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state legislation should carry with it adequate funds to operate the law, and should not be dependent on fees required. After all, such legislation is intended to protect the citizens of the state and therefore they should bear the cost of its operation. If funds are not made available for the proper inspection and enforcement service, the law will probably fall short of its goal.

**Publicity and Advertising.** The future of pest control, in addition to better and more ethical service, also calls for more ethical advertising and sales. Much has already been done in the improvement of advertising, especially in telephone directories, but there is still a need for betterment in such advertising.

Perhaps there is as much misrepresentation in retail sales of insecticides as in service, especially in the case of some of the new materials. For example, I have the following from a Chicago pest control operator: "I have in my hand at the moment an 'Aerosol Bomb,' which I purchased at Marshall Field and Company. The clerk that sold this bomb to me assured me that with the use of this bomb I would rid my house of flies and mosquitoes; by using it in the clothes closet I would positively kill all cockroaches present, and she further went on to cite a case of one purchaser, who had, in two applications, eliminated a bedbug condition that Pest Control Operators had fumigated for on different occasions, without success. I was told further that with the DDT that was in the bomb (.48 of an ounce) a deposit of DDT would be left, which would prevent the above insects returning.

"Incidentally, another selling point on the bomb was the fact that it was refillable—although I was not able to develop why that was an advantage when apparently one or two shots were supposed to fix my house up for keeps."

I don't mean to take picks on aerosol bombs particularly—I am just using this instance as a case in point. The aerosol bomb, I do believe, has a very distinct field and is highly efficient in that field, but we certainly know that it is not the answer to insects or insect eggs that are deep in cracks and crevices. By the same token we also know that application of fluoride or DDT back of sinks and along baseboards is not going to eliminate many flying insects. But Mr. John Q. Public doesn't know these things and it seems to me that along the lines of factual publicity John Q. could be materially helped by the entomologists.

# Some Ecological Factors Influencing the Control of Carpet Beetles and Clothes Moths[1/]

By E. GORTON LINSLEY, *University of California, Berkeley*

*Paper presented before a meeting of the Pest Control Operators' of California, February 26, 1946.*

CARPET beetles and clothes moths are among the oldest and most ubiquitous of man's household pests. As a result of this fact, the entomologist has devoted a considerable amount of study to their biology and control. In present practice, control measures center mainly about three approaches to the problem, (1) destruction of the insects within the household (primarily by fumigation), (2) exclusion of the insects from those portions of the house in which they would be likely to do the most damage (largely by means of repellents), or (3) protection of the products which they might injure (mainly by mothproofing). These methods and others in current use cannot be applied intelligently or economically and may even fail completely if adequate consideration is not given to the habits of the species involved.

Many valuable studies have been made on the biology of carpet beetles and clothes moths (Back & Cotton, 1936, 1938; Griswold & Greenwald, 1941; Herfs, 1936). These studies have been made in the laboratory and have provided us with information on the development of the various species under different physical conditions as well as other detailed data of interest. However, almost no attempts have been made to correlate laboratory observations with behavior in the field and, until very recently, scant interest has been shown in the occurrence of carpet beetles and clothes moths in nature or to natural foci for household and warehouse infestations. With few exceptions most of the information on this subject which has crept into the literature has been gathered in the course of taxonomic or general biologic, rather than economic, investigations. This has probably been due to the influence of the early workers who apparently accepted the view point that most of our carpet beetles and clothes moths were of Old World origin and existed in North America mainly as household insects, a habitat for which they were very well adapted. As a matter of fact, more than half of our pest species are probably endemic to the New World and the geographical origin of many of the remainder is in doubt. Furthermore, it would appear that both carpet bettles and clothes moths are far more abundant in nature than they are in man-made structures and evidence available at this time suggests that the household is actually a relatively unfavorable environment, at least for carpet beetles, and foci for infestations are frequently outside of the structure, a fact which must be kept clearly in mind if a control program is to succeed.

In the last few years a number of cases of extremely persistent infestations of carpet beetles or cloths moths have been called to our attention by home owners or pest control operators. In most of these cases repeated fumigation with unusually heavy dosages of hydrocyanic acid gas had provided little more than temporary relief. Further investigation revealed that these infestations were arising from bird nests under eaves or in tile roofs, honeybee nests in walls or chimneys, deserted hornet nests (Dolichovespula arenaria Fab.), and, in one case, nests of the yellow and black mud dauber (Sceliphron servillei Sauss.) in an attic. In order to determine to what extent such factors might influence household and warehouse infestations a survey of central California and the San Francisco Bay region was undertaken. This survey clearly indicated that nests of birds, rodents, insects and spiders were all factors which need to be reckoned with in the control of clothes moths and carpet beetles.

### Habits of Carpet Beetles and Clothes Moths in Nature

All of the carpet beetles and clothes moths which have been studied by the writer hibernate as full grown or nearly grown larvae or more rarely as transformed but quiescent adults (Anthrenus lepidus Lec.). During this period they require a protected and more or less dry environment in the presence of an abundance of food material (animal products such as fur, feathers, dead insects, or certain plant products such as seeds, pollen) for the resumption of feeding in the spring. In nature these conditions are best met in nests of birds, rodents, insects or spiders located in hollow trees,

under logs, in cliffs, banks, caves, etc. Exposed nests, especially of birds, rarely remain dry enough to permit survival of large populations during the winter months. In the spring, the larvae resume feeding, complete their development and, in the case of carpet beetles fly to flowers for nourishment and mating. Later, they seek out a breeding habitat for oviposition. Thus, for these beetles, the ideal habitat must not only be protected from moisture but also must be accessible to the flying beetle returning from flowers. Adult carpet beetles which have not fed on pollen and nectar lay fewer viable eggs, and in the case of some species lay no eggs at all. (This is, of course, not true of the clothes moths and once they have reached an inaccessible habitat they can continue to breed there as long as conditions remain otherwise favorable.) Obviously, the various conditions are met far more satisfactorily on the outside (especially the underside) of various man-made structures than they are within them. When we add to this that both clothes moths and carpet beetles prefer natural animal and plant products (feathers, fur, raw wool, dead insects, seeds, pollen) to processed products (woolen cloth, fabrics, flour, etc.), it is not surprising that these insects are far more abundant in nature than in houses. This is not meant to imply that they are not a serious household and warehouse problem, because they most certainly are. However, in order to understand such infestations it is necessary to view them in relation to the ecology of the insects as a whole.

The varied carpet beetle, **Anthrenus verbasci (Linn.).** In the field, as in the laboratory, this species has but a single generation a year. The winter is passed in the larval stage and when temperatures are favorable feeding continues during this period. In early spring (about the middle of March in central California) the larvae pupate and transform to adults. In the field the pupal period usually requires between two and three weeks although as little as nine days may be involved under laboratory conditions. After transformation the adults remain in the larval skin for a day or two and then emerge, seeking flowers for mating and feeding. After mating the females search out the nests of bees, wasps, spiders and other favorable habitats for oviposition. The favored larval food is dead insects and spiders, a fact which accounts for their ravages in insect collection. The nests of **Sceliphron,** which stocks its cells with spiders, and spider webs, with their accumulated insect carcasses, are common natural habitats, as are various other places where dead insects are available. Fur and feathers undobutedly serve as elements in their natural diet as does the pollen stored by bees. (This latter product provides a satisfactory laboratory diet, bringing the beetles to maturity in a little more than 300 days. Milled cereals such as whole wheat flour may require over 400 days for development.)

The birdnest carpet beetle, **Anthrenus lepidus, Lec.** This species is represented in the United States by several races or varieties. These may differ from each other slightly in habits but their general biology is similar and in contrast to that of **A. verbasci.** The black larvae are similar to those of the Buffalo carpet beetle, **A. scrophulariae** (Linn.) and the furniture carpet beetle, **A. vorax** Waterhouse. In California the adults emerge in March and April and fly to flowers, especially Umbelliferae and Compositae for mating and feeding. They then seek out birds nests for oviposition. The larvae feed primarily on feathers and animal hairs. In the laboratory we were unable to rear them successfully on diets of pollen or whole wheat flour although dead insects proved fairly satisfactory. On feathers or fur no difficulty was encountered, although we were unable to induce oviposition or to obtain viable eggs from females which had not first fed on pollen and nectar. The larvae grow more rapidly than do those of **A. verbasci.** They pupate in late fall and the adults overwinter in the last larval skin. They emerge a little earlier than **verbasci** and in warm spells can be found on flowers early in March.

The rodent nest carpet beetle, **Attagenus schafferi Herbst.** In the field this species appears to live primarily in rodent nests. It is somewhat of a montane species and is more abund-

TABLE I

**Occurrence of Carpet Beetles and Clothes Moths in Nests of Some Birds Which Nest About Buildings.**

| Bird | Nests | Insect | Specimens | Localities in California | Date |
|---|---|---|---|---|---|
| English Sparrow (Passer domesticus) | 6 | Anthrenus lepidus | 169 | Bakersfield | 2-17-44 |
| | 1 | | 43 | Tulare | 2-16-44 |
| | 3 | | 104 | Walnut Creek | 2-22-44 |
| | 1 | | 19 | Lafayette | 3- 2-44 |
| | 2 | | 21 | Berkeley | 3-10-44 |
| | 1 | Anthrenus obtectus | 34 | Woody | 2-18-44 |
| | 1 | Attagenus nigripes | 3 | Bakersfield | 2-17-44 |
| | 1 | | 14 | Woody | 2-18-44 |
| | 1 | | 11 | Walnut Creek | 2-22-44 |
| | 1 | Trogoderma versicolor | 28 | Woody | 2-18-44 |
| | 4 | Tineola bisselliella | 141 | Bakersfield | 2-17-44 |
| | 1 | | 73 | Tulare | 2-16-44 |
| | 1 | | 22 | Lafayette | 3- 2-44 |
| | 1 | Tinaea pellionella | 73 | Woody | 2-18-44 |
| | 1 | | 183 | Berenda | 2-15-44 |
| House Finch (Carpodacus mexicanus frontalis) | 1 | Anthrenus lepidus | 6 | Bakersfield | 2-17-44 |
| | 1 | | 14 | Walnut Creek | 2-22-44 |
| | 2 | | 31 | Lafayette | 3- 2-44 |
| | 1 | Attagenus nigripes | 11 | Woody | 2-18-44 |
| | 1 | | 2 | Berenda | 2-15-44 |
| | 1 | | 9 | Walnut Creek | 2-22-44 |
| | 1 | Endrosis sarcitrella | 4 | Woody | 2-18-44 |
| | 1 | | 19 | Walnut Creek | 2-22-44 |
| | 1 | Hofmannophila pseudospretella | 4 | Lafayette | 3- 2-44 |
| Black Phoebe (Sayornis nigricans) | 1 | Anthrenus lepidus | 3 | Patterson Pass | 3- 3-44 |
| | 1 | | 28 | Salinas | 3-19-44 |
| | 1 | Tinaea pellionella | 73 | Patterson Pass | 3- 3-44 |
| | 1 | Attagenus nigripes | 9 | Patterson Pass | 3- 3-44 |
| Barn Swallow (Hirundo erythrogaster) | 1 | Athrenus verbasci | 3 | Tulare | 2-16-44 |
| | 1 | Anthrenus lepidus | 2 | Berenda | 2-15-44 |
| | 1 | Tinaea pellionella | 266 | Tulare | 2-16-44 |
| Cliff Swallow (Petrocheildon albifrons) | 10 | Trogoderma sternale | 272 | Madera | 2-15-44 |
| | 10 | Attagenus nigripes | 31 | Madera | 2-15-44 |
| | 1 | | 3 | Bakersfield | 2-17-44 |
| | 1 | Tinaea pellionella | 9 | Madera | 2-15-44 |

TABLE II

Occurrence of Carpet Beetles and Clothes Moths in Nests of Some Wasps and Bees Which Nest About Buildings.

| Wasp or Bee | Nests | Insect | Specimens | Localities in California | Date |
|---|---|---|---|---|---|
| Polistes aurifer | 1 | Anthrenus verbasci | 8 | Bakersfield | 2-17-44 |
| Dolichovespula arenaria | 1 | Trogoderma sternale | 11 | Bakersfield | 2-17-44 |
| | 2 | Anthrenus verbasci | 28 | Bakersfield | 2-17-44 |
| Sceliphron servillei | 2 | Anthrenus verbasci | 6 | Chowchilla | 2-15-44 |
| | 1 | | 2 | Berenda | 2-15-44 |
| | 14 | | 27 | Tulare | 2-16-44 |
| | 9 | | 39 | Tipton | 2-16-44 |
| | 3 | | 16 | Kingsburg | 2-19-44 |
| | 4 | | 11 | Fowler | 2-19-44 |
| | 17 | | 43 | Merced | 2-19-44 |
| | 1 | | 3 | Tracy | 2-19-44 |
| | 4 | Trogoderma sternale | 11 | Chowchilla | 2-15-44 |
| | 2 | | 8 | Berenda | 2-15-44 |
| | 11 | | 16 | Tulare | 2-16-44 |
| | 9 | | 23 | Tipton | 2-16-44 |
| | 4 | | 12 | Oildale | 2-19-44 |
| | 6 | | 21 | Kingsburg | 2-19-44 |
| | 1 | | 3 | Fowler | 2-19-44 |
| | 12 | | 33 | Merced | 2-19-44 |
| | 6 | | 14 | Tracy | 2-19-44 |
| | 1 | Trogoderma versicolor | 4 | Bakersfield | 2-17-44 |
| | 2 | Perimegatoma veriegatum | 9 | Tracy | 2-18-44 |
| | 3 | Perimegatoma jaynei | 11 | Walnut Creek | 2-22-44 |
| | 1 | Trichophaga tapetzella | 3 | Tulare | 2-16-44 |
| | 2 | Endrosis sarcitrella | 3 | Tulare | 2-16-44 |
| | 1 | | 2 | Tipton | 2-16-44 |
| | 1 | | 1 | Kingsburg | 2-19-44 |
| Osmia lignaria | 9 | Anthrenus verbasci | 26 | Bakersfield | 2-17-44 |
| | 4 | Trogoderma sternale | 5 | Bakersfield | 2-17-44 |
| | 26 | Trogoderma ajax | 51 | Bakersfield | 2-17-44 |
| | 5 | | 23 | Woody | 2-18-44 |

ant at elevations of 4,000 to 6,000 feet. The adults are active in the summer time and lay their eggs in nests of chipmunks, woodrats, etc., as well as in those of birds. The winter is passed in the larval stage and pupation usually does not take place until May. The larvae prefer to feed on hair and fur but can be reared on pollen and whole wheat flour. They do not feed on the surface but bury themselves in food materials as has been previously noted for **Attagenus piceus** (Griswold, 1941). As a household pest it is largely confined to mountain cabins (Linsley, 1942).

The small black carpet beetle, **Attagenus nigripes** Casey. The habits of this species are similar to those of **A. schafferi** but it appears to be primarily a birdnest species and occurs more commonly at lower elevations. It has been found several times as a household pest.

The black carpet beetle **Attagenus piceus** (Oliv.). This species appears to be less common in the field than the two previous species, at least in California. Its habits, however, are similar. It breeds in both bird and rodent nests. The winter is passed in the larval stage and the adults are most abundant in the summer months. As with other species of carpet beetles the adults are flower visitors.

The webbing clothes moth, **Tineola bisselliella** (Hum.). This species apparently has at least two generations a year in the field. The second generation overwinters in the larval stage and transformation to the adult instar takes place in early spring (March and April). They breed in bird and rodent nests as well as in nests of bees and wasps. The larvae thrive on fur or feathers but appear to develop equally well on dead insects or on pollen. Frequently several hundred larvae may be found in a single nest of the English sparrow.

The case-making clothes moth, **Tineea pellionella** (Linn.). This species occurs commonly in bird nests as does its relative, **Tinaea fuscipunctella** Haw. It is not certain whether or not it has more than one generation a year in the field although there is evidence to suggest that there may be at least two generations. In any event, the species overwinters in the larval stage and emerges in the spring at about the same time as the webbing clothes moth. As with the latter species, several hundred individuals may occur in a single nest.

The white-shouldered house moth, **Endrosis sarcitrella** (Linn.). This species occurs rather commonly in bird nests and also in spider webs. It apparently has at least two generations a year and overwinters in the larval stage. However, adults appear very early in the spring and have been found in nests in the middle of March.

### Sources of Infestation

**Birds nests.** Yokoyama (1929), Herfs (1936) and Hinton (1934b) have called attention to the role of bird nests in relation to Old World household infestations of carpet beetles. The species involved are **Attagenus piceus** (Oliv.); **A. pellio** (Linn.), **Anthrenus fuscus** (Oliv.), **A. verbasci** (Linn.), **A. scrophulariae** (Linn.) and **A. pimpinellae** (Fab.). Apparently no similar studies have been made in America, although McAtee (1929) has noted the occurrence of **Attagenus piceus** Oliv. in nests of the English sparrow, starling, purple martin, house wren, and bluebird, **Trogoderma versicolor** Creutz. **(inclusum Lec.)** and **T. ornatum** (Say) in nests of the English sparrow and house wren, and Jellison and Philip (1933) have reported **Anthrenus occidens** Casey from magpie nests. In California, the commonest carpet beetle in the nests of birds which nest about houses and buildings (especially the English sparrow) is **Anthrenus lepidus** Lec. As a household pest this species behaves much like **Anthrenus scrophulariae** (Linn.) but it is regarded as of minor importance at the present time. Only twelve household infestations of **lepidus** have come to the attention of the writer in the last three years, although these may have all been traceable to birds' nests. Probably of more importance, however, are the various black carpet beetles which occur in birds' nests **(Attagenus schafferi** Herbst, **A. nigripes** Casey, etc.). In the last few years most of the household infestations which have been encountered by the writer have involved either **Attagenus nigripes** Casey or some other native species, less than half have been attributed to **A. piceus** Oliv., although in warehouses and granaries the latter species is predominent. In addition, the webbing clothes moth, **Tineola bisseliella** (Hum.), the white tip clothes moth, **Trichophaga tapetzella** (Linn.), the white-shouldered house moth, **Endrosis sarcitrella** (Linn.), and the brown house moth, **Hofmannophila pseudospretella**

(Staint.), and the case-making clothes moth, **Tenaea pellionella** (Linn.) all breed in birds' nests in California and thus have access to the house. McAtee (1929) has also recorded **Tinaea fuscipunctella** Haw. from nests of the English sparrow, starling, purple martin, house wren, bluebird, and crested flycatcher.

**Rodent nests.** The extent to which rodent nests may influence household infestations of carpet beetles and clothes moths is not known. The writer has recorded (Linsley, 1924b) infestations of **Attagenus shafferi** Herbst and **A. piceus** Oliv. (recorded as **piceus** Oliv.) in mountain cabins arising from chipmunk nests. The former species has also been found breeding in nests of the woodrat (**Neotoma fuscipes**) as well as domestic rats. **Trogoderma** spp. and **Anthrenus** spp. have also been occasionally found in rats' nests as have various clothes moths. Hubbard (1895) has reported the occurrence of the webbing clothes moth in nests of the kangaroo rat. However, except where rodents were unusually abundant or were using the same nest sites for long periods of time, it is probable that they play a far less important role than birds' nests as a source of household infestation.

**Insects nests.** The writer has previously (1942a) called attention to the fact that various household and stored products insects inhabit the nests of bees and wasps. Hinton (1934b) has stated that "in practice the nests of Aculeate Hymenoptera are rarely of even slight importance as reservoirs of injurious Dermestidae, and in this respect cannot be compared with either bird (chiefly sparrow) or spider nests which, because of their greater abundance and proximity to houses and warehouses where stored products are kept, are a factor to be reckoned with in the control of these beetles." It is possible that Hinton's statement may be true for England but it certainly does not apply to California. In this state, by far the most injurious dermestid to fabrics is **Anthrenus verbasci**, to foodstuffs, **Trogoderma sternale.** In a recent survey (Table I) the former species was encountered in birds nests only once, and in this case the nest was surrounded by those of **Sceliphron servillei** Sauss. On the other hand, both **Anthrenus verbasci** and **Trogoderma sternale** are common in the nests **Sceliphron, Polistes, Odynerus, Osmia** which regularly nest about buildings as well as in old nests of **Dolichovespula** and **Apis.** In many parts of California where carpet beetles are a serious problem, nests of **Sceliphron** and **Polistes** are far more numerous about buildings than are bird nests.

**Spider webs.** Hinton (1943a, 1943b) has called attention to the importance of spider webs as a reservoir for clothes moths and carpet beetles in two very interesting and informative papers. He has recorded both the white-shouldered house moth, **Endrosis sarcitrella** (Linn.) and the brown house moth, **Homannophila pseudospretella** (Staint.) from this habitat, as well as the dermestids **Attagenus pellio** (Linn.), **Ctesias serra** Steph., **Megatoma undata** (Linn.), **Globicornis marginata** Payk., **Trogoderma ornata** Say., **Anthrenus museorum** (Linn.), **A. fuscus** (Oliv.) and **Trinodes hirtus** (Fab.). In California, by far the most common dermestid in spider webs appears to be the varied carpet beetle, **Anthrenus verbasci** (Linn.), although we have found it consistently only in inhabited webs of the black widow spider, **Latrodectes mactans.** The larvae appear to feed on insect remains and damaged egg sacs. **Trogoderma sternale** Jayne, which also occurs in these webs, appears to actually enter undamaged egg sacs and to feed on the eggs as well as on insect remains and other debris in the web.

TABLE III

Occurrence of Carpet Beetles and Clothes Moths in Nests of Spiders Which Nest About Buildings.

| Spider | Nests | Insect | Specimens | Localities in California | Date |
|---|---|---|---|---|---|
| Black Widow (Latrodectes mactans) | 2 | Anthrenus verbasci | 119 | Merced | 2-18-44 |
| | 9 | | 281 | Tulare | 2-16-44 |
| | 2 | | 16 | Tipton | 2-16-44 |
| | 1 | | 78 | Fowler | 2-19-44 |
| | 4 | | 21 | Kingsburg | 2-19-44 |
| | 1 | | 13 | Chowchilla | 2-15-44 |
| | 1 | Trogoderma sternale | 5 | Chowchilla | 2-15-44 |
| | 2 | Hofmannophila pseudospretella | 9 | Merced | 2-19-44 |
| | 1 | | 7 | Chowchilla | 2-15-44 |
| | 1 | Endrosis sarcitrella | 14 | Tulare | 2-16-44 |
| | 1 | | 2 | Fowler | 2-19-44 |
| | 1 | | 5 | Kingsburg | 2-19-44 |

### Conclusion

Nests of birds, rodents, insects and spiders harbor large numbers of carpet beetles and clothes moths.

Nests about houses and other buildings are more apt to be heavily infested than those in the open. The protected environment provides drier conditions and favors survival of the insects.

Such nests provide foci for household and warehouse infestation and may invalidate control efforts applied within the structure.

Control programs should include destruction of nests at the close of the breeding season, before the onset of cool weather which may drive the insects indoors.

A number of the carpet beetles require pollen for successful production of eggs and care should be taken not to bring these insects into the house on cut flowers. Such individuals, having mated and fed are more likely to provide the source of a serious infestation that individuals which have reached maturity within the confines of the building.

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## PCO's Assist in Roanoke, Va. Rat Campaign

To Pests Magazine:

To implement a recently enacted city rodent-control ordinance, Dr. A. G. Evans, Roanoke Health Commissioner, invited the following members of the Industry, among others, to attend a meeting to discuss plans for a clean-up of the rats and mice infesting city dumps: Theodore Oser, president, N.P.C.A.; Henry Glasgow, Roanoke Exterminating Co.; Robert Duncan, Orkin Exterminating Co.; Ray K. Parks, Parks Exterminating Co. In essence, it was arranged that each firm would operate in monthly rotation on an advisory, applicating and result-checking basis.

My firm happened to be first in rotation so we decided to use Antu (Alphanapthylthiourea) on the first dumping area. One pound of Antu was mixed with every four pounds of finely ground corn meal (20 per cent), with an average of two ounces of bait blown into each accessible runway. 75 pounds of bait in all being used throughout the 5-acre dump.

Results proved most effective. On the evening of the second day (bait applications required a day and a half), dead rats by the hundreds were found; on the third day many more rats were lying all over the dump, sick and seeking the open air to die. It was estimated a thousand rats (Norwegian) were exterminated, some of which are shown in the enclosed snapshot. (See cut below.)

*Some of Roanoke's very dead rats. Antu-blitze*

We enjoy reading PESTS and look forward to receiving our copy each month. —RAY K. PARKS