming, but all four species have been well examined in laboratory trials since they are all common pest in stored products worldwide. This project examines population increase, development rates, flight activity and habitat preferences in the farm for all four species mentioned above. The investigation was carried out as a field study in two six-week periods. A new trap design was used in the experiment and was therefore tested. All experiments were carried out in a Danish broiler farm on Fünen. The preliminary results indicate that the population increase is in accordance with results obtained in laboratory experiments described in literature. However, *T. stercorea* and *Ahasverus advena*, which were expected to manage two generations, only managed one, as did *A. diaperinus* and *C. pumilio*. After each six-week period the houses were cleaned very thoroughly, so when a new test period started, the beetles had to resettle the houses and it seems that they never reached an equilibrium before the houses were cleaned again.

There was a very clear difference in flight activity of the two species that were observed flying (*Ahasverus advena* and *T. stercorea*). Another observation was that *T. stercorea* seems to prefer more humid surroundings, which is only natural since it is considered to be a fungus eater. All species of beetles were contagiously distributed in the house.

Key Subjects

biology & behaviour; disease association

ERICHSEN LD & JESPERSEN JB. 1997.

Behaviour and population dynamics of litter beetles in broiler houses. *Danish Pest Infestation Laboratory Annual Report*, 71.

Abstract

A master's degree project on the population dynamics and behaviour of litter beetles (specifically *Alphitobius diaperinus*, *Typhaea stercorea* and *Ahasverus advena*) in a broiler farm was initiated in September 1996, and is planned to end mid-1998. All of these species are common pests in stored products worldwide and have therefore been extensively studied in laboratory trials. However, little or no work has been carried out on the field biology of these beetles in chicken production facilities. This project examined population increase, development rates, flight activity and habitat preferences in a commercial broiler facility for the beetle species mentioned above. The investigation was carried out as a field study in two six-week periods. A new trap design was used in the experiment and was therefore tested as part of the study. All experiments were carried out on a Danish broiler farm on Funen. The development times from egg to adult emergence of *T. stercorea*, *A. diaperinus* and *A. advena* were estimated to be approximately three weeks, four weeks and five to six weeks, respectively. All three species were therefore only able to complete one generation within one chicken rearing period of six weeks. *T. stercorea* and *A. advena* were observed to leave the litter shortly after adult emergence. All three species had a distinct preference for a particular environment and the distribution of the two large fungus feeders, *T. stercorea* and *A. advena*, was closely correlated in all samples. *A. advena* was the only beetle to fly in significant numbers. Tube traps were well suited for monitoring the activity of adult *T. stercorea*, *A. advena* and *A. diaperinus* adult and larvae in the litter. Bait bags were well suited for monitoring of the activity of *T. stercorea* and *A. advena* on the walls. A full description of the investigation is now being published as a master's thesis by L.D. Erichsen; the results will later be published as a formal paper.

Key Subjects

biology & behaviour

FALOMO AA. 1987. **The pheromone biology of the lesser mealworm, *Alphitobius diaperinus* (Panzer), (Coleoptera: Tenebrionidae).** Thesis, University of Wisconsin, Madison, USA.

Abstract

No abstract available

Key Subjects

biology & behaviour

FERNANDES MA, SANTOS MAS & LOMONACO C. 1995. **Occurrence of arthropods in**

accumulated manure in a poultry house. *Anais da Sociedade Entomologica do Brasil* **24**, 649–654.

Abstract

The arthropod fauna of manure in a poultry house near Uberlandia, Minas Gerais State, Brazil, was studied monthly from October 1992 to August 1993. The manure was allowed to accumulate during this time and no insecticides were used to control flies. The most abundant species were and unidentified drosophilid fly (18 823 individuals collected during the study period, representing 66.65% of all the insects collected), *Chrysomya putoria* (5818, 20.60%) and *Musca domestica* (3251, 11.51%). Other arthropods which occurred frequently included several predators on the immature stages of Diptera, including the beetle *Carcinops* sp. (573 individuals), and unidentified dermapteran (943) and the mite *Macrocheles* sp. (672). Other fairly common species included the beetles *Alphitobius diaperinus* (1713) and *Tribolium confusum* (652), and a species of Pseudoscorpion (248). Most species showed monthly variations in frequency which were not correlated with temperature, rainfall or relative humidity.

Key Subjects

biology & behaviour

GANGOPADYAY AK & CHATTERJEE NB. 1989.

Effect of temperature and moisture content of the stored rice grain on the egg laying, hatching and post-embryonic development of the lesser mealworm, *Alphitobius diaperinus* (Panzer). *Indian Agriculturist* **33**, 115–124.

Abstract

Investigation was carried out to observe the effect of grain moisture (18.5% - 23.5%), grain temperature (29°C - 35°C) and starch content of the Patnai variety of rice grain (85%) on daily laying, egg hatch and postembryonic development of *Alphitobius diaperinus* in the laboratory during the month of August when maximal climatic factors prevailed. The percentage of each egg hatch, 68.2 to 77.0, was noted after 72 hours of incubation. The total larval period covered 26.45 ± 0.23 days for six larval instars and the last three stages are considered as the grand period of growth. Pupal period continued for 5 days. Adult females started laying rhythmically from seventh day onwards after emergence. A maximum of 264 and 52 eggs were laid during the month under review and in 24 hours period respectively.

Key Subjects

biology & behaviour

GAUTAM RD. 1989. **Exploration of the lesser mealworm for the control of storage insects together with its stages and effect on seed viability.** *Agricultural Situation in India* **64**, 487–489.

Abstract

The potential of the tenebrionid *Alphitobius diaperinus* as a biological control agent for stored products pests was studied in the laboratory at 27°C and 65% RH. Normal development of larvae occurred on either composite feed or with eggs and larvae of the pyralid *Corcyra cephalonica*. An average of 948.6 eggs were laid by females with *C. cephalonica* compared to 638.2 eggs with composite

feed. The larval period was 64.91 and 65.23 days on eggs of *C. cephalonica* and composite feed, resp. Larvae did not develop on whole wheat or sorghum grains or broken or powered sorghum. The germination of wheat grains which were infested for 45 days by adults of *A. diaperinus* declined from 99.80% to 79.80, 27.20 and 11.40% after 21, 45 and 90 days storage, resp. Larvae and adults of *A. diaperinus* fed most voraciously on eggs of the gelechiid *Sitotroga cerealella* (25 eggs/day), followed by eggs of the tenebrionid *Tribolium castaneum* and the bruchids *Callosobruchus chinensis*, *C. maculatus* and *C. analis* (14, 6, 5 and 7 eggs/day). Adults also preyed on larvae of *S. cerealella*, *T. castaneum* and the anobiid *Lasioderma serricorne*.

Key Subjects

biology & behaviour

GEDEN CJ. 1990. **Coleopteran and acarine predators of house fly immatures in poultry production systems.** In Rutz DA and RS Patterson RS (eds.) *Biocontrol of arthropods affecting livestock and poultry*. Westview Press, Inc., Colorado: 177–200.

Abstract

A general account is given of the beneficial arthropod predators of the eggs or larvae of *Musca domestica* and other Muscidae in poultry manure, dealing particularly with (1) predator species composition and succession patterns, (2) *Alphitobius diaperinus*, more a pest than beneficial under current poultry management systems, (3) *Carcinops pumilio* and (4) *Macrocheles muscaedomesticae*. Ecological considerations, attack rates and finally prospects for use in management programs are discussed. In conclusion, it is pointed out that the manure arthropod community is too complex for easy manipulation and that predator conservation is generally more practical than augmentation at present. Future research should address the problems of quantifying the ecological parameters necessary for predator establishment and efficacy, and to develop cost effective rearing methods for these beneficial predators.

Key Subjects

biology & behaviour

GEDEN CJ & AXTELL RC. 1987. **Factors affecting climbing and tunneling behaviour of the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **80**, 1197–1204.

Abstract

The propensity of late instar *Alphitobius diaperinus* (Panzer) for climbing and tunneling was evaluated with larvae at several densities in chambers containing poultry litter, both with and without a base of clay soil as a pupation site, and an elevated section of polystyrene insulation. In chambers with soil, no climbing or tunneling was observed until larval density reached 500 larvae per chamber; at this higher density the amount of damage caused by individual larvae was low (0.3–0.5 holes per tunnel). When soil was lacking, 36% of the larvae climbed at the lowest density treatment (10 larvae per chamber); the number of tunnelers increased with increasing density to a maximum of 60 immatures per section of insulation, although the proportion of climbing larvae

stabilized at ca. 6% at the higher density treatments. Larvae in chambers without soil caused ca. 4-fold as much damage at higher density (two holes per tunnel) than at lower densities (ca. 0.5 holes per climber). Mortality among nonclimbing larvae increased with density, and was much higher in chambers without soil than in chambers with soil at all densities. Trapping and observations of the beetles in a poultry house during a 24-h period demonstrated that the climbing population was composed almost solely of the late instars and adults. Early and late instars were present in comparable numbers in the nonclimbing population in the litter. Larvae climbed almost exclusively during the night, and this activity was maximal between 2000 and 2400 hours EST. Adults displayed broader peaks of activity, but also climbed primarily during periods of darkness.

Key Subjects

biology & behaviour

GEDEN CJ & AXTELL RC. 1988. **Effect of temperature on nematode (*Steinernema feltiae* (Nematoda: Steinernematidae)) Treatment of soil for control of lesser mealworm (Coleoptera: Tenebrionidae) in turkey houses.** *Journal of Economic Entomology* **81**, 800–803.

Abstract

In North Carolina, infective juveniles of *Steinernema feltiae* (*Neoplectana carpocapsae*) (All stain) were applied at the rate of 106 per m² to the soil floors of 2 turkey houses with small populations of *Alphitobius diaperinus*; a 3rd house was left untreated. The overall mean air temperature during the 9 weeks after treatment was 26.4°C. Soil bioassays indicated that nematodes were present in treated soil at 3 weeks but not at 5, 7 or 9 weeks after treatment. Larval or adult beetle population densities in the treated houses did not significantly compared with the control house. When nematodes were applied to soil and then assayed for survival after being held in the laboratory at 4 different temperatures, none survived beyond 2 weeks after treatment in soil held at temperatures >24°C. Nematodes were still detected at 9 weeks after treatment in soil held at 20 and 24°C.

Key Subjects

biology & behaviour; non insecticide control

GEISSLER H & KOSTERS J. 1978. **The significance of lesser mealworm infestations in poultry meat production.** *Deutsche Tierarztsblatt* **79**, 177–204.

Abstract

No abstract available

Key Subjects

biology & behaviour

GERSDORF E. 1969. **The cereal mildew beetle (*Alphitobius diaperinus* PZ. Ten.) in cockerel-fattening units.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **42**, 153–155.

Abstract

The author describes the way in which intensive rearing units for male chicks are used in northern Germany, many being built over pig- or cattle-fattening units in order to utilize the heat; insect or mite infestations can occur if there is any space between the ceiling of the lower unit and the floor of

the upper unit, in which spilt chick food and other litter can accumulate. The chickens become full-grown in six weeks and are reared at such a density that cleaning or spraying the floor is possible only in the intervals between broods. Among the insects present (most of which are harmless to the chicks), *Alphitobius diaperinus* (Panz.) has been reported in large numbers in some units, taking eight weeks to develop at about 22°C. Insects in the containers of mixed cereal feed or exposed on the floor of the upper unit are eaten by the chickens, and beetles hide mainly in the litter between the floors, passing right through to the lower unit when the upper unit is emptied and cleaned and the temperature falls at the end of a chick-rearing cycle. *A. diaperinus* can not develop for long in clean meal or other dry cereal food, unless this becomes damp and mouldy from spilt drinking water or chicken droppings on the floor of the rearing unit. The source of the infestations is not known, since the beetle cannot survive in the normal climatic conditions of northern Germany and has not been found in chick food before it reaches the rearing unit. It is suggested that adult may move from unit to unit on warm summer days, but in fact little spread occurs and large populations tend to build up in a few isolated units. Chemical control is not feasible unless rearing cycles can be arranged so as to allow both upper and lower units to be empty at the same time, but infestation can be reduced by filling holes or cracks in the upper floor and the space between the upper floor and the lower ceiling. At present, the beetle cannot be considered a pest of the chick food in the feeding containers, and it sometimes provides the birds with supplementary protein.

Key Subjects

biology & behaviour; non insecticide control

GORDH G & WILLS L. 1989. **Anatomical notes on *Uropoda* sp., a phoretic mite infesting dung-inhabiting beetles in southern California** (Acari: Uropodidae; Coleoptera: Tenebrionidae, Histeridae). *Pan Pacific Entomologist* **65**, 410–413.

Abstract

The morphology of the anal pedicel of *Uropoda* sp. is described. The deutonymph of this species is phoretic on adults of the tenebrionid *Alphitobius diaperinus* and the histerid *Dendrophilus punctatus* in poultry manure.

Key Subjects

biology & behaviour

GOULD GE & MOSES HE. 1951. **Lesser mealworm infestation in a brooder house.** *Journal of Economic Entomology* **44**, 265.

Abstract

No abstract available

Key Subjects

biology & behaviour

GREEN DB. 1979. **Predatory beetles in Lancashire deep-pit poultry houses.** *Entomologist's Monthly Magazine* **114**, 16.

Abstract

No abstract available

Key Subjects

biology & behaviour

GREEN DB. 1980. **The fauna of a Lancashire deep-pit poultry house.** *Entomologist's Monthly Magazine* **116**, 13–15.

Abstract

No abstract available

Key Subjects

biology & behaviour

GREEN DB. 1982. **The fauna and environment of two Lancashire deep-pit poultry houses.** *Ministry of Agriculture, Fisheries and Food Poultry* **140**, 15–32.

Abstract

Between 1976 and 1980, the fauna at two Lancashire deep-pit poultry houses was studied and temperature and relative humidity measurements were made. Some sixty-nine species of arthropods were identified, many previously unrecorded from this environment in the UK. The most abundant species at both sites were *Carcinops pumilio*, *Alphitobius diaperinus*, *Dermestes maculatus*, *Musca domestica*, *Leptocera* sp and Acarina, particularly *Caloglyphus berlesei*. The most diverse fauna was found at the end of the 13–15 months' egg laying period, by which time the depth of the manure was about one metre. Predatory beetles were numerous, including four species of Histeridae, two species of Cleridae and several species of Staphylinidae. These and other predators such as *Ophyra* sp and *Macrocheles muscaedomesticae* are important components of the fauna because of predation on pest species of flies such as *Musca domestica*, which develops rapidly in the constant warmth of deep-pit poultry houses. Only the fly *Leptocera* sp and the predatory beetle *Carcinops pumilio* were collected from manure depths greater than 25 cms and all the recorded species were found within 10 cms of the surface of the droppings. In future faunal studies of this type, manure sampling can be confined to the surface layers of droppings, but this should be combined with detailed visual examination of the pit fauna. Many of the species have been recorded in birds' nests, notable exceptions being species, such as *Tribolium confusum* and *Gnatocerus cornutus*, normally found in association with stored foodstuffs. The fauna is also comparable with that occurring at USA poultry farms, where many similar faunal studies of this type have been carried out.

Key Subjects

biology & behaviour

GREEN M. 1980. ***Alphitobius viator* Mulsant & Godart in stored products and its identification (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **16**, 67–70.

Abstract

Records of *Alphitobius viator* Muls. & Godt. on stored products in the UK, France and Africa are reviewed. The species is redescribed, and an illustrated key is presented for distinguishing it from the other stored-product species *A. diaperinus* (Panz.) and *A. laevigatus* (F.). In addition, characters for distinguishing it from *A. rufus* Ardoïn, a very similar species that is not found on stored products, are noted.

Key Subjects

biology & behaviour

HALSTEAD DGH. 1975. **Changes in the status of insect pests in storage and domestic habitats.** In *Proceedings of the First International Working Conference on Stored Product Entomology*, 142–153.

Abstract

Changes in the status of some storage and household insect pests that have occurred in Europe (especially Britain and Denmark) during the past 30 years are reviewed, mainly from the literature. In Britain, *Trogoderma granarium* Everts, which used to be an important pest in maltings, has become relatively insignificant, giving way to *Oryzaephilus surinamensis* (L.), which has also superseded *Sitophilus granarius* (L.) as the major pest of grain in farm stores. *Alphitobius diaperinus* (Panz.) has become widespread in intensive poultry-breeding units in Britain and elsewhere. The storage pest *O. surinamensis* and *Tribolium destructor* Uytt. have become common in Danish houses and *O. mercator* (Fauv.) in Canadian ones. *Dermestes peruvianus* Lap. and *D. haemorrhoidalis* Kust. have become important in town houses (especially tall apartment blocks) in Britain and Denmark. *Tineola bisselliella* (Humm.) is no longer a significant pest of clothes in Europe and has been superseded by *Anthrenus* and *Attagenus* spp.; *A. pellio* (L.) and *Anthrenus verbasci* (L.) are the most important pests of woolen textiles in Britain, but in Sweden, *Attagenus pellio* has been largely replaced by *A. fasciatus* (Thnb.), a tropical species, and in Copenhagen and Moscow, dwellings have recently been invaded by the African *A. smirnovi* Zhantiev. *Anthrenus sarnicus* Mroczkowski has become established in houses in London and *A. coloratus* Rtt. in apartments in the United States. In storage habitats in Britain, changes in pest status appear to be related to changes in agricultural practice including control measures. In domestic habitats in Europe, central heating has enabled certain storage pests to become established in houses and may be responsible for the increased importance of beetle pests of textiles.

Key Subjects

biology & behaviour

HARDING WL & BISSELL TL. 1958. **Lesser mealworm in a brooder house.** *Journal of Economic Entomology* **51**, 112.

Abstract

The lesser mealworm *Alphitobius diaperinus* (Panz.) (Tenebrionidae) is known as a pest of cereal products and grain that are in poor condition. It is cosmopolitan in distribution being commonly found in flour mill basements in damp or musty flour or grain (U.S. Dept. Agric., 1953). The paper reports an unusual outbreak of lesser mealworms in the corn cob litter of a brooder house on the Eastern Shore of Maryland during which larvae were observed to bore into and apparently feed on the flesh and internal organs of moribund and dead baby chicks. Results of limited control experiments against lesser mealworm adults and larvae in corn cob litter are also presented.

Key Subjects

biology & behaviour; insecticide control

HARRIS F. 1966. **Observations of the lesser mealworm *Alphitobius diaperinus* (Panz.).**

Journal of the Georgia Entomological Society **1**, 17–18.

Abstract

The distribution of the lesser mealworm, *Alphitobius diaperinus* (Panz.), and its abundance in poultry houses are discussed. A review of the food habits of this beetle with additional observations on their carnivorous habits is presented.

Key Subjects

biology & behaviour

HEALY WM. 1985. **Turkey poult feeding activity, invertebrate abundance, and vegetation structure.** *Journal of Wildlife Management* **45**, 466–470.

Abstract

No abstract available

Key Subjects

biology & behaviour

HEWLETT PS. 1958. **Secondary sexual characters in *Alphitobius laevigatus* (F.) and *A. diaperinus* (Panzer) (Col., Tenebrionidae).** *Entomologist's Monthly Magazine* **94**, 144.

Abstract

No abstract available

Key Subjects

biology & behaviour

HICKS EA. 1959. **Check-list and bibliography on the occurrence of insects in birds' nests.** The Iowa State College Press, Iowa.

Abstract

No abstract available

Key Subjects

biology & behaviour

HULLEY PE & PFLEIDERER M. 1988. **The Coleoptera in poultry manure - potential predators of house flies, *Musca domestica* Linnaeus (Diptera: Muscidae).** *Journal of the Entomological Society of Southern Africa* **51**, 17–29.

Abstract

Twenty-three species representing 12 families of beetles were collected from poultry manure in the eastern Cape of South Africa. The most numerous species was *Carcinops troglodytes*; 5 species were uncommon. Seasonal variation in numbers of the numerous species (*C. troglodytes*, *Cercyon quiquillus*, *Dactylosternum abdominale*, *Philonthus* sp., *Aleochara* sp., *Oxytelus* sp., *Phacophallus* sp., an unidentified merophysiid, *Gnathocerus cornutus*, *Palorus subdepressus* and *Alphitobius diaperinus*) is described. Laboratory feeding preference of selected species (*D. abdominale*, *C. dimidiatus*, *Carcinops troglodytes*, *A. diaperinus*, *Saprinus* sp., *Philonthus* sp., *Aleochara* sp., *Oxytelus* sp., *Dermestes maculatus*, *Monotoma* spp., *Euxestus phalacroides* and *Euxestoxenus* sp.), given a choice of potential foods, was determined. The results indicated that beetles are important in natural control of houseflies. The importance of management practices that keep the manure dry and favour predators and parasitoids is emphasized.

Key Subjects

biology & behaviour

ICHINOSE T, SHIBAZAKI S & OHTA M. 1980. **Studies on the biology and mode of infestation of the tenebrionid beetle, *Alphitobius diaperinus* Panzer, harmful to broiler-chicken houses.** *Japanese Journal of Applied Entomology and Zoology* **24**, 167–174.

Abstract

The development of *A. diaperinus* was promoted by high temperature and high population density, but was inhibited at a temperature of 15°C in every developmental stage. Three-day exposure of eggs at 7°C gave only 2% hatching. Water deficiency also prevented breeding. The relationship between activity and temperature was consistent with that of the developmental velocity and the temperature, with maximum values at 35°C. Only old-age larvae bored into various adiabatic materials, while younger ones and adults did not, and they failed to survive on these materials. Some coatings of the materials prevented boring. These results indicate that damage is caused merely by the requirements of a pupation site by the mature larvae and that the thermal, moist and tropic conditions in broiler-houses are conducive to the development and multiplication of the insect.

Key Subjects

biology & behaviour

JERRARD PC & WILDEY KB. 1980. **Beetle plague from deep pit muck spreading.** *Poultry World* **131**, 20–21.

Abstract

The poultry droppings in deep-pit units in Britain commonly harbour 3 species of beetle, *Alphitobius diaperinus* (Panz.), *Dermestes maculatus* Deg. and *Carcinops pumilio* (Erichs.). Very brief notes are given on the appearance of the adults and in 2 cases the larvae, of these species and on their habits. By their activity, they help to dry the manure and reduce fly infestation, but if the manure is spread on fields in warm weather, massive infestations of beetles can occur in nearby dwellings. A case of such an occurrence in southern England is described. Spraying the outside walls of the houses of a height of 1m and the ground around for the same distance with a 2% solution of idofenphos at 5 litres/100m² killed many beetles, but in spite of this and the use of aerosols indoors, the problem persisted because of reinvasion on warm days when the beetles were more active and flew in.

Key Subjects

biology & behaviour; insecticide control

JESPERSEN JB. 1996. **Litter beetles as disease reservoirs.** *Danish Pest Infestation Laboratory Annual Report*, 63–64.

Abstract

In broiler houses, litter beetles, in particular the lesser mealworm *Alphitobius diaperinus* and the hairy fungus beetle *Typhaea stercorea*, are found very frequently. The beetles are difficult to control chemically, and as the development time is rather short, they often constitute a pest problem. In addition they are potential transmitters of disease agents; for salmonella bacteria it has been shown that both species of beetles might be infected or surface-contaminated by salmonella bacteria. The Ministry of

Food, Agriculture and Fisheries therefore has supported a project with the following specific objectives 1) to investigate the occurrence, biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project is a collaborative project involving in Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (Project coordinator), as well as many veterinarians and poultrymeat farmers.

Key Subjects

biology & behaviour; disease association

KASZAB Z. 1980. **Contributions to the knowledge of the tenebrionids of North Vietnam (Coleoptera).** *Annales Historico Naturales Musei Nationalis Hungarici* **72**, 169–221.

Abstract

The author presents faunistic data for many species of Tenebrionidae collected in North Vietnam; the species previously mentioned in the Review include *Mesomorphus villiger* (Blanch.), *Tribolium castaneum* (Hbst.), *Alphitobius diaperinus* (Panz.) and *A. laevigatus* (F.). In addition, descriptions are given of many new species and subspecies of the family collected in the country.

Key Subjects

biology & behaviour

KEIFER HH. 1935. **The black fungus beetle and lesser mealworm.** *Bulletin - Department of Agriculture* **24**, 316.

Abstract

No abstract available

Key Subjects

biology & behaviour

KELEYNIKOVA SI. 1970. **Darkling beetle larvae of Palearctic tribes of the subfamily Tentyriinae (Coleoptera, Tenebrionidae).** *Entomology Revue* **49**, 245–253.

Abstract

No abstract available

Key Subjects

biology & behaviour

KELEYNIKOVA SI. 1976. **Darkling beetle (Coleoptera, Tenebrionidae) larvae of the tribe Steosini.** *Entomology Revue* **55**, 71–74.

Abstract

No abstract available

Key Subjects

biology & behaviour

KOMAREK S. 1988. **The glossy black cereal mould beetle (*Alphitobius diaperinus* Panzer), a little-known stored product pest.** *Pflanzenschutz Wein* **1**, 3–4.

Abstract

The tenebrionid *Alphitobius diaperinus*, a sporadic pest of stored products in Central Europe, was found recently in large numbers in a store room of a zoological garden in Austria. Notes are provided on the biology, injuriousness and control of this beetle,

which can harbour pathogens (such as *Salmonella* and *Escherichia coli*) of poultry.

Key Subjects

biology & behaviour; disease association; insecticide control

KOZLOV VI. 1970. **The tenebrionid *Alphitobius diaperinus*, a predator of *Dermanyssus gallinae*.** *Parazitologiya* **4**, 363–364.

Abstract

Observations made in 1967-1969 in chicken farms of the Krasnoyarsk area showed that (a) *A. diaperinus* was commonly found in long established sites of occurrence of *D. gallinae* and (b) that numbers of nymphs and adults of *D. gallinae* were 90-95% lower in such areas. Laboratory tests established that *A. diaperinus* is a predator on all stages of *D. gallinae*, including the eggs. Each *A. diaperinus* took up to 10 *D. gallinae* adults, with most predatory activity at 20-24 °C and 50-60% r.h. *A. diaperinus* has hitherto been known principally as a stored-products pest.

Key Subject

biology & behaviour

KUMAR P. 1986. **Flesh eating behaviour of *Alphitobius diaperinus* Panz. (Tenebrionidae; Coleoptera).** *Indian Journal of Entomology* **48**, 113–115.

Abstract

Larvae and adults of *A. diaperinus* were fed in poultry houses in Aligarh District, Kerala, India, feeding on feathers, excreta and spilt poultry meal. When attacking feathers the adult beetles preferred the margins but the larvae would even enter the quill and cause much greater damage. Adult beetles also bit through the skin at the base of the chickens' claws where they fed on the exuding blood. Most serious, however, was that the larva and adult beetles could kill newly hatched chicks. This was demonstrated experimentally by confining single chicks in wooden roosting cages each with 350 larvae and 150 adults of *A. diaperinus*. The larvae appeared to be more capable at penetrating the chick's skin and were more voracious feeders on flesh than adults. By 12 days of age the chick's skin had evidently become sufficiently tough to prevent penetration.

Key Subjects

biology & behaviour

LAMBKIN TA. 1998. **Controlling black beetles (*Alphitobius diaperinus* (Panzer), Coleoptera: Tenebrionidae) in chicken sheds.** *In Proceedings 1998 Poultry Industry Exchange Surfers Paradise 19-21 April 1998*. 33–37.

Abstract

The black or darkling beetle (*Alphitobius diaperinus* (Panzer)), which is of tropical origin, is a serious, cosmopolitan insect pest of chicken houses. Losses to production are indirect and result from the transmission of poultry disease, downgrading of bird feed quality, bird ingestion of large quantities of beetle larvae, damage to shed insulation and the high cost of pesticide applications. The duration of the pest's life cycle is dependent on temperature and humidity. As a result, beetle populations in chicken sheds tend to be localized around areas of high temperature and moisture. In very dry chicken sheds,

the beetle will eat dead birds and at night, bit sleeping live birds. *A. diaperinus*, which is omnivorous and active in low light conditions is also an active flier and can readily infest new areas. Control of the pest traditionally has been by the use of chemicals and now insecticide resistant populations of the pests have been reported. Hygiene is an important component of pest control, which incorporates proper shed cleanouts and disposal of manure litter. Indications are that in Australia, control of *A. diaperinus* is becoming increasingly difficult and there is a need to adopt and integrated pest management system for the beetle, which would encompass an insecticide resistance management strategy.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN T & CAMERON MC. 1999. **Darkling beetle control – Current difficulties and future prospects.** *The Eleventh Australian Poultry & Feed Convention Proceedings*, 184–192.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, as pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN TA & CAMERON MC. 2000. **Darkling beetle control in Australian broilers – a new direction.** *Proceedings 2000 Poultry Information Exchange*, 97–102.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, a pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated pest management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of

insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LANCASTER JL & SIMCO JS. 1967. **Biology of the lesser mealworm, a suspected reservoir of avian leucosis.** *Arkansas Experiment Station* **159**, 1–12.

Abstract

Attention has been drawn to the lesser mealworm, *Alphitobius diaperinus* (Panz.) by a recent report that it was capable of transmitting acute leucosis, an infectious agent producing tumors in broilers. This report created a flurry of excitement and worry throughout the major poultry production area in the South. The objectives of this study were to develop a method for culturing the insect, to determine its life cycle, to survey for its frequency of occurrence in broiler houses, and to attempt transmission by the beetles of the infectious agent.

Key Subjects

biology & behaviour; disease association

LEGNER EF & OLTON GS. 1968. **The biological method and integrated control of house and stable flies in California.** *California Agriculture* **22**, 1–4.

Abstract

Full utilization of the biological method in fly control requires the preservation of existing predatory and parasitic enemies in animal dung. The use of residual poisons to control adult flies did not interfere with natural enemy complexes in these tests. Alternating the removal deposits, and abstaining from chemical treatment of manure were essential procedures in maintaining largest populations of predators and parasites.

Key Subjects

biology & behaviour

LEGNER EF & OLTON GS. 1970. **Worldwide survey and comparison of adult predator and scavenger insect populations associated with domestic animal manure where livestock is artificially congregated.** *Hilgardia* **40**, 225–266.

Abstract

The following is virtually the authors' synopsis. The predatory and scavenger insects found associated with the developmental stages of Muscoid Diptera breeding in the manure that accumulates in dairies, poultry houses, and similar places are listed and their frequency and distribution are compared for the summer and winter seasons of the major climatic areas in the south-western United States. Insects were also identified under somewhat more limited conditions in the Neotropical, Palaearctic, Ethiopian, and Australasian regions. The Holarctic and Australian collections were similar, although the latter lacked many species. Collections made in the Ethiopian and Neotropical regions were not similar. Further search in these latter two regions might uncover additional predatory species for introduction elsewhere. Climatic similarity between the areas of origin and release appears to be necessary for the successful

establishment of any new species. The principal predators found were in the families Labiduridae, Histeridae and Staphylinidae, although other families predominated in certain areas. Although only two California predators, *Philonthus longicornis* Steph. and *P. rectangularis* Sharp, were common in both the Ethiopian and Neotropical regions, the Californian and the Neotropical regions had nine species in common. The distribution of scavengers was similar. The principal predators noted for their wide distribution and high relative abundance were *Carcinops* ?, *Alphitobius diaperinus* (Panz.) and *Aphodius lividus* (Ol.). The fauna in cattle droppings in the field was sparse, but the species found were similar to those in the accumulated manure.

Key Subjects

biology & behaviour

LEGNER EF, OLTON GS, EASTWOOD RE & DIETRICK EJ. 1975. **Seasonal density, distribution and interactions of predatory and scavenger arthropods in accumulating poultry wastes in coastal and interior southern California.** *Entomophaga* **20**, 269–283.

Abstract

Seasonal predatory and scavenger arthropod densities were studied at interior and coastal southern California poultry ranches. Though some seasonal population clumping occurred with some species, the distribution of predators and scavengers was fairly uniform within each ranch. Correlation analyses of key predators in the *Histeridae*, *Staphylinidae*, *Hydrophilidae* and *Dermaptera* with the potential hosts, *Musca domestica* L., *Tinea fuscipunctella* HAWORTH, and *Fannia* spp. suggested that predator activity was seasonally influenced. Possible periodic avoidance of a particular host's habitat was detected as significant negative correlations. The data tend to support the importance of different species of predators in different seasons and the need for natural enemy complexes rather than single species for biological control.

Key Subjects

biology & behaviour

LE TORC'H JM. 1979. **A new pest of rearing buildings (*Alphitobius diaperinus* in pigsties, Brittany).** *Phytoma* **308**, 31–33.

Abstract

In their search for pupation sites, larvae of *Alphitobius diaperinus* (Panz.) caused considerable damage to expanded polystyrene partitions and other structures in piggeries in Brittany, France, in the autumn of 1977. Methods for control and prevention of damage, including interfacing with the conditions.

Key Subjects

biology & behaviour

LE TORC'H JM & LETENNEUR R. 1983. **Laboratory tests of resistance of different thermic insulators to perforation by the tenebrionid, *Alphitobius diaperinus* Panzer (Col. Tenebrionidae).** *Comptes Rendus des Seances de l'Academie d'Agriculture de France* **69**, 188–200.

Abstract

Alphitobius diaperinus (Panz.), a stored product pest that also attacks rotten wood, was recently found in expanded polystyrene used as insulating material in the construction of pig and poultry houses in commercial rearing units in France. The mature larvae bored into the polystyrene to pupate. Laboratory tests with panels of 7 different materials used for this purpose showed that none was resistant and that all were similarly affected as regards numbers of holes, weight losses, number of insects harboured and insect mortality rates.

Key Subjects

biology & behaviour

LOMONACO C & PRADO AP. 1994. **Community structure, population dynamics and natural enemies of the dipteran fauna of caged poultry.**

Anais da Sociedade Entomologica do Brasil **23**, 71–80.

Abstract

Musca domestica (91.82%) and *Chrysomya putoria* (6.47%) were the most abundant of 23 species of Diptera recorded on a poultry farm near Uberlandia, Minas Gerais, Brazil, from August 1989 to October 1990. Populations of both dominant species showed marked seasonal variation, which was attributed to temperature changes during the year. The dipteran community structure showed a log-normal distribution, with the dominance of a few species. 27 species of arthropods were found in the poultry litter and 12 of these were considered to be natural enemies of Diptera; the most frequent were the Coleoptera *Dermestes ater* and *Alphitobius diaperinus*, and the Acari *Macrocheles muscaedomesticae*, *M. merdarius* and *Caloglyphus berlesei*.

Key Subjects

biology & behaviour

MACCREARY D & CATTS EP. 1954.

Ectoparasites of Delaware poultry including a study of litter fauna. *University of Delaware Agricultural Experimental Station Bulletin* **307**, 17–22.

Abstract

No abstract available

Key Subjects

biology & behaviour

MEKADA H, IMAEDA N & UMEDA K. 1984.

Effect of insecticide-impregnated insulation board on growth of chicks and vaporizing rate of the insecticide. *Japanese Poultry Science* **21**, 330–332.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1974. **Flies and other insects in poultry houses.** *Ministry of Agriculture, Fisheries and Food leaflet* **537**, 6pp.

Abstract

Fannia canicularis (L.) is the main pest found in poultry houses causing complaints from householders. *Musca domestica* L. and *Muscina stabulans* (Fall.) are

often serious pests also. The life-cycle and breeding habits of *F. canicularis* are described, and methods for its control and the control of other flies and preventive measures are noted. The habits and control of various beetles (particularly *Alphitobius diaperinus* (Panz.)), mites, moths and other flies found in poultry house litter are also briefly mentioned.

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1980. **Insects in poultry houses.** *Leaflet* **537**, 8 pp.

Abstract

In the UK, pest problems encountered in poultry houses are related to the type of house and frequency of droppings removal. In laying houses where droppings are removed by conveyor belt every 3 to 4 days and in deep-litter houses for broilers where the litter is replaced every 8 to 10 weeks, serious infestations are unlikely to develop. However, in deep-pit houses where droppings are allowed to accumulate for up to 14 months and in deep-litter houses where litter is not replaced frequently, insect pest problems may occur. The first insects to appear in new droppings are usually *Leptocera* spp. and *Sciara* spp. At a later stage, *Musca domestica* L., *Fannia canicularis* (L.) and *Muscina stabulans* (Fall.) may colonize the droppings. Occasionally, the predatory fly *Ophyra capensis* (Wied.) may also occur. A wide range of insect species can breed in poultry droppings. After a few weeks, predatory beetles such as *Carcinops pumilio* (Erichs.) and staphylinids may be found and, as the droppings become drier, other beetles occur, including *Alphitobius diaperinus* (Panz.), which is common in deep-pit houses. *Dermestes* spp. may be present in very large numbers in deep-pit houses. Moths are also common in poultry houses where the larvae are usually found living in the droppings or in residues of very dry material. Although the commonest is *Endorsis sarcitrella* (L.), *Niditinea fuscipunctella* (Haw.) may occur in large numbers on dry droppings. *Ephesia kuehniella* Zell. may be found in and around feed hoppers and *Pyrallis farinalis* (L.) has been found in several deep-pit houses. In this revised leaflet, information is presented on the biology, morphology, injuriousness and control of these insects.

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1983. **Poultry house insulation.** *Ministry of Agriculture, Fisheries and Food leaflet* **637**, 6pp.

Abstract

In a section on insects and vermin in this revised leaflet on poultry house insulation in the UK, it is reported that larvae of *Alphitobius diaperinus* (Panz.) and *Dermestes maculatus* Deg. are sometimes responsible for the deterioration of polystyrene and ureaformaldehyde insulations.

Key Subjects

biology & behaviour

MISHCHENKO AA & MASHKEI IA. 1987. **Harmful beetles (Coleoptera) - inhabitants of livestock premises.** *Veterinariya Kiev* **62**, 68–71.

Abstract

Details are given of the species and life stages of the beetles collected in pig, cattle and poultry quarters in the Ukraine, USSR, during 1979–85. The presence of *Alphitobius diaperinus* and dermestids was considered particularly important as they can transmit disease to livestock.

Key Subjects

biology & behaviour; disease association

NEMESERI L & GESZTESSY T. 1973. **Mass incidence and control of *Alphitobius diaperinus* on poultry farms.** *Magyar Allatorvosok Lapja* **28**, 335–338.

Abstract

Alphitobius diaperinus (Panz.) has been found on poultry farms in all parts of Hungary. Notes are given on the morphology and ecology of the Tenebrionid, which likes warm dark moist places and occurs mainly in the litter beneath water and feed troughs. It does not seem to play a part in the spread of coccidiosis or Ascarid infections among poultry. The larvae and adults can be destroyed by application of a 2% trichlorophon (cf. RAE/B 62, 380). In winter, it is recommended that poultry houses should be kept cool for 5 days as a control measure. Paper bags instead of gunny sacks should be used to distribute the poultry food in order to prevent the spread of the beetle.

Key Subject

biology & behaviour; insecticide control

O'CONNOR JP. 1987 *Alphitobius diaperinus* (Panzer) (Col., Tenebrionidae) damaging polystyrene insulation in an Irish piggery. *Entomologist's Monthly Magazine* **123**, 1472–1475.

Abstract

In September 1983, a large sample of extruded polystyrene slab that was riddled with large (4 mm and above) and small (about 2 mm) holes was received for diagnosis of the damage. The material came from an intensive pig farm in the Irish Republic, where it was being used for insulating animal housing. Since the damage was extensive, the pigs were suffering from draughty and cold conditions. The large holes were found to have been caused by *Alphitobius diaperinus* and the small ones by *Gnatocerus cornutus*.

Key Subjects

biology & behaviour

PAJANI HR & GILL KM. 1974. **Effect of light on the pests of stored products.** *Bulletin of Grain Technology* **12**, 151–153.

Abstract

Behaviour of insects towards light is rather well known and is mainly of two types i.e., they may be positively phototrophic or negatively phototrophic. Except for the general observations on the common species, orientation of different species to sources of light have not been studied in detail. During investigations on the biology of important pests of stored grains in the last two years, certain interesting observations relating to their reaction to light have

come to our notice, which are described in the present communication.

Key Subjects

biology & behaviour

PFEIFFER DG. 1978. **The coleoptera of poultry houses in North Carolina.** MS thesis, North Carolina State University, Raleigh, NC.

Abstract

No abstract available

Key Subjects

biology & behaviour

PFEIFFER DG & AXTELL RC. 1980. **Coleoptera of poultry manure in caged layer houses in North Carolina.** *Environmental Entomology* **9**, 21–28.

Abstract

At least 120 species of Coleoptera were recovered from poultry manure in narrow, wide-span, and high-rise types of caged-layer poultry houses in the Mountains, Piedmont, and Coastal Plain regions of North Carolina. *Carcinops pumilio* (Erichson) and *Alphitobius diaperinus* (Panzer) were consistently the most abundant species in all 3 regions, followed by *Gnathoncus nanus* (Scriba) and the *Aleocharinae* (Staphylinidae). According to 5 indices of diversity, the Piedmont ranked 1st in overall diversity, species richness and equitably, followed by the Coastal Plain, and thirdly, by the Mountains. Narrow and high-rise house types were compared for adult and larval *C. pumilio* and *A. diaperinus*. The larval population peak for *A. diaperinus* occurred significantly earlier in the high-rise than in the narrow houses, however, the narrow houses had significantly higher beetle diversity. A qualitative examination of overwintering forms showed that most species overwintered primarily, but not exclusively, as adults.

Key Subjects

biology & behaviour

PILETSKIS SA. 1984. **Three species of Coleoptera new to the Lithuanian SSR, found in 1982–1984.** *Novye I Redkie Dlia Litovskoi SSR Vidy Nasekomykh Soobshcheniia I Opisaniia*, 19–22.

Abstract

The 3 species mentioned in this paper that were recorded as new to the Lithuanian SSR, USSR, in 1982–84 are the tenebrionid *Alphitobius diaperinus*, the nitidulid *Carpophilus hemipterus* and the dermestid *Trogoderma versicolor*.

Key Subjects

biology & behaviour

PREISS FJ, DAVIDSON JA. 1970. **Characters for separating late stage larvae, pupae, and adults of *Alphitobius diaperinus* and *Alphitobius laevigatus* (Coleoptera: Tenebrionidae).** *Annals of the Entomological Society of America* **63**, 807–809.

Abstract

The urogomphus, epipharynx, 4th abdominal pupal segment and adult pronotum are illustrated. The structural differences used to distinguish late-stage larvae, pupae, and adults of *A. diaperinus* and *A. laevigatus* are discussed.

Key Subjects

biology & behaviour

PREISS FJ & DAVIDSON JA. 1971. **Adult longevity, pre oviposition and fecundity of *Alphitobius diaperinus* in the laboratory (Coleoptera: Tenebrionidae).** *Journal of the Georgia Entomological Society* **6**, 105–109.

Abstract

A semi-synthetic medium was developed on which *A. diaperinus* could be easily reared and maintained in the laboratory. Adult longevity is probably over 400 days. The average pre-oviposition period was 12.7 days (range 4–30 days). The females laid an average of 3.5 eggs per day. One female deposited 2684 apparently viable eggs during the study.

Key Subjects

biology & behaviour

PROPP GD & MORGAN PB. 1985. **Mortality of eggs and first-stage larvae of the house fly, *Musca domestica* L. (Diptera: Muscidae), in poultry manure.** *Journal of the Kansas Entomological Society* **58**, 442–445.

Abstract

The activity of predators and scavengers found in accumulated poultry droppings in Florida resulted in up to 97% reduction of eggs and larvae of *Musca domestica* recovered from artificially infested containers. The most abundant predators were the histerid *Carcinops pumilio*, the formicid *Solenopsis invicta*, the labidurid *Euborellia annulipes* and unidentified staphylinids, macrochelid mites and pseudoscorpions, and the most abundant scavenger was the tenebrionid *Alphitobius diaperinus* (which, while probably not a direct predator of *M. domestica*, appeared to have an adverse effect on the muscid larvae in the droppings). These results suggest that competitors, scavengers and generalist predators may be as important as parasites in reducing the numbers of *M. domestica*.

Key Subjects

biology & behaviour

REMUS B, BAUSCHKE K, VOGEL K & BAHR I. 1983. **The importance and control of the lesser mealworm (*Alphitobius diaperinus*) in industrial broiler rearing premises.** *Monatshefte fuer Veterinaermedizin* **38**, 358.

Abstract

Observations carried out in broiler rearing premises in the German Democratic Republic indicated that *Alphitobius diaperinus* (Panz.), and important pest of stored products, could also play an important role as a vector of microorganisms pathogenic to poultry. Brief notes on the biology of the insects are given. Since only part of the pest population can be eradicated by insecticides in the premises, other measures should be developed which take account of behavioural characteristics, such as behaviour-regulating effect of pheromones.

Key Subjects

biology & behaviour; insecticide control

RUEDA LM & AXTELL RC. 1996. **Temperature-dependent development and survival of the lesser mealworm, *Alphitobius diaperinus*.** *Medical and Veterinary Entomology* **10**, 80–86.

Abstract

Development, growth and survival of *A. diaperinus* were determined at 6 constant temperatures. No egg hatch or larval development occurred at 17°C. At temperatures of 20, 25, 30, 35 and 38°C the median development time (days), respectively, were for eggs (13.4, 6.0, 4.4, 2.6 and 2.6), larvae (133.0, 46.0, 26.2, 22.4 and 23.9), pupae (17.0, 8.0, 5.5, 4.0 and 4.1), and from oviposition to adult emergence (164.4, 60.2, 37.9, 29.0 and 30.8). The Sharpe and DeMichele (1977) (*Journal of Theoretical Biology*, 64: 649–670) model was used to describe the temperature-dependent development. The mean egg survival (Hatching) ranged from 61–86%, with lowest hatch at 20°C. Survival of the larvae and pupae ranged from 32–73% and from 85–95%, respectively, with lowest survival at 20°C. Pupae had significantly lower weights at 35°C and adults at 38°C than at the other temperatures. Female pupae (20 mg) and female adults (16 mg) were significantly heavier than male pupae (17 mg) and male adults (13 mg). Adults (0.5–9 months old) laid 4–7 eggs per female per day at 25°C.

Key Subjects

biology & behaviour

SAFRIT RD & AXTELL RC. 1984. **Evaluations of sampling methods for darkling beetles (*Alphitobius diaperinus*) in the litter of turkey and broiler houses.** *Poultry Science* **63**, 2368–2375.

Abstract

Materials placed on the litter in turkey and broiler houses in North Carolina were evaluated as sampling devices for the larvae and adults of *Alphitobius diaperinus*. Insects harboured in, on and between pieces of the materials were counted after exposure for 1 week. Pan traps consisting of 2 stacked pieces of 1.3 cm thick foil covered polyisocyanurate insulation (Celotex) placed under a protective metal pan stacked to the litter surface was a more effective sampling device than pan traps using thicker (5 cm) Celotex, 3.8 cm thick polystyrene (Styrofoam) or 2 stacked pieces of wood. A tube trap consisting of rolled fluted corrugated cardboard inserted in a section of poly(vinyl chloride) pipe was as effective a sampling device as the 2 pieces of Celotex in a pan trap and was more convenient to use. Six pieces of corrugated cardboard stacked under a pan caught larger numbers of beetle larvae and adults but was awkward to handle and impractical. Placement of sampling devices in the major subhabitats (open centre, near walls, near feeders and near waterers) in turkey and broiler houses affected catches of beetle larvae and adults. The open centre area was satisfactory and most convenient.

Key Subjects

biology & behaviour

SALIN C, VERNON P & VANNIER G. 1998. **The super-cooling and high temperature stupor points of the adult lesser mealworm *Alphitobius diaperinus* (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **34**, 385–394.

Abstract

Potential thermobiological limits in adult *Alphitobius diaperinus* were assessed during winter by measuring individual super-cooling points (SCP) and thermotupor points (TSP). Two experimental conditions were tested: SCP and TSP measured at 100% relative humidity (RH); and SCP with specimens which survive the TSP at 0% RH. The absolute temperature range compatible with life between the two limits SCP and TSP, termed thermobiological span (TBS), was calculated in both conditions. The potential adaptive capacity to withstand cooling and overheating was: at 100% RH, mean TSP=46.7°C (SD± 0.67); mean SCP=-9.4°C (SD+/-1.81); absolute TBS=56.1°C; at 0% RH, mean TSP=47.4°C (SD+/-0.61); mean SCP=-12.3°C (SD± 2.5); mean TBS=59.7°C (SD±2.43). The TSP at 0% RH was reached with a loss of 3.84% in fresh weight vs. 1.15% at 100% RH. The difference in the SCP (females = 2.1°C; males = 5.4°C) obtained in dry or moist conditions could also be explained by the influence of the heat shock preceding the SCP measured at 0% RH. A decrease of water content may increase the osmolarity of the body fluid and thus the supercooling capacity and could be an adaptation to avoid freezing. Supercooling capacity allows adults to survive in areas where freezing temperatures may occur in poultry houses and more specially during the winter litter removals when adults beetles migrate and overwinter in the soil floor or in the insulation materials of the building walls. The heat tolerance capacity is mainly ruled by the physiological and behavioural adaptations of this species. It is concluded that the adult population of *A. diaperinus* could be controlled by increasing the temperature above 48°C.

Key Subjects

biology & behaviour; non insecticide control

SAMISH M & ARGAMANN O. 1991. *Alphitobius diaperinus* beetles, a pest in poultry houses. *Hassadeh* **72**, 387–389.

Abstract

This article reviews the biology and damages of the lesser mealworm (darkling beetle, *Alphitobius diaperinus*) with special reference to the status of this beetle in Israel. The four species of the genus *Alphitobius* found in Israel are: *A. diaperinus*, *A. laevigatus*, *A. ruficolor* and *A. viator*. The lesser mealworm, which was first recorded in Israel in 1953, is the only serious pest of poultry from this genus in the country. The structural damage due to this beetle, its potential role as reservoir of pathogens, its direct damage to the birds and their feed, their nuisance to people, their life cycle and the problems encountered during their control are discussed.

Key Subjects

biology & behaviour; insecticide control

SARIN K. 1972. On food utilization and nutrients by *Alphitobius diaperinus* (Panz.). *Zoologische Jahrbuecher Abteilung fuer Allgemeine Zoologie und Physiologie den Tiere* **76**, 408–415.

Abstract

7th instar larvae were fed on broken wheat (*Triticum*) grains or starved in individual glass vials for 7 days. The food utilization (percentage assimilation) was

81% for protein, 24.5% for carbohydrate, 38% for fats, and 25.6% for minerals.

Key Subjects

biology & behaviour

SARIN K. 1978. Population variation of *Alphitobius diaperinus* (Panz.) during a year. *Indian Journal of Entomology* **40**, 358–359.

Abstract

No abstract available

Key Subjects

biology & behaviour

SARIN K. 1980. On population variation of a stored product pest *Alphitobius diaperinus* (Panz) during a year. *Pestology* **4**, 30–31.

Abstract

Population variation of a stored product pest *Alphitobius diaperinus* (Panz) during a year at environmental temperature and humidity was studied. Adult population reached its peak in late August whereas the larvae showed maximum density in May. There was complete absence in larval population in the months of December to March. Temperature preferred by both the instars was 26 to 40 °C. Adults increased only when r.h. was 90% whereas the larval population increased even at 50-60% r.h.

Key Subjects

biology & behaviour

SARIN K, et al. 1973. Effect of temperature and relative humidity on the development and mortality of *Alphitobius diaperinus* (Panz), a stored product pest. *Folia Biologica (Cracow)* **21**, 223–228.

Abstract

A very few workers have worked out the life development of *Alphitobius diaperinus* but at entirely different temperatures. The literature completely lacks information on the effect of temperature and relative humidity on this beetle. The present work determines and confirms the range of humidity and temperature, which is most favourable for the development of this beetle. Complete development is recorded at 30°C 33°C and 90% RH. At a higher temperature of 35°C to 37°C more time is required to complete the life development. At the lower temperature of 15°C there is no development. A high RH of 90% is required to complete the life development whereas at low RH (50%) the development is incomplete.

Key Subjects

biology & behaviour

SARIN K & SAXENA SC. 1975. Food preference and site of damage to preferred products by *Alphitobius diaperinus* Panz. *Bulletin of Grain Technology* **13**, 50–51.

Abstract

It is concluded from investigations in the laboratory in India with eight types of grains and pulses (wheat, curd (*Phaseolus mungo*), gram (*Cicer arietinum*), cowpea (*Vigna unguiculata*), groundnut, maize, barley and rice) that the larvae of *Alphitobius diaperinus* (Panz.) preferred wheat to the others, and that the adults preferred cowpea. Development did not take place on gram, groundnut or maize. In

investigations on the site of damage to wheat, rice and cowpea, 59-77% of the damaged grains were attacked at the germ end.

Key Subjects

biology & behaviour

SCARBOROUGH A. 1988. **How to deal with darkling beetles.** *Broiler Industry*, 48–49.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

SCHMITZ VM & WOHLGEMUTH R. 1988. **Investigations on mass increase and behaviour of *Alphitobius diaperinus* Panz. (Coleoptera, Tenebrionidae) in poultry houses as a basis for directed control in practice.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **61**, 108–114.

Abstract

A correlation was found between successive generations of *Alphitobius diaperinus* and the rhythm of rearing broilers and cleaning the poultry houses in Berlin. In the litter, many larvae of the tenebrionid, in various instars, were found. The larvae began to leave the litter and search for pupation and hiding sites in the walls of the building about 13 days before rearing of the broilers was completed. The tenebrionids remained in these hiding places until cleaning of the houses was completed. When the houses were prepared with new litter, and higher temperatures for rearing the chickens were maintained, the beetles and larvae left their hiding places and reinfested the new litter. The possibility of using temperature barriers to prevent the pests from migrating from their hiding places was investigated, and it was found that larvae and adults rarely crossed barriers with a temperature exceeding 45°C.

Key Subjects

biology & behaviour; non insecticide control

SILFVERBURG H. 1979. ***Alphitobius diaperinus* (Panz.) (Tenebrionidae) established in Finland.** *Notulae Entomologicae* **59**, 171.

Abstract

No abstract available

Key Subjects

biology & behaviour

SKEWES PA & MONROE JL. 1991. **The effects of darkling beetles (*Alphitobius diaperinus*) on broiler performance.** *Poultry Science* **70**, 1034–1036.

Abstract

Six polyvinylchlorine pipe darkling beetle traps were placed in 20 commercial broiler production facilities, and the relative level of beetle infestation was determined from weekly sampling during a 4 wk period. The average number of beetles found at each facility was compared with following production parameters: mortality, feed conversion, condemnation rate, and production cost. In the 20 commercial broiler flocks evaluated, the level of darkling beetles within the facility was not related to any of the production parameters measured.

Key Subjects

biology & behaviour; disease association

SMITH LB. 1975. **Occurrence of the depressed flour beetle, *Palorus subdepressus* (Coleoptera: Tenebrionidae), in Canada.** *Canadian Entomologist* **107**, 109.

Abstract

Palorus subdepressus (Woll.) was recorded for the first time in Canada in April 1974, when it occurred in residues of coarsely ground feed in pig styes in southern Manitoba. Adults and larvae were found in a heated area of a pen for young piglets where the temperature was maintained probably higher than 25 deg C and would permit the development of all stages (cf. RAE/A 55, 1646). The Tenebrionid was probably introduced in maize imported from the Great Plains area of the United States for the use in preparation of animal feed. As it does not survive the winter in southern England, it is unlikely to become established in unheated granaries in Canada, but it may do so in heated buildings or in heated grain or grain products. Other arthropods present in the feed residues included adults of *Cryptolestes pusillus* (Schnh.) and adults and larvae of *Alphitobius diaperinus* (Panz.) and *Dermestes lardarius* L.

Key Subjects

biology & behaviour

SPILMAN TJ. 1968. **Minutes of meeting: the lesser mealworm, *Alphitobius diaperinus*.** *Proceedings of the Entomological Society of Washington* **70**, 294–295.

Abstract

No abstract available

Key Subjects

biology & behaviour

SPENCER A & BRØCHNER JESPERSEN J. 1998. **Litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

The litter beetles, *Alphitobius diaperinus* (the lesser mealworm), *Typhaea stercorea* (the hairy fungus beetle), *Ahasverus advena* (the foreign grain beetle) and *Carcinops pumilio* are commonly found in Danish poultry houses. These beetles are difficult to control and often constitute a pest problem. In addition they are potential transmitters of human and avian disease. In 1996 the Ministry of Food, Agriculture and Fisheries supported a three year project with the following specific objectives: 1) to investigate the occurrence biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project involves collaboration between the Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (project coordinator), and many veterinarians and poultry meat farmers. The project will conclude in 1999, but has already achieved most of its objectives. The principal findings made so far are detailed below.

Key Subjects

biology & behaviour; disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.
A survey of litter beetles in Danish broiler houses. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

Samples were collected from 16 beetle infested broiler houses using two trap types. Wall-traps consisting of netting bags containing boiled wheat suspended against the outer wall out of reach of chickens were found to be effective in collected the fungus feeding species *Typhaea sterocera* and *Ahasverus advena*. Floor-traps made from sections of PVC pipe perforated with 4 mm holes, stoppered at each end and placed half-filled with chicken feed within the litter, were effective in collecting *Alphitobius diaperinus* and also collected *Carcinops pumilio*. Five of each trap types were placed in each broiler house for one week immediately prior to slaughter. The traps were then returned to the laboratory where the beetles were speciated and counted. *A. diaperinus* was the most prevalent species and was found in all the houses surveyed. *T. sterocera* and *A. advena* were also common and were found in large numbers in many houses. No other beetle species were identified.

Key Subjects

biology & behaviour

STAFFORD KC III & COLLISON CH. 1987.
Manure pit temperatures and relative humidity of Pennsylvania high-rise poultry houses and their relationship to arthropod population development. *Poultry Science* **66**, 1603–1611.

Abstract

No abstract available

Key Subjects

biology & behaviour

STAFFORD KC III, COLLISON CH, BURG JG & CLOUD JA. 1988. **Distribution and monitoring lesser mealworms, hide beetles, and other fauna in high-rise caged-layer poultry houses.** *Journal of Agricultural Entomology* **5**, 89–101.

Abstract

The distribution of *Alphitobius diaperinus*, *Dermestes maculatus* and several fly predators were determined from cross-sectional and surface sampling of manure cones within environmentally controlled high-rise, caged-layer poultry houses. Most of the adults and larvae of *A. diaperinus* were recovered from the lower-outer regions of the manure cone and the aisle between manure rows. Most of the fly predators, *Carcinops pumilio*, *Macrocheles muscaedomesticae* and an uropodid mite, were recovered at the crest and top side of the manure surface. The Arends tube trap, consisting of rolled, corrugated cardboard inserted into a length of polyvinyl chloride pipe, was evaluated as a monitoring technique for the tenebrionid and dermestid. Significantly greater numbers of adult tenebrionids and dermestids and larval tenebrionids were recovered from traps placed on the top of the manure cone (P, 0.05) than 3 other positions within the manure pit (floor, post and wall ledge). Manure tube trap sample sizes for monitoring tenebrionid densities at 5 levels of reliability were calculated. Recovery of *C. pumilio* and *L. campestris* in the traps

suggested population trends of other fauna could also be monitored with the tube trap.

Key Subjects

biology & behaviour

STEENBERG T & BRØCHNER JESPERSEN J. 1998. **Entomopathogenic fungi for control of litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

This was the final year of the project, aimed at evaluating the potential of entomopathogenic fungi for the control of the lesser mealworm in poultry houses. In the laboratory we have selected a number of fungal isolates with high pathogenicity to larvae or adult beetles. The field efficacy of these isolates should be tested in the future. Planned experiments with application of fungus in bait stations were abandoned, as initial experiments showed that is was very difficult to attract the pest into the bait stations when placed under realistic conditions, i.e. in substrates providing alternative hiding places for larvae and adults. During 24 hours 5-10% of late instar larvae would enter the bait stations, and the experiments indicated that the larvae were attracted to the stations primarily because they provided a hiding place, while the food provided (boiled wheat kernels or solid substrate consisting of corn flour, wheat bran, dry yeast, water and agar) was not very attractive. It should be evaluated whether the selected fungal isolates can control the lesser mealworm by spreading in the population after 5-10% have been inoculated in bait stations. Furthermore, other food sources should be evaluated as baits.

Key Subjects

biology & behaviour; non insecticide control

STEELMAN D. 1996. **Darkling beetles are costly pests.** *Poultry Digest* **55**, 22–23.

Abstract

Alphitobius diaperinus as a pest of poultry housing is discussed under the following headings: beetle life cycle; determining populations; economic impact; salmonellae; infectious bursal disease; turkey enteritis; method of control.

Key Subjects

biology & behaviour; disease association

STEINKRAUS DC & CROSS EA. 1993. **Description of life history of *Acarophenax mahunkai*, n. sp. (Acari, Tarsonemina: Acarophenacidae), an egg parasite of the lesser mealworm (Coleoptera: Tenebrionidae).** *Annals of the Entomological Society of America* **86**, 239–249.

Abstract

A new species of mite, *Acarophenax mahunkai* Steinkraus & Cross, n. sp., was discovered parasitizing eggs of the lesser mealworm, *Alphitobius diaperinus* (Panzer), a serious cosmopolitan poultry pest. *Acarophenax mahunkai* is an obligate, apparently host-specific parasitoid that kills the egg upon which it feeds. Therefore, it may help control the lesser mealworm. The systematics and biology of *A. mahunkai* are presented here. In the laboratory, 51.0% of lesser mealworm egg masses were parasitized by one or more female mites. Male mites

were not parasitic and had poor locomotory abilities. Significantly fewer lesser mealworm eggs hatched (23.9% egg hatch) in parasitized egg masses than in unparasitized egg masses (72.7%). Mite sex ratios were highly skewed, with means of 27.2 ± 3.9 females and 1.7 ± 0.2 male offspring produced per gravid mite. Physogastric female mites parasitizing lesser mealworm eggs gave birth to fertile adult females. The developmental time of the mites (3-5 d) was faster than that of lesser mealworm eggs (5-7 d).

Key Subjects

biology & behaviour; non insecticide control

UNKNOWN. 1990. **Darkling beetle control. *Broiler Industry***, 40-42.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association; insecticide control

SWATONEK F. 1970. **On the biology of the lesser mealworm beetle (*Alphitobius diaperinus*)**. *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **43**, 101-104.

Abstract

It is reported that large numbers of *Alphitobius diaperinus* (Panz.) developed in a fowlhouse near Vienna (cf. also RAE/A 60,4526), so that control measures became necessary. The house was cleared, thoroughly cleaned out and then sprayed with gamma BHC (lindane), care being taken to treat the cracks and gaps between the concrete floor and the structural woodwork. One day after treatment, the dead beetles numbered 34/m². The Tenebrionid may have been introduced with the feed. Studies showed that the beetle can reproduce only in conditions of high temperature and high humidity, and there appears to be no possibility that it will become a serious pest in the field in Europe.

Key Subjects

biology & behaviour; insecticide control

THOMPSON P. 1966. **Arthropods from the nests of house sparrows. *Proceedings of the Entomological Society of Washington*** 44-48.

Abstract

No abstract available

Key Subjects

biology & behaviour

TURNER EC JNR. 1986. **Structural and litter pests. *Poultry Science*** **65**, 644-648.

Abstract

The importance of rodents and Coleoptera as structural pests of poultry houses, particularly in Virginia, is discussed. The pests include mice (*Mus musculus*), rats (*Rattus norvegicus* and *R. rattus*, *Dermestes lardarius*, *D. maculatus* and the tenebrionid *Alphitobius diaperinus*, of which mice and the tenebrionid are the most important. These pests are destructive to the fibreglass and polystyrene insulation in structural walls, causing serious losses. Brodifacoum, bromadiolone and difenacoum are recommended for controlling rodents including those resistant to anticoagulant rodenticides. Studies have shown that an increase in manure moisture was an

important factor causing increased dispersion and migration of adults of *A. diaperinus* into the insulation of the houses. Larvae were more able to crawl up vertical pit walls constructed of wood than those made of cinder blocks, thus allowing easier access to insulation. Chlorpyrifos, permethrin, stirofos (tetrachlorvinphos) and carbaryl were toxic to both larvae and adults. Several new formulations of expanded polystyrene foam insulation were more resistant to beetle damage than untreated polystyrene insulation.

Key Subjects

biology & behaviour; insecticide control

VAUGHAN JA & TURNER EC. 1982. **Studies of the infestation into polystyrene insulation by the lesser mealworm, a common inhabitant of deep-pit caged layer houses. *Virginia Journal of Science*** **33**, 91.

Abstract

No abstract available

Key Subjects

biology & behaviour

VAUGHAN JA, TURNER EC JNR & RUSZLER PL. 1984. **Infestation and damage of poultry house insulation by the lesser mealworm, *Alphitobius diaperinus* (Panzer). *Poultry Science*** **63**, 1094-1100.

Abstract

The phenologic events occurring in various types of insulation during infestation by *A. diaperinus* were studied under laboratory conditions. Late instar larval *A. diaperinus* initiated tunneling behavior into polystyrene insulation. No oviposition occurred within the tunnels. Few middle instar larvae were present in the polystyrene. All lifestages of *A. diaperinus* invaded exposed fibreglass, but invading late instar larvae did not pupate successfully. Polystyrene seemed to be preferred by late instar larvae over polyurethane for pupation sites, but polyurethane was favored over polystyrene by oviposition beetles. The insulative capacity of polystyrene was reduced as a result of lesser mealworm infestation.

Key Subjects

biology & behaviour

VICTOR JR & OGONOR PS. 1987. **Humidity reactions in the two species of tenebrionid beetles infesting poultry and food storage houses in Nigeria. *Revue de Zoologie Africaine*** **101**, 423-430.

Abstract

The reactions to humidity of two species of tenebrionid beetles, *Alphitobius diaperinus* (Panzer) and *Alphitobius laevigatus* (Fabricius) co-existing in the poultry and food storage houses of Nigeria were investigated. The adults of both species showed preferences for dry conditions and the most preferred humidity was 20% R.H. The eighth instar larvae of *A. diaperinus* showed preferences for dry conditions similar to those exhibited by the adults of both species, while the eighth instar larvae of *A. laevigatus* showed preferences for wet conditions preferring the highest humidity offered. The hygroreceptors responsible for the response to humidity by the adults

of both species seem to be located in the proximal half of the antennae. The role of humidity as a factor in the ecology of these congeneric species of insects pests is discussed.

Key Subjects

biology & behaviour

VORIS JC, MEYER JA, PFOST R & WOODBURY R. 1994. **Temperature affects lesser mealworm populations in turkey brooder houses.** *California Agriculture* **48**, 18–21.

Abstract

The lesser mealworm beetle is a serious pest in turkey brooder houses. It tunnels into the building walls and insulation, and serves as a vector of poultry disease and an intermediate host of parasites. This research shows that population growth is encouraged by certain temperatures and by certain industry practices, but more research is needed to evaluate the population dynamics of the lesser mealworm, particularly its response to varying temperatures.

Key Subjects

biology & behaviour

WALLACE MMH, WINKS RG & VOESTERMENS J. 1985. **The use of a beetle, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) for the biological control of poultry dung in high-rise layer houses.** *Journal of the Australian Institute of Agricultural Science* **51**, 214–219.

Abstract

The lesser mealworm, *Alphitobius diaperinus* (Panzer), is commonly found in poultry houses and often considered a pest. A situation is described in which it has been encouraged to build up large populations in the dung of high-rise layer houses and now plays an important role in drying out the moist dung. As a result, the dung is rendered unfavorable for fly breeding, and is easy to remove.

Key Subjects

biology & behaviour; insecticide control

WEAVER JE. 1996. **The lesser mealworm, *Alphitobius diaperinus*: Field trials for control in a broiler house with insect growth regulators and pyrethroids.** *Journal of Agricultural Entomology* **13**, 93–97.

Abstract

Two trials were conducted under field conditions for control of the lesser mealworm, *Alphitobius diaperinus* (Panzer), in a broiler grow-out house. Larvae were controlled with treatments applied after litter cleanout and either before the addition of the new litter or to the surface of the new litter. Three benzoylurea insect growth regulators (IGRs) and two pyrethroids provided 95%–100% control of larvae through a 42 d grow-out period. The IGRs hexafluron, triflumuron and UC84572 were equally as effective in controlling larvae as the two pyrethroids, cyfluthrin and permethrin. The pyrethroids greatly reduced the adult beetle population within 7 d posttreatment and held the population at low levels through the 42 d study; control of adults with the IGRs was not comparable. Numbers of adults were lower in most IGR treatments but in general not significantly different than untreated controls. Adult

migration from untreated areas could have influenced these results.

Key Subjects

biology & behaviour; insecticide control

WILDEY KB. 1983. **Insect pests in animal houses - current control developments.** *Proceedings of the 6th British Pest Control Conference*, 11pp.

Abstract

Recent developments in the control of insect pests in intensive animal housing units in the United Kingdom are reviewed and discussed with reference to the increase in pest problems resulting from increased intensification, the main pests (flies (including *Musca domestica* and *Fannia canicularis*), beetles (including *Dermestes maculatus* and *Alphitobius diaperinus*), the lepidopterous *Niditinea fuscipunctella* and *Endrosis sarcitrella*, *Ceratophyllus gallinae* and *Pyemotes* spp.); control difficulties; measures currently in use (application of diflubenzuron and other insect growth regulators as larvicides, use of baits based on insecticides, and entomopathogenic nematodes against flies, and conventional residual surface treatments and use of physical barriers against beetles).

Key Subjects

biology & behaviour

WILLS LE & MULLENS BA. 1991. **Vertical distribution of dipterous larvae and predatory arthropods in accumulated caged layer poultry manure in southern California.** *Journal of Agricultural Entomology* **8**, 59–66.

Abstract

Vertical distribution of filth fly larvae (*Musca domestica*, *Muscina stabulans*, *Ophyra aenescens* [*Hydrotaea aenescens*], *Fannia canicularis*, *F. femoralis*), predaceous Coleoptera (Histeridae, Staphylinidae), Anthocoridae, Pseudoscorpionidae, and predaceous Acarina (Macrochelidae, Uropodidae) were determined in accumulated caged layer poultry manure. Three zones in the manure cones (top, middle, and bottom) were sampled every 2 weeks at each of the 3 facilities over 5–17 months. Most taxa preferred certain zones. Arthropods found most commonly in the top zone (fresh manure deposition) including fly larvae and *Macrocheles muscaedomesticae*. Adult *Carcinops pumilio*, adult *Philonthus* spp., staphylinidae larvae, and the mite *Fuscuropoda vegetans* were found most often in the top and middle zones. Adult *Gnathonchus rotundatus* (= *G. nanus* of some authors), anthocorids and pseudoscorpions were found mostly in the middle and bottom zones, while *Dendrophilus punctatus*, Aleocharinae and *Alphitobius diaperinus* were found most often in the bottom (driest) zone. Histerid larvae were widely distributed among the zones. Based on spatial overlap, the predaceous mites, *C. pumilio*, and *Philonthus* spp. would be expected to be primary predators on fly immatures.

Key Subjects

biology & behaviour

WILSON TH & MINER FD. 1969. **Influence of temperature on development of the lesser mealworm *Alphitobius diaperinus*.** *Journal of the Kansas Entomological Society* **42**, 294–303.

Abstract

The lesser mealworm, *Alphitobius diaperinus* (Panzer), was reared on ground wheat at constant temperatures of 50, 60, 70, 80, 90 and 100°F (+/- 2°F). From 8 to 11 larva instars were found, depending partly on temperature. The optimum temperature for development from egg to adult appeared to be 90°F, with a mean development time of 45.6 +/- 0.65 days. Most stages developed slightly faster and no larvae survived beyond the first instar at this temperature. More larvae were produced in cultures of adults when the rearing medium was held at 90°F and approximately 15% moisture than at any other combination of temperature and moisture. A sex ratio of 1:2.25, males to females, was obtained in laboratory rearing. Adults of both sexes were found to possess a pair of fleshy scent glands, which produced a secretion causing sexual excitement among adult mealworms.

Key Subjects

biology & behaviour

YAGI A & RAZIG MTA. 1972. *Alphitobius diaperinus* (Panzer) (Coleoptera, Tenebrionidae) in pigeon houses in the Sudan. *Current Science* Sept 5 41 717, 642-643.

Abstract

No abstract available

Key Subjects

biology & behaviour

YOSHIDA T. 1975. Rearing twelve coleopterous species and one psocid infesting cereal products on milk powder. *Journal of the Food Hygienic Society of Japan* 16, 80-84.

Abstract

Rearing experiments were carried out in Japan at 30 deg C and 70-80% R.H. with 12 species of Coleoptera and 1 psocid normally associated with stored grain on five types of milk powder sold commercially. Details of the compositions of these powders and of the results of the experiments are shown in tables. *Tribolium castaneum* (Hbst.), *Cryptolestes pusillus* (Schonh.), *T. confusum* Duv., *Oryzaephilus mercator* (Fauv.) and *O. surinamensis* (L.) developed well and produced numerous progeny; for *Lasioderma serricorne* (F.), *Gnathocerus cornutus* (F.), *Palorus subdepressus* (Woll.), *P. ratzeburgi* (Wissm), *Alphitobius diaperinus* (Panz.) and *Liposcelis bostrychophilus* Badonnel, milk powder proved a poor diet and only permitted only limited growth and adult emergence. *Stegobium paniceum* (L.) and *Latheticus oryzae* Waterh. did not survive to the pupal stage. The addition of water to the milk powder was not essential for growth but increased the rate of reproduction in some of the species.

Key Subjects

biology & behaviour

SECTION 3. DISEASE ASSOCIATION ARTICLES (BY AUTHOR/S)

ARENDS JJ. 1991. **External parasites and poultry pests.** In Calnek BW, Barnes HJ, Beard CW, Reid WM, Yoder HW Jnr (eds.) *Diseases of Poultry*, 9th ed. Iowa State University Press, Ames, IA: 702–730.

Abstract

No abstract available

Key Subjects

disease association

AVANCINI RMP & UETA MT. 1990. **Manure breeding insects (Diptera and Coleoptera) responsible for cestoidosis in caged layer hens.** *Journal of Applied Entomology* **110**, 307–312.

Abstract

The role of insects in the life cycle of cestode parasites of caged layer hens was studied in Campinas, Brazil. Of forty-one 81 week old Hyline birds necropsied, 15 were negative for cestodes, 17 were positive for *Raillietina laticanalis*, and 9 were positive for both *R. laticanalis* and *Hoanotaenia Infundibulum*. Of 1462 individuals of *Dermestes ater* collected from poultry droppings under the hen cages and examined for parasites, 702 (48%) were found harbouring *C. infundibulum* and *R. laticanalis*, and 1030 individuals of *Musca domestica* examined, 165 (16%) harboured *C. infundibulum* (only). *Stomoxys calcitrans*, *Muscina stabulans*, *Chrysomya putoria*, *C. megacephala*, *Alphitobius diaperinus*, a histerid and *Trox* sp. were not found to harbour cysticercoids, although 12 of 243 individuals of another species of histerid, 4 of 131 of a third species of histerid and 3 of 108 of a staphylinid did (for these cysticercoid-positive insects, the number of cysticercoids per insect was one, except for an individual staphylinid which harboured 4).

Key Subjects

disease association

BAGGESEN DL, OLSEN JE & BISGAARD M. 1992. **Plasmid profiles and phage types of *Salmonella typhimurium* isolated from successive flocks of chickens on three parent stock farms.** *Avian Pathology* **21**, 569–579.

Abstract

S. typhimurium (387 strains) obtained from successive generations of parent stock originating from 3 different rearing farms in Denmark were characterized by phage typing and plasmid profiling; 76 strains representing dominant types were selected for restriction enzyme analysis and colony hybridization. The main phage of each of the 3 farms was 110. Plasmid profiling, however, allowed further subtyping. All but 3 isolates carried the serotype-specific virulence-associated plasmid. Restriction enzyme analysis showed variations in this plasmid as well as the presence of co-migrating plasmids of the same size. At each locality one or more clonal lines of *S. typhimurium* were reisolated from successive generations, indicating that the infections were persistent. Although house construction, sanitation and disinfestation procedures, and precautionary

measures in general were improved significantly during the observation period, infection with *S. typhimurium* was not eliminated until eradication of the beetle *Alphitobius diaperinus* was complete.

Key Subjects

disease association

CASTRILLO LA et al. 1998. **Differentiation of *Beauveria bassiana* isolates from the darkling beetle, *Alphitobius diaperinus*, using isozyme and RAPD analyses.** *Journal of Invertebrate Pathology* **72**, 190–196.

Abstract

No abstract available

Key Subjects

disease association

COGAN P, WEBB D & WAKEFIELD M. 1996. **A comparison of four residual insecticides for the control of the lesser mealworm beetle (*Alphitobius diaperinus* Panzer) in turkey broiler houses in the UK.** *International Pest Control* March/April, 52–55.

Abstract

Residual applications of iodofenphos SC, fenitrothion WP, permethrin WP and azamethiphos WP were evaluated for the control of *Alphitobius diaperinus* (the lesser mealworm or darkling beetle) in earth floored turkey broiler units. Single applications of either iodofenphos SC, fenitrothion WP or permethrin WP were found to be ineffective, but azamethiphos WP was found to be effective over the stocking period of four months. A total of only four beetles found during the four months of the final stocking cycle throughout the five sheds treated with azamethiphos WP. This may be compared with the shed treatment with iodofenphos SC where more than 3300 *A. diaperinus* were found in the samples of litter in the final population assessment. The level of control of *A. diaperinus* was not significantly improved by a supplementary application of dichlorvos as a space spray after treatment with a residual insecticide, before restocking with birds. Bioassays showed that azamethiphos was the most persistent of the insecticides used and was effective at even high summer temperatures. Persistence of iodofenphos deposits indicated that survival of *A. diaperinus* was most likely to be due to resistance and not poor treatment or insecticide breakdown.

Key Subjects

biology & behaviour; disease association; insecticide control

DAVIES R & WRAY C. 1995. **Contribution of the lesser mealworm beetle (*Alphitobius diaperinus*) to carriage of *Salmonella enteritidis* in poultry.** *Veterinary Record* **137**, 407–408.

Abstract

None of the 20 live *Alphitobius* beetles fed fish meal contaminated with 103 to 104 *S. enteritidis* per gram for 6 days, experimentally, were found to have surface contamination with *Salmonella* and *Salmonella* could

not be cultured from the beetles after they had been killed and macerated. Environmental surface swabs, mice *Mus musculus domesticus* and *Alphitobius* beetles collected from 2 broiler breeder units which had contained *S. enteritidis* infected flocks were cultured for *Salmonella*. *S. enteritidis* was present in 22% of the swabs and 48.6% of mice PM but none of the 500 beetles examined were positive. The results suggest that *Alphitobius* beetles may be relatively resistant to *Salmonella* colonization and infected mice and environmental contamination are likely to be a greater hazard

Key Subjects

disease association

DAVILA M, REBOLLO M & TELLEZ G. 1996.

The importance of the beetle *Alphitobius diaperinus* in poultry litter as a vector of *Salmonella* sp. and *Escherichia coli* in poultry farms in Mexico. *Proceedings of the Western Poultry Disease Conference 45th*, 291–293.

Abstract

The purpose of this work was to evaluate the presence of *A. diaperinus* in poultry litter by monitoring several areas within the Mexican Republic. Ten sample collections from different farms with the problem were performed in the States of Coahuila, Mexico, Yucatan, Jalisco, Morelos, Queretaro and Mexico City with the purpose of isolating *Salmonella* sp. and *E. coli* from this black beetle. These farms had not necessarily presented salmonella problems in the past. Results from bacteriological tests indicated that 21.42% isolated were positive to *Salmonella* sp. and 28.57% were positive to *E. coli*.

Key Subjects

disease association

DE LAS CASAS E, HAREIN PK, DESHMUKH DR & POMEROY BS. 1973. **The relationship between the lesser mealworm and avian viruses. I. Reovirus 24.** *Environmental Entomology* 2, 1043–1047.

Abstract

Reovirus 24 survived in *Alphitobius diaperinus* for at least 9 days when fed infected choriollantoic membrane for 2 days, followed by a 9 day starvation period; the titre decreased with time. The virus also survived the metamorphosis of the insect, but the concentration of the virus in newly emerged adults was relatively low. Artificially infected mealworms successfully contaminated a mixture of poultry litter, food and faeces, and this mixture remained contaminated for 7 days; excrement of the infected mealworms was the major source of contamination for at least 3 days. When uninfected mealworms were exposed to the infected mixture of litter, food and faeces, the virus was recovered from the insects following the first day of feeding, but the virus titre within the adults never increased in spite of its high concentration in the infected medium; reovirus 24 could not be detected in these insects 5 days after exposure. In general, the lesser mealworm is a relatively inefficient carrier of reovirus 24, even when exposed to highly infected sources.

Key Subjects

disease association

DE LAS CASA E, HAREIN PK, DESHMUKH DR & POMEROY BS. 1976. **Relationship between the lesser mealworm, fowl pox and Newcastle disease virus in poultry.** *Journal of Economic Entomology* 69, 775–779.

Abstract

Alphitobius diaperinus (Panzer) was investigated under laboratory conditions to determine its importance as a potential carrier of 2 avian viruses. The lesser mealworm, exposed to a medium contaminated with the fowl pox virus, ingested the virus within the 1st 6h but retained it less than 7 days. Artificially infected lesser mealworms transferred fowl pox virus through their excrement into a noncontaminated medium within the 1st 6h. The virus failed to multiply inside the lesser mealworms. All attempts to recover the Newcastle disease virus from the lesser mealworm were unsuccessful with the exception of adult beetles fed on highly infected chorioallantoic membranes. The toxicity of a bacterial-free suspension of the lesser mealworm on the Newcastle disease virus was demonstrated.

Key Subjects

disease association

DE LAS CASAS E, HARIEN PK & POMEROY BS. 1972. **Bacteria and fungi within the lesser mealworm collected from poultry brooder houses.** *Entomops* 1, 27–30.

Abstract

During 1968 and 1969, adult *A. diaperinus* were collected from turkey brooder houses in Minnesota, Wisconsin and S. Dakota, USA, and were analyzed for bacteria and fungi. The animals were surface disinfected, macerated and cultured on different media, the choice depending on the experimental objectives. A wide range in the number of micro-organisms was found within individual animals. Some harboured several thousand colonies, whereas others were comparatively clean. *Micrococcus* spp, *Streptococcus* spp and the *Bacillus subtilis* group were the most common gram-positive bacteria. Emphasis was given to gram-negative bacteria, especially those belonging to the enterobacteriaceae group. *Escherichia intermedia* was isolated from a relatively high percentage. *Salmonella saint-paul* occurred only in 3% of the *A. diaperinus*, such animals coming from only a single locality. *Aspergillus flavus* was the dominant fungus, an average of 25% being positive. Other spp of *Aspergillus*, *Penicillium* spp and *Candida* spp were also present, but in relatively low numbers.

Key Subjects

disease association

DE LAS CASAS E, HAREIN PK, YORK MD & POMEROY BS. 1974. ***Escherichia coli* serotypes isolated from within the lesser mealworm and evaluated for virulence.** *Annals of the Entomological Society of America* 67, 967–970.

Abstract

Differences in virulence of strains of *Escherichia coli* isolated from the lesser mealworm, *Alphitobius diaperinus* (Panz.), were demonstrated in embryonating chicken eggs by the use of the allantoic route of inoculation. The ability of certain strains to

kill a percentage of the inoculated eggs showed a reproducible pattern from the individual strains. Thus, grouping of strains into arbitrary categories of virulence (high, medium, low and avirulent) according to the percentage of embryos killed seems feasible and comparable to similar experiments carried out with strains isolated from man and animals. The disease producing ability strains of *E. coli* appears to be reduced when recovered from within the mealworm. It is likely that these insects are an abnormal host for those strains of *E. coli* that are adapted and pathogenic to warm blooded animals.

Key Subjects

disease association

DE LAS CASA E, POMEROY BS & HAREIN PK. 1968. **Infection and quantitative recovery of *Salmonella typhimurium* and *Escherichia coli* from within the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **47**, 1871–1875.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

DESPINS JL, AXTELL RC, RIVES DV, GUY JS & FICKEN MD. 1994. **Transmission of enteric pathogens of turkeys by darkling beetle larva (*Alphitobius diaperinus*).** *Journal of Applied Poultry Research* **3**, 61–65.

Abstract

Larvae of the darkling beetle (lesser mealworm) were exposed to turkey feces from an enteritis-affected flock and determined to contain turkey enterovirus and rotavirus. Growth depression and increased mortality were observed in turkey poults, which fed on the exposed larvae. Exposed larvae, which had been surface-sterilised also, produced clinical signs of enteritis after consumption by the poults, indicating that pathogens were able to survive within the larvae. This experiment demonstrated the capacity of the larva of the darkling beetle to serve as a mechanical vector for enteric pathogens of turkeys.

Key Subjects

disease association

EIDSON CS, SCHNITTLE DC, LAI JB & GOODE RB. 1965. **The role of the darkling beetle, *Alphitobius diaperinus* in the transmission of acute leucosis in chickens.** *Poultry Science* **44**, 1366–1367.

Abstract

No abstract available

Key Subjects

disease association

EIDSON CS, SCHMITTLE SC, GOODE RB & LAL JB. 1966. **Induction of leukosis tumors with the beetle *Alphitobius diaperinus*.** *American Journal of Veterinary Research* **37**, 1053–1057.

Abstract

Chickens dead of leukosis had larvae and adults of the beetle *Alphitobius diaperinus* in the subcutis. Poultry litter from a poultry house, where there was an increasing incidence of leukosis, was found teeming with the beetles. A prepared suspension of larvae or

adult beetles collected from the litter was injected into susceptible day-old chicks either orally or intra-abdominally and resulted in leukosis tumor development in 25 to 83% of the chicks by 4 weeks of age; uninoculated controls were negative. Chicks placed on used litter with beetles also developed tumors. Treatment of the external surface of the beetles with bichloride of mercury did not appreciably diminish the oncogenic properties; on the other hand, sterilization (by autoclaving) of beetles prior to processing in activated the tumor-producing properties.

Key Subjects

disease association

ELOWNI EE & ELBIHARI S. 1979. **Natural and experimental infection of the beetle *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) with *Choanotaenia inlundibulum* and other chicken tapeworms.** *Veterinary Science Communications* **3**, 171–173.

Abstract

Naturally occurring cysticercoids of *Choanotaenia infundibulum* were recovered by dissection from 78 out of 542 adults of *Alphitobius diaperinus* (Panz.) collected from 2 poultry farms in Khartoum, Sudan. Larvae were also found to be infected, but only at the rate of 0.75%. Experimental infection of healthy adults confirmed the suitability of this species as an intermediate host for *C. infundibulum*, but 4 other species of tapeworms affecting poultry failed to develop in *A. diaperinus*. This is the first record of *A. diaperinus* as an intermediate host for *C. infundibulum*.

Key Subjects

disease association

ERICHSEN LD. 1996. **Behaviour and population dynamics of litter beetles in broiler houses.** *Danish Pest Infestation Laboratory Annual Report*, 64–65.

Abstract

A master's degree project on the population dynamics and behaviour of four species of beetles (*Alphitobius diaperinus*, *Typhaea stercorea*, *Ahasverus advena* and *Carcinops pumilio*) in a broiler farm started in September 1996, and is planned to end in the winter of 1997. In the autumn of 1995, a Danish farmer reported to the Danish Pest Infestation Laboratory that he had an unusually high number of beetles in his farm and that he also had salmonella-infested poultry. To obtain additional proof of a possible link between salmonella and beetle presence, a few simple experiments were carried. The results indicate that salmonella could be transferred from beetles to a previously clean stock of poultry. To control the beetles, different traditional pesticides and methods have been used. However, further knowledge on population dynamics and behaviour of the beetles is important for a satisfactory control of the beetles. I have found no references to field studies of these beetles in chicken poultry farming, but all four species have been well examined in laboratory trials since they are all common pest in stored products worldwide. This project examines population increase, development rates, flight activity and habitat preferences in the farm for all four species mentioned

above. The investigation was carried out as a field study in two six-week periods. A new trap design was used in the experiment and was therefore tested. All experiments were carried out in a Danish broiler farm on Funen. The preliminary results indicate that the population increase is in accordance with results obtained in laboratory experiments described in literature. However, *T. stercorea* and *Ahasverus advena*, which were expected to manage two generations, only managed one, as did *A. diaperinus* and *C. pumilio*. After each six-week period the houses were cleaned very thoroughly, so when a new test period started, the beetles had to resettle the houses and it seems that they never reached an equilibrium before the houses were cleaned again. There was a very clear difference in flight activity of the two species that were observed flying (*Ahasverus advena* and *T. stercorea*). Another observation was that *T. stercorea* seems to prefer more humid surroundings, which is only natural since it is considered to be a fungus eater. All species of beetles were contagiously distributed in the house.

Key Subjects

biology & behaviour; disease association

ESPAINÉ L & JURASEK V. 1971. **First finding of the cysticeroids of *Raillietina* (S.) *cesticillus* (Molin, 1858) in the beetles *Carcinops troglodytes*, Paykull (Histeridae) under natural poultry-rearing conditions.** *Revista Cubana de Ciencias Veterinarias* 2, 217–222.

Abstract

A list is given of some 100 species of Coleoptera previously recorded as intermediate hosts of the Cestode *Raillietina cesticillus*, and the finding in Cuba of cysticeroids of *R. cesticillus* in the Histerid *Carcinops troglodytes* (Payk.) for the first time is recorded. Examples of *C. troglodytes* were collected from fowl houses at a farm in the Havana area, and on examination 4 out of 160 were found to contain a single cysticeroid. As beetles are plentiful and could be eaten in large numbers by the fowls, it is concluded that they could be responsible for infecting them with *R. cesticillus* and should be considered as intermediate hosts under normal conditions of poultry keeping in Cuba, together with *Dermestes ater* Deg., the chief vector there, and *Alphitobius diaperinus* (Panz.).

Key Subjects

disease association

EUGENIO C, DE LAS CASAS E, HAREIN PK & MIROCHA CJ. 1970. **Detection of the mycotoxin F-2 in the confused flour beetle and the lesser mealworm.** *Journal of Economic Entomology* 63, 412–415.

Abstract

The mycotoxin, F-2, produced by *Fusarium roseum* var. *graminearum* was ingested and retained by *T. confusum* and *A. diaperinus*. F-2 persisted in the animals through metamorphosis and was detected after starvation and death. The amount of F-2 recovered increased with increasing F-2 concentrations in the culture media.

Key Subjects

disease association

GEISSLER H & KOSTERS J. 1972. **Hygienic significance of the lesser mealworm beetle (*Alphitobius diaperinus* Panz.) in broiler production.** *Deutsche Tierärztliche Wochenschrift* 79, 178–181.

Abstract

Adult beetles and larvae about to pupate were fed *S. thompson* culture. Infection was demonstrated in the adult beetles for up to 15 days and in newly emerged beetles infected as larvae. It is considered that the presence of these insects in a chicken house could cause various bacterial and viral infections in successive batches of birds. Exposure to cold (-5 deg C) is the best method of control.

Key Subjects

disease association

GOGOI AR & CHAUDHURI RP. 1982. **Contribution to the fowl cestodes *Raillietina tetragona*, *Raillietina echinobothrida* and *Raillietina cesticillus*.** *Indian Journal of Animal Sciences* 52, 246–253.

Abstract

In Assam, India, 8933 ants from 8 species and 1383 beetles from 3 species were examined for cysticeroids. *Raillietina tetragona* was recovered from 1.6% of 1331 *Tetramorium tortosum*, 0.4% of 536 *T. rothneyi*, 0.3% of 4238 *T. simillimum* and 1.4% of 2809 *Phidole* sp. *R. echinobothrida* was recovered from 8%, 14.9%, 5.0% and 0.1%, respectively. Mixed infections occurred in 3.9%, 0, 0.09% and 0.03%. The number of cysts/ant ranged from one to 27. *R. cesticillus* only was recovered from 7.6% of 707 *Tribolium confusum*, and *Hymenolepis minutissima* only from 1.1% of 557 *Alphitobius diaperinus*. The prevalence of *Raillietina* spp. increased during the monsoon months. Infected ants were fed to White Leghorn chicks and the prepatent periods of *R. tetragona*, *R. echinobothrida* and *R. cesticillus* were 13, 14 and 13 days, respectively. *Tetramorium rothneyi* and *A. diaperinus* represent new host records.

Key Subjects

disease association

GOODWIN MA & WALTMAN WD. 1996. **Transmission of *Eimeria*, viruses, and bacteria to chicks: darkling beetles *Alphitobius diaperinus* as vectors of pathogens.** *Journal of Applied Poultry Research* 5, 51–55.

Abstract

Darkling beetle homogenates (DBH) were prepared from beetles collected from chicken houses on 7 farms. DBH were shown to contain many infectious organisms including bacteria (e.g., *Salmonella*, viruses (e.g., reovirus) and *Eimeria*. It is concluded that darkling beetles serve as vectors for common avian pathogens.

Key Subjects

disease association

HAREIN PK, DE LAS CASAS E, LARSEN CT & POMEROY BS. 1972. **Microbial relationship between the lesser mealworm and its associated environment in a turkey brooder house.** *Environmental Entomology* 1, 189–194.

Abstract

Insect, litter and dust samples were collected weekly and cultured on different media in order to identify bacteria and fungi and estimate relative levels of microbiological contamination. The number of bacteria and fungi increased during the 13 week sampling period, the amount of increase depending on the type of sample. Surface and sub-surface litter became heavily contaminated with bacteria, both having similar bacterial counts. The total number of bacteria in the dust was less than in the litter. *A. diaperinus* carried the least. However, a greater percentage of the surface disinfected animals were contaminated with *Escherichia coli* (bacteria) than any other type of sample, and they represented the largest number of the different isolates identified. *A. diaperinus* was also the first type sample found to be positive for *Salmonella* spp (bacteria). Sub-surface litter and dust had the greatest amount of fungi, surface litter was second, while *A. diaperinus* had the least.

Key Subjects

disease association

HAREIN PK, DE LAS CASAS E, POMEROY BS & YORK MD. 1970. *Salmonella* spp. and serotypes of *Escherichia coli* isolated from the lesser mealworm collected in poultry brooder houses. *Journal of Economic Entomology* **63**, 80–82.

Abstract

Adult *Alphitobius diaperinus* (Panzer) were collected from the litter of poultry brooder houses in 1967 and 1968. One thousand of the lesser mealworms were individually surface disinfected, macerated, and cultured in thioglycolate enrichment broth at 37°C and streaked on eosin methylene blue agar or brilliant green agar plates for detection of *Escherichia coli* (Migula) Castellani & Chalmers and *Salmonella* spp., respectively. Five species of *Salmonella* found within the lesser mealworms were identified as *S. heidelberg* Kauffman, *S. worthington* Edwards and Bruner, *S. saint paul* Kauffmann, *S. typhimurium* var. copenhagen Kauffmann, and *S. chester* Kauffmann and Tesdal. Forty-eight serotypes of *E. coli* were recovered from within 251 lesser mealworms. Twenty-six of these serotypes are known pathogens for man or animals.

Key Subjects

disease association

JACOBS-REITSMA WF, GIESSEN AW, VAN DE BOULDER NM & MULDER RWA. 1995. *Epidemiology of Campylobacter* spp. at two Dutch broiler farms. *Epidemiology and Infection* **114**, 413–421.

Abstract

Broiler flocks on 2 Dutch poultry farms were screened weekly for the presence of *Campylobacter* in fresh caecal droppings during 8 consecutive production cycles. Hatchery and fresh litter samples were taken at the start of each new cycle. Water, feed, insects, and faeces of domestic animals, present on the farms were also included in the sampling. Flocks became colonized with *Campylobacter* at about 3–4 weeks of age with isolation percentage of 100%, and stayed colonized up to slaughter. A similar pattern of

serotypes was found within the various broiler houses on one farm during one production cycle. New flocks generally showed a new pattern of serotypes. Most serotypes isolated from the laying hens, pigs, sheep and cattle were different from those isolated from the broilers at the same time. Serotypes from darkling beetles (*Alphitobius diaperinus*) inside the broiler houses were identical to ones isolated from the broilers. No *Campylobacter* was isolated from any of the hatchery water, feed or fresh litter samples. Conclusive evidence of transmission routes was not found, but results suggest horizontal transmission from the environment.

Key Subjects

disease association

JESPERSEN JB. 1996. *Litter beetles as disease reservoirs*. Danish Pest Infestation Laboratory Annual Report, 63–64.

Abstract

In broiler houses, litter beetles, in particular the lesser mealworm *Alphitobius diaperinus* and the hairy fungus beetle *Typhaea stercoraria*, are found very frequently. The beetles are difficult to control chemically, and as the development time is rather short, they often constitute a pest problem. In addition they are potential transmitters of disease agents; for salmonella bacteria it has been shown that both species of beetles might be infected or surface-contaminated by salmonella bacteria. The Ministry of Food, Agriculture and Fisheries therefore has supported a project with the following specific objectives 1) to investigate the occurrence, biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project is a collaborative project involving in Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (Project coordinator), as well as many veterinarians and poultrymeat farmers.

Key Subjects

biology & behaviour; disease association

KARUNAMOORTHY G, CHELLAPPA DJ & ANANDAN R. 1994. *The life history of Subulura brumpti in the beetle Alphitobius diaperinus*. *Indian Veterinary Journal* **71**, 12–15.

Abstract

Thirty-nine of 86 *Alphitobius diaperinus* collected from deep litter houses in the Namakkal area of Tamil Nadu, India, were found to be naturally infected with *Subulura brumpti*, with 1–5 encysted larvae in each infected beetle. The life cycle of the nematode was established by experimental infection of beetles and fowls. Adult worms were removed from the caeca of infected birds and their eggs mixed with poultry mash and fed to beetles from deep litter houses with no history of *S. brumpti* infection. L2 were observed in beetles 8 days pi and encysted infective L3 appeared 12–16 days pi. Eggs appeared in the droppings of previously uninfected fowls 30–35 days after they were fed with infected *A. diaperinus*.

Key Subjects

disease association

KOMAREK S. 1988. **The glossy black cereal mould beetle (*Alphitobius diaperinus* Panzer), a little-known stored product pest.** *Pflanzenschutz Wein* 1, 3–4.

Abstract

The tenebrionid *Alphitobius diaperinus*, a sporadic pest of stored products in Central Europe, was found recently in large numbers in a store room of a zoological garden in Austria. Notes are provided on the biology, injuriousness and control of this beetle, which can harbour pathogens (such as *Salmonella* and *Escherichia coli*) of poultry.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN TA. 1998. **Controlling black beetles (*Alphitobius diaperinus* (Panzer), Coleoptera: Tenebrionidae) in chicken sheds.** *Proceedings 1998 Poultry Industry Exchange Surfers Paradise 19-21 April 1998*, 33–37.

Abstract

The black or darkling beetle (*Alphitobius diaperinus* (Panzer)), which is of tropical origin, is a serious, cosmopolitan insect pest of chicken houses. Losses to production are indirect and result from the transmission of poultry disease, downgrading of bird feed quality, bird ingestion of large quantities of beetle larvae, damage to shed insulation and the high cost of pesticide applications. The duration of the pest's life cycle is dependent on temperature and humidity. As a result, beetle populations in chicken sheds tend to be localized around areas of high temperature and moisture. In very dry chicken sheds, the beetle will eat dead birds and at night, bit sleeping live birds. *A. diaperinus*, which is omnivorous and active in low light conditions is also an active flier and can readily infest new areas. Control of the pest traditionally has been by the use of chemicals and now insecticide resistant populations of the pests have been reported. Hygiene is an important component of pest control, which incorporates proper shed cleanouts and disposal of manure litter. Indications are that in Australia, control of *A. diaperinus* is becoming increasingly difficult and there is a need to adopt and integrated pest management system for the beetle, which would encompass an insecticide resistance management strategy.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN T & CAMERON MC. 1999. **Darkling beetle control – Current difficulties and future prospects.** *The Eleventh Australian Poultry & Feed Convention Proceedings*, 184–192.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries'

replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, as pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN TA & CAMERON MC. 2000. **Darkling beetle control in Australian broilers – a new direction.** *Proceedings 2000 Poultry Information Exchange*, 97–102.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, a pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated pest management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LANCASTER JL & SIMCO JS. 1967. **Biology of the lesser mealworm, a suspected reservoir of avian leucosis.** *Arkansas Experiment Station* 159, 1–12.

Abstract

Attention has been drawn to the lesser mealworm, *Alphitobius diaperinus* (Panzer) by a recent report that it was capable of transmitting acute leucosis, an infectious agent producing tumors in broilers. This report created a flurry of excitement and worry throughout the major poultry production area in the South. The objectives of thesis study were develop a method for culturing the insect, to determine its life cycle, to survey for its frequency of occurrence in broiler houses, and to attempt transmission by the beetles of the infectious agent.

Key Subjects

biology & behaviour; disease association

MATHUR N, KHERA S & SHARMA N. 1994. **A study of infectivity and propagation of *Steinernema feltiae* on some insect pests.** *Journal of Parasitology and Applied Animal Biology* 3, 47–53.

Abstract

Laboratory inoculation of last-instar larvae of *Pieris brassicae*, *Alphitobius diaperinus*, *Oryzaephilus mercator* and adults of *O. meractor* with *S. felitiae* (N-25 strain) was carried out to study the infectivity of this nematode after inoculation with 500, 1000 and 200 infective juveniles/ml/insect. It was found that the body weight of inoculated insects decreased steadily on each of the 5 successive days measured, but the time taken to kill the various insects varied. The infectivity of *S. felitiae* varied with the size of the inoculum, and with increasing density of insects inoculated with 1000 juvenile *S. felitiae*, the number of infected insects and number of invading nematodes per insect decreased. The number of nematodes recovered per insect varied considerably among the different insect species and according to the inoculum size.

Key Subjects

disease association

MCALLISTER JC. 1993. **Determination of the potential of lesser mealworms, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae), to transmit poultry pathogens.** *Ph.D. Dissertation, University of Arkansas.*

Abstract

No abstract available

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD, NEWBERRY LA & SKEELS JK. 1995. **Isolation of infectious bursal disease virus from the lesser mealworm, *Alphitobius diaperinus* (Panzer).** *Poultry Science* **74**, 45–49.

Abstract

Infectious bursal disease (IBDV) is an acute, highly contagious viral disease of young chickens. The relationship between the lesser mealworm, *Alphitobius diaperinus*, and IBDV was investigated. 60 adult lesser mealworms and 60 larvae were placed in sterile petrie dishes and starved for 24 hours, after which time they were provided with 1g of ground commercial chicken feed inoculated with IBDV for 24 hours. Adult and larvae mealworms were removed 1, 5, 10 and 15 days after exposure to the virus and the presence of IBDV tested for. The virus was undetected after 24 hours in beetle larvae. IBDV was present in adult lesser mealworm blood, all regions of the digestive tract and on the mouthparts 24 hours after exposure. Foregut samples from day 10 contaminated IBDV but other tissues sampled at this time were negative for virus. It is concluded that the lesser mealworm is capable of serving as a reservoir for IBDV.

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD & SKEELES JK. 1994. **Reservoir competence of the lesser mealworm (Coleoptera: Tenebrionidae) for *Salmonella typhimurium* (Eubacteriales: Enterobacteriaceae).** *Journal of Medical Entomology* **31**, 369–372.

Abstract

The reservoir competence of *Alphitobius diaperinus* is reported for *S. typhimurium* relative to broiler chicken production. *S. typhimurium* was isolated from faeces of the adult beetles at least 28 days after feeding for 24 hours on 1g of chicken feed (containing corn and soybean meal) inoculated with 3x10⁸ bacteria/ml. All larvae fed *S. typhimurium* ceased voiding the bacteria in their faeces before pupal moult, except one. One beetle continued to void *S. typhimurium* after it emerged as an adult, providing evidence that transstadial transmission of *S. typhimurium* may occur. The bacteria were found both on the external body surface and inside the body of surface-sterilized adults and larvae during 16 days exposure. *Salmonella*-positive cloacal swabs were obtained from 1 day old broiler chicks within 24h after eating 1 infected lesser mealworm adult or larvae.

Key Subjects

disease association

MCALLISTER JC, STEELMAN CD, SKEELES JK, NEWBERRY LA & GBUR EE. 1996. **Reservoir competence of *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) for *Escherichia coli* (Eubacteriales: Enterobacteriaceae).** *Journal of Medical Entomology* **33**, 983–987.

Abstract

Larval and adult lesser mealworms, *Alphitobius diaperinus* (Panzer), were found to harbor a Congo red-binding strain of *Escherichia coli* (Migula) Castellani & Chalmers both on the external surface of their body and internally for 12d. Thereafter, *E. coli* was not detected, even though the beetle were exposed continually to a food source inoculated with the bacteria. Lesser mealworm larvae and adults discharge *E. coli* bacteria in their feces for up to 6 and 10 d, respectively. However, bacteria were no longer detected in their feces after larvae underwent a single molt to the next larval stage. This indicated there was no transstadial transmission of this strain of *E. coli*. Consumed infected larvae were found to cause 1-d-old chicks to have positive cloacal swabs for Congo red-binding *E. coli* than consumed infected adults. The data indicated that the lesser mealworm may play a role in the direct transmission of *E. coli* and contribute to the spread of this bacteria in broiler production systems. This may be achieved by beetles being directly consumed by chickens or indirectly by spread of the bacteria throughout the broiler house by lesser mealworm feces.

Key Subjects

disease association

MISHCHENKO AA & MASHKEI IA. 1987. **Harmful beetles (Coleoptera) - inhabitants of livestock premises.** *Veterinariya Kiev* **62**, 68–71.

Abstract

Details are given of the species and life stages of the beetles collected in pig, cattle and poultry quarters in the Ukraine, USSR, during 1979–85. The presence of *Alphitobius diaperinus* and dermestids was considered particularly important as they can transmit disease to livestock.

Key Subjects

biology & behaviour; disease association

MOYA A, FLORES R & OVIES D. 1977. **On the epizootiology of heteroxenous helminths of the hen (*Gallus gallus forma domestica*) in Cuba.** *Revista Cubana de Ciencias Veterinarias* **8**, 25–29.

Abstract

A group of 15 four-week-old Plymouth Rock chicks was fed 100 *Dermestes ater* beetles during 4 consecutive days and killed 75 days later. Autopsy of 13 birds showed 6 infected with *Raillietina cesticillus*, 4 with *Choanotaenia infundibulum*, 5 with *Tropisurus confusus*, 3 with *Chelospirura hamulososa* and 5 with *Subulura suctorina*; the mean intensity of infection was about one to 5 worms. Another 15 chicks were fed with 100 *Alphitobius diaperinus* during 3 consecutive days. At autopsy, 7 were found to be infected with *S. suctorina* (mean intensity, 6 worms). Another 15 were fed with 100 *Musca domestica* during 2 days. At autopsy of 14, one was infected with 2 *R. cesticillus*. A control group, not fed with arthropods, showed no worms.

Key Subjects

disease association

OVIES D & BIROVA V. 1976. **Epizootiology of *Subulura suctorina* in Cuba.** *Revista Cubana de Ciencias Veterinarias* **3**, 71–79.

Abstract

Subulura suctorina is widely distributed among poultry in Cuba. It is present throughout the year but with seasonal variations. The intermediate coleopteran host, *Alphitobius diaperinus*, occurs in most poultry establishments. In the present work, 358 White Leghorn chickens were autopsied at the rate of 30/month, and 1000 *A. diaperinus* were examined. About 77% of the chickens were infected with a mean number of 21.6 worms/bird. The maximum infection rate occurred in February and the minimum in August. In the beetles, the maximum rate occurred in October to December, preceding the maximum in the chickens. It is recommended that measures to control the beetles should be intensified during October to December and that anthelmintic treatment should be given to the birds in December and January.

Key Subjects

disease association

REYNA PS, MCDUGALD LR & MATHIS GF. 1983. **Survival of coccidia in poultry litter and reservoirs of infection.** *Avian Diseases* **27**, 464–473.

Abstract

The survival of coccidia was studied in poultry litter, soil and invertebrate animals. The populations of coccidia in litter were recorded during broiler growout in 16 broiler houses and in floor-pen trials involving anticoccidial drugs. The viability of oocysts declined rapidly in poultry litter regardless of species; it was retained best in 40% moisture of 4 deg C, regardless of the carrier. In four floor-pen experiments designed to study the efficacy of anticoccidial drugs, the oocyst counts correlated in a general way with lesion sources and performance, indicating the oocyst counts might be useful along with other parameters to judge the effectiveness of drugs. Coccidia were transmitted to susceptible chicks by feeding them beetles (*Alphitobius diaperinus*), flies, or house dust from

poultry houses. More carrier samples were positive during warmer months. Oocyst counts in litter of commercial poultry houses were very low during the first or last weeks of broiler growout but were high during the normal 3 to 6 week stress period. These results confirm that poor survival of a few oocysts in poultry litter and suggest that carryover from one flock to the next on the survival of a few oocysts in dust or arthropod vectors

Key Subjects

disease association

SCARBOROUGH A. 1988. **How to deal with darkling beetles.** *Broiler Industry*, 48–49.

Abstract

No abstract available

Key Subjects

biology & behaviour; disease association

SCHMITTLE SC. 1966. **Leukosis - new or changed disease?** *Poultry Tribune* **72**, 32–34.

Abstract

No abstract available

Key Subjects

disease association

SCHROECKENSTEIN DC, MEIER-DAVIS S, GRAZIANO FM, FALOMO A & BUSH RK. 1988. **Occupational sensitivity to *Alphitobius diaperinus*.** *Journal of Allergy and Clinical Immunology* **82**, 1081–1088.

Abstract

Alphitobius diaperinus is an important beetle in the grain and poultry industries. We evaluated three individuals with work related symptoms of asthma, rhinitis, conjunctivitis, urticaria, and angioedema on exposure to the insects. Prick skin tests with extracts prepared from the larval, pupal, and adult life stages were positive in all three patients. Specific IgE antibodies to these extracts were demonstrated by RAST or radioimmunoassay. RAST and radioimmunoassay inhibition confirmed the specificity of IgE binding and further demonstrated immunologic cross reactivity between the three life stages. Peripheral blood leukocytes from two of the individuals demonstrated significant histamine release when they were compared with cells from nonexposed atopic and normal control subjects. The proteins in the extracts; however, the patterns of separation were different for each life stage. After immunoblotting and autoradiography, IgE binding proteins were recognized by sera from all three individuals in the larval extract at 90 kilodaltons (kd), in the pupal extract at 90, 64 and 38 kd, and in the adult extract at 84 kd. Additionally, several other proteins were identified as being allergenic in some of the patients. We conclude that these three patients developed IgE mediated sensitivity to *A. diaperinus* antigens as the result of occupational exposure. To our knowledge, this is the first description of sensitivity to this grain beetle.

Key Subjects

disease association

SHALABY FM, REFAII AH, MICHAEL SA, BISHARA SI, NAZMI NH & MOSTAFA MA. 1979. **The role of dung beetles in the**

epidmiology of helminth parasites of animals in Egypt. *Journal of the Egyptian Society of Parasitology* 9, 339–348.

Abstract

Twelve species of scarabaeid and one tenebrionid beetle were captured from various semidesert or desert areas in Egypt where they were abundant around dung. They were kept in the laboratory for various periods before being dissected. Guinea-pigs, rabbits and dogs were inoculated with encysted larvae that were recovered. It was evident that 75.4 to 100% of *Scarabaeus puncticolis*, 80% of *S. sacer*, 60% of *S. cornifrons*, 85% of *Bubas bubalus* and 17.35% of *Onitis alexis* were harbouring encysted larvae of *Spirocerca lupi* in the coelomic cavity. *B. bulbulus* also harboured another unidentified nematode species. *Aphodius lividus*, *A. nitidulus*, *A. contractus*, *Corpis hispanus*, *Heliocopris gigas*, *H. isidis*, *Oniticellus pallens* and *Alphitobius diaperinus* were all free of encysted larvae, but some carried free-living nematode larvae or suspected parasites. Puppies inoculated with larvae from *S. puncticolis*, *S. sacer* or *S. cornifrons* developed nodules on the aorta; each nodule contained a *Spirocerca lupi* larva. Inoculated guinea pigs and rabbits did not become infected.

Key Subjects

disease association

SKEWES PA & MONROE JL. 1991. **The effects of darkling beetles (*Alphitobius diaperinus*) on broiler performance.** *Poultry Science* 70, 1034–1036.

Abstract

Six polyvinylchlorine pipe darkling beetle traps were placed in 20 commercial broiler production facilities, and the relative level of beetle infestation was determined from weekly sampling during a 4 wk period. The average number of beetles found at each facility was compared with following production parameters: mortality, feed conversion, condemnation rate, and production cost. In the 20 commercial broiler flocks evaluated, the level of darkling beetles within the facility was not related to any of the production parameters measured.

Key Subjects

biology & behaviour; disease association

SNEDEKER C, WILLS FK & MOULTHROP IM. 1966. **Some studies on the infectious Bursal agent.** *Avian Diseases* 11, 519–528.

Abstract

No abstract available

Key Subjects

disease association

SPENCER A & JESPERSEN JB. 1997. **Litter beetles as disease reservoirs.** *Danish Pest Infestation Laboratory Annual Report*, 70.

Abstract

Litter beetles, in particular the lesser mealworm *Alphitobius diaperinus*, the hairy fungus beetle *Typhaea stercorea* and foreign grain beetle *Ahasverus advena* are commonly found in broiler houses. These beetles are difficult to control chemically, and as their developmental time is rather short, they often constitute a pest problem. In addition they are potential transmitters of disease agents; for salmonella

bacteria it has been shown that these species can be infected or surface-contaminated by salmonella bacteria. The Ministry of Food, Agriculture and Fisheries has therefore supported a project with the following specific objectives: 1) to investigate the occurrence, biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project involves collaboration between the Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (Project coordinator), as well as many veterinarians and poultry meat farmers. The project was established in 1996, and by now samples of beetles have been collected and analysed for the presence of *Salmonella* and *Campylobacter* from a number of sites across Denmark. This work will continue in 1998. A survey of the distribution and extent of beetle infestation and a study of insecticide resistance are also planned for 1998.

Key Subjects

disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.

Litter beetles. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

The litter beetles, *Alphitobius diaperinus* (the lesser mealworm), *Typhaea stercorea* (the hairy fungus beetle), *Ahasverus advena* (the foreign grain beetle) and *Carcinops pumilio* are commonly found in Danish poultry houses. These beetles are difficult to control and often constitute a pest problem. In addition they are potential transmitters of human and avian disease. In 1996 the Ministry of Food, Agriculture and Fisheries supported a three year project with the following specific objectives: 1) to investigate the occurrence biology and behaviour of the beetles, 2) to develop and implement strategies for the prevention and control of the beetles, and 3) to investigate if persistent infections with *Salmonella* or *Campylobacter* are related to the occurrence of beetle infestations. The project involves collaboration between the Danish Veterinary Laboratory, the Danish Poultry Meat Association, the Danish Pest Infestation Laboratory (project coordinator), and many veterinarians and poultry meat farmers. The project will conclude in 1999, but has already achieved most of its objectives. The principal findings made so far are detailed below.

Key Subjects

biology & behaviour; disease association

SPENCER A & BRØCHNER JESPERSEN J. 1998.

The role of litter beetles in the transmission of disease. *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

Fourteen broiler houses were non-randomly selected based on their salmonella infection status. Nine were persistently contaminated with salmonella while the remaining five were salmonella negative. In each house, beetles collected from two consecutive flocks and during the empty period between these flocks were monitored for the presence of salmonella and

campylobacter. Beetles sampled during production were shown to be able to harbour salmonella and/or campylobacter, confirming earlier studies in Denmark and elsewhere. More significantly however, in one house, beetles collected during the empty period were also found to be salmonella positive. This demonstrates the potential for litter beetles to transfer infections between successive flocks. However, our results also suggest that salmonella from beetles may not always be transmitted to the chickens and that beetles living in infested houses can remain free of infection. All cases of campylobacter positive beetle samples were detected in connection with a positive chicken flock. In no case was campylobacter isolated from beetles taken from an empty house. This work was carried out in collaboration with M. N. Skov, L. Petersen and M. Madsen of the Danish Veterinary Laboratory, Århus. The findings will shortly be submitted for publication. All bacterial analysis was carried out by collaborators at DVL, Århus.

Key Subjects

disease association

isolated from pools of the following insect species as follows: 25 of 72 adults of *Musca domestica*, 9 of 23 adults of *Ophyra aenescens* (*Hydrotaea aenescens*), 9 of 25 adults of *Coproica hirtula*, 1 of 51 adults of *Alphitobius diaperinus*, and 1 of 26 larvae of *Dermestes maculatus*.

Key Subjects

disease association

STEELMAN D. 1996. **Darkling beetles are costly pests.** *Poultry Digest* **55**, 22–23.

Abstract

Alphitobius diaperinus as a pest of poultry housing is discussed under the following headings: beetle life cycle; determining populations; economic impact; salmonellae; infectious bursal disease; turkey enteritis; method of control.

Key Subjects

biology & behaviour; disease association

STUKE P & KALENTA EF. 1970. **The role of the beetle *Alphitobius diaperinus* for spreading of infectious bronchitis of chicks.** *Deutsche Tierärztliche Wochenschrift* **77**, 38–41.

Abstract

No abstract available

Key Subjects

disease association

UCHIDA A. 1980. **Studies on the life cycle of a cestode parasitic in the small intestine of Japanese quail.** *Bulletin of the Azabu University* **1**, 61–73.

Abstract

Various insects were collected from the rearing rooms of Japanese quails and examined for cysticercoids of *Metroliastrongylus coturnix*. 5 species of beetles (*Dermestes maculatus*, *D. ater*, *Alphitobius diaperinus*, *Tenebrio molitor* and *T. obscurus*) were infected. *D. maculatus* was the most numerous beetle and the most commonly infected. At 30 deg C cysticercoids matured in the beetles in 12 days, and in quails development took 7 to 12 days.

Key Subjects

disease association

WILSON DD, SCHMIDTMANN ET, RICHARD RD, LEHMAN RD, ST GEORGE TD & BLOK J. 1986. **Isolation of avian influenza from insects.** *Arbovirus research in Australia*, 221–226.

Abstract

During an outbreak of avian influenza virus in poultry flocks in Pennsylvania in 1983–84, the virus was

SECTION 4. INSECTICIDE CONTROL ARTICLES (BY AUTHOR/S)

BLAHUTIAK A. 1970. **Comparison of the effectiveness of five insecticides for control of *Alphitobius diaperinus***. *Academia de Ciencias de Cuba Instituto de Biología* **20**, 17.

Abstract

Fosfotion (an insecticide made in Czechoslovakia) proved to be the most efficient, compared to four other insecticides, in laboratory experiments on the beetle *Alphitobius diaperinus* Panzer, by the topical method of application. Results were the best for Fosfotion not only according to toxicity on the beetles tested, but also for its tolerance regarding warm blooded vertebrates, which makes it usable also in the semioperative test for the control of intermediary hosts of the nematode *Subulura suctoria* (Molin, 1860). Two of the other insecticides (Soldep and Lindano), less efficient than Fosfotion but with higher toxicity on warm blooded vertebrates, are also suitable for semioperative trials. DDT and Aldrin proved less suitable: DDT, for its lower toxicity on the beetles tested; Aldrin' for its higher toxicity on hens and other warm blooded vertebrates.

Key Subjects

insecticide control

BONIN W. 1977. **The results of laboratory investigations on the effectiveness of the insecticide heptenophos - from the point of view of the possibility of its use as a compound against ectoparasites in veterinary medicine.** *Berliner und Muenchener Tieraerztliche Wochenschrift* **90**, 34–37.

Abstract

The results are presented of laboratory toxicity tests of heptenophos against 7 species of arthropods that are (mainly) ectoparasites of domestic animals and man. Against *C(imex) lectularius* L. and (in brackets) *D(ermanussus) gallinae* (Deg.), the LC50 (expressed as a percentage) was 5.3×10^{-3} (5.0×10^{-6}), as compared with 3.2×10^{-2} (1.3×10^{-4}) for trichlorphon, 3.8×10^{-2} (1.3×10^{-3}) for carbaryl and 6.2×10^{-2} (1.3×10^{-2}) for bromocyclen. The lethal times and residual action are given, together with further results with various insecticides are acaricides for comparison with heptenophos against *M(elophagus) ovinus* (L.), *L(ucilia) cuprina* (Wied.), *A(lphitobius) diaperinus* (Panz.), *Ps(oroptes) cuniculi* (Delafond) and *A(mblyomma) hebraeum* Koch. Heptenophos was strongly insecticidal and acaricidal, had an extremely rapid action and short residual effect, and was effective as a vapor.

Key Subjects

insecticide control

COGAN P, WEBB D & WAKEFIELD M. 1996. **A comparison of four residual insecticides for the control of the lesser mealworm beetle (*Alphitobius diaperinus* Panzer) in turkey broiler houses in the UK.** *International Pest Control* **March/April**, 52–55.

Abstract

Residual applications of iodofenphos SC, fenitrothion WP, permethrin WP and azamethiphos WP were evaluated for the control of *Alphitobius diaperinus* (the lesser mealworm or darkling beetle) in earth floored turkey broiler units. Single applications of either iodofenphos SC, fenitrothion WP or permethrin WP were found to be ineffective, but azamethiphos WP was found to be effective over the stocking period of four months. A total of only four beetles found during the four months of the final stocking cycle throughout the five sheds treated with azamethiphos WP. This may be compared with the shed treatment with iodofenphos SC where more than 3300 *A. diaperinus* were found in the samples of litter in the final population assessment. The level of control of *A. diaperinus* was not significantly improved by a supplementary application of dichlorvos as a space spray after treatment with a residual insecticide, before restocking with birds. Bioassays showed that azamethiphos was the most persistent of the insecticides used and was effective at even high summer temperatures. Persistence of iodofenphos deposits indicated that survival of *A. diaperinus* was most likely to be due to resistance and not poor treatment or insecticide breakdown.

Key Subjects

biology & behaviour; disease association; insecticide control

CHAIX MO. 1980. **The disinsection of rearing premises.** *Phytoma* **314**, 18–20.

Abstract

The injuriousness and control of arthropods in premises for rearing domestic animals, especially cattle, pigs and poultry in France, are reviewed. Special attention is paid to flies as vectors of disease, flies and fleas causing reductions in production of milk and eggs, respectively, and the infestation of feed by stored-product pests. *Alphitobius diaperinus* (Panz.) has caused important damage to insulating structures made of polystyrene and related materials in the past 2 years, especially where stock is reared on an industrial scale. Good agricultural practice, including maintaining atmospheric conditions unsuitable for pests, eliminating cover where they can breed, and the use of netting over windows, are recommended, and a list of 12 insecticides that can be used is given.

Key Subjects

biology & behaviour; insecticide control

DESPINS JL, TURNER EC JNR & PFEIFFER DG. 1991. **Evaluation of methods to protect poultry house insulation by lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Agricultural Entomology* **8**, 209–217.

Abstract

Insecticide sprays and paint barriers applied to the surface of extruded polystyrene, and different types of insulation, were evaluated for prevention of lesser mealworm, *Alphitobius diaperinus* (Panzer),

infestations. In a laboratory study, tetrachlorvinphos 50 WP and pirimiphos-methyl 7E on extruded polystyrene produced > 90% mortality in larval and adult lesser mealworm populations 71 wk after application. These insecticide spray treatments, however, were not effective under conditions found in the manure pit of a high rise cage layer house. Our field study showed that Styrofoam BB and Ethafoam 220, were resistant to lesser mealworm infestations. Super IQ paint, a latex paint impregnated with chlorpyrifos, was also effective in protecting extruded polystyrene from infestations under field conditions.

Key Subjects

biology & behaviour; insecticide control

DEMILO AB, MILLER RW, BORDAS B, REDFERN RE & MILLS G JNR. 1995. **Larvicidal effects of benzoylphenylureas against the lesser mealworm (Coleoptera: Tenebrionidae): quantitative structure-activity relationships.** *Journal of Entomological Science* **30**, 324–332.

Abstract

Larvicidal activity of a congeneric set of *N*-2-halo- (and 2,6-dihalo) benzoyl-*N'*-phenylureas was determined in *in vivo* tests and *Alphitobius diaperinus*. Substituent modifications were made in both the benzoyl and anilide portions of the molecule. Linear regression analysis was used to derive quantitative structure-activity relationships (QSAR) from LC50 and LC99 values and a series of physicochemical substituent parameters. The analysis resulted in 2 significant single parameter regression equations selecting Hammett σ constant as the only relevant chemical descriptor and rejecting the other descriptors as insignificant. Penfluron and 2,6-difluoro-*N*-[[[4-(trifluoro-methoxy)phenyl]amino]carbonyl]benzamide were potent larvicides in these tests and exceeded the effectiveness of diflubenzuron and triflumuron.

Key Subjects

insecticide control

EDWARDS JP & ABRAHAM L. 1985. **Laboratory evaluation of two insect juvenile hormone analogues against *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **21**, 189–194.

Abstract

The insect juvenile hormone analogues methoprene and fenoxycarb have been tested against larval stages of the lesser mealworm, *Alphitobius diaperinus*. Methoprene completely prevented the formation of adult insects at a concentration of 5.0 ppm in food medium. The same effect was achieved with only 0.05 ppm fenoxycarb. There was no evidence that sub-lethal levels of methoprene decreased the fecundity of insects that successfully completed adult development. The results of these laboratory tests are discussed in relation to the potential use of these compounds for control of *A. diaperinus* in intensive poultry production units.

Key Subjects

biology & behaviour; insecticide control

GEDEN CJ, EDWARDS TD, ARENDS JJ & AXTELL RC. 1987. **Efficacies of mixtures of**

disinfectants and insecticides. *Poultry Science* **66**, 659–665.

Abstract

Efficacies of mixtures of diluted commercial formulations of selected insecticides and disinfectants were evaluated. Insecticides tested included representative pyrethroids (fenvalerate (Ectrin WDL and WD) and permethrin (Ectiban EC), organophosphates (dichlorvos (Vapona EC), tetrachlorvinphos (Rabon WP) and dichlorvos/tetrachlorvinphos (Ra Vap EC), and carbamate (carbaryl (Sevin S)). Disinfectants tested included representatives of cresylic acid (Biolene), cresylic acid/phenol (BioGuard X-185), phenol (1-Stroke Environ), quaternary ammonium (BioGuard S-3 and PFP-4), quaternary ammonium/formalin (DC & R), and formalin classes of disinfectants. Mixtures were tested for toxicity to two target insects (*Musca domestica* on plywood, *Alphitobius diaperinus* in litter) and two bacteria (*Pseudomonas aeruginosa* and *Staphylococcus aureus*). Of 56 mixtures evaluated, 24 showed reduced insecticidal toxicity and 35 showed reduced bactericidal activity compared with insecticides or disinfectants alone.

Key Subjects

insecticide control

GIGA DP. 1987. **Evaluation of the insect growth regulators cyromazine and diflubenzuron as surface sprays and feed additives for controlling houseflies *Musca domestica* (L.) in chicken manure.** *International Pest Control* **29**, 66–69.

Abstract

Cyromazine or diflubenzuron were added as surface sprays or admixes to poultry food to determine their efficacy in controlling populations of *Musca domestica* breeding in poultry droppings in Zimbabwe. Cyromazine was mixed with the food as Larvadex 0.3% premix at 1.5 g a.i. or sprayed on the surface as Neporex 2% WSG at 5.0 g a.i./m². Diflubenzuron was added to the feed as Dimilin 25% WP at 5.0 g a.i. or sprayed on the food at 1.0 g a.i./m². Both growth regulators were equally effective in controlling breeding flies. Significant differences in the number of flies which emerged and in the ratio of normal to abnormal pupae were found between the 2 methods of application; admixes were more effective than surface sprays. Populations of the tenebrionid *Alphitobius diaperinus*, which lived in the manure in great numbers, were unaffected by either chemical.

Key Subjects

insecticide control

HARDING WL & BISSELL TL. 1958. **Lesser mealworm in a brooder house.** *Journal of Economic Entomology* **51**, 112.

Abstract

The lesser mealworm *Alphitobius diaperinus* (Panz.) (Tenebrionidae) is known as a pest of cereal products and grain that are in poor condition. It is cosmopolitan in distribution being commonly found in flour mill basements in damp or musty flour or grain (U.S. Dept. Agric., 1953). The paper reports an unusual outbreak of lesser mealworms in the corn cob litter of a brooder house on the Eastern Shore of Maryland during which larvae were observed to bore

into and apparently feed on the flesh and internal organs of moribund and dead baby chicks. Results of limited control experiments against lesser mealworm adults and larvae in corn cob litter are also presented.

Key Subjects

biology & behaviour; insecticide control

HEIMBUCHER J & KUTZER E. 1979. **Lesser mealworm (*Alphitobius diaperinus*) in poultry farms.** *Wien Tierärztliche Monatsschrift* **66**, 334–337.

Abstract

Studies are carried out on the occurrence of *Alphitobius diaperinus* (Panz.), a possible intermediate host of fowl helminths, on a poultry farm in Austria. The insect occurred in large numbers, the conditions of modern fowl houses being ideal for its development and multiplication. A spray containing 2% chlorpyrifos (Gesektin K) was effective against the pest in empty fowlhouses while in inhabited fowlhouses a spray containing a mixture of permethrin and pyrethrum (Permanent) was successfully applied. Both preparations had residual activity. In the inhabited fowlhouses, sprays containing 0.5% fenvalerate (Sumifly), 2% fenchlorphos (Nankor) or an organophosphorus compound in combination with pyrethrum (Lysozid S) (5%) were less effective; in addition, the latter should be used cautiously on poultry farms.

Key Subjects

insecticide control

JERRARD PC & WILDEY KB. 1980. **Beetle plague from deep pit muck spreading.** *Poultry World* **131**, 20–21.

Abstract

The poultry droppings in deep-pit units in Britain commonly harbour 3 species of beetle, *Alphitobius diaperinus* (Panz.), *Dermestes maculatus* Deg. and *Carcinops pumilio* (Erichs.). Very brief notes are given on the appearance of the adults and in 2 cases the larvae, of these species and on their habits. By their activity, they help to dry the manure and reduce fly infestation, but if the manure is spread on fields in warm weather, massive infestations of beetles can occur in nearby dwellings. A case of such an occurrence in southern England is described. Spraying the outside walls of the houses of a height of 1m and the ground around for the same distance with a 2% solution of idofenphos at 5 litres/100m² killed many beetles, but in spite of this and the use of aerosols indoors, the problem persisted because of reinvasion on warm days when the beetles were more active and flew in.

Key Subjects

biology & behaviour; insecticide control

KARTMEN L, TANADA Y, HOLDAWAY FG & ALICATA JE. 1950. **Laboratory tests to determine the efficiency of certain insecticides in the control of arthropods inhabiting poultry manure.** *Poultry Science* **29**, 336–346.

Abstract

No abstract available

Key Subjects

insecticide control

KHAN BA, DAY PA, GOONEWARDENE LA, ZUIDHOF MJ & HAWKINS G. 1998. **Efficacy of tetrachlorvinphos insecticide dust against darkling beetles in commercial broiler chicken barns.** *Canadian Journal of Animal Science* **78**, 723–725.

Abstract

Residual application of tetrachlorvinphos dust (Debantic 50WP) was evaluated against *Alphitobius diaperinus* in commercial broiler chicken barns. The dust formulation was applied using an electrostatic duster after clean out of old litter at the start of a new broiler cycle. Tetrachlorvinphos dust provided adequate control of beetle larvae and adults up to 5 weeks. 1 application is adequate for 1 commercial broiler chicken production cycle only.

Key Subjects

insecticide control

KOMAREK S. 1988. **The glossy black cereal mould beetle (*Alphitobius diaperinus* Panzer), a little-known stored product pest.** *Pflanzenschutz Wein* **1**, 3–4.

Abstract

The tenebrionid *Alphitobius diaperinus*, a sporadic pest of stored products in Central Europe, was found recently in large numbers in a store room of a zoological garden in Austria. Notes are provided on the biology, injuriousness and control of this beetle, which can harbour pathogens (such as *Salmonella* and *Escherichia coli*) of poultry.

Key Subjects

biology & behaviour, disease association; insecticide control

LAMBKIN TA. 1998. **Controlling black beetles (*Alphitobius diaperinus* (Panzer), Coleoptera: Tenebrionidae) in chicken sheds.** *Proceedings 1998 Poultry Industry Exchange Surfers Paradise 19-21 April 1998*, 33–37.

Abstract

The black or darkling beetle (*Alphitobius diaperinus* (Panzer)), which is of tropical origin, is a serious, cosmopolitan insect pest of chicken houses. Losses to production are indirect and result from the transmission of poultry disease, downgrading of bird feed quality, bird ingestion of large quantities of beetle larvae, damage to shed insulation and the high cost of pesticide applications. The duration of the pest's life cycle is dependent on temperature and humidity. As a result, beetle populations in chicken sheds tend to be localized around areas of high temperature and moisture. In very dry chicken sheds, the beetle will eat dead birds and at night, bit sleeping live birds. *A. diaperinus*, which is omnivorous and active in low light conditions is also an active flier and can readily infest new areas. Control of the pest traditionally has been by the use of chemicals and now insecticide resistant populations of the pests have been reported. Hygiene is an important component of pest control, which incorporates proper shed cleanouts and disposal of manure litter. Indications are that in Australia, control of *A. diaperinus* is becoming increasingly difficult and there is a need to adopt and integrated pest management system for the beetle, which would encompass an insecticide resistance management strategy.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN T & CAMERON MC. 1999. **Darkling beetle control – Current difficulties and future prospects.** *The Eleventh Australian Poultry & Feed Convention Proceedings*, 184–192.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, as pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LAMBKIN TA & CAMERON MC. 2000. **Darkling beetle control in Australian broilers – a new direction.** *Proceedings 2000 Poultry Information Exchange*, 97–102.

Abstract

The pest status of *Alphitobius diaperinus* (Panzer) and associated production losses in broiler and egg barn systems are discussed. In particular *A. diaperinus* transmits a large number of poultry diseases and parasites, and the degree of production loss from disease is related directly to beetle population size. Recent control failures of beetle populations in southeast Queensland are a result of fenitrothion resistance and the pest's ability to avoid contact with the insecticide. Australia's poultry industries' replacement of fenitrothion with a pyrethroid to control *A. diaperinus* is questioned, a pyrethroid resistance is known to develop quickly in many insect species. A proposed integrated pest management system is outlined that includes studies of beetle behaviour and population dynamics, a rotation of insecticides, an insecticide resistance management protocol and the use of novel insecticides and alternative control strategies.

Key Subjects

biology & behaviour; disease association; insecticide control

LANCASTER JL, SIMCO JS & EVERETT R. 1969. **Pre-treated rice hull for the control of the lesser mealworm.** *Report Series, Arkansas Agricultural Experiment Station* 174, 14pp.

Abstract

Infestations of *Alphitobius diaperinus* (Panz.) in poultry houses may give rise to a serious problem

because the larvae transmit the virus of fowl leucosis (cf. RAE/B 59, 338, etc.). In tests in Arkansas, coumaphos, Dursban, fenchlorphos (ronnel), malathion, carbaryl and Mobam (benzo(b)thien-4-yl methylcarbamate) were evaluated for the control of the beetle. The insecticides were applied to rice husks, a material frequently used as poultry litter, in the form of dusts and emulsifiable concentrates mixed with water and with oil. After treatment, the rice husks were stored in bags for various periods or used in poultry pens for eight weeks, and samples were tested at weekly intervals by placing them in containers, adding adults and larvae of *A. diaperinus* and recording mortalities after 72h. In tests of the rice husks used in poultry pens, material containing about 0.17% Dursban caused 100% mortality for eight weeks, that containing fenchlorphos at 0.17% was equally effective for three weeks, that containing Dursban at 0.125% was nearly as effective for three weeks and those containing the other insecticides at 0.07-0.18% were effective for 1-2 weeks. When stored, the treated rice husks remained effective for longer periods. No residues of Dursban were detected in the skin, muscle or liver and not more than 0.02 ppm in the fat of fowls kept for eight weeks on rice husks containing 0.125% Dursban. It is considered that complete elimination of the beetle from poultry houses may be possible by use of litter treated with 0.25% Dursban and that a high degree of effectiveness can be expected from treatment with carbaryl, coumaphos or malathion.

Key Subjects

insecticide control

LOHREN U. 1972. **The effect of different insecticides on the corn mould beetle (*Alphitobius diaperinus*).** *Deutsche Tierärztliche Wochenschrift* 79, 504–506.

Abstract

Results are given of studies on the control of the Tenebrionid *Alphitobius diaperinus* (Panz.), a tropical species that has been introduced into poultry houses in Germany with imported feeding stuff and become a severe pest. It is particularly favored by underground heating. It is known to transmit various pathogens of fowls (cf. RAE/B 60, 1535, etc.), including the virus of Marek's disease (an acute form of leucosis (57, 260)) and also some helminths (59, 1955, etc.). In laboratory tests in which adult beetle were topically treated with various insecticides in acetone solution, the LD95 of fenchlorphos (Gesektin K) in mg/beetle was 0.21 (cf. 57, 794; 59, 338), as compared with 0.6 for malathion (cf. 61, 1313), 4.2 for chlordane and 9.2 for diazinon. When exposed to concentrated serial solutions in petrie dishes, all beetles were killed by 0.1% fenchlorphos, but this concentration of propoxur killed only 5%. In tests of the duration of effectiveness and possible repellent effect on various surfaces, fenchlorphos was still giving 90% kill after 20 weeks among beetles exposed to treated concrete in a petrie dish in which they could avoid the treated surface. Diazinon gave 90% kill for 7 weeks. On all other surfaces tested, fenchlorphos was effective for about three times as long as diazinon. It was particularly effective on alkaline surfaces. To test the effectiveness of fenchlorphos as a mist, 100 beetles were exposed for 6h in each of four pails containing a

layer of filter paper or crumpled filter paper or 5 cm fresh or old litter. At the end of exposure and (in brackets) after 24h, 20(89), 14(35), 5(22) and 3(18) of the beetles in the four pails were dead. All were dead after 48h. Slabs of various materials were also placed in different positions in a room before it was treated and exposed to the action of the mist for 24h. their toxicity was then evaluated. Kill was less on perpendicular than on horizontal surfaces. A concentration of 5-15 ml/m³ is considered sufficient, and it is recommended that a film should be left on the floor and in places where the beetles are likely to congregate. A field test of fenclorophos was made in the Weser-Ems region, where *A. diaperinus* was increasing in spite of careful cleaning and treatment of poultry houses with broad-spectrum disinfectants before new stock was introduced, and spraying with BHC (HCH) had effected only a limited improvement. One section of a heavily infested farm was sprayed with a 0.5% solution of fenclorophos and a second and part of a third with 1% solution; the rest of the third farm and a fourth farm remained untreated. No beetles were seen after the treatment in the sprayed sections, whereas the others remained heavily infested. The treated farms remained free of infestation during an observed period of four months. Fenclorophos has medium toxicity for mammals and birds (an LD50 for fowls of 36 mg/kg, a compared with 8.4 for diazinon and 50 for DDT). It is concluded that it provides a contact, stomach and respiratory insecticide that is better than any hitherto described in ease of use and effectiveness against *A. diaperinus*.

Key Subjects

insecticide control

MILLER RW & REDFERN RE. 1988. **Feed additives for control of lesser mealworm (Coleoptera: Tenebrionidae) in poultry broiler houses.** *Journal of Economic Entomology* **81**, 1137-1139.

Abstract

In laboratory tests, lesser mealworm, *Alphitobius diaperinus* (Panzer), larvae were fed chicken rations containing one of six benzoylphenylurea compounds, thuringiensin, cyromazine, or ivermectin. The more active compounds were incorporated into the feed of broiler chicks housed in small pens to which adult lesser mealworms had been introduced. After 8 wk, essentially no lesser mealworm larvae could be found in the pens to which penfluron; 2,6-difluoro-N-[[[4-(trifluoromethoxy)phenyl]amino]carbonyl]benzamide; N-[[[3,5-dichloro-4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]phenyl]amino]carbonyl]-2,6-difluorobenzamide; N-[[[3,5-dichloro-4-(1,1,2,2-tetrafluoroethoxy)phenyl]amino]carbonyl]-2,6-difluorobenzamide; or ivermectin had been added to the feed at a level of ≤ 2.5 ppm.

Key Subjects

insecticide control

MILLER RW. 1990. **Use of ivermectin to control the lesser mealworm (Coleoptera: Tenebrionidae) in a simulated poultry broiler house.** *Poultry Science* **69**, 1281-1284.

Abstract

Broiler chickens were fed ivermectin (Ivomec) at a level of 2 p.p.m. for 5 weeks to determine its efficacy against *Alphitobius diaperinus*. This treatment essentially eliminated beetle larvae; no ivermectin residues were found in the livers of the treated chickens, even without a withdrawal period. However, the feeding of ivermectin may reduce body weights, body weight gain and feed efficacy at older ages.

Key Subjects

insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1974. **Flies and other insects in poultry houses.** *Ministry of Agriculture, Fisheries and Food leaflet 537*, 6pp.

Abstract

Fannia canicularis (L.) is the main pest found in poultry houses causing complaints from householders. *Musca domestica* L. and *Muscina stabulans* (Fall.) are often serious pests also. The life cycle and breeding habits of *F. canicularis* are described, and methods for its control and the control of other flies and preventive measures are noted. The habits and control of various beetles (particularly *Alphitobius diaperinus* (Panz.)), mites, moths and other flies found in poultry house litter are also briefly mentioned.

Key Subjects

biology & behaviour; insecticide control

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 1980. **Insects in poultry houses.** *Leaflet 537*, 8 pp.

Abstract

In the UK, pest problems encountered in poultry houses are related to the type of house and frequency of droppings removal. In laying houses where droppings are removed by conveyor belt every 3 to 4 days and in deep-litter houses for broilers where the litter is replaced every 8 to 10 weeks, serious infestations are unlikely to develop. However, in deep-pit houses where droppings are allowed to accumulate for up to 14 months and in deep-litter houses where litter is not replaced frequently, insect pest problems may occur. The first insects to appear in new droppings are usually *Leptocera* spp. and *Sciara* spp. At a later stage, *Musca domestica* L., *Fannia canicularis* (L.) and *Muscina stabulans* (Fall.) may colonise the droppings. Occasionally, the predatory fly *Ophyra capensis* (Wied.) may also occur. A wide range of insect species can breed in poultry droppings. After a few weeks, predatory beetles such as *Carcinops pumilio* (Erichs.) and staphylinids may be found and, as the droppings become drier, other beetles occur, including *Alphitobius diaperinus* (Panz.), which is common in deep-pit houses. *Dermestes* spp. may be present in very large numbers in deep-pit houses. Moths are also common in poultry houses where the larvae are usually found living in the droppings or in residues of very dry material. Although the commonest is *Endorsis sarcitrella* (L.), *Niditinea fuscipunctella* (Haw.) may occur in large numbers on dry droppings. *Ephestia kuehniella* Zell. may be found in and around feed hoppers and *Pyralis farinalis* (L.) has been found

in several deep-pit houses. In this revised leaflet, information is presented on the biology, morphology, injuriousness and control of these insects.

Key Subjects

biology & behaviour; insecticide control

MEKADA H, IMAEDA N & UMEDA K. 1984. **Effect of insecticide-impregnated insulation board on growth of chicks and vaporizing rate of the insecticide.** *Japanese Poultry Science* **21**, 330–332.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

MEKADA H, IMAEDA N, SHIGEZUMI S & EBISAWA S. 1983. **Control of *Alphitobius diaperinus* by polyurethane boards impregnated some insecticides.** *Japanese Poultry Science* **20**, 149–157.

Abstract

No abstract available

Key Subjects

insecticide control

NEMESERI L & GESZTESSY T. 1973. **Mass incidence and control of *Alphitobius diaperinus* on poultry farms.** *Magyar Allatorvosok Lapja* **28**, 335–338.

Abstract

Alphitobius diaperinus (Panz.) has been found on poultry farms in all parts of Hungary. Notes are given on the morphology and ecology of the Tenebrionid, which likes warm dark moist places and occurs mainly in the litter beneath water and feed troughs. It does not seem to play a part in the spread of coccidiosis or Ascarid infections among poultry. The larvae and adults can be destroyed by application of a 2% trichlorphon (cf. RAE/B 62, 380). In winter, it is recommended that poultry houses should be kept cool for 5 days as a control measure. Paper bags instead of gunnysacks should be used to distribute the poultry food in order to prevent the spread of the beetle.

Key Subjects

biology & behaviour; insecticide control

OHIO STATE UNIVERSITY. 1987. **Pesticides for poultry and poultry buildings.** *Ohio Cooperative Extension Service*, 12.

Abstract

No abstract available

Key Subjects

insecticide control

POSPISIL J. 1973. **Tests of olfactory repellents against *Alphitobius diaperinus* Panzer (Scarabaeidae) and *Dermestes maculatus* DeGeer (Dermestidae) (Col.).** Regulation of Insect Reproduction – Program & Abstracts – International Conference – Institute of Entomology Czechoslovak Academy of Sciences **112**, 1–10.

Abstract

Menthol, thymol and paradichlorobencene were tested on *A. diaperinus*, and they and naphthalene on *D. maculatus*. *A. diaperinus* were repelled by thymol

and by high concentrations of paradichlorobencene; menthol was only slightly repellent. *D. maculatus* was repelled by thymol; menthol and naphthalene showed some repellent action, while paradichlorobencene was relatively ineffective. *D. maculatus* lost its sensitivity to repellents when exposed to them for long periods.

Key Subjects

insecticide control

REMUS B, BAUSCHKE K, VOGEL K & BAHR I. 1983. **The importance and control of the lesser mealworm (*Alphitobius diaperinus*) in industrial broiler rearing premises.** *Monatshefte fuer Veterinaermedizin* **38**, 358.

Abstract

Observations carried out in broiler rearing premises in the German Democratic Republic indicated that *Alphitobius diaperinus* (Panz.), and important pest of stored products, could also play an important role as a vector of microorganisms pathogenic to poultry. Brief notes on the biology of the insects are given. Since only part of the pest population can be eradicated by insecticides in the premises, other measures should be developed which take account of behavioral characteristics, such as behavior-regulating effect of pheromones.

Key Subjects

biology & behaviour; insecticide control

SAMISH M & ARGAMANN O. 1991. ***Alphitobius diaperinus* beetles, a pest in poultry houses.** *Hassadeh* **72**, 387–389.

Abstract

This article reviews the biology and damages of the lesser mealworm (darkling beetle, *Alphitobius diaperinus*) with special reference to the status of this beetle in Israel. The four species of the genus *Alphitobius* found in Israel are: *A. diaperinus*, *A. laevigatus*, *A. ruficolor* and *A. viator*. The lesser mealworm, which was first recorded in Israel in 1953, is the only serious pest of poultry from this genus in the country. The structural damage due to this beetle, its potential role as reservoir of pathogens, its direct damage to the birds and their feed, their nuisance to people, their life cycle and the problems encountered during their control are discussed.

Key Subjects

biology & behaviour; insecticide control

SAXENA SC & SARIN K. 1972. **Relative toxicity of some common insecticides to the adults of *Alphitobius diaperinus* (Panz.).** *Indian Journal of Entomology* **34**, 349–351.

Abstract

In laboratory tests in India on the contact toxicity of five commonly used insecticides to adults of *Alphitobius diaperinus* (Panz.), a pest of stored food-stuffs, the LC50's calculated from mortality percentages 48h after a direct spray application showed that mevinphos was the most toxic material, followed by fenitrothion, pyrethrins (Pyrethrum), gamma BHC (lindane) and *p,p'*-DDT.

Key Subjects

insecticide control

SILBERMANN MS & SCHMITTLE SC. 1967. **Chemical control of the lesser mealworm, *Alphitobius diaperinus* (Panz.), (Coleoptera: Tenebrionidae).** *Journal of the Georgia Entomological Society* **2**, 1–8.

Abstract

Various compounds were evaluated in the laboratory and field to determine their efficacy in controlling the adult beetle, *Alphitobius diaperinus* (Panz.), in poultry houses. Dimethoate, ronnel, Dursban, and carbaryl, all give satisfactory results within three days after treatment. Eidson et al., (1966), showed that the lesser mealworm, *Alphitobius diaperinus* (Panz.) was capable of inducing acute leukosis (Marek's disease) in chickens. Almost all poultry houses in Georgia visited by the authors harbored this insect. Eidson (1965) found the beetle in New York and Maine, while one of the authors found it in Minnesota in 1966. We have received specimens of *A. diaperinus* from Maryland, Missouri, North Carolina and South Carolina. The prevalence of this insect and its relationship to leukosis has led to these studies on the evaluation of various chemical controls in the laboratory and in the field.

Key Subjects

insecticide control

SPENCER A & BRØCHNER JESPERSEN J. 1998. **Insecticide use and resistance in beetles infesting broiler houses in Denmark.** *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

A survey of Danish broiler producers was conducted by way of detailed questionnaire to ascertain the prevalence of litter beetle infestation, and the control measures used to manage them. A total of 177 questionnaires were returned completed and are included in our analysis. This represents approximately 54% of Denmark's broiler producers. Almost 60% of those responding reported litter beetle infestation. Of these 76% used insecticidal treatments. A wide variety of insecticides were used, with organophosphates being the most popular one. In spite of the persistence of most infestations, all but one of the respondents reported good or moderately good effect from insecticidal treatment. However, in visits to infested farms soon after treatment we have often found large numbers of apparently unaffected beetles. We are therefore currently carrying out a survey of insecticide resistance on litter beetles collected from infested farms. This study involves a range of insecticides including organophosphates, carbamates and pyrethroids. We plan to report on our findings in 1999.

Key Subjects

insecticide control

SWATONEK F. 1970. **On the biology of the lesser mealworm beetle (*Alphitobius diaperinus*).** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **43**, 101–104.

Abstract

It is reported that large numbers of *Alphitobius diaperinus* (Panz.) developed in a fowlhouse near Vienna (cf. also RAE/A 60,4526), so that control measures became necessary. The house was cleared,

thoroughly cleaned out and then sprayed with gamma BHC (lindane), care being taken to treat the cracks and gaps between the concrete floor and the structural woodwork. One day after treatment, the dead beetles numbered 34/m². The Tenebrionid may have been introduced with the feed. Studies showed that the beetle can reproduce only in conditions of high temperature and high humidity, and there appears to be no possibility that it will become a serious pest in the field in Europe.

Key Subjects

biology & behaviour; insecticide control

SCHULTKA H, BETKE P & STUBGEN H. 1984. **Device to generate insecticide-aerosol-air mixtures in broiler houses for controlling the lesser mealworm (*Alphitobius diaperinus*).** *Monatshefte fuer Veterinaermedizin* **39**, 561–562.

Abstract

Described in this paper is a technology for the control of *Alphitobius diaperinus*, Panzer 1797, on broiler production units, with due consideration being given to biological attitudes. The beetle can be controlled right into the wall insulation in the service period by preheating of the hall temperature between 32°C and 37°C and application of insecticide aerosol mixture in hot-air flow with temperatures between 50°C and 60°C, using Py-ULV 78 or Delicia-Milon aerosol. The population can thus be reduced to levels below the damage threshold.

Key Subjects

insecticide control

SIMCO JS, EVERETT R & LANCASTER JL JNR. 1966. **Preliminary studies on control of lesser mealworm in broiler houses.** *Arkansas Farm Research* **15**, 8.

Abstract

No abstract available

Key Subjects

insecticide control

SCHMITZ VM & WOHLGEMUTH R. 1988. **Studies on mass development and behavior of the lesser mealworm *Alphitobius diaperinus* Panz. in poultry houses and its control.** *Anzeiger fuer Schaedlingskunde Pflanzenschutz Umweltschutz* **61**, 108–114.

Abstract

No abstract available

Key Subjects

biology & behaviour; insecticide control

TURNER EC JNR. 1986. **Structural and litter pests.** *Poultry Science* **65**, 644–648.

Abstract

The importance of rodents and Coleoptera as structural pests of poultry houses, particularly in Virginia, is discussed. The pests include mice (*Mus musculus*), rats (*Rattus norvegicus* and *R. rattus*, *Dermestes lardarius*, *D. maculatus* and the tenebrionid *Alphitobius diaperinus*, of which mice and the tenebrionid are the most important. These pests are destructive to the fiberglass and polystyrene insulation in structural walls, causing serious losses. Brodifacoum, bromadiolone and difenacoum are recommended for controlling rodents including those

resistant to anticoagulant rodenticides. Studies have shown that an increase in manure moisture was an important factor causing increased dispersion and migration of adults of *A. diaperinus* into the insulation of the houses. Larvae were more able to crawl up vertical pit walls constructed of wood than those made of cinder blocks, thus allowing easier access to insulation. Chlorpyrifos, permethrin, stirofos (tetrachlorvinphos) and carbaryl were toxic to both larvae and adults. Several new formulations of expanded polystyrene foam insulation were more resistant to beetle damage than untreated polystyrene insulation.

Key Subjects

biology & behaviour; insecticide control

TOYOSHIMA K, BANBA H & KAMIYA M. 1996. **Control of *Alphitobius diaperinus* Panzer in chicken houses. I. Sensitivity to insecticides of adult.** *Research Bulletin of the Aichi-ken Agricultural Research Center* **28**, 363–367.

Abstract

Experiments were conducted to control *A. diaperinus* in high floor chicken houses. The sensitivity of adults to insecticides was examined by filter paper and spray methods. Using the filter paper method, the adult was sensitive to naled, metriphosphate (trichlorfon), carbaryl, fenitrothion + permethrin, and fenitrothion + resmethrin with piperonyl butoxide. From the results, the authors consider that sprinkling these insecticides on the droppings surface would be effective in controlling the insect pest in spring, autumn and winter. With the spray method, the adult was sensitive to cyfluthrin, permethrin, naled, fenitrothion + permethrin, and fenitrothion + resmethrin with piperonyl butoxide. The authors thought it would be effective to spray these insecticides in poultry houses in summer.

Key Subjects

insecticide control

TABASSUM R, NAQVI SNH, JAHAN M, NURULAIN SM, KHAN MF & AZMI MA. 1998. **Determination of the toxicities of fenpropathrin (pyrethroid) and neem formulation (RB-a + PBO + Tx-100) against *Alphitobius diaperinus* adults and their effects on transaminases.** *Turkish Journal of Zoology* **22**, 319–322.

Abstract

The toxicity of a neem formulation (RB-a plus piperonyl butoxide plus Triton X 100) and fenpropathrin (Danitol) to adults of *Alphitobius diaperinus* was determined in the laboratory at 30±2°C and 60±5% RH. A 117.8 ug/cm² dose of neem formulation caused 70% mortality, while a 1.96 ug/cm² dose of fenpropathrin caused 88% mortality. The LD50 of fenpropathrin WS 0.2749 ug/cm², and that of the neem formulation was 58.92 ug/cm². Fenpropathrin-treated *Alphitobius diaperinus* adults showed inhibitions of 44.66 and 45.91% of GPT (alanine aminotransferase) and GOT (aspartate aminotransferase) activity, respectively. In insects treated with neem formulation, these activities were inhibited by 52.48 and 12.15%, respectively.

Key Subjects

insecticide control

TEN HAKEN EH. 1981. **Assessment of seven insecticides for the control of the lesser mealworm *Alphitobius diaperinus* in poultry houses.** M.A.F.F. Internal Report.

Abstract

No abstract available

Key Subjects

insecticide control

WEAVER JE & KONDO VA. 1987. **Laboratory evaluation of insect growth regulators in producing lesser mealworm mortality and egg fertility.** *Journal of Agricultural Entomology*. **4**, 233–245.

Abstract

Five benzoylurea insect growth regulators (IGRs), triflumuron (= Alsystin), and Union Carbide compounds UC76724, UC75118, UC75150, and UC84572 were evaluated for efficacy in producing larval mortality and infertility in eggs from treated adults of the lesser mealworm, *Alphitobius diaperinus* (Panzer). Triflumuron treated diets of 0.125 to 0.0312% AI produced 100% mortality in instars 1-6 and 7-last at the end of 2 and 4 wk on diets respectively. High rates of larval mortality were also observed in larvae on UC treated diets of 0.1 to 0.001% AI. At the 0.1% AI rate, the UC compounds compared favorably with triflumuron; UC84572 was the most effective UC compound. Adults maintained on triflumuron treated litter or treated diet mixed with litter, did not produce larval populations; low numbers of larvae did begin to appear at 4 wk post removal from treated litter (spray and diet). Complete inhibition of hatch of eggs produced by adults on diets of triflumuron mixed with low chow occurred at 16d post-treatment and continued through 56d on the treatments; after transfer to untreated diet (at 56d), the first egg hatch did not occur until day 28. Adults on UC84572 diets were affected about equally as those on diets of triflumuron, especially at the one comparable rate of 0.1% AI; no hatch occurred until 53d after transfer to untreated diet. Abnormalities occurring in immature stages exposed to the IGRs are shown. These abnormalities include ecdysis inhibition, deformed larvae, and larval/pupal intermediates.

Key Subjects

insecticide control

VAUGHAN JA & TURNER EC JNR. 1984. **Residual and topical toxicity of various insecticides to the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **77**, 216–220.

Abstract

Experiments were conducted to determine the relative toxicities of seven insecticides to adult and late instar lesser mealworms and to compare the residual activity of permethrin and carbaryl on polystyrene and unpainted plywood. In the residual activity tests, insecticide performance was altered by differences in formulation, surface type, and life stage of the insect. Wettable powder formulations were more effective on polystyrene than were emulsifiable concentrate formulations. Residual activity of permethrin and carbaryl was longer and more effective on polystyrene surfaces than on unpainted plywood.

Tetrachlorvinphos WP (0.50% AI) gave excellent control on both surfaces. In the topical application experiments, permethrin, famphur, and tetrachlorvinphos, carbaryl, and propoxur were more toxic to late instars than to adults. The reverse was true for malathion. Protection administered to polystyrene insulation by surface sprays may be nullified by the burrowing habits of the insects. Toxicity profiles of different mealworm populations may depend on different spray regimes within poultry houses.

Key Subjects

insecticide control

WEAVER JE. 1996. **The lesser mealworm, *Alphitobius diaperinus*: Field trails for control in a broiler house with insect growth regulators and pyrethroids.** *Journal of Agricultural Entomology* **13**, 93–97.

Abstract

Two trials were conducted under field conditions for control of the lesser mealworm, *Alphitobius diaperinus* (Panzer), in a broiler grow-out house. Larvae were controlled with treatments applied after litter cleanout and either before the addition of the new litter or to the surface of the new litter. Three benzoylurea insect growth regulators (IGRs) and two pyrethroids provided 95%-100% control of larvae through a 42 d grow-out period. The IGRs hexafluron, triflumuron and UC84572 were equally as effective in controlling larvae as the two pyrethroids, cyfluthrin and permethrin. The pyrethroids greatly reduced the adult beetle population within 7d post-treatment and held the population at low levels through the 42 d study; control of adults with the IGRs was not comparable. Numbers of adults were lower in most IGR treatments but in general not significantly different than untreated controls. Adult migration from untreated areas could have influenced these results.

Key Subjects

biology & behaviour; insecticide control

WILDEY KB. 1983. **Insect pests in animal houses - current control developments.** *Proceedings of the 6th British Pest Control Conference.*

Abstract

Recent developments in the control of insect pests in intensive animal housing units in the United Kingdom are reviewed and discussed with reference to the increase in pest problems resulting from increased intensification, the main pests (flies (including *Musca domestica* and *Fannia canicularis*), beetles (including *Dermestes maculatus* and *Alphitobius diaperinus*), the lepidopterous *Niditinea fuscipunctella* and *Endrosis sarcitrella*, *Ceratophyllus gallinae* and *Pyemotes* spp.); control difficulties; measures currently in use (application of diflubenzuron and other insect growth regulators as larvicides, use of baits based on insecticides, and entomopathogenic nematodes against flies, and conventional residual surface treatments and use of physical barriers against beetles).

Key Subjects

biology & behaviour; insecticide control

WALLACE MMH, WINKS RG & VOESTERMENS J. 1985. **The use of a beetle, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) for the biological control of poultry dung in high-rise layer houses.** *Journal of the Australian Institute of Agricultural Science* **51**, 214–219.

The lesser mealworm, *Alphitobius diaperinus* (Panzer), is commonly found in poultry houses and often considered a pest. A situation is described in which it has been encouraged to build up large populations in the dung of high-rise layer houses and now plays an important role in drying out the moist dung. As a result, the dung is rendered unfavorable for fly breeding, and is easy to remove.

Key Subjects

insecticide control; biocontrol agent

WAKEFIELD ME & COGAN PM. 1992. **Laboratory study of resistance to iodofenphos and malathion in *Alphitobius diaperinus*.** *Central Science Laboratory Report* **42**, 19.

Abstract

Alphitobius diaperinus is considered a major pest in poultry houses because of its disease carrying capability and the damage it causes to insulation materials. Failure of treatments to control *Alphitobius diaperinus* in a turkey broiler house led to a laboratory investigation to determine whether this population was resistant to current M.A.F.F. approved insecticides. This investigation led to the determination of tentative discriminating doses of 0.5% for iodofenphos and 0.25% for malathion using the F.A.O. recommended filter paper method. Other methods for the production of probit response lines were also investigated.

Key Subjects

insecticide control

WAKEFIELD ME & COGAN PM. 1990. **Resistance to iodofenphos and malathion in the lesser mealworm *Alphitobius diaperinus*.** *In Proceedings 5th International Working Conference of Stored Protection, Bordeaux 1990*, 1065–1074.

Abstract

Alphitobius diaperinus is a major pest in poultry houses due to the damage that it causes to insulation material and to its disease carrying capability. Recently, treatment failures for *Alphitobius diaperinus* have been reported and an investigation was undertaken to determine whether these populations were resistant to the insecticide approved by M.A.F.F. for fabric treatments. Using a method based on the FAO recommended filter paper method for stored product beetles, tentative discriminating doses for iodofenphos and malathion were determined as 0.5% and 0.25% respectively. Using these discriminating doses it was found that almost half of the field populations tested were resistant to one or both of the insecticides. These findings have serious implications for both the feed milling and poultry industries.

Key Subjects

insecticide control

SECTION 5. NON INSECTICIDE CONTROL ARTICLES (BY AUTHOR/S)

ALICATA JE. 1945. **The value of crude naphthalene in controlling the beetle, *Alphitobius diaperinus*.** *Hawaii Agricultural Experiment Station Report 1943-1944*, 106–107.

Abstract

No abstract available

Key Subjects

non insecticide control

APUYA LC, STRINGHAM SM, ARENDS JJ & BROOKS WM. 1994. **Prevalence of protozoan infections in darkling beetles from poultry houses in North Carolina.** *Journal of Invertebrate Pathology* **63**, 255–259.

Abstract

A study was conducted from November 1990 to February 1992 on the prevalence of protozoan infections in *Alphitobius diaperinus*, from turkey and broiler houses in the southeastern, northeastern and central Piedmont regions of North Carolina, USA. Beetles were commonly infected with the eugregarine *Gregarina alphitobii*, an undescribed species of *Gregarina* (Eugregarinorida, Gregarinidae) and the neogregarine *Farinocystis tribolii* (Neogregarinorida, Lipotrophidae). Both eugregarine and neogregarine parasites were present throughout the sampling period. A decreased trend in percentage infection by eugregarines in beetles from broiler houses was observed through time, while percentage infection in turkey houses showed a variable trend. Percentage neogregarine infection exhibited a variable trend with a significant difference in the overall rate of infection in the 2 types of production houses. Neogregarine infection was higher in the broiler houses than in turkey houses. Both adult and larval stages of the beetle were infected with the gregarines, with higher levels of infection observed in the larval stages. Mixed infections with both types of gregarines were highest in the smallest larvae.

Key Subjects

non insecticide control

ARENDS JJ & STRINGHAM SM. 1989. **Poultry Pest Management.** North Carolina Cooperative Extension Service, College of Agriculture and Life Sciences, North Carolina State University.

Abstract

No abstract available

Key Subjects

non insecticide control

BALA P, KAUR D, LIPA JJ & BHAGAT RC. 1990. ***Gregarina alphitobii* sp. n. and *Mattesia alphitobii* sp. n., parasitizing *Alphitobius diaperinus* Panz (Tenebrionidae, Coleoptera).** *Acta Protozoologica* **29**, 245–256.

Abstract

Gregarina alphitobii sp. nov., and *Mattesia alphitobii* sp. nov., parasitizing natural and laboratory populations of *Alphitobius diaperinus* Panz. in Africa (Nigeria), Europe (France, Poland, Germany), North America (USA) and Asia (India, Tonga Island) are

described. *G. alphitobii* sp. nov. which is found in the mid and hindgut, is similar to *Gregarina cuneata* but differs from it in having a narrower protomerite and deutomerite and smaller cysts. *M. alphitobii* sp. nov., which infects the midgut and fat body of *A. diaperinus*, can be characterized by the size and shape of spore, prominence of polar protuberances, and the presence of polar plugs and two annular ridges. The life histories of both species is described. Some data on prevalence and distribution are also presented.

Key Subjects

non insecticide control

BATTU GS & DHALI WAL GS. 1975. **On the activity of certain spider predators against stored grain insect pests.** *Current Science* **44**, 893–894.

Abstract

In the light of evidence of predation on certain stored-product insects by spiders in India, adults and juveniles of *Artema atlanta* Walck., *Marpissa* sp., *Oecobius* sp., *O. putus* Cambridge, *Selenops agumbensis* Tikader and *Uloborus dandolius* Tikader collected from rural wheat stores near Ludhiana in July and August 1974 were starved and then offered adults or larvae of *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.), *Tribolium castaneum* (Hbst.) and *Alphitobius* sp. as prey in the laboratory, observations on insect mortality were made every 24h and the results are presented in a table. All 6 spider species preyed actively on the grain pests, and their methods of feeding are described. The preferred prey, against which all the spiders were very efficient, was the larvae of *T. castaneum*; *Artema atlanta* was equally effective against *S. oryzae*, and *Selenops agumbensis* against *R. dominica*.

Key Subjects

non insecticide control

CRAWFORD PJ, BROOKS WM & ARENDS JJ. 1998. **Efficacy of field-isolated strains of *Beauveria bassiana* (Moniliales: Moniliaceae) as microbial control agents of the lesser mealworm (Coleoptera: Tenebrionidae).** *Journal of Economic Entomology* **91**, 1295–1301.

Abstract

Two field isolates (NC2 and NC3) of *B. bassiana* were evaluated as microbial control agents of *Alphitobius diaperinus* in a bioassay system incorporating physical characteristics of commercial poultry houses. Both isolates produced >90% mortality in new litter against larval *A. diaperinus* at the highest application rate (2.37×10^{11} conidia per square metre) 2 wk after application. Neither isolate achieved as high a rate of mortality in used litter. Adult *A. diaperinus* were less susceptible than larvae to these isolates. At the highest application rate (2.37×10^{11} conidia per square metre), isolate NC2 conidia achieved 60% mortality of adults in new litter and 33% mortality in old litter. The same concentration of isolate NC3 conidia produced 68 and 33% mortality in new and used litter, respectively.

Key Subject

non insecticide control

DASS R, AGARUAL RA & PAULAUN. 1984.

Feeding potential and biology of lesser mealworm *Alphitobius diaperinus* (Panz.) (Col., Tenebrionidae), preying on *Corcyra cephalonica* St. (Lep., Pyralidae). *Zeitschrift fuer Angewandte Entomologie* **98**, 444–447.

Abstract

The grubs and adults of the lesser mealworm, *Alphitobius diaperinus* (Panz.) were found gregariously feeding on the eggs and larvae of *Corcyra cephalonica* St. for the first time in India. The development period from egg to adult was completed in 70 to 89 days at $27 \pm 1^\circ\text{C}$ and $65 \pm 5\%$ R.H. The mean egg, larval and pupal periods were 6.6, 68.8 and 8.4 days, respectively. The longevity of most of the beetles was between 14 and 16 months and they laid fertile eggs ranging between 1059 to 1874 per female. Some of the beetles are found to survive beyond 16 months and lay very few eggs. The beetle remained active in the laboratory throughout the year with a peak during summer season.

Key Subjects

biology & behaviour; non insecticide control

DUFOUR L, SANDER JE, WYATT RD, ROWLAND GN & PAGE RK, 1992.

Experimental exposure of broiler chickens to boric acid to assess clinical signs and lesions of toxicosis. *Avian Diseases* **36**, 1007–1011.

Abstract

The safety of using orthoboric acid in poultry houses to control darkling beetles (*Alphitobius diaperinus*) was assessed. One-day-old broiler chicks were housed on litter treated with 0, 0.9, 3.6 or 7.2 kg of boric acid per 9.3 m² of floor space. After 15 days, average body weights were 340.7, 278.1 and 213.2g for chickens exposed to 0, 3.6 and 7.2kg boric acid/9.3 m², respectively. Feed conversion was 1.68 and 2.29 in chickens exposed to 0 and 7.2 kg boric acid/9.3 m². In a second experiment, after birds ingested feed treated with 2500 and 5000 PPM (mg/kg) of boric acid for 2 weeks, body weights were 254.8 and 149.6g, respectively. The chickens in the control group weighed an average of 285.0g. The 5000 PPM treatment group had a feed conversion of 1.70 compared with 1.45 in the controls. A dose-related feathering abnormality was evident in treated chickens. No significant histopathological changes were observed. Survival, weight gain, and feed conversion were not adversely affected in broilers as a result of exposure to litter treated with boric acid at the recommended levels of 0.4-0.9 kg/9.3 m². (unknown if this is complete abstract)

Key Subjects

non insecticide control

GEDEN CJ, ARENDS JJ & AXTELL RC. 1987.

Field trials of *Steinernema feltiae* (Nematoda: Steinernematidae) for control of *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) in commercial broiler and turkey houses. *Journal of Economic Entomology* **80**, 136–141.

Abstract

Infective juveniles of the All strain of *Steinernema feltiae* (*Neoaplectana feltiae*) were applied at a rate of 100 000/m² to the soil floors of 1 broiler and 2 turkey houses in North Carolina with known recent histories of infestation with *Alphitobius diaperinus*. After the addition of fresh litter and new flocks of birds, beetle populations increased more slowly in treated than in untreated houses. Soil samples were bioassayed biweekly for the presence of nematodes by adding beetle larvae. Nematodes persisted (63-87% beetle mortality) for 7 weeks after treatment on 2 of the farms; on the 3rd farm, beetle mortality was <50% at 3 weeks after treatment. When soil in plastic containers was treated a varying nematode rates and held for 6 months in a poultry house, beetle mortality ranged from 0 (103 nematodes/m²) to 48.2% (106 nematodes/m²).

Key Subjects

non insecticide control

GEDEN CJ, ARENDS JJ, RUTZ DA & STEINKRAUS DC. 1998.

Laboratory evaluation of *Beauveria bassiana* (Moniliales: Moniliaceae) against the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae), in poultry litter, soil, and a pupal trap. *Biological Control* **13**, 71–77.

Abstract

The virulence of 4 strains of *Beauveria bassiana* was tested against larvae of *Alphitobius diaperinus* using contact bioassays, treated litter and treated soil in the laboratory at 26°C, LD 16:8 and 60-70% RH. The relative susceptibility of different stages of tenebrionids to *B. bassiana* was also determined and a trap for infecting mature larvae was tested. Five- and 10-day-old larvae were highly susceptible to the WV strain of *B. bassiana* with LC50s of 1.73×10^2 and 2.49×10^2 conidia/ml, respectively. The LC50s for adults and 15-day-old larvae were 1.94×10^5 and 1.01×10^4 , respectively. Two *A. diaperinus*-derived strains of *B. bassiana* (WV and NC) were more virulent for larvae and adults than house fly-derived strains (HF88 and HF89) in forced-contact bioassays. Strain HF88 caused higher larval mortality than WV and NC in poultry litter, but adult mortality in litter never exceeded 20% with HF88. In soil bioassays, strain WV and NC gave 90-100% control of prepupae when conidia were applied in starch dust to the soil surface at 2.5×10^{11} conidia/m². Both WV and NC strains killed 100% of larvae that were exposed to treated pupation traps at 4×10^3 conidia/cm².

Key Subjects

non insecticide control

GEDEN CJ & AXTELL RC. 1988. **Effect of temperature on nematode (*Steinernema feltiae* (Nematoda: Steinernematidae)) Treatment of soil for control of lesser mealworm (Coleoptera: Tenebrionidae) in turkey houses.** *Journal of Economic Entomology* **81**, 800–803.

Abstract

In North Carolina, infective juveniles of *Steinernema feltiae* (*Neoaplectana carpocapsae*) (All stain) were applied at the rate of 106 per m² to the soil floors of 2 turkey houses with small populations of *Alphitobius diaperinus*; a 3rd house was left untreated. The

overall mean air temperature during the 9 weeks after treatment was 26.4°C. Soil bioassays indicated that nematodes were present in treated soil at 3 weeks but not at 5, 7 or 9 weeks after treatment. Larval or adult beetle population densities in the treated houses did not significantly compared with the control house. When nematodes were applied to soil and then assayed for survival after being held in the laboratory at 4 different temperatures, none survived beyond 2 weeks after treatment in soil held at temperatures >24°C. Nematodes were still detected at 9 weeks after treatment in soil held at 20 and 24°C.

Key Subjects

biology & behaviour; non insecticide control

GEDEN CJ, AXTELL RC & BROOKS WM. 1985.

Susceptibility of the lesser mealworm, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae) to the entomogenous nematodes *Steinernema feltiae*, *S. glaseri* (Steinernematidae) and *Heterorhabditis heliothidis* (Heterorhabditidae). *Journal of Entomological Science* 20, 331–339.

Abstract

The pathogenicity of *Steinernema feltiae* (*Neoplectana carpocapsae*), *S. glaseri* (*N. glaseri*) and *Heterorhabditis heliothidis* to early-instar larvae, late-instar larvae, pupae and adults of the tenebrionid *Alphitobius diaperinus* were evaluated under different habitat conditions in the laboratory in North Carolina. When kept in petri dishes with nematode-treated filter paper, all stages of the beetle were highly susceptible to attack by *N. carpocapsae*, the LD50s ranging from 9 to 56 nematodes/host. Early-instar larvae (LD50 = 26) and pupae (LD50 = 36) were most susceptible than late-instar larvae (LD50 = 1971) and adults (LD50 = 724) to *H. heliothidis*. Only adult beetles (LD50 = 714) were susceptible to *N. glaseri*. Late-instar beetle larvae were more susceptible to *N. carpocapsae* in rearing medium (LD50 = 24), broiler litter (LD50 = 258) and poultry faeces (LD50 = 212) than to *H. heliothidis*, which caused <50% mortality at all dose rates in these substrates. Adults were less susceptible than larvae in these substrates, and mortality only exceeded 50% in litter treated with *N. carpocapsae* (LD50 = 971). Late-instar larvae were highly susceptible to both *N. carpocapsae* and *H. heliothidis* in sandy loam and clay soils, the LD50s ranging from 1 to 14 nematodes/larva. Pupal mortality was higher in sandy loam (the LD50s for *N. carpocapsae* and *H. heliothidis* being 46 and 444, respectively) than in clay soil (95 and 5796, respectively).

Key Subjects

non insecticide control

GERSDORF E. 1969. **The cereal mildew beetle (*Alphitobius diaperinus* PZ. Ten.) in cockerel-fattening units.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* 42, 153–155.

Abstract

The author describes the way in which intensive rearing units for male chicks are used in northern Germany, many being built over pig- or cattle-fattening units in order to utilize the heat; insect or mite infestations can occur if there is any space between the ceiling of the lower unit and the floor of

the upper unit, in which spilt chick food and other litter can accumulate. The chickens become full-grown in six weeks and are reared at such a density that cleaning or spraying the floor is possible only in the intervals between broods. Among the insects present (most of which are harmless to the chicks), *Alphitobius diaperinus* (Panz.) has been reported in large numbers in some units, taking eight weeks to develop at about 22°C. Insects in the containers of mixed cereal feed or exposed on the floor of the upper unit are eaten by the chickens, and beetles hide mainly in the litter between the floors, passing right through to the lower unit when the upper unit is emptied and cleaned and the temperature falls at the end of a chick-rearing cycle. *A. diaperinus* can not develop for long in clean meal or other dry cereal food, unless this becomes damp and mouldy from spilt drinking water or chicken droppings on the floor of the rearing unit. The source of the infestations is not known, since the beetle cannot survive in the normal climatic conditions of northern Germany and has not been found in chick food before it reaches the rearing unit. It is suggested that adult may move from unit to unit on warm summer days, but in fact little spread occurs and large populations tend to build up in a few isolated units. Chemical control is not feasible unless rearing cycles can be arranged so as to allow both upper and lower units to be empty at the same time, but infestation can be reduced by filling holes or cracks in the upper floor and the space between the upper floor and the lower ceiling. At present, the beetle cannot be considered a pest of the chick food in the feeding containers, and it sometimes provides the birds with supplementary protein.

Key Subjects

biology & behaviour; non insecticide control

JESPERSEN JB & LAURIDSEN MK. 1997.

Chemical control of litter beetles in a parent flock farm. *Danish Pest Infestation Laboratory Annual Report*, 74–75.

Abstract

The lesser mealworm *Alphitobius diaperinus* (together with certain other beetle species) is a problem in the egg production houses of parent flock farms, which produce eggs for broiler production. The problems are mainly related to the damage that the beetles cause to the insulation of the houses and the potential of the beetles to act as reservoirs for pathogens, in particular salmonella. A field test was carried out to evaluate the efficacy of treatments made with Baycidal WP 25 alone or in combination with Baythion-EC or Solfac WP 10 to control litter beetles (in particular *A. diaperinus*) in such parent flocks. The active ingredients in Baycidal WP 25, Baythion-EC, and Solfac WP 10 are triflumuron, phoxim and cyfluthrin, respectively. The test was carried out in a parent flock in South Jutland and ran from February 1997 until January 1998. The farm comprises eight houses, separated by a feed alley. One week before new hens were introduced, two of the houses were sprayed with Baythion-EC, while two other houses were sprayed with Solfac WP 10. In both cases the treatment involved spraying the walls up to one metre above ground level, and spraying the floor up to one metre from the walls. These four houses, together with two further houses, were treated with Baycidal

WP 25 treatments involved topical application to the manure heaps under the slats. Two houses were left as untreated controls. The efficacy of the treatments was monitored every two weeks by the placement of 10 tube traps in each house between one and three days on the top of the manure, out of reach of the hens. All the treatment strategies successfully controlled *A. diaperinus* in the six treated poultry houses, whereas in the two untreated control houses the numbers of *A. diaperinus* increased steadily during the period.

Key Subjects

insecticide control

LE TORCH JM. 1983. **Laboratory study of the susceptibility to carbon dioxide and nitrogen of several species of stored product insects with a view to the disinfestation of stores.** *Agronomie* 3, 399–406.

Abstract

Studies were made on the tolerance of several insect pests of stored products to exposure to carbon dioxide or nitrogen gas. The experiments were carried out in a controlled environment chamber in a set of small exposure cells containing the batches of insects, exposed to continuous flow of the inert gas or air (control). The reactions of seven species: *Trogoderma granarium* Everts, *Carpophilus ligneus* Murr., *Alphitobius diaperinus* Panz., *Tenebrio molitor* L., *Tribolium confusum* Duv., *Anagasta kuehniella* Zell. and *Plodia interpunctella* Hubn. were observed at different development instars at temperatures of 15, 18 and 25°C and 85% RH. The exposure time needed to kill 99% of the population was generally estimated by regression after probit transformation of the mortality rate. The curves showed both gases to have effective killing action: 6 of the species withstood less than 10 days of exposure at all temperatures for all stages except eggs. Only the larvae of the khapra beetle, *Trogoderma granarium*, survived more than 25 days with nitrogen and nearly 17 days with carbon dioxide. Some variation was observed with species, stages and temperatures. In some cases, the 2 gases did not have the same effect, particularly at the lowest temperature: carbon dioxide was more efficient than nitrogen for *T. granarium*, *C. ligneus*, *A. diaperinus*, *T. molitor* and less efficient for *T. confusum*, *A. kuehniella*, *P. interpunctella*. Keeping stored products under an inert atmosphere could be used, like fumigation, as a disinfestation process, with practicable exposure times.

Key Subjects

non insecticide control

LORENZO P. 1990. **Application of 60Co gamma radiation to control insects in stored rice. Part IV. *Lasioderma serricorne* (Anobiidae: Coleoptera), *Alphitobius diaperinus* and *Tenebrionido* sp. (Tenebrionidae: Coleoptera).** *Ciencia y Técnica en la Agricultura (Arroz)* 13, 1–2, 67–76.

Abstract

The effects of 60Co gamma radiation from 0.2 to 1.0 kGy on *Lasioderma serricorne*, *Alphitobius diaperinus* and *Tenebrionido* sp. were investigated. A dose of 0.6 kGy effectively controlled these pests in stored rice.

Key Subjects

non insecticide control

RUEDA LM & AXTELL RC. 1997. **Arthropods in litter of poultry (broiler chicken and turkey) houses.** *Journal of Agricultural Entomologie*. 14, 81–91.

Abstract

Samples (110) of litter were collected in November–December 1993 and May–June 1994 from 26 commercial broiler chicken houses (18 farms) and 30 turkey (brooder and growout) houses (15 farms) in 5 counties of North Carolina, USA, and the arthropods within the litter were recovered by using Tullgren funnels. Mites extracted from the litter samples belonged to 2 orders (Parasitiformes and Acariformes) and 9 families (Macrochelidae, Urodynychidae, Tetraturidae, Parasitidae, Digamasellidae, Laelapidae, Cheyletidae, Acaridae, and Eremulidae). The most common mites were Acaridae and the trematid *Trichouropoda orbicularis*. Predatory macrochelid mites (*Macrocheles muscaedomesticae*, *M. merdaria*, and *Macrocheles* sp.) were collected in 45% and 49% of the litter samples from poultry houses in 1993 and 1994, respectively. Other predatory mites extracted were *Fuscuropoda marginata* and *Cheyletus malaccensis*. In addition, 110 duplicate litter samples were held with sentinel eggs of the beetle *Alphitobius diaperinus* to detect mites preying on the eggs; the mite *Acarophenax mahunkai* (Acarophenacidae) was recovered from 2 broiler houses and 1 turkey house. Insects collected from the litter samples belonged to 7 orders and 14 families. *Alphitobius diaperinus* was the dominant insect species and was found in all litter samples. The predatory histrid beetle *Carcinops pumilio* was found in 59% of litter samples. The pyralid moth pest *Pyralis farinalis* occurred in 10% of the litter samples. Other insects identified to species or genus were *Musca domestica* (larvae), *Palorus subdepressus*, *Dendrophilus xavieri* (larvae), *Gnathoncus nanus*, *Monotoma* sp. and *Trox* sp.

Key Subjects

non insecticide control

RUEDA LM, OSAWARU SO, GEORGI LL & HARRISON RE. 1993. **Natural occurrence of entomogenous nematodes in Tennessee nursery soils.** *Journal of Nematology* 25, 181–188.

Abstract

To isolate potential insect biocontrol agents, entomogenous nematodes were surveyed in Tennessee plant nurseries in 1991. Soil samples from 113 nursery sites were baited with greater wax moth (*Galleria mellonella*) larvae, house cricket (*Acheta domesticus*) adults, lesser mealworm (*Alphitobius diaperinus*) adults, and house fly (*Musca domestica*) larvae. *Heterorhabditis bacteriophora* and *Steinernema carpocapsae* were each recovered from 17 soil samples. *Heterorhabditis bacteriophora* was more common in habitats with crape myrtle (*Lagerstroemia indica*) and Chinese juniper (*Juniperus chinensis*) than other nursery plants, and *S. carpocapsae* was more frequently recovered from habitats with juniper and Southern magnolia (*Magnolia grandiflora*). Bulk density, electrical conductivity, organic matter, pH, temperature, and

moisture content of the entomogenous-nematode positive soil samples were compared. Other nematode genera recovered with insect baits included *Rhabditis* sp., *Pelodera* sp., *Cryptaphelenchoides* sp., and *Mesodiplogaster* sp., which was recovered from a greater percentage of soil samples than the other 5 genera.

Key Subjects

non insecticide control

SALIN C, VERNON P & VANNIER G. 1998. **The super-cooling and high temperature stupor points of the adult lesser mealworm *Alphitobius diaperinus* (Coleoptera: Tenebrionidae).** *Journal of Stored Products Research* **34**, 385–394.

Abstract

Potential thermobiological limits in adult *Alphitobius diaperinus* were assessed during winter by measuring individual super-cooling points (SCP) and thermostupor points (TSP). Two experimental conditions were tested: SCP and TSP measured at 100% relative humidity (RH); and SCP with specimens which survive the TSP at 0% RH. The absolute temperature range compatible with life between the two limits SCP and TSP, termed thermobiological span (TBS), was calculated in both conditions. The potential adaptive capacity to withstand cooling and overheating was: at 100% RH, mean TSP=46.7°C (SD±0.67); mean SCP=-9.4°C (SD±1.81); absolute TBS=56.1°C; at 0% RH, mean TSP=47.4°C (SD±0.61); mean SCP=-12.3°C (SD±2.5); mean TBS=59.7°C (SD±2.43). The TSP at 0% RH was reached with a loss of 3.84% in fresh weight vs. 1.15% at 100% RH. The difference in the SCP (females = 2.1°C; males = 5.4°C) obtained in dry or moist conditions could also be explained by the influence of the heat shock preceding the SCP measured at 0% RH. A decrease of water content may increase the osmolarity of the body fluid and thus the supercooling capacity and could be an adaptation to avoid freezing. Supercooling capacity allows adults to survive in areas where freezing temperatures may occur in poultry houses and more specially during the winter litter removals when adults beetles migrate and overwinter in the soil floor or in the insulation materials of the building walls. The heat tolerance capacity is mainly ruled by the physiological and behavioural adaptations of this species. It is concluded that the adult population of *A. diaperinus* could be controlled by increasing the temperature above 48°C.

Key Subjects

biology & behaviour; non insecticide control

SCHMITZ M & WOHLGEMUTH R. 1988. **Investigations on mass increase and behaviour of *Alphitobius diaperinus* Panz. (Coleoptera, Tenebrionidae) in poultry houses as a basis for directed control in practice.** *Anzeiger fuer Schaedlingskunde und Pflanzenschutz* **61**, 108–114.

Abstract

A correlation was found between successive generations of *Alphitobius diaperinus* and the rhythm of rearing broilers and cleaning the poultry houses in Berlin. In the litter, many larvae of the tenebrionid, in

various instars, were found. The larvae began to leave the litter and search for pupation and hiding sites in the walls of the building about 13 days before rearing of the broilers was completed. The tenebrionids remained in these hiding places until cleaning of the houses was completed. When the houses were prepared with new litter, and higher temperatures for rearing the chickens were maintained, the beetles and larvae left their hiding places and reinfested the new litter. The possibility of using temperature barriers to prevent the pests from migrating from their hiding places was investigated, and it was found that larvae and adults rarely crossed barriers with a temperature exceeding 45°C.

Key Subjects

biology & behaviour; non insecticide control

STEENBERG T & JESPERSEN JB. 1997. **Entomopathogenic fungi for control of litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, 72–73.

Abstract

In 1996 a survey was conducted of the natural occurrence of entomopathogenic fungi in litter beetles. Beetles from only five locations (N=45) were infected by entomopathogenic fungi, and the fungus prevalence was low not only for the lesser mealworm (*Alphitobius diaperinus*) but also for other potential beetle pests in poultry farms (*Typhaea stercorea*, *Ahasverus advena*). However, despite the limited natural occurrence of entomopathogenic fungi, a previous screening showed that larvae of the lesser mealworm (*Alphitobius diaperinus*) were susceptible to strains of most species of hyphomycetes tested (*Beauveria bassiana*, *B. brongniartii*, *Paecilomyces farinosus*, *P. fumosoroseus*, *Metarhizium anisopliae*, *Verticillium lecanii*, *Acremonium* sp. and *Fusarium* sp.). Tests with *B. bassiana*, *M. anisopliae* and *P. fumosoroseus* confirmed earlier observations that larvae and pupae were much more susceptible to infection than adults. Bioassays, in which insects were immersed in aqueous spore suspensions, showed that it was possible to select fungal strains that were not only highly pathogenic to larvae but also showed relatively high pathogenicity against adult beetles. These strains will be tested in cage experiments to evaluate their potential for spread in populations of the lesser mealworm.

Key Subjects

non insecticide control

STEENBERG T & JESPERSEN JB. 1997. **Entomopathogenic fungi for control of litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, 72–73.

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Key Subjects

non insecticide control

STEENBERG T & BRØCHNER JESPERSEN J. 1998. **Entomopathogenic fungi for control of litter beetles.** *Danish Pest Infestation Laboratory Annual Report*, DPIL Website.

Abstract

This was the final year of the project, aimed at evaluating the potential of entomopathogenic fungi for the control of the lesser mealworm in poultry houses. In the laboratory we have selected a number of fungal isolates with high pathogenicity to larvae or adult beetles. The field efficacy of these isolates should be tested in the future. Planned experiments with application of fungus in bait stations were abandoned, as initial experiments showed that it was very difficult to attract the pest into the bait stations when placed under realistic conditions, i.e. in substrates providing alternative hiding places for larvae and adults. During 24 hours 5-10% of late instar larvae would enter the bait stations, and the experiments indicated that the larvae were attracted to the stations primarily because they provided a hiding place, while the food provided (boiled wheat kernels or solid substrate consisting of corn flour, wheat bran, dry yeast, water and agar) was not very attractive. It should be evaluated whether the selected fungal isolates can control the lesser mealworm by spreading in the population after 5-10% have been inoculated in bait stations. Furthermore, other food sources should be evaluated as baits.

Key Subjects

biology & behaviour; non insecticide control

STEINKRAUS DC & CROSS EA. 1993. **Description of life history of *Acarophenax mahunkai*, n. sp. (Acari, Tarsonemina: Acarophenacidae), an egg parasite of the lesser mealworm (Coleoptera: Tenebrionidae).** *Annals of the Entomological Society of America* 86, 239–249.

Abstract

A new species of mite, *Acarophenax mahunkai* Steinkraus & Cross, n. sp., was discovered parasitizing eggs of the lesser mealworm, *Alphitobius diaperinus* (Panzer), a serious cosmopolitan poultry pest. *Acarophenax mahunkai* is an obligate, apparently host-specific parasitoid that kills the egg upon which it feeds. Therefore, it may help control the lesser mealworm. The systematics and biology of *A. mahunkai* are presented here. In the laboratory,

51.0% of lesser mealworm egg masses were parasitized by one or more female mites. Male mites were not parasitic and had poor locomotory abilities. Significantly fewer lesser mealworm eggs hatched (23.9% egg hatch) in parasitized egg masses than in unparasitized egg masses (72.7%). Mite sex ratios were highly skewed, with means of 27.2 ± 3.9 females and 1.7 ± 0.2 male offspring produced per gravid mite. Physogastric female mites parasitizing lesser mealworm eggs gave birth to fertile adult females. The developmental time of the mites (3-5 d) was faster than that of lesser mealworm eggs (5-7 d).

Key Subjects

biology & behaviour; non insecticide control

STEINKRAUS DC, GEDEN CG & BROOKS WM. 1992. **Discovery of the neogregarine *Farinocystis tribolii* and an eugregarine in lesser mealworm.** *Journal of Invertebrate Pathology* 59, 203–205.

Abstract

Larvae and adults of *Alphitobius diaperinus* were collected from poultry litter on poultry farms in Arkansas, North Carolina and New York. Various tissues were examined for spores of neogregarines and microsporidia. *Farinocystis tribolii* and an apparently undescribed eugregarine were found in all areas. *F. tribolii* occurred with a frequency ranging from 44.4% of field collected larvae from Arkansas to more than 90% in laboratory reared colonies. The severity of the infections in moribund larvae ranged from 5×10^4 to 1.6×10^6 oocysts/larva. Eugregarine gamonts occurred in 52% of larvae in Arkansas.

Key Subjects

non insecticide control

STEINKRAUS DC, GEDEN CJ & RUTZ DA. 1991. **Susceptibility of lesser mealworm (Coleoptera: Tenebrionidae) to *Beauveria bassiana* (Moniliales: Moniliaceae): effects of host stage, substrate, formulation, and host passage.** *Journal of Medical Entomology* 28, 314–321.

Abstract

Mature larvae of *Alphitobius diaperinus* were susceptible to infection with *B. bassiana* when larvae were shaken with conidia in an aqueous suspension or in a starch dust. Approximately 98 and 60% larval mortality rates were observed 2 weeks after exposure to suspensions containing 5×10^7 conidia per ml of aqueous suspension or 2.5×10^8 conidia per g of dust, respectively. Substantially lower larval infection rates (<30% mortality at all doses) were observed when aqueous suspensions of conidia (high rate of 5×10^7 conidia) were applied to 250 cm³ of used poultry litter containing beetle larvae; dust-treated litter resulted in mortality similar to forced-contact assays. Mortality was higher when larvae were exposed to extruded polystyrene insulation treated at 7.3×10^6 conidia/cm² than when larvae were exposed to weathered plywood treated at the same rate. The fungus used in the tests was originally isolated from and subsequently produced in adult houseflies (*Musca domestica*); a single passage through mature *A. diaperinus* larvae resulted in a substantial increase in virulence for *A. diaperinus* larvae. Mortality among adult beetles was low (<27%) in all assays.

Key Subjects

non insecticide control

WOHLGEMUTH R. 1989. **Control of mealworm (*Alphitobius diaperinus* Panz.) in poultry housing.** *In World Association of Veterinary Food Hygienists Proceedings of the Xth Jubilee International Symposium*, 18–20.

Abstract

The use of barrier systems for the control of larvae and adults of *A. diaperinus* in poultry housing is described.

Key Subjects

non insecticide control

ZAEDDE IHM & IGNATOWICZ S. 1994. **Mortality of larvae and adults of the lesser mealworm *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), caused by gamma radiation.** *Annals of Warsaw Agricultural University SGGW AR, Veterinary Medicine* **18**, 131–140.

Abstract

The post-radiation mortality of *Alphitobius diaperinus* was positively related to the radiation dosage. Adults of the pest showed a 2 week latent period before any significant increase in mortality occurred. Larvae were more susceptible to gamma radiation than adults, but were found to more sensitive to irradiation than larvae of other tenebrionids. Doses higher than 1.0 kGy are recommended for irradiation of animal feed infested by *A. diaperinus*.

Key Subjects

non insecticide control