THE BIOLOGY AND ECONOMIC DAMAGE OF THE CYPRUS PROCESSIONARY MOTH *Thaumetopoea wilkinsoni*, Tams.

by

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ABSTRACT

The present work deals with the life-history and the damage caused by the pine processionary caterpillar to its hosts, the Calabrian pine, the Aleppo pine, and the Canary Island pine, in Lebanon. The insect was bred in the laboratory, and at the same time was observed in nature. The number of eggs laid by a female was found to be variable, but the average was about 200 eggs, laid in cylindrical masses. The duration of the various larval instars varied between 125 and 142 days. The resting period lasted for about six months.

Data was collected on the consumption of pine needles by the caterpillars to evaluate the damage caused by them. The damage was found to be not only quantitative, but qualitative as well. A field survey was carried out to evaluate the extent of infestation of pine trees by _T. wilkinsoni_. This varied between 17 and 93 percent in different localities in Lebanon.

During the breeding of the processionary moth, different predators and parasites of this insect were found. An unidentified acarine preyed on the eggs. The third and fourth instar larvae were parasitised by Tachinid fly. The pupae were parasitised by a Bombyliid fly, hitherto not reported in literature.

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INTRODUCTION

According to the survey made by the Green Plan of the Ministry of Agriculture in Lebanon[x], there are three species of pine trees planted in Lebanon. The stone pine, *Pinus pinea* L., is widespread and covers an area of about 7700 hectars. Its seeds are used for edible purposes. The other two species planted adjacent to stone pine are the Aleppo pine, *Pinus halepensis*, Mill. and the Calabrian pine, *Pinus brutia*, Ten. The latter species is spread over an area of about 7000 hectars, while the Aleppo pine is limited to about 160 hectars. There is a fourth species, the Canary Island pine, *Pinus canariensis*, Smith. which is planted in gardens. The last three species are used for timber, fuel, and for ornamental purposes. These species are attacked by the pine processionary moth, *Thaumetopoea wilkinsoni*, Tams. while the stone pine is not. In an oral communication, Dr. Basbous, Director of the Forestry Section in the Ministry of Agriculture of Lebanon, said that about fifty percent of *Pinus brutia* and *P. halepensis* are affected by *T. wilkinsoni* in Lebanon.

Needles of pine trees are the only part that is attacked by the caterpillars. The caterpillars build

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[x] An oral communication with Dr. Robert Baltaxe.

nests on the trees and move in a processionary way.

Since Lebanon's economy depends to a great extent on tourism (7), the damage caused by this insect may spoil the aesthetic value of the country.

In view of the fact that the processionary caterpillar is a serious pest of pine trees in Lebanon, and that the attacked species of pine trees are a source of beauty, and help the preservation of soil against erosion, and are a source of timber and fuel, and since the biology and economic importance of this species have not been locally studied, an attempt has been made to study its life-cycle, and assess the type of damage caused by it. Eventually this study may be useful for developing a sound control program against the caterpillars of this pest.

REVIEW OF LITERATURE

A. Systematic Position and Taxonomy

Until the beginning of this century, the genus *Thaumetopoea*, to which the subject of this paper belongs, was always placed with the Notodontids, under the generic name *Cnethocampa*. Later, it became established under a separate family name, Thaumetopoeidae. This latter family contains only one genus, *Thaumetopoea* Hbn, which comprises the following eight species (17):

1. *Thaumetopoea solitaria*, Frr. (4, 17).
2. *Thaumetopoea processionea*, L. (2, 8, 17 and others).
3. *Thaumetopoea pityocampa*, Schiff. (10, 17, 21 and others).
4. *Thaumetopoea pinivora*, Tr. (9, 17, 22 and others).
5. *Thaumetopoea herculeana*, Ramb. (3, 17).
6. *Thaumetopoea jordana*, Stgr. (17).
7. *Thaumetopoea bonjeani*, Oberth.
8. *Thaumetopoea wilkinsoni*, Tams. (18).

Tams described the pine processionary moth of Cyprus and named it after Wilkinson, as *Thaumetopoea wilkinsoni* (19).

B. Distribution

Wilkinson reports that the Cyprus processionary moth, *Thaumetopoea wilkinsoni*, Tams, is a major pest of the pine throughout the island, especially at altitudes ranging from sea-level to 4,500 feet (21), and Ellison and Wiltshire report that this moth is found at middle heights in Lebanon (6).

C. Host Plants

According to Wilkinson, the favourite larval food plant of this species in Cyprus is *Pinus halepensis*, Mill. Lesser preference is shown towards *P. pinea* L., *P. laricio* Prior., and *P. canariensis* Smith (21). Ellison and Wiltshire (loc. cit.), report that it attacks *P. halepensis* Mill., but does not attack the stone pine, *P. pinea* L., in Lebanon (6).

D. Life History

The only published study on the biology of *Thaumetopoea wilkinsoni* Tams, was done by Wilkinson, in 1926. He reported that in Cyprus, at an altitude of 500 feet, moths emerge towards the end of August, and continue to do so until the beginning of October. Oviposition extends from the first week of September until the middle of October. Egg-laying begins about ten days after emergence. An average of 150 eggs are laid in five to seven rows in the form of cylindrical masses around a pine needle. The female lays only one cylindrical mass throughout its life. The eggs are then covered by light puff scales. The incubation period is about 45 days.

The larvae of this moth pass into five instars. A description of each larval instar, the habits of the insect, and the nest are given. Pupation starts from the middle of March and takes place in a silken cocoon in the soil.

Altitude has a great influence on the life-history of T. wilkonsini, Tams. As the altitude increases, moths emerge earlier and pupate later in the season.

The caterpillars of this moth cause great damage especially to small pine trees by defoliating them. This might often lead to their death (21).

The caterpillars bear numerous hairs on their bodies. When touched, these hairs break off, enter the flesh, and cause intense irritation (11). The hairs contain formic acid, and moreover ferments are said to increase the irritation so as to produce itching and inflamation (17).

For comparison with close species, it is worthwhile to report here that the pine processionary moth, Thaumetopoea pityocampa, Schiff., has five (though sometimes only four, 10, 21) larval instars (1). After the first moulting takes place during the cold weather, the larvae hibernate in the soil. When the temperature rises to 42^0 to 43^0F in the spring, the second and third moultings take place (10). Thaumetopoea processionea, L., attacks oaks (2, 14, 21). Eggs are deposited in small heaps and the larvae hibernate and pupate in the nest (2, 14, 21). On the other hand, Thaumetopoea pinivora, Treit, which attacks pine trees, has five larval instars (16, 21). It overwinters as a pupae in the soil and might remain so for one, two (9, 15) or sometimes three or four years (21). The larvae do not build true nests, as in the last two species. Nevertheless, they crowd together in bunches (21).

E. Natural Enemies

Natural enemies of Thaumetopoea wilkinsoni, Tams are to be found at both the egg stage and the larval stage. There are three such parasites or predators at the egg stage, as reported by Wilkinson (21). These are the Encyrtid, Ooencyrtus pityocampae, Mercet., the Eupelmid, Anastatus bifasciatus, Fonscolombe, which is also reported by Morris (12) and the ant, Monomorium gracillimum, Sm. After May, the Ooencyrtus pityocampae has an alternative host. Both the Ooencyrtus pityocampae and the Anastatus bifasciatus have two generations a year. It is suspected that the Anastatus bifasciatus is a hyperparasite on the _Ooencyrtus pityocampae_ (21).

There are four such parasites or predators at the larval level according to Wilkinson (21). These are the Ichneumonid, _Erigorgus melanobatus_, Grav., and the three Tachinid flies, _Compsilura concinnata_, Mg., _Tricholyga segregata_, Rond., and _Ceratochata caudata_, Rond.

We may observe that the pupae of the second, third and fourth parasites named, are hyperparasitised by _Dibrachys boucheanus_, Ratz.

Papachrysostomou observed another ant, _Tapinoma erratica_, Latr. feed on the larvae (13).

No parasites of the pupae were reported (21).

MATERIALS AND METHODS

Specimens of the Cyprus processionary moths were collected from the campus of the American University of Beirut, Beirut, Lebanon, according to the following procedure:

1. Pupae were collected on August 31, 1964, from the soil around the collar of the Canary pine, *Pinus canariensis*. They were placed in soil in a rearing cage in the laboratory, designated cage number one.

Most males were observed to have emerged before the females. Since the males are good fliers (21), they struck against the wire of the cage which apparently caused them to die before they had the possibility of impregnating females in the cage. Many of the females died also as a result of the same reason.

2. Beginning on September 21, 1964, a mercury vapour light trap was used to attract the moths[x]. It was located in the front of the infirmary at the A.U.B. campus, ten meters from the pine trees. The trap faced the trees, six meters above the ground. The live moths thus trapped were put in cage number one, along with the females which remained in order to encourage copulation. Many of these

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[x] The power of the lamp is 125 W. Trade mark: Robinson's Registered Mercury Vapour moth trap.

moths also died due to the mechanical injury already reported. Only one egg-cylinder was obtained from the captured moths.

3. Since only one egg-cylinder was obtained from cage number one, four additional egg-cylinders were collected from the Canary pine trees. Of the four egg-cylinders collected, the first one was obtained on October 21, 1964, and the others on October 23, 1964. They were placed in cages, numbered, two, three, four, and five, respectively. After egg-hatching the larvae were provided with pine needles.

For the purpose of determining the average number of eggs per female, 15 unfertilized females, which emerged from collected pupae, were dissected and the eggs in their ovaries were counted. Other data were obtained from counting eggs in 15 cylinders collected from pine trees at the A.U.B. campus.

The economic damage was measured for each instar alone in the five cages. Green pine branches were cut close to the branches that bore the egg-cylinders. These were weighed in the laboratory, and then put in bottles of equal sizes, half filled with water, in order to keep the branches green and fresh. At the same time, a sixth cage was used as a check and was provided with similar branches in order to assess the loss of weight from the needles. The branches were removed every four days after larval feeding to assess the food consumption of the larvae. Since the fifth instar larvae are greedy feeders branches were provided once every three days. The branches in the sixth cage were removed at the same time, and weighed.

The growth of the larvae was followed by measuring the weight and length of ten caterpillars from each cage, taken at random, before and after each moulting. The length of the larvae was measured on a millimeter scale, and their weight was obtained by means of a metric balance. In order to measure the length accurately, the caterpillars had to be slightly narcotized with chloroform[x]. As a result of this treatment, the larvae became slightly curved and these were made straight with the help of needles for taking proper measurements.

The extent of infestation of the different pine species which are attacked by T. wilkinsoni, was assessed at four different localities in Lebanon:

1. A.U.B. campus, (alt. 10 - 30 m) where 15 Pinus canariensis and 15 P. halepensis were examined on March 7, 1965.

2. Alfanar locality, (alt. 30 - 50 m) where 46 P. brutia were examined on June 29, 1965.

3. Derqubel locality, (alt. 150 - 250 m) where 100 P. brutia were examined on July 12, 1965.

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[x] Narcotizing the larvae by chloroform causes the segments to contract, giving a misleading appearance.

4. Yerzeh locality, (alt. 250 - 300 m) where 100 *P. brutia* were examined on July 13, 1965.

The trees were selected at random and examined one by one. The percentage of infestation was observed and assessed according to the presence of nests on the tree. Only nests of the fifth larval instar of the current year were counted and data recorded.

Observations on the biology of the insect and the damage it causes, were recorded every day, in the morning and at night.

Observations in the field were recorded periodically from time to time. Nests of the different larval instars were collected in nature and kept in separate cages, in order to study the natural enemies of each larval instar alone.

RESULTS AND DISCUSSION

A. THE LIFE CYCLE

1. Moth Emergence

The first moths appeared in the trap and in the cage on the twenty-fifth and twenty-sixth of September, 1964 respectively, while the last moths emerged in the cage on October twenty-second, 1964. The single egg-cylinder which was obtained in this cage was laid on the seventh of October 1964. The period which elapsed between emergence and oviposition could not be detected with complete accuracy, but must have been very close to thirteen days, on the assumption that the first female brought from the field was fertilized soon after being introduced into the cage. This assumption is partly based on the fact that the Thaumetopoeidae are usually fertilized soon after emergence (21), and that all males appeared first in the cage followed by the females. On the same assumption, Wilkinson (21), reported that the period was ten days. The eggs hatched on the fifteenth of November, 1964. Therefore, the incubation period in this case was 39 days.

Since the eggs in the cylinder that were obtained from the field on the twenty-third of October, 1964 were found already hatched, the moths could have emerged in the field by the beginning of September, 1964. At the other extreme, the late moths might have appeared in the field by the beginning of December. This assumption is based on the fact that on the fourteenth of February, 1965, a nest in the beginning of its second larval instar was obtained, when most of the larvae in the cages were at the end of their fourth instar; these eggs, however, might have been exposed to cold temperatures which caused the delay of egg-hatching.

2. Egg-Laying

Eggs are laid in rows mostly on three, though sometimes on two, combined needles, in the form of a cylindrical mass, at the base or the middle of the needles, as shown in Figures 1 and 2. Sometimes, however, the rows are irregular at the upper end of the cylinder. The average number of eggs was found to be 198 per dissected female, and 203 per cylinder (Table I). The eggs were held together by a white gummy substance secreted by the colleterial gland (20). In colour, the egg is pearly to light yellow and having the shape of an inverted pot of five sides, the upper and lower edges being slightly rounded. The length and width as reported by Wilkinson are 1.00 by 0.6 mm, the length is from the basal attachment to the rounded dome. The females covered the eggs with waxy, brown, shining scales, thus giving the cylinder a silvery sheen, Figure 1. The average length of the cylinder is 28.2 mm, and its average width is 4.7 mm, (Table II). A further six to ten millimeters of the combined needles were covered with wax by the female in order to fasten the cylinder. After hatching, the scales became lighter in colour, fluffy, and formed an angle of about 45 degrees with the needles (Figure 2)[x]. The egg-cylinders are laid on the needles on different branches and at different positions on the same tree. A heavily infested tree may contain many egg-cylinders, as is shown in Figure 9. The egg-cylinders are found on the trees at a height always exceeding two meters.

3. First Larval Instar

The egg-cylinder which was bred in the laboratory, was put in cage number one. The other four which were obtained from the trees, were put in cages number two, three, four,and five. The eggs hatched on the fifteenth, tenth, nineteenth, eleventh and twenty-fourth of November 1964, respectively. The first moulting, according to the same order, took place on the second of December, twenty-seventh of November, fifth of December, twenty-sixth of November, and seventh of December, 1964. Therefore, the length of stadium is between 13 and 17 days. The colour of the emerging larvae, which is light greenish yellow at first, turns to green, with the

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x Wilkinson, reported that the minimum number obtained was 677 in a cylinder of 135 eggs (21).

exception of the last two segments which become greyish yellow at the end of this instar. The length of the larvae ranges between 2.1 and 2.5 mm after emergence, and increases to 3.9 and 4.3 mm before the first moulting, as is recorded in Tables III to VII.

a. <u>The building of the nest</u>

Right after emergence, the larvae, being gregarious, gather towards the base of the needles where they build their nests. These nests are invariably constructed in the vicinity of the cylinders. In building them, they secrete white silk-like threads mixed with small amounts of their greenish yellow excreta. The nest is conical with its apex pointing downwards. The larvae leave one to three openings in the nest for their entrance. The openings are commonly found on the lower part of the nest, but sometimes on its side, and, very rarely, on the upper side of the nest. The building of the nest is completed in one to two days.

During the breeding experiment, the auther has observed the larvae have the habit of changing their nest after the needles in its vicinity are consumed. In the first instar, they change their nest four to six times. Each time the larvae change their nest, they build a new one. These observations agrees more or less with those of Wilkinson (21). They start building nests approximately 1 x 1 cm, and gradually increase them until they become 3 x 2 cm, by the end of the first instar (Figure 3).

b. <u>The behaviour of the first larval instar</u>

Right after hatching from the eggs, the larvae live gregariously inside and outside the nest. During the day, they remain in their nest, in which they void their greenish yellow excreta. Groups of about five larvae sometimes leave the nest and move in a processionary way, head to tail, outside the nest. They move on the needle for a distance not farther than two centimeters in the first few days. As they grow older they wander further, to a distance of some eight to ten centimeters. At night, all the larvae seek food and build their nest. They also move in groups of about five, to perform the same procession as during the day.

c. <u>The mode of feeding</u>

After emergence, the larvae start feeding by gnawing the epidermis of the needles at different places. They eat close to the base of the needle, roughly on the first five centimeters. These parts soon assume a whitish colour. Two days later, larval feeding becomes more regular. The larvae then eat all the epidermis, starting from the middle of the needle, at a point eight to ten centimeters from its base, and continue posteriourly until they are within a distance of one to two centimeters from the twig. This causes the gnawed, as well as the intact part of the needle, to droop, twist, become brownish green, and dry in few days, as a consequence of the cessation of the translocation of sap (Figure 3). The damage caused by this type of feeding is thus of a wasteful nature, being qualitative as well as quantitative. It is interesting to note, however, that the caterpillars avoid feeding on the needles on which the egg cylinder is laid.

d. Moulting

Moulting usually takes place in the nest, with the exception of a very few larvae which moult near the nest between the needles. Two days before moulting, the larvae fast and remain in the nest, during the day as well as at night. Contraction and relaxation of the body continue until the larvae moult. This whole operation requires about three to four days at room temperature, in the laboratory.

4. Second Larval Instar

The second moulting of the larvae in the five cages occurred on the twenty-first, sixteenth, twenty-second, seventeenth and twenty-fourth of December, 1964, respectively. Therefore, the length of the second instar is between 17 and 21 days (Tables III to VII) The percentages of moulted larvae in the consequent four days in the cages wère 18, 44, 34 and 4 respectively (Table VIII). The head of the larva, immediately after each moulting, is rather big compared to the size of its body. The colour of the emerging larvae is light brown at first, becoming darker as they grow older. The length of the larvae range between 3.8 and 4.2 mm after moulting, reaching a length of 6.4 and 6.8 mm before the second moulting. As shown in Tables III to VII the length and weight of the larvae in all the instars is more, immediately before moulting, than immediately after moulting. This loss in weight is due to the fasting and the metabolism of the stored fat in their bodies, as well as the weight of the shed skin.

The second instar larvae differ from those of the first instar in the following ways:

First, the nests they construct are slightly bigger, i.e. 3.5 x 2.5 cm (Figure 4).

Second, they are much more active.

Third, two to three days before the second moulting, the larvae chew deeper on the tissues of the needles and leave only a very thin thread-like part, which is cut in many places. Therefore, some cut parts of the needles are found.

Fourth, two days before the second moulting, they strengthen their nests by weaving denser webs, incorporating with them their excreta and a few cut needles.

In addition, they enlarge the periphery of their nests by one to two centimeters. This is done by secreting thin silk-like threads between the needles, without the addition of feces and cuttings. The new layer adds rigidity to the nest, and possibly affords further protection for its inhabitants.

Fifth, they change their nest two to four times during this instar.

Sixth, during the day-time, some of them gather on the needles.

In all other respects, as far as nest type, feeding, damage and behaviour, they behave like the first instar larvae.

5. Third Larval Instar

The third moulting in the five cages was on the seventeenth, tenth, twenty-first, thirteenth and nineteenth of January, 1964 respectively. Therefore, the length of the third larval instar is between 25 and 30 days (Tables III to VII). The percentages of moulting in the consequent four days were 20, 40, 22 and 18 percent respectively, as shown in Table VIII. The larvae of this instar have denser hairs than those of the previous larval instars. This at first gives them a light reddish-brown colour which darkens after few days. The length of the larvae varies between 5.7 and 6.0 mm after the second moulting, and reaches 11.2 to 11.9 mm before the third moulting.

a. The building of the nest

The larvae change their nest only once during the third instar, although occasionally they use the nest of the second instar. The periphery of the nest is constructed in two parts. The inner part measures approximately 35 x 40 mm. It is built of a mixture of silk-like threads, larval excreta and some cut needles. This mixture is opaque enough to hide the larvae. The outer part surrounds the inner part by silk-like threads intermingling with the needles. By the end of the third instar, the larvae build the dense outer part and at the same time, strengthen their nest by tying it with silk-like threads to the branch. The silk-like threads are wrapped for at least eight centimeters around the branch at the base of the nest. The length and width of the entire nest is ten to twelve by five to seven centimeters. As usual, the larvae leave an opening for their movement on the lower or middle sides of the nest, which is closed before moulting by a mixture of silk-like threads and excreta (Figure 5).

b. The behaviour of the third larval instar

During the day-time, the larvae sometimes leave the nest and wander on branches (or on the cage wire). They move in one line, sometimes in circles, head to tail in a processionary way. Each one seems to weave a white silk-like thread, or superimpose it on the threads of the others, wherever it moves. The larvae are all attached to this thread, and when trying to lift the latter, all the larvae, as much as the thread can hold, are lifted together.

c. <u>The mode of feeding</u>

The larvae feed usually at night and remain in the nest during the day. At the beginning of this instar, they gnaw around the needles, leaving a very thin light yellow core of the latter's tissues. A few days later, they change their mode of feeding and consume the whole of the anterior half of hitherto intact needles. By the end of this instar, the larvae extend their feeding to the whole needle, leaving uneaten only one to two centimeters from the needle's base. During the first five days, the larvae cut many parts of the needle without consuming them. This wasteful type of feeding becomes less serious afterwards. Generally, the larvae of this instar feed greedily when compared with those of the first and second instars. The rate of feeding is at first low, then increases slowly until it reaches the peak approximately at the middle of the instar. Following that, the rate decreases slowly until the larvae finally rest for moulting.

d. Moulting

Moulting in the cages usually takes place in the nest, but occasionally some larvae may moult outside the nest in the vicinity of the opening. Two days before moulting, the larvae remain in the nest, stop feeding and start contraction and expansion movements of their bodies typical of moulting.

6. Fourth Larval Instar

The fourth moulting took place in the five cages on the fourteenth, seventh, tenth and twelfth of February, 1965, respectively. Therefore, the length of this instar varies between 24 and 28 days (Tables III to VII). The percentages of moulting in the consequent three days were 24, 52, and 24 respectively (Table VIII). The morphological characters of this instar do not differ from those of the third except that the fourth instar larvae bear thicker brick-red coloured hairs on the thoracis and abdominal tergites. The length of the larvae varies between 9.9 and 10.7 mm immediately after moulting, and subsequently reaches 19.4 and 20.9 mm immediately before the fourth moulting.

a. The building of the nest

The larvae do not change their nest in this larval period, but use the same nest built by the third instar larvae. At about the middle of this larval period, the caterpillars start to thicken the inner and outer parts of the nest. This is done by weaving more silk-like threads and incorporating their excreta in the inner part only. As a result of this operation, the nest grows in size. It then measures about 11.5 to 13 cm in length, and 6.5 to 7.5 cm in width. By the end of this instar, the larvae again tie the nest to the branch in the same manner done by the larvae of the previous instar (Figure 6).

b. The mode of feeding

The fourth instar larvae are less wasteful in their feeding as compared to those of the third instar. At no age do they leave a central core. They start feeding on the anterior part, consuming all the tissues, and stop feeding when they reach the basal two centimeters or so.

7. Fifth Larval Instar

The habits and morphology of the fifth instar larvae differ from those of the fourth instar in the following ways:

First, the larvae widen and thicken the inner part of the nest by the addition of silk-like threads mixed with excreta. The heavy weight of the larvae, especially at the end of the instar, causes the elastic walls of the inner nest to expand. At the same time, the larvae thicken the outer part of the nest without increasing its width (Figure 7).

Second, they seem to be greedier in this instar. They start eating from the tip of the needles and continue backwards almost to the bottom of the needles (Figure 8).

Third, the larvae are more active and quicker in movement. They make many trips outside the nest during the day-time, on the branches and on the wire of the cages. In many cases, the larvae gather gregariously outside the nest.

In all other respects, as far as nest type, feeding, damage and behaviour, they do not differ from the fourth instar larvae.

Unfortunately, the larvae in the breeding cages died before completing this instar. They were struck by what appears to have been a polyhedral virus disease. The following symptoms of the disease, as observed, were very close to those which are given for the "polyhedral" disease by DeBach (5). In chronological order, the symptoms are:

First, the larva withdraws and remains in the nest, ceases feeding and movement.

Second, it becomes very soft and watery.

Third, it hangs down by its front legs and shrinks.

Fourth, the colour becomes dull.

Fifth, it eventually dies.

Further study should be done to identify the virus particles.

The larvae in the nest which were brought from the field by the end of the fifth instar, started to pupate on the twenty-second of March, 1965. Therefore, the length of this instar is about 46 days on the assumption that these larvae moulted around the seventh of February, 1965. This date was chosen because the larvae in the second cage were expected to moult around this time. The average length of the larvae is between 16.8 and 18.5 mm immediately after moulting, and 34 mm immediately before pupation.

8. Pupation

On the seventeenth of March, 1965, the larvae left the nest and buried themselves in the soil. They were so sensitive to touch that every time they were inspected, they changed their place. As a result of molestation they dispersed either in the soil, or on the cloth of the nest, and very few remained in the nest. Therefore, pupation was delayed until the twenty-second of March. At first the larvae spun very thin silk-like threads through which they could be seen clearly. Later, more threads were spun until the cocoons became opaque. The colour of the cocoon, at first creamy white, turned to light brown in a few days (Figure 2). The length of a cocoon, in a sample of twenty, varied between 16 and 24 mm and the width varied between 6.5 and 9 mm. Since the moths of the previous year had emerged about the twenty-fifth of September, the length of the resting period is about six months (187 days).

Observations taken in the field show that the larvae pupate in the soil around the collar of the tree. The depth at which they pupate ranges between one and fourteen centimeters. Most pupae, however, are found between five and fourteen centimeters in the soil.

9. Natural Enemies

1. Egg predator: An unidentified acarine egg predator was found during the breeding experiment. The percentage of eggs eaten by the acarine predator was 4.5 percent as shown in Table IX.

2. Larval parasites: No parasites emerged from the first and second larval instars. *Compsilura concinnata* Mg., (Diptera: Tachinidae) which emerged from nests of the third and fourth larval instars, started appearing on the twenty-first of February and continued to do so till the first of April, 1965 (Figure 2). As stated previously, a virus disease struck the fifth instar larvae and, therefore, no parasites were obtained from this instar during the breeding experiment.

3. Parasites of pupae: In the summer of 1964, one hundred and sixty-four cocoons were collected from the

soil around the collars of pine trees. Twenty-nine flies emerged starting on the fourth of September, 1964. The flies were determined as, *Villa venusta* Mg., (Diptera: Bombyliidae), Figure 2. Accordingly, the percentage of parasitism was about 18 which is fairly high. This parasite was not reported by Wilkinson in his studies conducted in Cyprus (21).

B. DAMAGE

Assessment of the damage caused by the caterpillars of the pine processionary moth, Thaumetopoea wilkinsoni, Tams, to pine trees was made by measuring the consumption of food, growth of the larvae and the extent of infestation in four different localities in Lebanon. The surveyed trees were chosen at random.

1. Consumption of Food

Referring to Tables III to VII, it can be concluded that the quantity of needles consumed by the larvae of the second instar was a little more than that by the first. The consumption of food in the second larval instar was between 1.17 and 1.27 times greater than the first, and the third 0.88 to 2.04 greater than the second larval instar, except in cage 1. Since the larvae of the first two instars feed mainly on the epidermis, their damage might be equal to or exceed that caused by the third instar. Feeding of the fourth larval instar was between 2.42 and 3.37 times as much as the third instar. Damage was at a maximum in the fifth instar larvae. In this instar, defoliation of the twigs became serious. Food consumption was approximately 2.78 times more by the fifth instar than by the fourth instar larvae (cage number 4).

2. Growth of the Larvae (Tables III to VII)

The length of the second instar larvae in the five cages increased 1.4 to 2.0 times over that of the first, that of the third 2.0 to 2.3 times over the second, that of the fourth 1.6 to 1.9 over the third, and that of the fifth about one and a half times over the fourth.

The weight of the larvae in the five cages increased by 9.8 to 18.0 times in the second instar over the first. Although feeding greatly increased in the instars that followed, the increase in weight of the larvae became proportionately less. It was found that the weight of the third instar larvae increased 4.4 to 5.9 times over the second, and the fourth instar larvae increased 4.3 to 6.5 times over the third. The weight of the fifth instar larvae (Table VI), increased 2.8 times over the fourth. This seems to indicate that the larvae were in need of building their bodies in the second instar more than in any other instar. Therefore, anabolism was at its peak in this instar.

The quotient of growth reaches the maximum in the second larval instar in all cages except in the fourth, where it is reached in the fourth larval instar. Then it generally decreases gradually in the following instars.

3. Extent of Infestation

The percentage of infestation at the American University of Beirut campus and Alfanar locality, as shown in Tables X and XI, is very high. It is about 87 percent on Pinus canariensis and 80 percent on Pinus halepensis, in the first locality, about 93 percent on Pinus brutia in the second locality. Since the second and third hosts are planted in small groves of ten to twenty trees between a wide area of Pinus pinea, the population density of the caterpillars is high. This is a density-dependent factor, represented by the shortage of food. Accordingly, the trees are greatly injured and become very weak compared to the adjacent Pinus pinea.

The amount of branches provided to the larvae in the five cages is equal to at least one-quarter of a ten meters high tree. This is similar to observations taken in the field. A three-quarter defoliated pine tree, P. canariensis, of ten meters high, was infested with 14 nests (Figure 9). This shows what a great damage these insects might cause to pine trees.

On the other hand, when P. brutia was found spread over a wide area, the percentage of infestation was found to be relatively low. It is 17 percent at Derqubel, and 28 percent at Yerzeh (Tables XII and XIII). The action of parasites, predators and disease, which attack the different stages of this pest through its life cycle except in the adult stage, is effective in keeping its population endemic at a relatively low level of infestation in Lebanon.

As the Tables X to XIII show, most of the nests are built at heights exceeding two meters. The medium and small trees are usually heavily damaged when attacked by caterpillars.

The author wishes to stress that the pine species, *Pinus canariensis*, is heavily attacked in Lebanon, while it is reported not to suffer much from its attack in Cyprus. This could be due to a possible differences in the races of the pine tree and, or the moth in the two countries. Another possibility could be the abundance of *P. halepensis* in Cyprus which seems to be its prefered choice.

Table I. The Number of Eggs in 15 Dissected Females and in 15 Egg-cylinders.

Case No.	Number of eggs per	
	Dissected female	Cylinder
1	229	259
2	203	290
3	230	258
4	163	165
5	197	219
6	156	131
7	212	244
8	128	188
9	270	246
10	205	183
11	188	137
12	217	117
13	260	205
14	181	220
15	142	183
Total	2981	3045
Average	198.73	203.00

Table II. The Description of the Egg-cylinders.

Specimen Number	Length of Cylinder mm	Width of Cylinder mm	No. of Rows / Cylinder	No. of Combined Needles/ Cylinder	Height of Cylinder on Tree (meter)	The Position of the Cylinder on the Needle
1	39.0	5.0	7	3	2.0	base
2	45.0	4.5	8	3	2.0	base
3	37.0	5.0	8	3	2.0	base
4	26.0	6.0	9	2	4.0	base
5	33.0	5.0	8	3	3.5	middle
6	20.0	5.0	8	3	bred in cage	base
7	33.0	4.0	8	3	3.0	base
8	22.0	4.0	9	3	2.5	base
9	36.0	5.0	8	3	2.5	base
10	39.0	4.5	8	3	3.5	middle
11	11.5	4.5	9	3	4.0	base
12	11.5	4.0	8	3	4.0	middle
13	38.0	4.0	6	3	3.0	base
14	25.0	4.5	9	3	2.5	base
15	7.0	5.0	8	3	4.0	base
Total	423.0	70.0	121			
Average	28.2	4.7	8			

Table III, Cage 1. The Food Consumption and Larval Growth of <u>T. wilkinsoni</u>.

Instar No.	Date of Moulting	No. of Larvae	Leaves Consumed (gm)	Leaves Consumed Per Larvae (gm)	Times Increase in Consumption	Length of Stadium (days)	After Moulting Ave. Length (mm)+	After Moulting Ave. Weight (mg)+	Before the Next Moulting Ave. Length (mm)+	Before the Next Moulting Ave. Weight (mg)+	Quotient of Growth	Increase in Length (mm)	Increase in Weight (mg)	Times Increase in Length	Times Increase in Weight
1	Nov. 15, 1964	124	41.5	0.33	1.00	17	2.8	0.65	4.1	1.06	1.62	1.3	0.41	1	1
2	Dec. 2, 1964	117	49.3	0.42	1.27	19	4.0	0.82	6.6	6.04	7.36	2.6	5.22	2.0	12.7
3	Dec. 21, 1964	114	42.3	0.37	0.88	27	6.0	5.10	11.2	35.98	7.05	5.2	30.88	2.0	5.91
4	Jan. 17, 1965	114	142.3	1.25	3.37	28	10.3	30.02	19.4	163.98	5.46	9.1	133.96	1.7	4.33
5	Feb. 14, 1965	114[x]	287.1				16.8	130.88	∂	∂					

x The average number of ten larvae.

\+ The disease struck the colony on March 7; therefore taking samples for measuring the length and weight was impossible.

∂ The length and weight of larvae at pupation.

Table IV, Cage 2. The Food Consumption and Larval Growth of _T. wilkinsoni_.

Instar No.	Date of Moulting	No. of Larvae	Leaves Consumed (gm)	Leaves Consumed Per Larvae (gm)	Times Increase in Consumption	Length of Stadium (days)	After Moulting Ave. Length (mm)+	After Moulting Ave. Weight (mg)+	Before the Next Moulting Ave. Length (mm)+	Before the Next Moulting Ave. Weight (mg)+	Quotient of Growth	Increase in Length (mm)	Increase in Weight (mg)	Times Increases in Length	Times Increases in Weight
1	Nov. 10, 1964	244	61.8	0.25	1	17	2.2	0.58	4.0	0.96	1.65	1.8	0.38	1	1
2	Nov. 27, 1964	239	74.5	0.31	1.24	19	4.0	0.85	6.8	6.62	7.78	2.8	5.77	1.5	15.1
3	Dec. 16, 1964	238	104.9	0.44	1.41	25	5.7	6.12	11.4	37.94	6.19	5.7	31.82	2.0	5.5
4	Jan. 10, 1965	238	321.2	1.34	3.06	28	10.7	35.00	20.1	210.34	6.00	9.4	175.34	1.6	5.5
5	Feb. 7, 1965	238[x]	379.7												

+ The average number of ten larvae.

x The disease struck the colony on March 7, therefore taking samples for measuring the length and weight was impossible.

Table V, Cage 3. The Food Consumption and Larval Growth of T. *Wilkinsoni*.

Instar No.	Date of Moulting	No. of Larvae	Leaves Consumed (gm)	Leaves Consumed Per Larvae (gm)	Times Increase in Consumption	Length of Stadium (days)	After Moulting Ave. Length (mm)+	After Moulting Ave. Weight (mg)+	Before the Next Moulting Ave. Length (mm)+	Before the Next Moulting Ave. Weight (mg)+	Quotient of Growth	Increase in Length (mm)	Increase in Weight (mg)	Times Increases in Length	Times Increases in Weight
1	Nov. 19, 1964	175[ø]	40.1	0.23	1	16	2.4	0.61	4.2	1.02	1.67	1.8	0.41	1	1
2	Dec. 5, 1964	170	46.6	0.27	1.17	17	4.0	0.92	6.6	7.34	7.97	2.6	6.42	1.4	15.6
3	Dec. 22, 1964	161	89.0	0.55	2.04	30	6.0	6.68	11.3	35.10	5.25	5.3	28.42	2.0	4.42
4	Jan. 21, 1965	160	212.4	1.33	2.42	24	10.3	30.01	20.6	216.08	7.16	10.3	186.07	1.9	6.54
5	Feb. 21, 1965	160[x]	484.8				18.4	182.98							

+ The average number of ten larvae.

x The disease struck the colony on February 14, 1965; therefore taking samples for measuring the length and weight was impossible.

ø The larvae died when narcotized

Table VI, Cage 4. The Food Consumption and Larval Growth of T. wilkinsoni.

Instar No.	Date of Moulting	No. of Larvae	Leaves Consumed (gm)	Leaves Consumed Per Larvae (gm)	Times Increase in Consumption	Length of Stadium (days)	After Moulting Ave. Length (mm)+	After Moulting Ave. Weight (mg)+	Before the Next Moulting Ave. Length (mm)+	Before the Next Moulting Ave. Weight (mg)+	Quotient of Growth	Increase in Length (mm)	Increase in Weight (mg)	Times Increases in Lenght	Times Increases in Weight
1	Nov. 11, 1964	240	69.3	0.28	1	15	2.5	0.79	4.3	1.48	1.87	1.8	0.69	1	1
2	Nov. 26, 1964	232	79.6	0.34	1.21	21	4.2	1.37	6.7	8.20	5.97	2.5	6.83	1.4	9.8
3	Dec. 17, 1964	228	119.6	0.52	1.50	27	6.2	6.82	11.9	41.90	6.14	5.7	35.08	2.3	5.1
4	Jan. 13, 1965	226	341.5	1.51	2.90	28	10.7	31.08	20.9	238.16	7.66	10.2	207.08	1.8	5.9
5	Feb. 10, 1965	226[x]	952.9	4.21	2.78	46	18.5	208.00	34.0	806.96	3.87	15.5	598.96	1.5	2.8

+ The average number of ten larvae.

x The disease struck the colony on March 7, 1965; therefore taking samples for measuring the length and weight of the larvae was impossible.

Table VII, Cage 5. The Food Consumption and Larval Growth of T. wilkinsoni.

Instar No.	Date of Moulting	No. of Larvae	Leaves Consumed (gm)	Leaves Consumed Per Larvae (gm)	Times Increase in Consumption	Length of Stadium (days)	After Moulting Ave. Length (mm)+	After Moulting Ave. Weight (mg)+	Before the Next Moulting Ave. Length (mm)+	Before the Next Moulting Ave. Weight (mg)+	Quotient of Growth	Increase in Length (mm)	Increase in Weight (mg)	Times Increases in Length	Times Increases in Weight
1	Nov. 24, 1964	183	46.9	0.25	1	13	2.1	0.60	3.9	0.98	1.73	1.8	0.38	1	1
2	Dec. 7, 1964	177	55.6	0.31	1.24	17	3.8	0.83	6.5	7.68	9.13	2.7	6.85	1.5	18.0
3	Dec. 24, 1964	174	90.4	0.52	1.67	26	5.7	6.46	11.4	37.06	5.73	5.7	30.60	2.1	4.5
4	Jan. 19, 1965	172	226.4	1.32	2.54	24	9.9	31.89	19.8	208.98	6.55	9.9	177.09	1.7	5.7
5	Feb. 12, 1965	172[x]	550.4				17.5	182.12							

+ The average number of ten larvae.

x The disease struck the colony on February 27, 1965; therefore taking samples for measuring the length and weight of the larvae was impossible.

Table VIII. The Percentage of Moulting in Fifty Larvae, Four Days After Moulting Starts.

Moulting Number	Cage Number	First Day	Second Day	Third Day	Fourth Day
Second	1	2	4	4	0
	2	2	4	3	1
	3	2	4	4	0
	4	2	6	2	0
	5	1	4	4	1
Total	-	9	22	17	2
Percentage		18	44	34	4
Third	1	2	2	4	2
	2	2	4	2	2
	3	2	8	0	0
	4	2	2	2	4
	5	2	4	3	1
Total	-	10	20	11	9
Percentage		20	40	22	18
Fourth	1	2	2	6	0
	2	2	8	0	0
	3	4	4	2	0
	4	2	6	2	0
	5	2	6	2	0
Total	-	12	26	12	0
Percentage		24	52	24	0
Average Percent		20.66	45.33	26.66	7.33

Table IX. The Percentage of Eggs Eaten by the Acarine Predator.

Cylinder Number	1	2	3	4	5	Total	%
Number of Eggs per Cylinder	259	165	290	258	117	1089	
Number of Eggs Parasitised	13	7	19	4	6	49	4.5

Table X. The Percentage of Infestation by T. wilkinsoni, on Pinus canariensis, Smith and P. halepensis, Mill. on the A.U.B. Campus.

Tree Number	Pinus canariensis: No. of nests Per Tree	Size of the Tree[x]	Height of the Nest on the Tree (m)	Pinus halepensis: No. of Nests Per Tree	Size of the Tree[x]	Height of the Nest on the Tree (m)
1	3	Small	3-5	6	Large	12-15
2	4	Medium	5-8	6	Large	10-20
3	2	Medium	8-10	6	Large	15-20
4	1	Large	12	12	Large	15-25
5	3	Large	10-12	7	Large	12-20
6	2	Medium	7-8	0	Medium	-
7	2	Medium	7.5	0	Medium	-
8	1	Medium	8	2	Medium	8-10
9	1	Medium	8	2	Medium	10
10	1	Large	12	1	Medium	8
11	0	Medium	-	2	Medium	8-10
12	0	Medium	-	1	Medium	10
13	3	Large	12-15	1	Medium	8
14	4	Large	10-15	1	Medium	8
15	2	Medium	8-10	0	Small	-
The total of infested trees	13			12		
The percentage of infestation	86.66			80.00		

[x] Small tree = less than five meters height.
Medium tree= between five and ten meters height.
Large tree = more than ten meters height.

Table XI. The Percentage of Infestation by _T. wilkinsoni_ on _Pinus brutia_, Ten., at Alfanar.

Tree Number	Number of Nests Per Tree	Size of[x] the Tree	Height of the Nest on the Tree (m)
1	1	Medium	10
2	2	Medium	8, 10
3	0	Medium	-
4	2	Medium	7, 10
5	1	Medium	10
6	2	Medium	8, 10
7	4	Medium	7-10
8	4	Medium	7-10
9	1	Large	10
10	3	Small	6-8
11	2	Medium	8, 10
12	1	Large	7
13	3	Small	4-5
14	3	Small	4-5
15	4	Large	6-7
16	2	Medium	3.5, 4
17	1	Small	3
18	2	Small	3, 3.5
19	5	Medium	8-10
20	4	Large	6-7
21	3	Small	3-4

(Continued)

Table XI (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
22	2	Small	2.5, 3
23	2	Medium	8, 10
24	1	Medium	8
25	3	Medium	8-10
26	2	Medium	8, 10
27	2	Large	6, 7
28	4	Large	10-12
29	2	Large	7, 8
30	4	Medium	8-10
31	3	Medium	9-11
32	3	Medium	8-10
33	1	Medium	8
34	1	Small	2
35	2	Small	6
36	3	Medium	10-12
37	2	Small	2, 2.5
38	0	Small	-
39	4	Medium	10-12
40	3	Small	3-3.5
41	0	Small	-
42	2	Small	3-3.5

(Continued)

Table XI (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
43	2	Small	3-3.5
44	2	Small	3-3.5
45	3	Small	3-4
46	4	Medium	7-9
The total of infested trees	43		
Percentage of infestation	93.48		

x See explanation on the bottom of Page 41.

Table XII. The Percentage of Infestation by <u>T. wilkinsoni</u> on <u>Pinus brutia</u> Ten. at Derqubel.

Tree Number	Number of Nests Per Tree	Size of the Tree[x]	Height of the Nest on the Tree (m)
1	0	Large	-
2	0	Small	-
3	0	Small	-
4	0	Small	-
5	0	Large	-
6	1	Large	8
7	0	Large	-
8	1	Large	7-8
9	1	Small	3
10	0	Large	-
11	0	Large	-
12	1	Large	6
13	0	Large	-
14	0	Large	-
15	0	Large	-
16	1	Medium to Small	3.5
17	0	Small	-
18	0	Medium	-
19	0	Medium	-
20	0	Small	-

(Continued)

Table XII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
21	0	Large	-
22	0	Small	-
23	0	Small	-
24	0	Large	-
25	0	Medium	-
26	0	Medium	-
27	0	Large	-
28	0	Large	-
29	0	Medium	-
30	0	Medium	-
31	0	Medium	-
32	0	Large	-
33	0	Medium	-
34	0	Large	-
35	0	Medium	-
36	0	Medium	-
37	0	Medium	-
38	1	Large	8
39	0	Large	-
40	1	Large	3
41	0	Large	-

(Continued)

Table XII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
42	0	Large	-
43	0	Medium	-
44	0	Large	-
45	0	Large	-
46	0	Medium	-
47	0	Large	-
48	0	Large	-
49	0	Medium	-
50	0	Large	-
51	1	Small	2.5
52	1	Small	3
53	2	Medium	8, 10
54	0	Small	-
55	0	Small to Medium	-
56	0	Small to Medium	-
57	1	Large	12
58	0	Medium	-
59	0	Medium	-
60	0	Medium	-
61	0	Large	-
62	0	Large	-

(Continued)

Table XII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
63	0	Small	-
64	0	Medium	-
65	0	Medium	-
66	1	Medium	8
67	0	Medium	-
68	0	Large	-
69	1	Large	14
70	0	Medium	-
71	0	Medium	-
72	0	Large	-
73	1	Large	15
74	0	Large	-
75	0	Small	-
76	1	Medium	7
77	1	Medium	6
78	0	Medium	-
79	0	Medium	-
80	1	Small	3
81	0	Large	-
82	0	Medium	-
83	0	Medium	-

(Continued)

Table XII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
84	0	Large	-
85	0	Medium	-
86	0	Medium	-
87	0	Medium	-
88	0	Medium	-
89	0	Large	-
90	0	Large	-
91	0	Medium	-
92	0	Medium	-
93	0	Medium	-
94	0	Medium	-
95	0	Small	-
96	0	Large	-
97	0	Small	-
98	0	Medium	-
99	0	Medium	-
100	0	Medium	-
The total of infested trees	17		
The percentage of infestion	17		

x See explanation on the bottom of Page 41.

Table XIII. The Percentage of Infestation by _T. wilkinsoni_ on _Pinus brutia_, Ten. at Yerzeh.

Tree Number	Number of Nests Per Tree	Size of the Tree[x]	Height of the Nest on the Tree (m)
1	0	Large	-
2	0	Large	-
3	1	Large	-
4	0	Medium	-
5	0	Small	-
6	1	Large	12
7	0	Small	-
8	0	Small	-
9	0	Small to Medium	-
10	0	Medium	-
11	0	Medium	-
12	0	Small to Medium	-
13	0	Medium	-
14	1	Medium	8
15	0	Medium	-
16	0	Medium	-
17	2	Large	15
18	0	Large	-
19	0	Medium	-
20	1	Large	15

(Continued)

Table XIII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
21	0	Small to Medium	-
22	0	Large	-
23	1	Medium	10
24	1	Medium	10
25	0	Small	-
26	0	Medium	-
27	0	Medium	-
28	1	Large	15
29	0	Large	-
30	0	Medium	-
31	0	Large	-
32	0	Medium	-
33	3	Medium	8-12
34	0	Small	-
35	0	Medium	-
36	0	Small to Medium	-
37	0	Small	-
38	3	Large	8-10
39	0	Large	-
40	0	Small	-
41	0	Small	-

(Continued)

Table XIII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nest on the Tree (m)
42	0	Small to Medium	-
43	0	Medium	-
44	0	Small	-
45	0	Small	-
46	0	Small	-
47	0	Small	-
48	0	Small	-
49	0	Small	-
50	0	Small	-
51	1	Medium	8
52	0	Large	-
53	0	Medium	-
54	0	Small	-
55	0	Small	-
56	0	Medium	-
57	0	Small to Medium	-
58	1	Large	12
59	3	Medium	8-10
60	0	Small	-
61	0	Small	-
62	2	Large	8, 10

(Continued)

Table XIII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nests on the Tree (m)
63	0	Medium	-
64	1	Medium	10
65	1	Medium	12
66	0	Small	-
67	2	Large	7, 10
68	0	Small	-
69	0	Small	-
70	0	Small	-
71	0	Small	-
72	0	Small	-
73	0	Medium	-
74	0	Medium	-
75	1	Small to Medium	7
76	1	Small to Medium	7
77	1	Small to Medium	7
78	0	Small	-
79	1	Small to Medium	6
80	0	Small	-
81	0	Small	-
82	4	Large	15-20, 4
83	0	Small	-

(Continued)

Table XIII (Continued)

Tree Number	Number of Nests Per Tree	Size of the Tree	Height of the Nests on the Tree (m)
84	0	Small	-
85	0	Small	-
86	3	Large	5-8
87	0	Small	-
88	1	Medium	6
89	0	Small	-
90	1	Small	2
91	2	Small	3
92	0	Medium	-
93	0	Small	-
94	0	Small	-
95	0	Medium	-
96	0	Medium	-
97	0	Large	-
98	1	Medium	2.5
99	1	Small	2.5
100	0	Small	-
The total of infested trees	28		
The percentage of infestion	28		

x See explanation on the bottom of Page 41.

SUMMARY AND CONCLUSIONS

Thaumetopoea wilkinsoni, Tams is a serious pest of the pine tree in Lebanon. It attacks the Aleppo pine, *Pinus halepensis*, Mill, the Calabrian pine, *Pinus brutia*, Ten., and the Canary Island pine, *Pinus canariensis*, Smith. On the other hand, *Pinus pinea*, L., is resistent to this insect. *Pinus brutia* is spread over a wide area in Lebanon, while the other pine species are confined to smaller areas. The damage which this insect causes has a great effect on the Lebanese economy, from the standpoint of tourism, usage of timber, and the preservation of soil.

The purpose of the present study is to investigate the life cycle of this pest and the expected damage. Cocoons from the soil around the collars of pine trees were bred in the laboratory in order to obtain the moths upon their emergence. Only one egg-cylinder was laid in the laboratory; four other egg-cylinders were obtained from the field. The damage was measured for each instar alone. This was done by measuring the consumption of food, growth of the larvae, and by calculating the percentage of infestation from the surveys made in nature. Field observations were made periodically and nests were collected in order to study the natural enemies of each instar.

At sea-level, the moths began emerging early in September, 1964, and continued to do so until about the last week of October, 1964. The pre-oviposition period was about thirteen days.

An adult female, after copulation, lays on the average, some 200 eggs. Eggs are laid on two to three combined needles in a cylindrical mass, on the base or the middle of the needle. They are laid in seven to nine rows which are then covered by waxy, shining scales. The egg is pearly to light yellow in colour. The incubation period was found to be about 39 days.

The caterpillar passes into five larval instars. The time taken to complete each instar ranges between 13 and 17, 17 and 21, 25 and 30, 24 and 28, and about 46 days, respectively. The larvae have numerous hairs all over their bodies, which when touched, break off and enter the flesh, causing intense irritation. After emergence, the colour of the larvae is light greenish-yellow which changes to light brown after the first moulting, and to reddish-brown after the second moulting and then becomes darker after the third and fourth moultings.

The larvae build different nests in each larval instar. In general they build the nest between the junctures of the needles. In doing so, they secrete white silk-like threads mixed with their excreta and some cuttings of the needles. Usually the larvae leave an opening in the nest for their movement, either on the side, or, more often on the base. The size of the nest increases from 1 x 1 cm in the first instar to 12 x 13 cm in the fifth instar. Nests of the first and second instars are so thinly woven that one can see through them clearly, while those of later instars are opaque. The larvae have the habit of changing their nests four to six times in the first instar, two to four times in the second instar, once in the third and none in the fourth and fifth instars. Each time the larvae change their nest, they build a new one.

The larvae live gregariously inside the nest. They also move in lines, head to tail in a processionary way.

The larvae in the first and second instars cause a more qualitative than quantitative damage, because they feed only on the epidermis of the first five centimeters of the needle. This causes the needle to droop, twist and dry in few days. In the third instar, the larvae start feeding on all the tissues of the needle inner and outer, but by only making cuttings in the needles. Later, after four to five days, they extend their feeding to the rest of the length of the needle. This mode of feeding becomes the normal pattern for the fourth and fifth instar larvae. In general, the larvae start feeding at night from the tip of the needle and continue backwards until they reach a point of two centimeters from the base.

Ecdysis, during which the larvae stop feeding, takes place in the nest. The average percentage of moulting during the four consequent days are 20.66, 45.33, 26.66 and 7.33, respectively.

Pupation took place in the soil during the third week of March 1965. The length of the resting period was about six months. Therefore, the insect has only one generation per year.

An unidentified acarine preys on the eggs, a Tachinid, Compsilura concinnata, Mg. parasitises the third and fourth larval instars, and a Bombyliid, Villa venusta, Mg. parasitises the pupae.

Assessment of the damage caused by the caterpillars of this moth was done by measuring the consumption of food, growth of the larvae and the extent of infestation. The consumption of the leaves is greatly increased in the fifth larval instar. In this instar, defoliation of the twigs becomes serious. It is found that five nests can defoliate one quarter of a ten meters high pine tree. The growth of the larvae reaches its maximum in the second larval instar, which seems to indicate that anabolism is at its peak in this instar. The percentage of infestation is very high in small groves of pine trees, being between 80 and 93 percent. In groves in which the trees are relatively spread out, the percentage of infestation is relatively low, being between 17 and 28 percent. The small and medium-size trees are more injured by the attack of the caterpillars than are the large trees.

It is interesting to note that P. canariensis is more heavily attacked by T. wilkinsoni, than seems to be the case in Cyprus.

The fifth instar larvae were struck by a disease which seemed to be a polyhedral virus disease. Further study should be done to identify this virus.

LITERATURE CITED

1. Androic, M. Contribution a l'etude *Cnethocampa pityocampa*, Schiff. - Rev. Path. Veg. 35 fasc. pp. 251-262, Paris, 1956. R.A.E. (A) 45: 301-302. 1957.

2. Canzanelli, A. L'Entomofauna dei nostri boschi. 1. Le processionarie. The insect Fauna of Italian Forests. 1. The Processionaries - Rev. forest. ital. pp. 253-258, 1939. R.A.E. (A) 27: 516. 1939.

3. Comte, A. Chenilles nuisibles aux plants basses. Caterpillars injurious to herbaceous plants. - Rev. Agric. et Vitic. de L'Agric. du Nord, Algiers. pp. 33-34. 1913. R.A.E. (A) 1: 199, 1913.

4. Davatichi, G.A. Etude biologique de la faune entologique des Pistacia sauvages et cultives - Rev. Path. Veg. pp. 1-166, 1958. R.A.E. (A) 47: 295. 1959.

5. DeBach, P. *Biological Control of Insect Pests and Weeds*, pp. 529, Chapman and Hall, London, 1964.

6. Ellison, R.E., and Wiltshire, E.P. The Lepidoptera of Lebanon. The Transaction of the Royal Entomological Society, London. Vol. 88, Part I. pp. 1-56. 1939.

7. F.A.O. Mediterranean Development Project, Lebanon, Country Report, F.A.O., Rome, Italy, 1959, pp. 1-3.

8. Hase, A. Ueder den Pinienprozessionsspinner und uber die Grefahrlichkeit seiner Raupenhaare (*Thaumetopoea pityocampa*, Schiff.). On the Pine Processionary and on the Dangerousness of the Hairs of its Larva. - Anz. Schadlinask. 15 pt. pp. 133-142, Berlin, 1939. R.A.E. (A) 28: 161. 1940.

9. Koch, M. Zur Biologie de kiefernprozessionsspinners, Thaumetopoea pinivora, Tr. The Bionomics of the Pine Processionary. - Beitr. Ent. 3, no. 4, pp. 423-427, Berlin, 1953. R.A.E. (A) 43: 182. 1955.

10. Leonardi, G. La Processionaria del Pino in Ligura. The Pine Processionary Caterpillar in Liguria. - Minerva Agraria, Milan, ix, no.19-20, pp. 227-228, 1917. R.A.E. (A) 6:144. 1918.

11. Mckeown, K.C. The Cup Moths. - Aust. Mag. 6, no. 5, pp. 149-151, Sydney, 1937. R.A.E. (A) 25: 535. 1937.

12. Morris, H.M. Entomological Notes. Cyprus Agric. Jour. xxii, pt. 3, pp. 65-67, Nicosia, 1927. R.A.E. (A) 15: 656. 1927.

13. Papachrysostomou, C. Entomological Notes. Cyprus Agric. Jour. xxii, pt. 3, pp. 69-70, Nicosia, 1926. R.A.E. (A) 14: 519. 1926.

14. Pustovoit, A.F. The Control of the Processionary Oak Moth, Thaumetopoea processionea, L., in the District Pervomaisk, Government of Kherson, in 1927. (In Russian) - Plant Protection, vii (1930), no. 4-6, pp. 239-243, Leningrad, 1931. R.A.E. (A) 20: 230. 1932.

15. Schedl, K.E. Zur Bekampfung des kiefernprozessions-spinners. The Control of the Pine Processionary Caterpillar. - Anz. Schad-lingsk. 13, no. 2, pp. 18-20, Berlin, 1937. R.A.E. (A) 25: 308. 1937.

16. Scheidter, F. Forstentomologische Beitrage. 14-38. Contributions to forest Entomology, 14-38. - Z. Pflkrankh. 44. nos. 5, 7, 8, 10. pp. 223-226, 362-379, 386-423, 497, 525, Stattgart, 1934. R.A.E. (A) 22: 719, 1934.

17. Seitz, A. The Macrolepidopetra of the World. II. Text. pp. 143. Alfred Kernen, Publisher, Stuttgart, 1913.

18. __________. The Macrolepidoptera of the World. II. Text and Plate. Supplement to vol. 2, pp. 107. Alfred Kernen, Publisher, Stuttgart, 1934.

19. Tams, W.H.T. A new Processionary Moth (Notodontidae) Injurious to Pine Trees in Cyprus. Bull. Ent. Res. 15: 293-294. 1924-1925.

20. Wigglesworth, V.B. The Principles of Insect Physiology. pp. 460. Methauen and Co. Ltd., London, 1961.

21. Wilkinson, D.S. The Cyprus Processionary Caterpillar. (*Thaumetopoea wilkinsoni*, Tams.). Bul. Ent. Res. 17: 163-182. 1926-1927.

22. Wolf, N.L. Fyrreprocessionsspinderen, *Thaumetopoea pinivora*, Tr., i. Danmark. The Pine Processionary, *T. pinivora*, in Denmark. - Ent. Medd. 20. no. 2, pp. 111-120, Copenhagen, 1938. R.A.E. (A) 26: 518. 1938.

APPENDIX

Figure 1. An egg-cylinder laid at the base of three combined needles.

Figure 2. A and B. An egg-cylinder after hatching. Notice how the eggs are laid in rows.

C. The larva.

D. The cocoon.

E. The adult.

F. Larval parasite, Compsilura concinnata, Mg.

G. Pupal parasite, Villa venusta, Mg. Approximately, two third natural size.

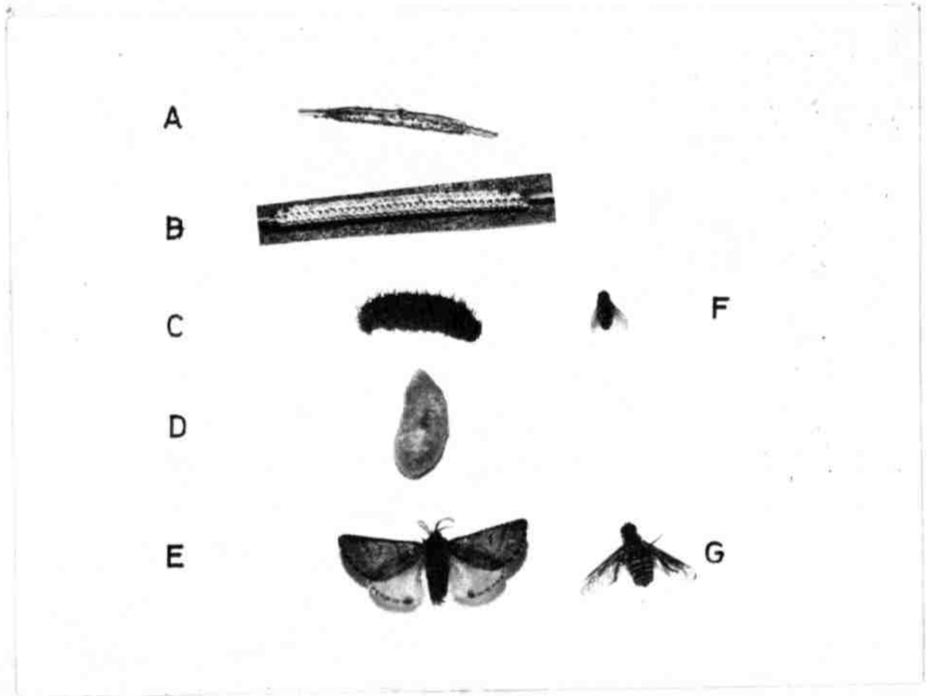

Figure 3. Note the gnawed needles, drooped and twisted. Two small nests of the first larval instar could be seen as well.

Figure 4. Nests of the second larval instar. Approximately, one half natural size.

Figure 5. Nest of the third larval instar. Note the opening at the lower side of the nest. Approximately, one third natural size.

Figure 6. Nest of the fourth larval instar. Approximately, one third natural size.

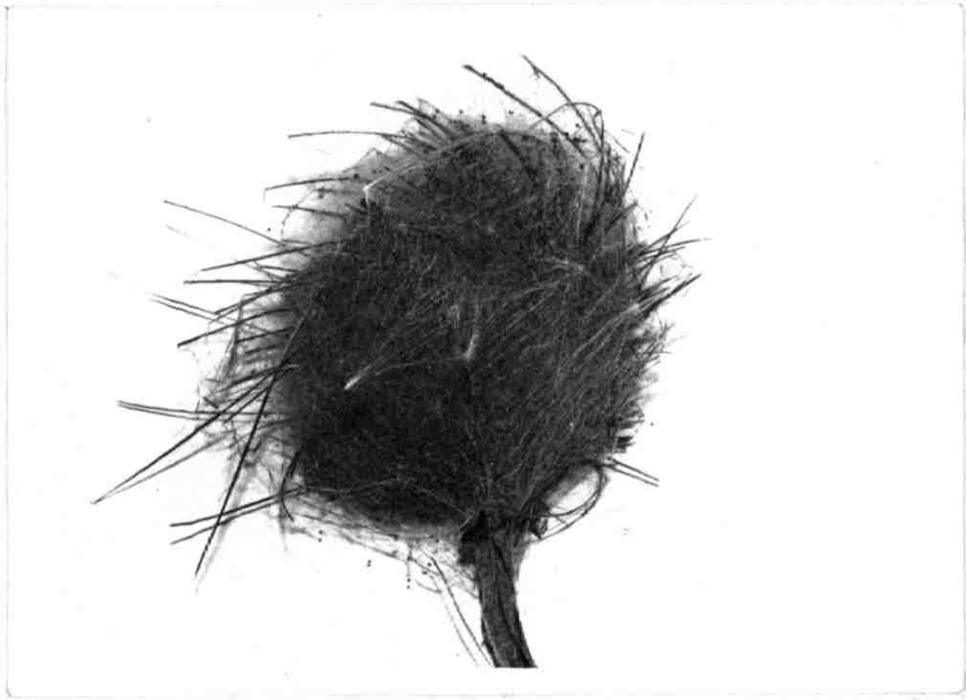

Figure 7. Nest of the fifth larval instar. Note the opening at the lateral side of the nest. Approximately, one third natural size.

Figure 8. Upper: The fifth instar caterpillars feeding on the needles.

Lower: The injury done by the caterpillars. Left natural, right eaten.

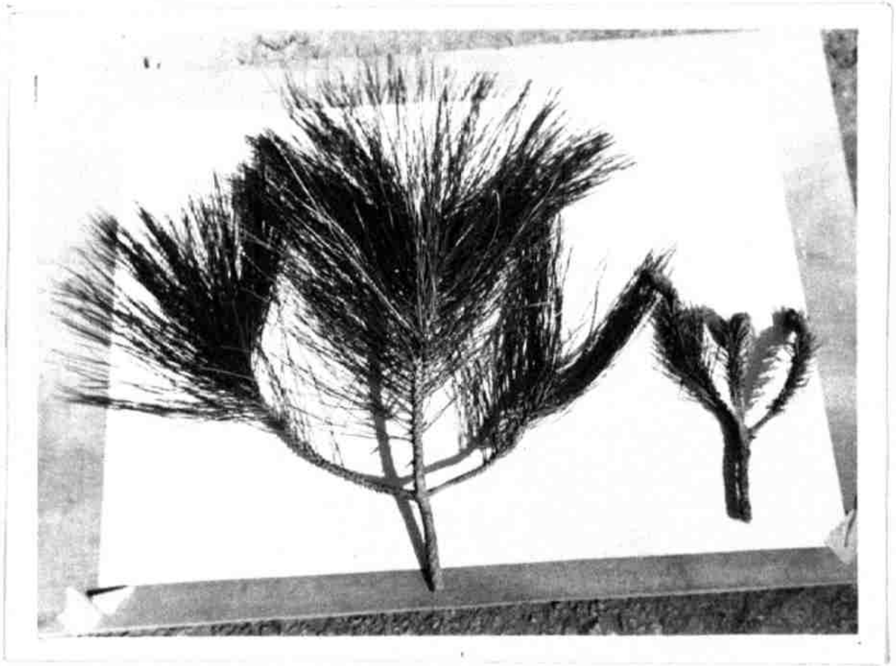

Figure 9. A pine tree, heavily infested by T. wilkinsoni.