A17-628-8,000-L180

TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 382 JULY, 1928

DIVISION OF ENTOMOLOGY

THE BAGWORMS OF TEXAS

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

T. O. WALTON, President

STATION STAFF†

ADMINISTRATION:
A. B. CONNER, M. S., *Director*
R. E. KARPER, M. S., *Vice-Director*
J. M. SCHAEDEL, *Secretary*
M. P. HOLLEMAN, JR., *Chief Clerk*
J. K. FRANCKLOW, *Assistant Chief Clerk*
CHESTER HIGGS, *Executive Assistant*
C. B. NEBLETTE, *Technical Assistant*

CHEMISTRY:
G. S. FRAPS, Ph. D., *Chief; State Chemist*
S. E. ASBURY, M. S., *Assistant Chemist*
E. C. CARLYLE, B. S., *Chemist*
WALDO H. WALKER, *Assistant Chemist*
VELMA GRAHAM, *Assistant Chemist*
R. O. BROOKE, M. S., *Assistant Chemist*
T. L. OGIER, *Assistant Chemist*
J. G. EVANS, *Assistant Chemist*
ATHAN J. STERGES, B. S., *Assistant Chemist*
G. S. CRENSHAW, A. B., *Assistant Chemist*
JEANNE M FUEGAS, *Assistant Chemist*

HORTICULTURE:
HAMILTON P. TRAUB, Ph. D., *Chief*
H. NESS, M. S., *Berry Breeder*

RANGE ANIMAL HUSBANDRY:
J. M. JONES, A. M., *Chief; Sheep and Goat Investigations*
J. L. LUSH, Ph. D., *Animal Husbandman; Breeding Investigations*
STANLEY P. DAVIS, *Wool Grader*

ENTOMOLOGY:
F. L. THOMAS, Ph. D., *Chief; State Entomologist*
H. J. REINHARD, B. S., *Entomologist*
R. K. FLETCHER, M. A., *Entomologist*
W. L. OWEN, JR., M. S., *Entomologist*
FRANK M. HULL, M. S., *Entomologist*
J. C. GAINES, JR., M. S., *Entomologist*
C. J. TODD, B. S., *Entomologist*
F. F BIBBY, B. S., *Entomologist*
S. E. MCGREGOR, JR., *Acting Chief Foulbrood Inspector*
GILLIS GRAHAM, *Foulbrood Inspector*

AGRONOMY:
E. B. REYNOLDS, M. S., *Chief*
A. B. CONNER, M. S., *Agronomist; Grain Sorghum Research*
R. E. KARPER, M. S., *Agronomist; Small Grain Research*
P. C. MANGELSDORF, Sc. D., *Agronomist; in charge of Corn and Small Grain Investigations*
D. T. KILLOUGH, M. S., *Agronomist; Cotton Breeding*
H. E. REA, B. S., *Agronomist; Cotton Root Rot Investigations*
E. C. CUSHING, M. S., *Assistant in Crops*
P. R. JOHNSON, B. S., *Assistant in Soils*

VETERINARY SCIENCE:
*M. FRANCIS, D. V. M., *Chief*
H. SCHMIDT, D. V. M., *Veterinarian*
J. D. JONES, D. V. M , *Veterinarian*

PLANT PATHOLOGY AND PHYSIOLOGY:
J. J. TAUBENHAUS, Ph. D., *Chief*
WALTER N. EZEKIEL, Ph. D., *Plant Pathologist and Laboratory Technician*
W. J. BACH, M. S., *Plant Pathologist*
J. PAUL LUSK, S. M., *Plant Pathologist*
B. F. DANA, M. S., *Plant Pathologist*

FARM AND RANCH ECONOMICS:
L. P. GABBARD, M. S., *Chief*
G. L. CRAWFORD, M. S., *Marketing Research Specialist*
C. A. BONNEN, M. S., *Farm Management Research Specialist*
V. L. CORY, M. S., *Grazing Research Botanist*
**T. L. GASTON, JR., B. S., *Assistant; Farm Records and Accounts*
**J. N. TATE, B. S., *Assistant; Ranch Records and Accounts*

RURAL HOME RESEARCH:
JESSIE WHITACRE, Ph. D., *Chief*
MAMIE GRIMES, M. S., *Textile and Clothing Specialist*
EMMA E. SUMNER, M. S., *Nuirition Specialis*

SOIL SURVEY:
**W. T. CARTER, B. S., *Chief*
E. H. TEMPLIN, B. S., *Soil Surveyor*
T. C. REITCH, B. S., *Soil Surveyor*
HARVEY OAKES, *Soil Surveyor*

BOTANY:
H. NESS, M. S., *Chief*

PUBLICATIONS:
A. D. JACKSON, *Chief*

SWINE HUSBANDRY:
FRED HALE, M. S., *Chief*

DAIRY HUSBANDRY:
———————, *Chief*

POULTRY HUSBANDRY:
R. M. SHERWOOD, M. S., *Chief*

***AGRICULTURAL ENGINEERING:**

MAIN STATION FARM:
G. T. MCNESS, *Superintendent*

APICULTURE (San Antonio):
H. B. PARKS, B. S., *Chief*
A. H. ALEX, B. S., *Queen Breeder*

FEED CONTROL SERVICE:
F. D. FULLER, M. S., *Chief*
S. D. PEARCE, *Secretary*
J. H. ROGERS, *Feed Inspector*
W. H. WOOD, *Feed Inspector*
K. L. KIRKLAND, B. S., *Feed Inspector*
W. D. NORTHCUTT, JR., B. S., *Feed Inspector*
SIDNEY D. REYNOLDS, JR., *Feed Inspector*
P. A. MOORE, *Feed Inspector*

SUBSTATIONS

No. 1, Beeville, Bee County:
R. A. HALL, B. S., *Superintendent*

No. 2, Troup, Smith County:
W. S. HOTCHKISS, *Superintendent*

No. 3, Angleton, Brazoria County:
R. H. STANSEL, M. S., *Superintendent*
FRANK M. HULL, M. S., *Entomologist*

No. 4, Beaumont, Jefferson County:
R. H. WYCHE, B. S., *Superintendent*

No. 5, Temple, Bell County:
HENRY DUNLAVY, M. S., *Superintendent*
B. F. DANA, M. S., *Plant Pathologist*
H. E. REA, B. S., *Agronomist; Cotton Root Rot Investigations*

No. 6, Denton, Denton County:
P. B. DUNKLE, B. S., *Superintendent*

No. 7, Spur, Dickens County:
R. E. DICKSON, B. S., *Superintendent*

No. 8, Lubbock, Lubbock County:
D. L. JONES, *Superintendent*
FRANK GAINES, *Irrigationist and Forest Nurseryman*

No. 9, Balmorhea, Reeves County:
J. J. BAYLES, B. S., *Superintendent*

No. 10, Feeding and Breeding Station, near College Station, Brazos County:
R. M. SHERWOOD, M. S., *Animal Husbandman in Charge of Farm*
L. J. MCCALL, *Farm Superintendent*

No. 11, Nacogdoches, Nacogdoches County:
H. F. MORRIS, M. S., *Superintendent*

No. 12, Chillicothe, Hardeman County:
**J. R. QUINBY, B. S., *Superintendent*
**J. C. STEPHENS. M. A., *Junior Agronomist*

No. 14, Sonora, Sutton-Edwards Counties:
W. H. DAMERON, B. S., *Superintendent*
E. A. TUNNICLIFF, D. V. M., M. S., *Veterinarian*
V. L. CORY, M. S., *Grazing Research Botanist*
**O. G. BABCOCK, B. S , *Collaborating Entomologist*
O. L. CARPENTER, *Shepherd*

No. 15, Weslaco, Hidalgo County:
W. H. FRIEND, B. S., *Superintendent*
SHERMAN W. CLARK, B. S., *Entomologist*
W. J. BACH, M. S., *Plant Pathologist*

No. 16, Iowa Park, Wichita County:
E. J. WILSON, B. S., *Superintendent*
J. PAUL LUSK, S. M., *Plant Pathologist*

Teachers in the School of Agriculture Carrying Cooperative Projects on the Station:

G. W. ADRIANCE, M. S., *Associate Professor of Horticulture*
S. W. BILSING, Ph. D., *Professor of Entomology*
V. P. LEE, Ph. D., *Professor of Marketing and Finance*
D. SCOATES, A. E., *Professor of Agricultural Engineering*
H P. SMITH, M. S., *Associate Professor of Agricultural Engineering*
R. H. WILLIAMS, Ph. D., *Professor of Animal Husbandry*
A. K. MACKEY, M. S., *Associate Professor of Animal Husbandry*
J. S. MOGFORD, M. S., *Associate Professor of Agronomy*

†As of June 1, 1928.
*Dean, School of Veterinary Medicine.
**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture

SYNOPSIS

Injury to the foliage of shade and ornamental trees, in Texas, is often the work of bagworms. Though in the past this injury has usually been accredited to the Evergreen Bagworm *Thyridopteryx ephemeraeformis* Haworth, several species possessing different habits and life-cycles are involved and have almost equal capacity for becoming major pests. They show remarkable adaptability to a variety of foodplants; and are often more abundant upon cultivated trees and shrubs than upon their original plant-associates in the wild. Nowhere are bagworms actually or potentially more injurious than in Texas. Of the thirteen named species known to occur within the State, six were first described from Texas specimens. Approximate identification of the species involved and some knowledge of their seasonal history, are requisites for the intelligent control of bagworm depredations. For these reasons illustrations and descriptions are given of all the species known to occur within the State, together with the available information in regard to their distribution, foodplants, life-cycles, and methods for their control.

Bagworms are almost unique in many respects. The larval life is passed within the protection of a portable but cumbrous silken bag; the adult females are destitute of wings and legs; and all the eggs of each female are deposited at one time within her larval bag and pupa-shell, there remaining concealed and protected until hatched. These conditions limit its means of dispersal and tend to retard the spread of the bagworm from centers of infestation; but they also contribute to the severity of localized infestations, which usually persist from year to year.

Unintentional introduction and spread by human agency in the transportation of trees or shrubs to which bagworms are attached, should be avoided. Bagworm infestation may be controlled by the use, at suitable times, of arsenical sprays, and by hand-picking.

CONTENTS

BULLETIN NO. 382 JULY, 1928

THE BAGWORMS OF TEXAS

FRANK MORTON JONES AND HARRIS BRALEY PARKS*

In Texas, bagworms are usually the most obvious source of insect injury to the foliage of shade and ornamental trees and shrubs. Few native species are entirely immune; some are especially liable to bagworm infestation and suffer severely from their defoliations (Figure 1). Shade trees along the streets of cities and towns, and choice trees planted in parks, cemeteries, and private grounds are notably subject to attack by these insects, which do not confine themselves to broad-leaved species but are especially injurious to conifers, a complete defoliation of which is usually fatal (Figure 2). Fruit and nut trees are not immune from their attacks, and in irrigated areas some of the desert species of bagworms quickly adjust themselves to the new foodplants and to the

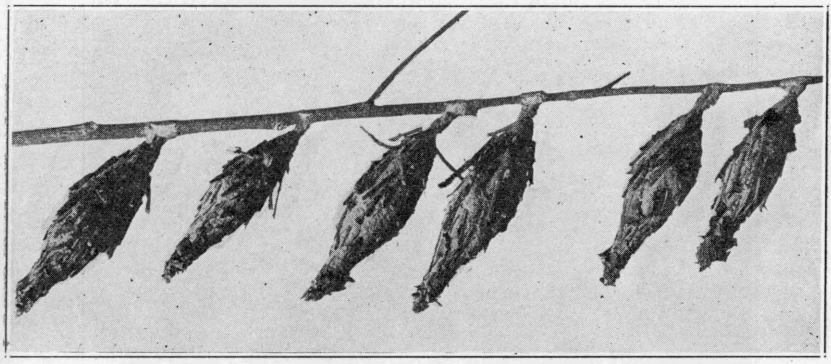

Figure 1. Defoliation complete, the bags festooning the twigs.

uninterrupted supply of food thus provided, and unless proper means are taken for their control, do serious injury. Those species whose original foodplants are comparatively worthless thus sometimes become pests of major importance, more abundant in the streets of towns and cities, in parks and cemeteries, and in the vicinity of cultivated ground, than in the wild. This is a result of the operation of Hopkins' Law that "an insect which breeds in two or more hosts will prefer to breed in the host to which it has become adapted," and is also due to the almost unique habits of these insects, which favor intensity and persistence of localized infestation rather than a general distribution.

*This Bulletin is largely the work of Mr. Frank Morton Jones of Wilmington, Delaware, who has specialized in the study of the Psychidae, here and abroad, for the past twenty years, and who made two extensive trips through Texas collecting the material presented in this Bulletin. He made all of the photographs for the cuts, the majority of them especially for this Bulletin. By permission, Fig. 8 and Fig. 11 are reproduced from the Transactions of the American Entomological Society.

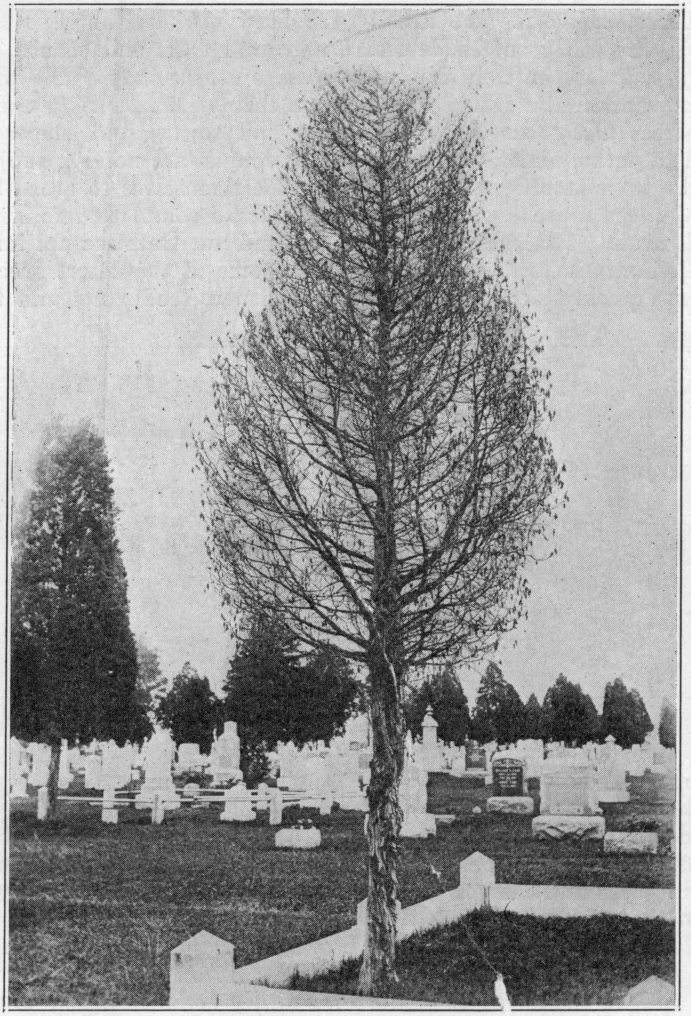

Figure 2. The Evergreen Bagworm. Fatal infestation of an ornamental conifer.

Bagworm attack in Texas has usually been referred to the work of the Evergreen Bagworm *Thyridopteryx ephemeraeformis* Haworth, a species whose distribution extends from Massachusetts to Texas, and whose list of possible food plants includes most of the native and introduced trees and shrubs throughout its range. When other food fails, it is even able to complete its growth upon herbaceous plants and sedges. This insect has been responsible for all of the more severe bagworm depredations reported from eastern Texas. There is a marked but irregular periodicity in its relative abundance, and records obtained from various sources indicate that 1913-14, 1918-19, 1925-27 have been bagworm years, marked by intensity of infestation at various points throughout eastern Texas from the Oklahoma border to Houston. The Evergreen Bagworm is usually noted in greatest abundance in and near towns and cities where its presence might reasonably be attributed to human agency, but is nevertheless widely distributed. It is probably indigenous, as it sometimes flourishes on the native cedars of Dallas County, and even as far westward as Kerr County, where it is firmly established on the cypress and willows bordering the streams which come down from the Edwards Plateau.

At San Antonio the common bagworm of the streets and parks is a different species. This is the Live-oak Bagworm *Oiketicus abbotii* Grote, distributed from Cape Henry, Virginia, south to Florida and west to Texas. Compared with the Evergreen Bagworm, this insect has a list of food plants almost equally long, but its more severe injuries result from purely localized infestations rather than from widespread coincident devastations. Its control is more difficult than that of the Evergreen Bagworm, for it is very irregular in its seasonal life-cycles, and larvae of all ages may be present at the same time and place. Though its northward distribution extends well into the range of the Evergreen Bagworm, in Texas it has not been noted as a pest much north of Austin or west of Uvalde; and though complete records are wanting, its distribution to the eastward is probably continuous, for it is a familiar insect on the shade trees of New Orleans, thence eastward along the whole Gulf Coast. In the Trans-Pecos region neither of these insects is ordinarily present, but an entirely distinct series of desert species has invaded the towns and cultivated areas. We have grouped some of these as "Desert-shrub Bagworms," for their habits and life-cycles are almost identical and for general purposes they may be treated as a unit. In areas favorable to their multiplication and spread they have shown themselves capable of the same rapid increase and intensity of infestation as the preceding species, and they have already demonstrated their adaptability to a wide range of foodplants.

Of the remaining forms found in Texas, a few have occasionally given cause for complaint, but their injuries thus far have been of a minor character. All will be included in the descriptive text and illustrations which follow.

Figure 3. The feeding bagworm.

It has already been indicated that bagworms are unique among leaf-eating insects in some of their structural and biological aspects. This, and their variations in seasonal history, in preferred foodplants, in geographical distribution, and in capacity for harm, plainly indicate that to enable intelligent control we should have a fairly complete knowledge of the peculiarities of these insects as a group, and that we should be able to make an approximate identification of the species involved in any outbreak. After a short account of the life of the bagworm and its various transformations, illustrations are given of the sixteen species* whose presence in Texas is known or is to be anticipated. The available data are also presented relative to their geographical distribution, their food-plants and injuries, their identification, and their life-cycle, as well as the indicated means for the control of the injurious species.

THE LIFE OF THE BAGWORM

The Feeding Bagworm. In its feeding or larval stage, the bagworm is readily recognizable and all too familiar. It inhabits a tough portable silken case or "bag" of its own manufacture, which it never willingly leaves, and from which it can scarcely be dragged without injury. The bag has a small opening at the narrow lower end through which refuse is expelled, and a wider opening at the top from which, in creeping, feeding (Figure 3), and the repair and enlargement of its bag, the worm protrudes its head and several segments of its body. The first three segments are protected by horny plates, those remaining being soft and easily injured. On the slightest alarm the bagworm retreats wholly within its bag, holding the flexible top tightly closed by hooking its strong curved legs into the silken lining of the bag. Outside, the

*_Oedonia exigua_ Hy. Edw., described from Texas and usually listed as a bagworm, does not belong to that family. It is an _Epipyrops_, and it is not an injurious insect.

silken texture of the bag is usually more or less concealed and strengthened by a layer of leaves, leaf-stems, small sticks, and gnawed fragments of bark. The material used and its arrangement are often characteristic of the sex and species of bagworm making the bag and of the plant upon which it has been feeding. The individual bagworm is a voracious feeder, and its life as a feeding caterpillar usually occupies most of one summer and in some species is resumed the following spring, after a winter's hibernation.

Small newly-hatched bagworms make low conical bags, which they carry upright as they walk; as the insect grows and enlarges its bag this assumes a more elongate form, and in most species, with the increasing weight of insect and bag, is carried pendant from the twigs and foliage, and is supported by the clinging feet of the worm or by

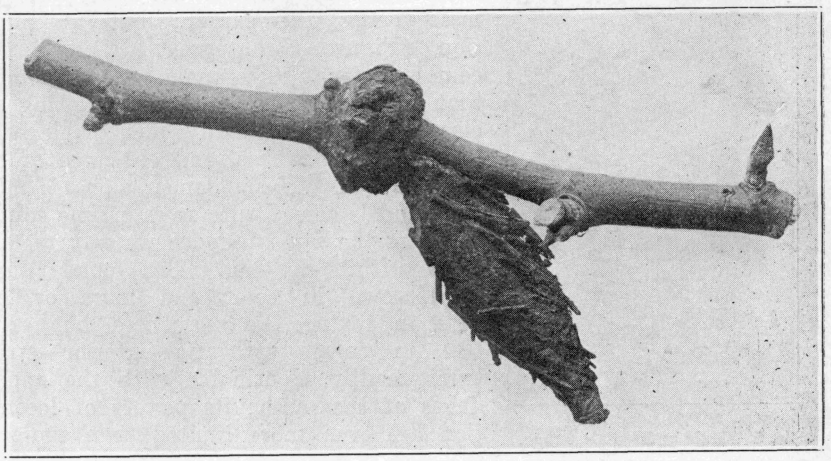

Figure 4. A bagworm-strangled twig.

threads of silk which attach the upper rim of the bag to the plant. This silken attachment relieves the feeding bagworm from supporting its own weight and that of its bag. The silk is cut loose and reattached as the worm has occasion to shift its position on the plant. At intervals in its larval life the bagworm strengthens this silken attachment and securely closes the upper opening of its bag. This is done preceding each of the four or more molts of its skin; also preceding its winter hibernation, and for other and irregular periods of lethargy and cessation of feeding; and finally, as a preparation for pupation the bag is very firmly attached and for the last time closed at the top. In some species a molt occurs between the last closing of the bag, and pupation; but in all, before the final molt the larva reverses its position in the bag and hangs with its head downward toward the narrow lower opening of the bag preparatory to its change to the pupal form.

This closes the period of direct injury to the foliage, for in its succeeding stages the bagworm takes no food, all its activities centering about the survival and propagation of the species.

Though recognized injuries usually consist of the partial or complete defoliation of the foodplant, the strength of the silken band by which the bag is attached to a twig sometimes causes a novel form of injury. This constricting band, persisting after the escape of the contained insect or even after the fall of the bag itself, stops the normal flow of sap and the expansion of the growing twig, and results in a gall-like growth (Figure 4), weakening or even killing the twig beyond the point of bagworm attachment.

The Pupa. Throughout larval life there is little apparent difference except in size between the sexes, the female being the larger; but at pupation (Figure 5) a great difference becomes obvious. The male pupa resembles that of moths in general, in exhibiting enclosed structures readily identifiable with the wings, legs, eyes, and antennae of the future moth. The abdomen alone is movable, and is armed with rows of fine spines, enabling the pupa to push its way up and down within the bag. The female pupa, also brown in color and more or less firm in texture, is segmented but grub-like in form, with no exterior structures readily identifiable with the appendages of the moth; its powers of locomotion are even more limited than those of the male.

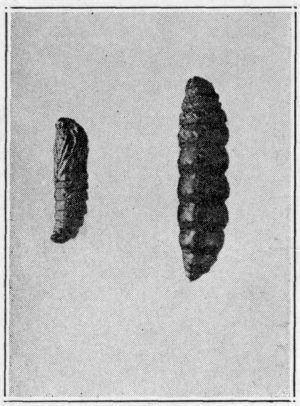

Fig. 5. Male and female pupae.

Emergence of the Adult. When the time arrives for the emergence of the male moths, there is sometimes a violent twitching of the bag, due to the movements of the contained pupa. Usually the first external symptom of an imminent emergence is the swelling out of the narrow lower end of the bag as the pupa pushes its way downward until its head and thorax are extruded from the bag. When this position is reached (Figure 6), the pupa-shell splits promptly and the moth creeps out, its wings partially expanding as it emerges. For a few minutes it clings to the pupa-shell or to the lower portion of the bag, its moist wings pendulous. When these are dried, with a sudden flirt it reverses the position of its wings over its back, and is ready for flight.

Though emergence of males may occur at any hour of the twenty-four, each species has a definite period of the day during which the greater number of emergences take place. Emergence of the males of the Evergreen Bagworm, for example, is much more frequent after midday and before dark.

The female bagworm at this stage does not completely emerge from her pupa-shell, which splits in a T-shaped slot at the head end. Through this slot the moth pushes out her head and a portion of her thorax and hangs thus head downward, still concealed within her bag, and awaits the coming of the mating male.

The duration of the pupal stage varies with the species and with the season, but in general it is much shorter than that of the larval stage, and usually does not exceed one month.

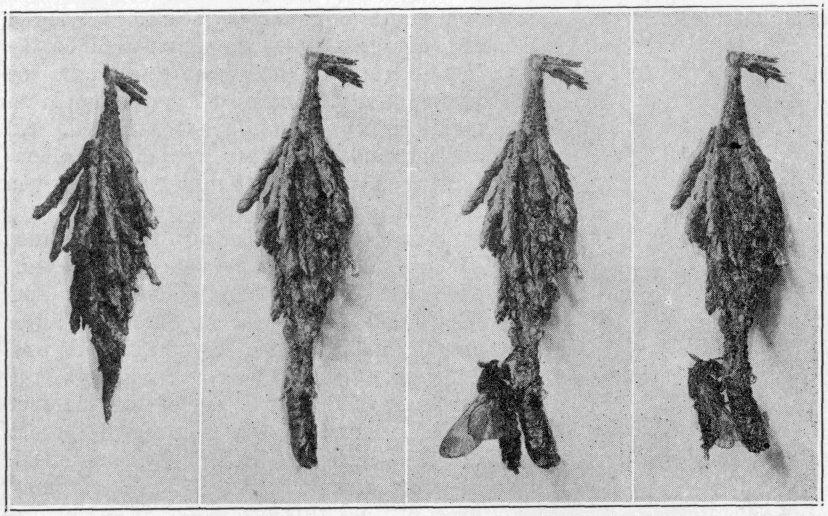

Figure 6. The emergence of the winged male.

The Adult Male and Female. The male bagworm moth, short-lived and in this stage taking no food, is capable of prolonged though rather blundering flight. In some species (the Evergreen Bagworm and its near allies) the wing-scales are so loosely attached that most of them drop off as the moth emerges from its pupa or in the first few moments of flight, leaving the wing-membrane transparent and giving the insect a bee-like aspect (Figure 7). In other narrow-winged species (the Live-oak Bagworm, for example) the scales are more firmly attached, coloring the wings various tones of brown. The smaller broad-winged species are uniformly smoky brown or blackish in color. The males of all species have broadly feathered antennae and hairy bodies and legs.

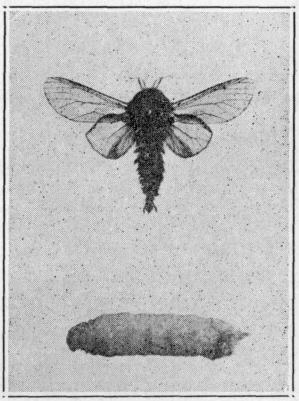

Figure 7. Male and female of the Evergreen Bagworm.

The females of all the Texas bagworms are destitute of wings. They are maggot-like in form and appearance (Figure 7), and are without functional eyes, legs, or antennae. Their bodies are soft, yellowish-white, and almost naked. Through the translucent skin great numbers of whitish eggs may be distinguished, forming a large part of the insect's bulk. Female bagworms have been aptly described as "mere sacks of eggs."

Bagworm Matings. The male bagworms are attracted to receptive females from long distances (even a mile or more) by scent. No males are attracted until the pupa-shell of the female has split, but when this occurs she immediately becomes attractive and remains so for several days if unmated. An attracted male, having located a bag containing a receptive female, alights upon it with wings and body a-quiver with excitement. Confirming the accuracy of his selection by a few seconds of excited exploration of its outer surface, he takes position at the lower end of the bag; then, by prolonged muscular exertion of legs and body, he introduces the pointed end of his abdomen into the narrow lower opening of the bag of the female. Aided by pneumatic pressure from within his inflated body, he continues this process of insertion until his entire abdomen, up to the wing-bases, is hidden in the bag. He then becomes quiescent and hangs suspended, head downward (Figure 8), throughout the mating period, which usually occupies ten minutes or less; and then slowly retracting his body, he rests on the bag for a few seconds, and flies away.

Fig. 8. A male in mating position.

If we kill a mated pair quickly so that the insects have no opportunity to change their relative positions, and then remove the silken bag which conceals the female, we find the inflated body of the male, greatly extended longitudinally, passing into the split pupa-shell of the female (Figure 9); and if we continue the investigation and remove the pupa-shell, too (Figure 10), we find his body still further extended along the whole length of the female, making possible a mating in this most extraordinary position.

Male bagworm moths are capable of two or more successive matings, and sometimes they pass directly from the bag of one female to that of another.

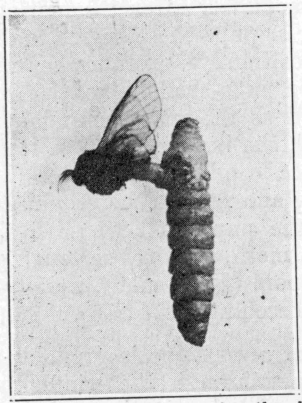

Figure 9. A mating pair, the bag removed.

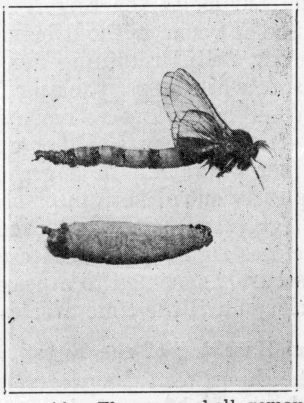

Figure 10. The pupa-shell removed.

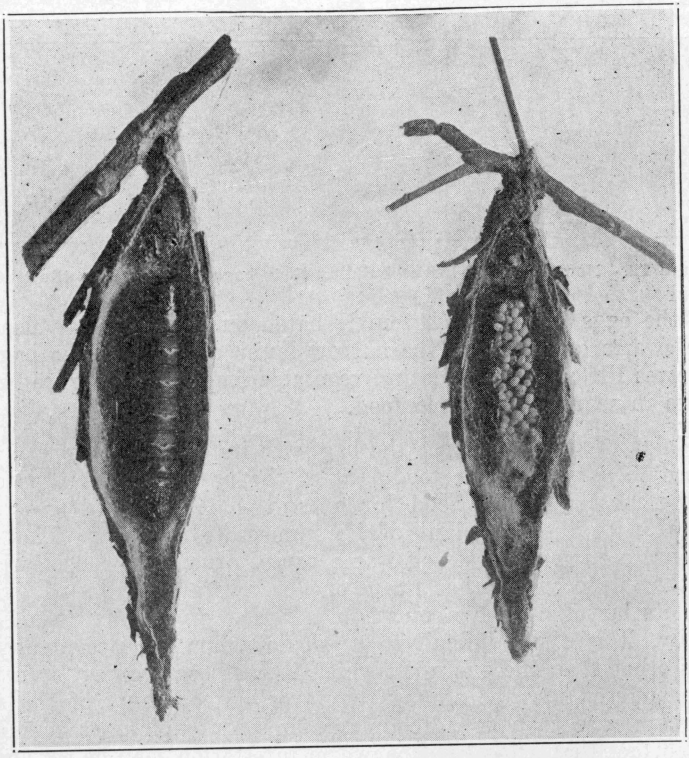

Figure 11. Section of bag of female, showing pupa and eggs.

The Laying of the Eggs. Almost immediately after the mating, the female bagworm, without leaving her bag or pupa-shell, begins to deposit her eggs. Still retaining her inverted position she extrudes her numerous soft white eggs, packing them in her pupa-shell, mixed with down from her body, and retreating downward as the space behind her fills up. In a few hours all her eggs are laid, she has shrunken to less than half her bulk, and in a greatly weakened condition she forces herself completely out of both pupa-shell and bag and falls to the ground to die. The eggs, concealed and protected by the pupa-shell whose T-shaped slot closes tightly after the escape of the moth, and by the tough silken bag securely fastened to a permanent support (Figure 11), usually hang in safety until the time arrives for their hatching.

The Hatching of the Eggs. The eggs of several species, notably those of the Evergreen Bagworm, always hang through the winter in the pupal case and bag of the parent moth, and hatch in the spring; other species which pass the winter as larvae or which have less regular life-cycles deposit eggs in the spring or summer. These hatch the same season.

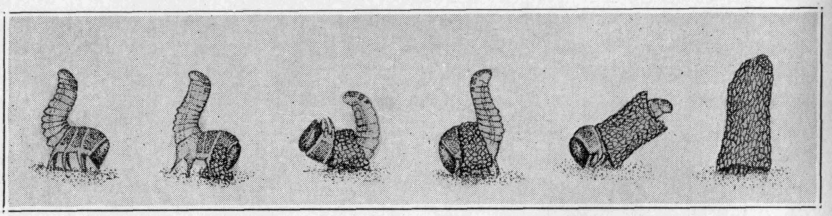

Figure 12. Newly-hatched larvae building their bags (after Riley's illustration).

All the eggs laid by each female hatch simultaneously. The young larvae swarm out through the narrow lower opening of the bag, build themselves little bags of silk and vegetable fragments (Figure 12), and disperse in search of suitable food.

Foodplant Selection. Since the bag with its contained eggs is usually attached to a twig of the foodplant of the parent insect, it is obvious that the most available food for a newly-hatched larva as a rule is identical with the foodplant of its immediate ancestry. Though the occasional occurrence of a bag whose varied ornamentation clearly indicates that its occupant has made one or several changes of foodplant within its larval life, this condition is rather exceptional; and, experimentally, it is often difficult to persuade a larva to accept any plant species other than the one upon which it has been feeding, even though the one offered may be among the favorite foodplants of the species. This reluctance to change foodplants in part explains the frequently observed fact that a localized bagworm infestation may be confined to a single plant species. In mixed growths of available foodplants, selective

infestation of a single plant species is often apparent, and it is believed there is abundant evidence that foodplant choice by the young larvae rests on an inherited preference as well as on early proximity and reluctance to change. In this way impermanent foodplant races persisting for a number of years often result. Since each foodplant supplies a characteristic material for the ornamentation of the bags, and indeed sometimes has a direct effect on the color of the silk and on the method of attaching the vegetable fragments, these races may simulate species in the uniformity of their bag-structures, which may be in wide contrast to those of the same species from other foodplants. These foodplant associations, however, break down through failure of food-supply and the enforced acceptance of other plant species, and through the chance dispersal of some larvae to other foodplants which they accept. That is, a bagworm infestation on a single plant species is especially dangerous to all nearby plants of the same species; furthermore, the presence of an infestation on a relatively worthless plant often becomes a source of danger to other unrelated plants of greater value.

Means of Dispersal. Since the egg-laying female is destitute of wings and legs, she cannot contribute toward the distribution of the species, but only to its localized continuance. When the eggs hatch and the young larvae swarm out from the bag of their female parent, they have the power of spinning a thread of silk even before they have fed. At this time some of them may be observed letting themselves down from the bag and from adjacent twigs and leaves, while others proceed immediately to the manufacture of bags from the nearest available material. Both the newly-hatched naked caterpillars and those of the same age which have just completed tiny bags, letting themselves down by silken threads or releasing their hold on the herbage, are readily wafted by the breeze from plant to plant, and even for very considerable distances. Within a short time from the hatching of an egg-mass, many of the young larvae may be observed upon the ancestral foodplant in the vicinity of the bag of the parent, but some may be on plants many yards away in the direction of the air-currents at the time. This appears to be the time and method of greatest dispersal from a center of infestation, and under exceptional circumstances the result may be a new area of infestation within a single season. Haseman (Bulletin 104, Mo. Agr. Exp. Sta., 316, 1912) records an intensive infestation of several thousand rose bushes by young larvae wind-transported from an infested pine grove a quarter of a mile distant. Accidental carriage of the young larvae by grazing animals and by vehicles is always a possibility.

Older larvae often wander long distances from their first foodplant. This sometimes comes about from a failure of the food-supply, sometimes from an accidental fall to the ground. Stream-side bushes and trees, such as willows, cypress, button-ball, are often severely infested when upland plants escape, and flood-distribution of bags containing

larvae or eggs is probably frequent. Wide distribution by exceptional windstorms is an occasional factor, for Dr. Seitz has recorded finding on the treeless pampas of Uruguay branches of trees with living bagworms attached to their twigs carried for many miles by a gale; and the junior author has made a somewhat similar observation in Texas, of numerous living insects being transported by small whirlwinds. A common source of new infestations in parks and cemeteries is the unsuspected inclusion of bagworm bags containing eggs, on the branches or foliage of transplanted trees and shrubs.

When we remember that a single bag of the female of the Evergreen Bagworm usually contains more than five hundred eggs, that the number may exceed 1600 or even 3000 (Girault, Felt), the possibilities for harm in the unintentional introduction of a single egg-bag, or even in the overlooking of a single larva, become evident.

Enemies and Natural Control. The behavior of the bagworm when alarmed is evidence that its tough silken case serves as a defensive retreat. Against some birds, reptiles, and predacious insects this defense is adequate; but some bird species have been observed to feed upon the larvae, and bags with holes pecked in them, through which pupae or egg-masses have been abstracted, are not unusual.

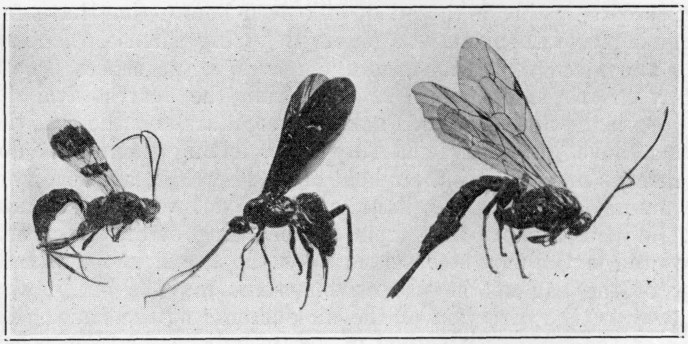

Figure 13. Some common bagworm parasites (enlarged).

By their own intensity of infestation, bagworms often exhaust a limited food-supply, resulting in the starvation of some and the weakening and stunting of others of their number. These dense assemblages offer the most favorable conditions for the spread of bacterial or fungoid diseases and for the multiplication of parasites. Parasites of many species attack them; and against some of these (Figure 13), armed with needle-like ovipositors, the bag offers no defense, for the egg-laying parasite may be observed proceeding from bag to bag, probing through their close-textured walls and ovipositing in the contained larvae. In old bagworm infestations, parasitism often results in the death of a very large percentage of the larvae and pupae present. These checks, in

varying degree, with fluctuating weather conditions, are the probable explanation of the observed irregular periodicity of bagworm attack; but while bagworm colonies often show a high rate of mortality from one or several of these causes, they usually result in only a temporary diminution of numbers and a consequent lessening of the injuries inflicted; for however great the proportion of bagworms succumbing to starvation, to disease, or to parasites, in any infestation a few individuals almost invariably survive, and in greater or fewer numbers the colony persists from year to year.

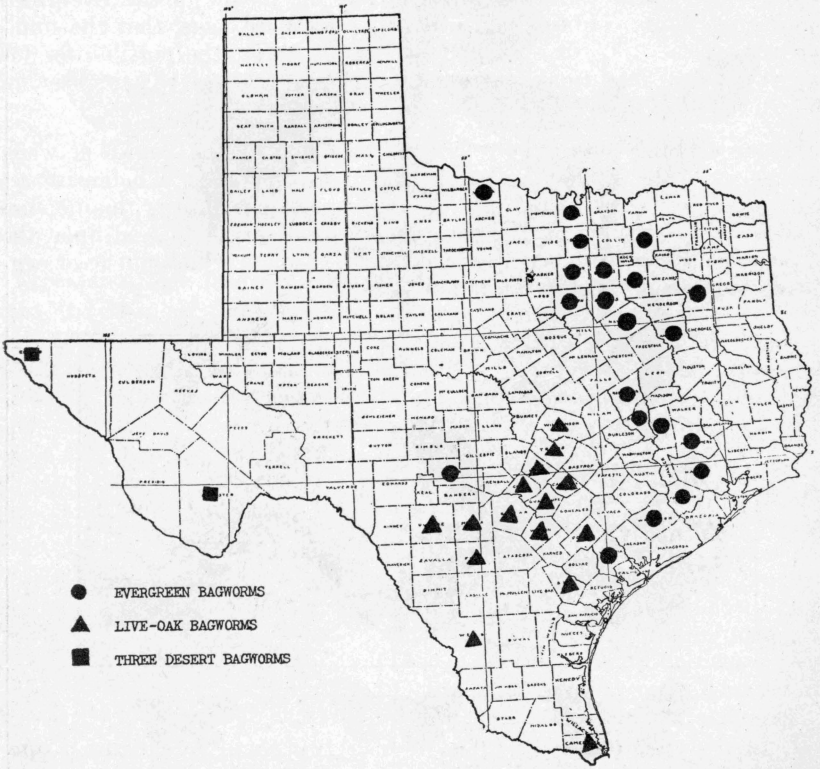

Figure 14. Map showing distribution (as far as recorded) of the more injurious Texas bagworms.

The accompanying map (Figure 14) illustrates by counties the distribution of the more injurious species and groups, as far as we have positive record of their occurrence; although their actual limits of distribution are probably much more extensive. In Figure 15 are illustrations of the males of all the known bagworm species of Texas; and in succeeding figures their bags are shown, which together with the accompanying text, should ordinarily suffice for the identification of the

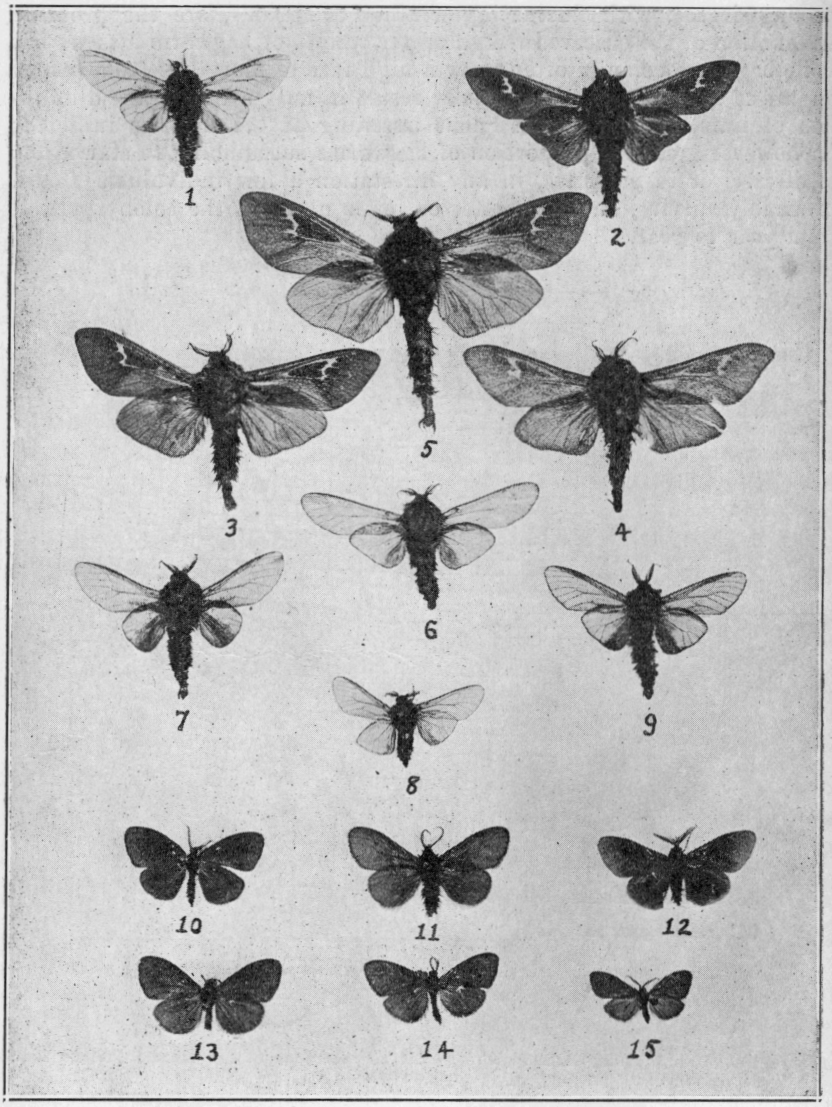

Figure 15. Adult Males of Texas Bagworms.

1. Evergreen Bagworm.
2. Live-oak Bagworm.
3. Tornillo Bagworm.
4. Locust Bagworm.
5. Big-stick Bagworm.
6. Mesquite Bagworm.
7. Pine Bagworm.
8. Creosote-bush Bagworm.
9. Solitary Bagworm.
10. Lawn Bagworm.
11. Chalk-hills Bagworm.
12. Oasis Bagworm.
13. Orange Bagworm.
14. Mimosa Bagworm.
15. Lichen Bagworm.

species. Number 1 of Figure 19 is from a specimen in the collection of the Academy of Natural Sciences, Philadelphia; all the remaining figures are based on photographs of specimens preserved in the collection of the senior author.

THE EVERGREEN BAGWORM

Thyridopteryx ephemeraeformis Haworth

Original Description. Haworth, Lepidoptera Britannica, 72, 1803 (as *Sphinx ephemeraeformis,* in error described as an English insect).

Recent Literature. Haseman, Bulletin 104, Mo. Agr. Exp. Sta., 309-330, 16 ill., 1912.

Howard & Chittenden, U. S. Dept. Agr. Farmers' Bulletin, 701, 1-12, 13 ill., 1916.

Jones, Trans. Am. Ent. Soc., LIII, 293-312 and 6 pl., 1927.

Distribution. From southern Massachusetts to Kansas, south to Florida and Texas. In Texas, east of the center from Oklahoma to the Gulf; for recorded distribution by counties see map, page 17.

Foodplants and Injuries. Attacking the foliage of most species of trees and shrubs; frequently defoliating willow, cedar, cypress, white pine, hemlock, box elder, locust, sycamore, maple, wild cherry, sumac, sassafras, persimmon; especially dangerous to arbor-vitae and other ornamental conifers; sometimes severely injuring apple and other fruit trees.

Identification. Compared with the Live-oak Bagworm (page 21), the bags of the Evergreen Bagworm (Figure 16) are usually smaller, and proportionately wider at the middle. When leaf-stems or small twigs are used in their ornamentation, these are placed lengthwise of the bag by the Evergreen Bagworm, crosswise by the Live-oak Bagworm. Its present range of distribution does not seem to overlap that of the Desert-shrub Bagworms, from which, too, it is readily distinguishable by bag structure.

The adult male (No. 1, Figure 15) has a black furry body, and after the first few moments of flight its wings are almost entirely transparent.

Life Cycle. This insect passes the winter in the egg stage. These eggs hatch in the spring, the caterpillars complete their growth and pupate in August or September; the moths emerge in September or October, deposit their eggs and die.

Control. Smaller infestations on deciduous trees and shrubs are readily controlled by hand-picking in the winter, when the bags are easily seen on the bare twigs. If hand-picking is not practicable, spraying the infested herbage with arsenicals at the season when the larvae are small and non-resistant to poison gives satisfactory control.

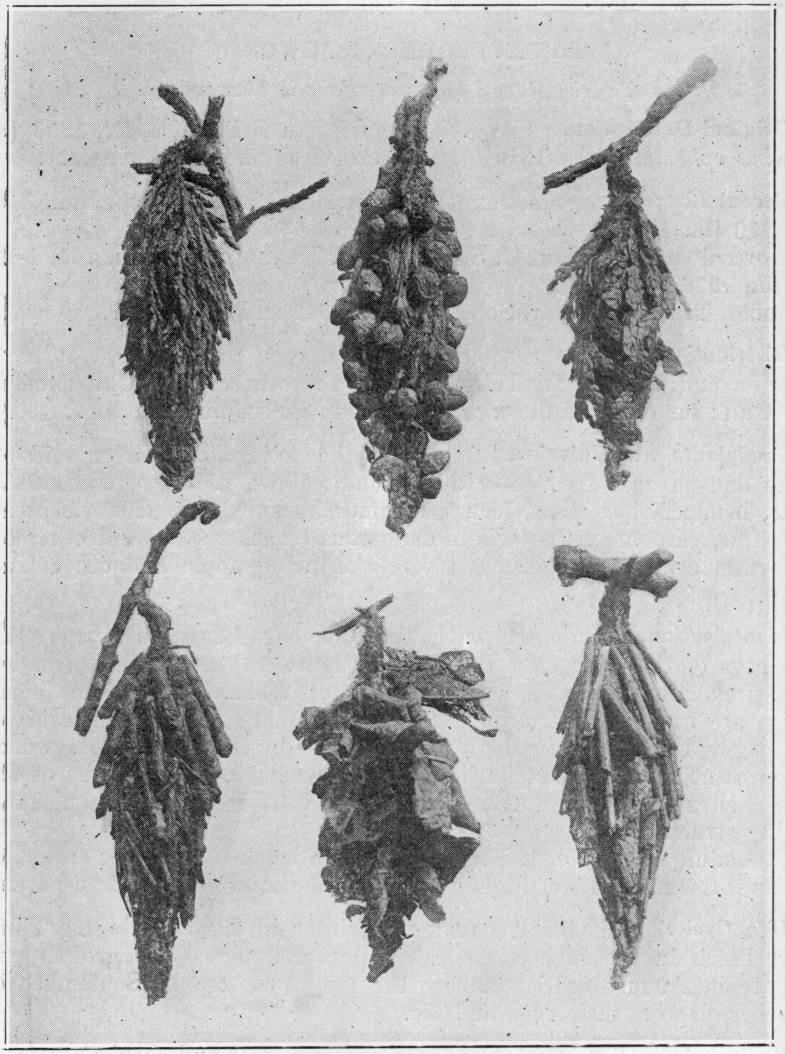

Figure 16. Bags of Evergreen Bagworm from various foodplants.

Cedar	Cedar	Arbor vitae
Cypress	Locust	Willow

THE LIVE-OAK BAGWORM

Oiketicus abbotii Grote

Original Description. Grote, The North American Entomologist, I, 52, 1880 (described from a Texas specimen).

Distribution. The coastal tier of States from Virginia to Texas inclusive. In Texas, abundant in the south-central portion, thence eastward (complete records lacking) to the Louisiana line; for recorded distribution by counties see map, Figure 14.

Foodplants and Injuries. Attacking the foliage of most trees and shrubs, but on its wild foodplants usually manifesting greater uniformity of numbers and less intensity of infestation than does the preceding species. Among wild foodplants its preferences include live oak, catsclaw (and other Mimosaceae), cypress, Myrica, and hackberry. In the streets and parks of San Antonio this is an abundant insect. Complete defoliations of arbor vitae, and severe infestations of sycamore, box elder, rose, and other plant species have been noted.

Identification. The bag is very variable (Figure 17), but the crosswise arrangement of sticks and other attached fragments usually serves to distinguish it; these fragments are sometimes swathed in silk; when leaf-fragments only are used, the bag may present a more or less regularly shingled aspect, and sometimes it closely resembles a similarly decorated bag of the Evergreen Bagworm. The adult male (No. 2, Figure 15) is dark brown, its wings opaque except for a narrow vitreous bar in the middle of each front wing.

Life Cycle. Seasonally much less regular than the Evergreen Bagworm, and feeding larvae of all ages may be found throughout the spring and summer. The greater number of moths emerge in the spring (April and May), but others appear at later dates until October. The winter is passed, frequently as hibernating larvae, most of which reopen their bags and feed in the spring, before pupation; hibernated eggs may hatch as early as February.

Control. Hand-picking when practicable; spraying with arsenicals, preferably when the larvae are small. A localized infestation may consist of caterpillars of approximately the same age, controllable when young by a single application of arsenate of lead; but when young and old are mixed, or when unhatched eggs are present, successive sprayings will be necessary.

THREE DESERT BAGWORMS

I. The Tornillo Bagworm, *Oiketicus townsendi* Townsend, Canadian Entomologist, XXIV, 199, 1892 (as *"Thyridopteryx sp."*); Zoe, IV, 356, 1894 (as *Oiketicus townsendi,* Riley MSS.).

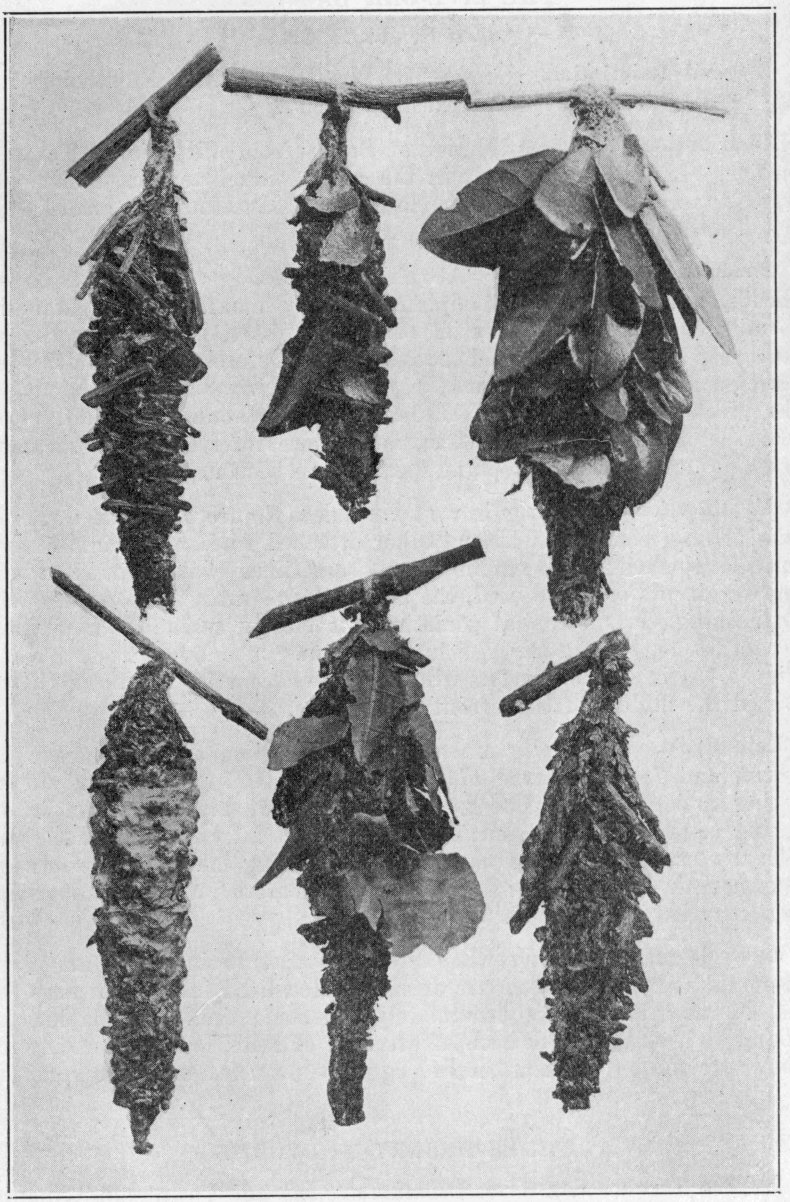

Figure 17. Bags of Live-oak Bagworm from various foodplants.

Rubus (?) | Live Oak | Live Oak
Acacia | Sycamore | Arbor vitae

II. The Locust Bagworm, *Oiketicus bonniwelli* Barnes & Benjamin, Bulletin Brooklyn Entomological Society, XIX, 24, 1924.

III. The Big-stick Bagworm, *Oiketicus dendrokomos* Jones, Trans. American Entomological Society, LII, 1, 1926.

Whatever the finally accepted status of these forms, their identity of habit and similarity of appearance render their separate consideration unnecessary here.

Distribution. The Tornillo Bagworm has been recorded from the Mesilla Valley, N. M.; Juarez, Mexico; El Paso, Texas. The Locust Bagworm was described from specimens collected at El Paso. The Big-stick Bagworm is a shade-tree pest at Alpine, Texas. Similar if not identical bags have been collected at a number of localities in southwest Texas and southeastern Arizona, and representatives of this closely allied group doubtless occur throughout much of Trans-Pecos Texas. For recorded distribution by counties see map, Figure 14.

Foodplants and Injuries. The Tornillo Bagworm is a frequent defoliator of the shrub whose name it bears. The Big-stick Bagworm (No. 3, Figure 18) has several observed wild foodplants, one being *Aloysia wrightii.* All three are almost general feeders on the limited number of species utilized as shade and ornamental trees within their range, being especially prevalent on locust, sycamore, and salt cedar (*Tamarix*). Townsend records their presence as an orchard pest in New Mexico.

Identification. The bags of the Tornillo Bagworm (No. 1, Fig. 18) and of the Locust Bagworm (No. 2, Figure 18) are indistinguishable, when taken from the same foodplant; they are longer and more cylindrical than those of the Evergreen Bagworm, though resembling them in the longitudinal arrangement of their ornamentation. The adult males of all three (Nos. 3, 4, 5, Figure 15) are tawny brown, those of the Locust Bagworm more smoky and less yellowish in tone; its larger size usually serves to distinguish the male of the Big-stick Bagworm from the other two.

Life Cycle. These insects usually pass the winter as large larvae, feed a little in the spring, pupate in April or May, and emerge as moths in April, May, June, or even later. Their growth and changes are probably as much influenced by rainfall as by season.

Control. When their foodplants are bare of leaves, the large size of these bags renders hand-picking easy; when this measure is inadequate or impracticable, spraying with arsenicals, preferably, when the larvae are young, should give satisfactory control.

Figure 18. Three Desert Bagworms.

1. The Tornillo Bagworm.
2. The Locust Bagworm.
3. The Big-stick Bagworm.

THE MESQUITE BAGWORM

Oiketicus toumeyi Jones

Original Description. Jones, Entomological News, XXXIII, 12 and 133, 1922.

Distribution. Widely distributed in southeastern Arizona; not definitely recorded from Texas, but will probably be found within the State boundaries.

Foodplants and Injuries. An abundant species on mesquite, catsclaw, and other Mimosaceae. It adapts itself to cultivated and unrelated plant species and quickly acquires preference for them. In Tucson, severe and persistent infestations of locust, Italian cypress, and ailanthus have been noted, while nearby mesquites were untouched. Ailanthus is widely unrelated to the native foodplants of this insect, and is almost immune from attack by other general-feeding lepidoptera. Its foreign origin, of necessity, would indicate that its acceptance as a preferred foodplant, by *toumeyi,* is recent. This seems a remarkable instance of the success and persistence of a recently acquired foodplant association.

Identification. The long slender bag (Nos. 2-7, Fig. 19) of this species usually shows a great deal of bare silk (white when found on mesquite), with only a few stick fragments, attached lengthwise; on some other food plants (especially on ailanthus) leaf material closely applied covers the silk. The adult male (No. 6, Figure 15) has clear wings; its body is pale brown.

Life Cycle. Seasonally irregular, though hibernation is more usual as full-grown larvae, some of which reopen their cases in the spring and feed sparingly. Most of the moths emerge in May and June.

Control. Hand-picking when practicable; if spraying must be resorted to, this will be more effective if done when the caterpillars are small.

THE MOUNTAIN-CEDAR BAGWORM

Oiketicus sp. (?)

Number 1, Figure 19, illustrates a large bagworm of unidentified species, which has been found at various times in Texas (El Paso region) and southeastern Arizona, usually at considerable elevations. The few definite records indicate that this insect passes the winter in the larval stage, and that *Juniperus sp.* is a usual foodplant. The bag is of the crossed-stick type like that of the Live-oak Bagworm, but larger and thicker, and the sticks are closely swathed in silk. The adult is not known, but it may prove to be a described Mexican species.

If this insect should ever occur in injurious numbers, the measures suggested for the control of related species would be applicable.

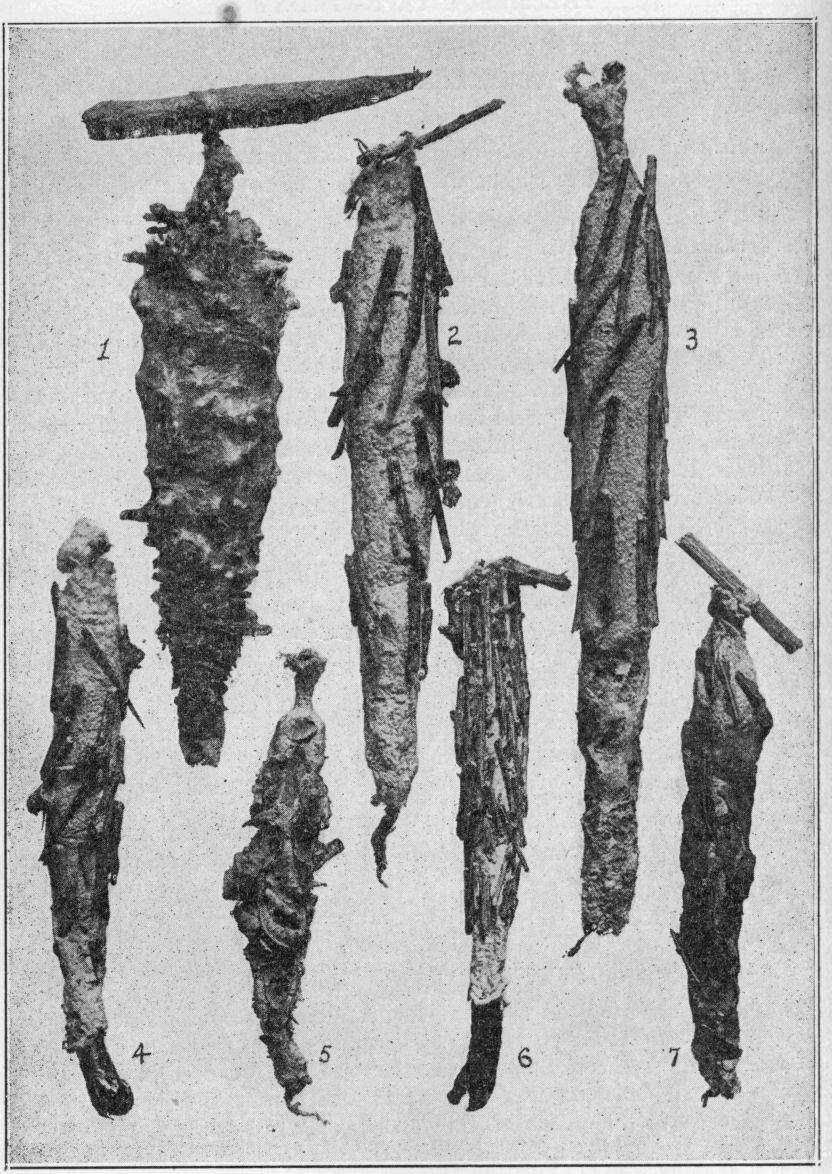

Figure 19. The Mountain-Cedar and the Mesquite Bagworms.

1. Mountain-Cedar Bagworm.
2 to 7. Mesquite Bagworms.
2. Bag of female, from mesquite.
3. Bag of female, from locust.
4. Bag of male, from mesquite.
5. Bag of male, from locust.
6. Bag of male, from Mimosa.
7. Bag of male, from ailanthus.

THE PINE BAGWORM

Thyridopteryx vernalis Jones

Original Description. Jones, Entomological News, XXXIV, 100, 1923.

Distribution. Coastal States, southern Delaware to southeastern Texas. Only one Texas record (Houston), but probably widely distributed in the State.

Foodplants and Injuries. Pines, other than white pine; *Pinus taeda, Pinus rigida,* etc. Infestations rarely severe, and then usually limited to a single tree or to a few closely adjacent ones.

Identification. Bag (No. 1, Fig. 20) smoother and more slender than that of the Evergreen Bagworm, and usually decorated with small fragments of bark or lichen rather than with leaf material; for pupation, often attached to the trunk of the tree. The adult male (No. 7, Figure 15) is almost indistinguishable from that of the Evergreen Bagworm.

Life Cycle. Winter hibernation of the larvae and the spring emergence of the adults characterize this species, in comparison with the egg-hibernation and fall emergence of the Evergreen Bagworm. The larvae resume activity and feed in the spring, before pupation.

Control. This insect has never been recorded as seriously injurious. Among the pine needles it is so difficult to see, that hand-picking can not be depended upon for its control. By its observed life-cycle, June or early July is indicated as a favorable time to spray.

THE CREOSOTE-BUSH BAGWORM

Thyridopteryx meadii Hy. Edwards

Original Description. Hy. Edwards, Papilio, I, 116, 1881.

Distribution. Southern California, Arizona, southwestern Texas. In Texas, definitely recorded from El Paso and Brewster Counties, but probably may be found wherever its foodplant abounds.

Foodplants and Injuries. This insect seems to confine its feeding strictly to the foliage of the Creosote Bush (*Covillea*), and consequently it has no present economic importance.

Identification. The bag (No. 3, Fig. 20) is very variable in appearance, dependent upon the proportion of leaf-material or of sticks used in its ornamentation; a spiral arrangement of the sticks is often apparent. The adult male (No. 8, Figure 15) resembles that of the Evergreen Bagworm, but is smaller and slighter, with narrower wings.

Life Cycle. Extremely irregular, and more dependent upon rainfall than upon season.

Control. Arsenical spraying; too difficult to see, for hand-picking.

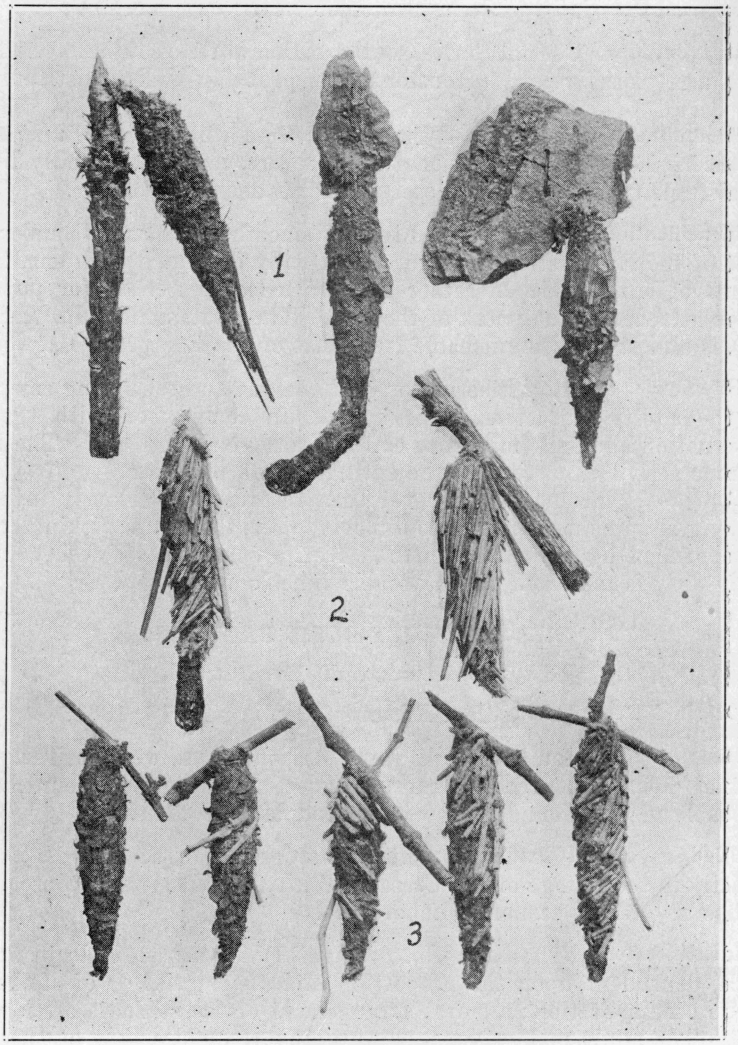

Figure 20.

1. The Pine Bagworm.
2. The Solitary Bagworm.
3. The Creosote-Bush Bagworm.

THE LAWN BAGWORM

Eurukuttarus confederata Grote & Robinson

Original Description. Grote & Robinson, Trans. Am. Ent. Soc., II, 191, 1868-9; described from a Texas specimen.

Distribution. New England to Texas. In Texas, recorded from Tarrant, Bexar, Frio, DeWitt, and Cameron Counties.

Foodplants and Injuries. An inconspicuous ground-feeding species, preferring grasses as its food. In Texas a single complaint has been received of its injury to lawns.

Identification. The bag (No. 1, Fig. 21) is closely thatched with fragments of grass applied lengthwise. The adult male (No. 10, Figure 15) is black throughout, its wings densely opaque. Slightly different bags collected at Point Isabel may indicate the presence there of another but closely-allied species.

Life Cycle. In the spring the winter-hibernated larvae creep up posts, tree trunks, or rocks, and attach their bags for pupation; emergence of the adults and the hatching of the eggs follow in the course of a few weeks.

Control. Hand-picking, if this can be done between the creeping up of the larvae (in March or April) and the hatching of the eggs; otherwise, spraying at the time injury is observed.

THE ORANGE BAGWORM AND ITS ALLIES

Under this heading we include:

I. The Orange Bagworm (No. 13, Fig. 15), *Platoeceticus gloverii* Packard, Guide to Study of Insects, 291, 1869.

II. The Mimosa Bagworm (No. 14, Fig. 15), *Platoeceticus jonesi* Barnes & Benjamin, Contrib. Nat. Hist. Lep. N. A., V, No. 1, 47, 1922, & V, No. 3, 188, 1924; and possibly other races or species of similar structure and habit, not yet satisfactorily differentiated.

Distribution. Coastal States, South Carolina to Texas. In Texas, San Antonio eastward, south to the Gulf.

Foodplants and Injuries. Occasionally injuring the leaves, buds, and green fruits of citrus trees (*gloverii*). The family *Mimosaceae* furnishes favorite foodplants (for *jonesi*). Cypress, oak, crepe myrtle, arbor vitae are frequently attacked. These insects are to some extent scavengers, and sometimes carnivorous, eating waxy scale insects and ornamenting their bags with the remains. The bark of crepe myrtle and other shrubs is often disfigured by their feeding.

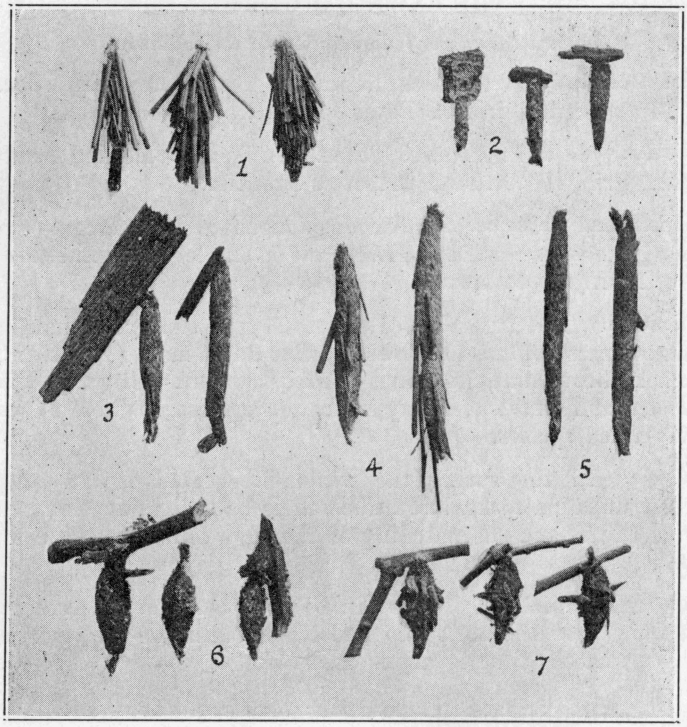

Figure 21. The Smaller Texas Bagworms.

1. The Lawn Bagworm.
2. The Lichen Bagworm.
3. The Chalk-hills Bagworm.
4. Bagworm sp.?, Alpine.
5. The Oasis Bagworm.
6. The Orange Bagworm.
7. The Mimosa Bagworm.

Identification. On orange, the bags (of *gloverii*) are often almost bare of leaf-fragments (No. 6, Figure 21); on other foodplants the shape of the bag (No. 7, Figure 21) is usually obscured by attached material.

Life Cycle. Seasonally irregular. The winter is passed usually as eggs or as larvae, and various stages occur simultaneously throughout the summer.

Control. To some degree controllable by hand-picking. For extensive infestations, spray as directed on pages 32-33.

THE CHALK-HILLS BAGWORM

Eurukuttarus edwardsii Heylaerts (*carbonaria* Packard)

Literature. Original Description—Heylaerts, C. R. Soc. Ent. Belg., XXVIII, ci, 1884.

Packard, Ent. Amer., III, 51, 1887 (as *Psyche carbonaria*).
Jones, Ent. News, XXXVI, 33, 1925.

***Distribution.** Described from Texas specimens and not known to occur in other States. It has been found in Tarrant, Dallas, Bosque, Llano, Kerr, Kendall, Comal, Bexar, Frio, and DeWitt Counties.

Foodplants and Injuries. Prefers barren areas where the thin herbage only partially covers the chalky soil. The larvae probably eat both living and dead vegetable matter. Never reported as injurious.

Identification. The slender pencil-like form of the bag (No. 3, Fig. 21) is characteristic of this and of the Oasis Bagworm. The adult males of both species are black, the Chalk-hills Bagworm (No. 11, Fig. 15) having more rounded wings and lacking the pale edging which characterizes the wings of the Oasis Bagworm.

Life Cycle. The full-grown larvae creep up posts or tree-trunks in September and attach their bags for pupation; the moths emerge in October or November; the winter is probably passed in the egg stage.

Control. The Chalk-hills Bagworm is rarely seen, except when it has crept up for pupation; it probably has no economic importance, but if it be desirable to eradicate it, this could be accomplished by spraying in the summer season.

THE OASIS BAGWORM

Eurukuttarus polingi Barnes & Benjamin

Original Description. Barnes & Benjamin, Contrib. Nat. Hist. Lep. N. A., V, No. 3, 186, 1924.

***Distribution.** Indian Oasis, Arizona.

Differences between this species and the preceding are noted above. The Oasis Bagworm emerges as a moth (No. 12, Fig. 15) in the spring (April); of its feeding habits nothing is known with certainty, but it is probably of no economic importance. The identity of the bags illustrated as those of the Oasis Bagworm (No. 5, Fig. 21) has not been confirmed by breedings.

THE LICHEN BAGWORM

Prochalia pygmaea Barnes & McDunnough

Original Description. Barnes & McDunnough, Contrib. Nat. Hist. Lep. N. A., II, No. 4, 171, 1913.

Distribution. Coastal States, South Carolina to Texas. In Texas, Bexar County southward.

*The bagworm bags illustrated by number 4 of Fig. 21 (page 30), were found attached to the sides of boulders in Musquiz Canyon, a few miles north of Alpine, Texas. Specimens of the moths were not obtained, and it is not yet possible to determine whether these bags indicate the presence of either the Chalk-hills Bagworm or the Oasis Bagworm in that locality, or whether they belong to a third and undescribed species.

Foodplants and Injuries. Found, often in colonies, on the trunks and main branches of trees, or even on lichen-covered fences. Their principal food seems to consists of adherent vegetable growths, but they also eat the tree-foliage and the buds, and on smooth-barked species leave disfiguring tortuous marks where they have fed. They are rarely present on conifers, but oak, maple, magnolia, crepe myrtle, orange, and pecan are favorite hosts, and even *Opuntia* is sometimes utilized.

Identification. The bags (No. 2, Fig. 21) are borne upright by their occupants, and they vary greatly in the amount of attached lichen and bark-fragments, which sometimes completely disguise their slender cylindro-conical shape. One or probably several additional species of similar size, appearance, and habit are found in the United States, and the proper application of the names, in some cases, must await fuller knowledge; this reference of the Texas specimens is therefore provisional.

Life Cycle. Irregular seasonally. Available records indicate emergence of the moths in the spring or early summer.

Control. If it is desirable to remove these bagworms from tree-trunks, a long-handled stiff brush would probably suffice. It has been observed that its colonies disappeared from trees sprayed with arsenicals for other purposes.

THE SOLITARY BAGWORM

Thyridopteryx alcora Barnes

Original Description. Barnes, Canadian Entomologist, XXXVII, 214, 1905.

This insect has not yet been recorded from Texas, the few known specimens having been found in southeastern Arizona. Pupae and full-grown larvae have been found in May, the moths emerging in June; the type was captured in August. For pupation the bags are attached to overhanging rocks or to low-growing shrubs, and apparently the insect feeds on low vegetation. The bags (No. 2, Fig. 20) are larger and thicker than those of the Creosote-bush Bagworm, which they resemble in the spiral arrangement of the attached grass-stems and sticks. The adult male (No. 9, Fig. 15) resembles the male of the Evergreen Bagworm. The insect has no recognized economic importance.

MEANS OF CONTROL

Hand Picking. The simplest method of control—that of hand picking—is often entirely effective. When the branches are bare of leaves, the bags of the larger species of bagworms are readily seen on bushes or on deciduous trees of moderate size. Unless other infested herbage is permitted to remain nearby, the complete removal of the bags in the winter puts an end to the infestation. On such herbage, if it is desirable to terminate a threatened defoliation without waiting for the

winter season, the feeding larvae may often be reduced to a negligible number by several successive pickings; but this should be supplemented, the next winter, by a careful search of the bare branches for bags which may have been overlooked in the earlier searches and which would be sufficient to renew the infestation another year. On compact evergreens of considerable size, such as arbor vitae or cedar, complete eradication by hand picking is not practicable, and spraying with insecticides is the only recourse for permanent relief.

The use of a knife or of scissors will obviate injury to the twigs in the removal of the tough silken bags, and a pole-pruner is often a convenience in reaching the higher branches.

Though it is frequently recommended that the gathered bags be kept for a time in a coarsely-screened or an open receptacle to permit the survival and escape of the beneficial parasites, the danger of the distribution of newly-hatched bagworm larvae which would creep up through the screen offsets any possible advantage of this nature. We recommend the prompt destruction by fire of the gathered bags.

When practicable, hand picking is especially effective against the Evergreen Bagworm, which passes the winter in the egg stage. These are contained in the bags of the female parent. It is often equally effective against the Live-oak Bagworm and the Desert-shrub Bagworms, most of which survive the winter as full-grown larvae or as eggs.

The smaller species of bagworms, less conspicuous by their size and habits, can not be effectively eradicated by hand picking unless the area of infestation is of very limited extent. Fortunately, few of the smaller species ever give occasion for serious complaint.

The foliage of tender herbs, of roses and of some other delicate-leaved shrubs, is often severely burned by arsenical sprays of the strength necessary to eradicate the bagworm, and for its control on such herbage hand picking is our best reliance.

Spraying with Arsenicals. The only satisfactory control measure is to spray the infested foliage with arsenicals if any of the following conditions exist: when the infested area is too great for control by hand picking; when the infested trees are too numerous or too tall for this method; when the trees consist of evergreen species whose foliage precludes the discovery and removal of all the bags; when old and young bagworms are mingled in the infestation, so that the removal of the easily-found larger bags inevitably leaves many smaller larvae to continue the defoliation; or when the infesting species is one of the smaller bagworms whose size and habits prevent its easy discovery and thorough elimination by hand picking.

We recommend the use of arsenate of lead paste, in the proportion of two pounds of the paste to fifty gallons of water, to be thoroughly applied with the full force of the sprayer.

The selection of the time for spraying is of equal importance with the proper strength and thorough application of the spray. If the

spraying can be done when all the bagworm larvae are young and small, a single application may completely terminate the infestation; if the larvae are older or of various ages, two or more sprayings may be necessary for control, with the possibility of further attention being required the succeeding season. With some species it is possible to indicate an approximate date at which all the eggs will have hatched and none of the larvae will be past the age of high poison-susceptibility; with other species of less regular life-cycles, the proper time for spraying can be less definitely indicated, and a careful examination of prevailing conditions is the only certain guide. It is obviously of little utility to spray, when most of the bags contain living pupae (Figure 5) or unhatched eggs (Figure 11) or lethargic larvae in bags closed at the top. The presence of small larvae in miniature bags (Figure 12) indicates the most favorable time, and the presence of feeding larvae (Figure 3) of some age is a necessary condition for spray control.

The examination at various seasons of thousands of bags of the Evergreen Bagworm shows that this species habitually passes the winter in the egg stage; these eggs hatch in the spring (in Texas, usually in early May); therefore, a time between the middle and the end of May is, in most years, a favorable time to spray, for the control of this species; though from this period until the bags are closed for pupation in the late summer, good results are possible. The older the larvae, the less satisfactory are the results to be anticipated from a single spraying; and on foliage sufficiently resistant to arsenical burning, the substitution of three pounds of arsenate of lead paste instead of two will be more effective.

Similarly, though at less predictable dates, many eggs of the Live-oak Bagworm hatch in the spring. There are records of hatchings in February, March, April, and even as late as mid-September. Other larvae of various ages hibernate through the winter and resume feeding in the spring. Moth emergences occur every month from February to October, but are more numerous in the spring. This extreme irregularity of the life cycle of this species results in the frequent presence, simultaneously, of larvae of various ages, and greatly complicates the problem of their control. In small infestations it sometimes happens that all of the larvae are of the same age, and like the preceding species, controllable when young with a single spraying; but usually, on account of the presence of older larvae or of eggs which hatch subsequent to the first spraying, several successive sprayings are required.

The three "Desert-shrub Bagworms" (Figure 18) usually pass the winter as hibernating larvae which often resume feeding for a brief period in the spring. Emergence records of the moths have been made in March, April, May, and early June, with a few belated stragglers even later. The presence of young larvae will indicate the more favorable time for spraying, and mid-June may be suggested as an average date under usual conditions. Older larvae, more resistant to poison,

continue to feed throughout the summer and autumn (until late October, El Paso, 1923).

Fortunately the smaller species of bagworms, some of which are equally as irregular in their seasonal life cycles as are the larger species, have less capacity for serious injury, and less frequently do they give occasion for complaint, and when hand picking is not practicable or effective, spraying should be resorted to at a season of larval activity, preferably when the larvae are young and comparatively non-resistant to poison. Careful subsequent examinations should be made at intervals of about two weeks, to determine whether living larvae still survive; their presence indicating the advisability of a repetition of the spray.

THE EFFECTIVENESS OF SPRAY CONTROL

The effectiveness of spray control for bagworms has had frequent demonstration. Dr. Haseman (Bulletin 104, Missouri Agricultural Experiment Station, 1912) records several very satisfactory experiences in the control of severe and extensive infestations of the Evergreen Bagworm in Missouri. The years 1918 and 1919 marked the culmination of an Evergreen Bagworm infestation in Texas, and the junior author, while Entomologist for the Texas Extension Service, was called upon to aid in combating these insects in almost every large town in Central and East Texas. The first trial was made in Dallas, and the infested trees were sprayed on May 28th, with two pounds of arsenate of lead paste to fifty gallons of water. The worms were very small at the time; but though a high percentage of kill was effected, a few survived, and the spraying was repeated on June 6th. On this latter date a new lot of trees was sprayed, but the worms were then older, and it became apparent that equal results could not be obtained without increasing the dosage. Sprayings at Houston on July 5th made still more apparent the importance of age-difference in larval susceptibility to poison. This series of demonstrations plainly indicated that when the larvae are young, two pounds of arsenate of lead paste to fifty gallons of water will give satisfactory control; but that when they are older, better results may be anticipated from increased dosage, within the limits of the plant-endurance of arsenical sprays.

In 1927, Evergreen Bagworms were very numerous on the various species of conifers on the campus of the A. and M. College, College Station, Texas. Sprayings by the Department of Entomology checked the threatened defoliation of these trees, and careful analyses were made of the results obtained. Arsenate of lead paste was used, in the proportion of two pounds to fifty gallons of water. The spray was applied June 16 and 26. Earlier application of the spray, when the larvae were younger, undoubtedly would have been more effective. The older larvae on the sprayed trees exhibited the usual phenomena of unwillingness to feed on the sprayed foliage. The following results were obtained:

Two hundred bags were collected six weeks after the second applica-

tion, 100 bags from ten trees and 100 from one tree. Twenty-nine empty bags were found, including older bags of the year before and probably some which had been deserted by poisoned larvae. Ninety-six per cent of the bagworms found were dead, including fifteen per cent which were parasitized. The twenty-six parasitized larvae contained ninety-nine parasites.

SUMMARY

Bagworms are important enemies of trees and shrubs, especially those grown for ornamental purposes. Of the thirteen species listed from Texas, the Evergreen Bagworm and the Live-oak Bagworm are the most destructive. These two are confined almost entirely to the eastern half of the State. The Evergreen Bagworm passes the winter in the egg stage. The Live-oak Bagworm sometimes hibernates in the egg stage, but usually passes the winter as a larva. Infestations of the Evergreen Bagworm are easier to control because the larvae all hatch at about the same time. In the case of the Live-oak Bagworm both young and old larvae may be found throughout the spring and summer.

None of the females of Texas bagworms possess wings. Distribution and spread of the species are frequently due to winds which transport the young larvae as they let themselves down by silk threads or release their hold on the herbage. Hundreds, sometimes thousands, of eggs are laid by the female in her silken bag. Diseases and insect parasites play an important part in holding bagworm infestations in check, and are doubtless responsible for the irregularity of injurious outbreaks.

Hand picking when practical, and the use of arsenical sprays applied when the larvae are young, are measures recommended for their control.