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# *SCLERODERMUS NIPPONICUS* YUASA (BETHYLIDAE, HYMENOPTERA, HEXAPODA) A PARASITE OF THE LARVAE OF CERAMBYCID BEETLES

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## ABSTRACT

*Sclerodermus nipponicus* Yuasa, an ectoparasitic bethylid, was reared in the laboratory on larvae of four species of cerambycids. The morphology of the developmental stages of this species was studied and its biology was observed at room temperature. Reproduction was sexual or parthenogenetic when there was no male in the tunnel of their hosts. The characteristics of oviposition of seven females are given in TABLE I. The adult stage lived longer in cool weather (TABLE II) than in warm. However, development of the immature stages was delayed and high mortality occurred in egg and larval stages at temperature below 18 C as shown in TABLES III-IV. Immature stages were also affected by the presence of ventricose mites, *Pyemotes ventricosus* (Newports) at temperatures above 28 C. Females and young larvae of *S. nipponicus* feed by sucking the juice from the surface of the body; the mature larvae embed their anterior part into the body of the host and feed on the body content of the host. Because of the facts that they can reproduce parthenogenetically, they are non-specific in their host requirements, females are active with high fecundity, and they tolerate cold temperature, *S. nipponicus* could be an effective agent for the control of cerambycids.

There are many kinds of cerambycids in Taiwan, which are seriously destructive to trees and wood products as a consequence of larval boring in the wood. Chang (1-6) reported that seven species of cerambycids injure citrus plants; seven species damage apple tree; nine species, pear trees; four species, grapes, and four species tea trees in Taiwan. Trees of the damaged gradually die after the larvae have bored in the stem of the tree. Owing to the tree boring habit of the larva, it is very difficult to control them with insecticides.

*Sclerodermus nipponicus* has received little attention. There are only few references available. Ishii (7) found that this species feeds on the death watch beetle, *Ptilineurus marmoratus* Reittar, in Japan. In U. S. A., Clausen (8) recorded that *S. nipponicus* parasites on the larvae of both Coleoptera and Lepidoptera. The Coleopterous hosts are pests of stored grain and bark and wood borers. The Lepidopterous hosts are largerly grain and flour moths, leaf miners, leaf rollers, case bearers, shoot and fruit borers. In Taiwan,

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this species is only found on the larvae of cerambycid beetles and occasionally on the pupal stage of these beetles.

The purpose of this paper is to understand the biology and ecology of this bethylid wasp, and to provide a background for a possible introduction of the parasite in order to control cerambycid biologically.

## MATERIALS AND METHODS

*Sclerodermus nipponicus* was reared in the laboratory on the larvae of four species of cerambycid beetles: *Anpoplophora macularia* (Thomson), *Apomecyna maculaticallis* Pic, *Apomecyna excavaticeps* Pic and *Stromatium longicorne* Newman. The larvae of these beetles were collected from Pu-Li, Taichung Hsien and the suburb of Taichung city. One host larva was placed in a vial 10 cm long and 3 cm in diameter with one pair of adult parasites, and two to four larvae according to the size of the host larvae. Each vial was wraped with black paper. The opening of the vial was closed with a heavy cloth and fixed by a rubber-band.

By removing the host larva togather with parasites from the vial, the activity of the adult parasites and the development of the larvae were examined with a magnifier. Since the eggs of the parasites were rather small, the number of the eggs on each host larva and their hatching were observed with a low power microscope.

## RESULTS AND DISCUSSION

*I. Description of the stages of* ***S. nipponicus:***

*Adult* (*Figs. 1–5*): The adults are small, parasitoid wasps. The male measures 1.8–2.5 mm, and the female 3.5–5.0 mm in length. Both are brownish black in color.

*1. The head*—The head in general is square, that of the female appears slightly longer than wide; the compound eyes are oval and locating at the upper lateral sides of the head; the ocelli are triangularly arranged at the vertex; and the antennae protrude from the base of the inner side each mandible. The antennae are not elbowed, having thirteen segments with rather large scape and small pedicel, the flagellum enlarges gradually in size from base to tip; the mandibles are tridentate; the maxillary palpi have five segments; and the labial palpi are three segmented.

*2. The thorax*—The prothorax appears bell-shaped; the mesothorax is well developed and sightly convex; in the winged from (*Figs. 1–4*), the mesoscutum and mesoscutellum are divided by a scutoscutellar suture; the scapula and axilla are separated by suture from the sides of mesoscutum and mesoscutellum; the metathorax is not well developed and is almost covered by mesonotum. The propodeum is very large.

*3. The wings*—Wings are present in males and some females. They are hyaline with microtrichia hairs. The venation of the fore wing is interpreted following Ross (9): Sc+R and M+Cu are combined at the base of the wing but separate more apically, M+Cu is divided again into M and Cu, M runs anteriorly to Sc+R, and Cu posteriorly. The anal vein is present.

*4. The leg*—Unlike most parasitic Hymenoptera (10), *S. nipponicus* has a one-jointed trochanter. Other segments of the leg are normal; each tibia has one pair of spurs, and the tarsus is five segmented with a pair of strong ungues and a round empodium.

*5. The abdomen*—The female abdomen is elongate and seven segmented, approximately one third longer than the thorax. The ovipositor exserts beyond the abdominal tip. The abdomen of the male differs from that of the female, in that it is about the same length as thorax, and the genitalia structure is very different.

*Egg* (*Fig. 6*): The egg is elongate-oval, 0.38–0.54 mm long, and 0.18–0.23 mm wide; the egg surface is smooth and transparent. It is attached to the body of the host.

*Larva* (*Figs. 7–8*): The larvae are maggot-like, with two developmental stages:

*1. Young larva*—Oval, yellow, 0.49–0.74 mm long. The body is thirteen segmented. The head is spherical. The mandibles falcate and the external rim of the hypopharynx is sclerotized. The thorax and the abdomen are elongate, with while or colorless urate cells and fat granules beneath the cuticle. Spiracles are located in the meso-, metathorax and on abdominal segments I to V.

*2. Mature larva*—Mature larvae are spindle-shaped, yellowish brown in color; 3.5–4.2 mm long. The head is smaller than the thorax; the mandibles are triangular in shape; the maxillae appear little differentiated; maxillary palpi are represented by small papillar; labial palpi by small papillae; the hypopharynx is fused with the liqula to make the opening of the labial gland. Urate cells and fat granules beneath the cuticle of thorax and abdomen are evident and moved by the rhythm of respiration. Spiracles are located on the mesothorax, metathorax and I to VII abdominal segments.

*Pupa* (*Fig. 9*) and *Cocoon:*

*1. Pupa*—The pupa is the exarat Hymenopterous type with wings and appendages free. It varies in color from white to brown with age; the compound eyes have many facets; the vertex has several setae and each abdominal segment has one row of seven to eight setae on the dorsal surface. Urate cells and fat granules are not clearly visible beneath the cuticle of the abdomen. Genitalia do not developed.

*2. Cocoon*—The cocoon is silken, elongate-oval and white.

*II. Biology of* ***S. nipponicus:***

*Parasitism and fecundity: S. nipponicus* is ectoparasitic like other genera and species of Bethylidae. Both females and larvae feed on the larvae of cerambycid beetles. The host is paralyzed by biting and ovipositing of the female, Eggs of *S. nipponicus* are oviposited individually on the dorsal and the lateral surfaces of the body of the host. The females feed on the surface of the preys but the males do not eat. In the field, males leave the tunnel of the prey after mating and in the laboratory, they died after a short period. Females can appearently discriminate between parasitized and non-parasitized larvae. Once a female laid eggs on a host, she never laid eggs on the same host again, and did not lay any more eggs until she found a fresh host.

Mating takes place right after the female emerges or while she still rests in the cocoon with only the end of her abdominal segments extending out of the cocoon. From three to six days after mating, the female begins to oviposit. In this study, the average preoviposition period varies inversely with the temperature. Parthenogenesis occurs only when no males are in the tunnel.

The oviposition of *S. nipponicus* female and number of times of oviposition per female are shown in TABLE I.

The number of eggs laid by individual females varied each time according to the size of the prey and the temperature. The females usually deposite more eggs on the larva of *Anopoplophora macularia* and *Stromatium longicorne*, than on those of *Apomecyna maculaticellis* and *Apomecyna excavaticeps*. The optimum temperature was 22–25 C. Below 18 C or above 30 C, the number of eggs deposited per female decreased. The period between the successive deposition of eggs also varied with temperature. At the optimum temperature about 25 C, the second oviposition took place 2 to 6 days after the first. However, in the winter at about 18 C, the time between the first and second oviposition lasted more than 10 days or even as long as two months.

*Length of adult life span:* The life span of *S. nipponicus* is summarized as TABLE II.

TABLE I
*Oviposition of* ***S. nipponicus***

| Times of oviposition | No. of eggs laid per female each time | | | | | | |
|---|---|---|---|---|---|---|---|
| | *1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I | 17 | 150 | 23 | 32 | 23 | 14 | 20 |
| II | 56 | 16 | 34 | 25 | 21 | 25 | 32 |
| III | 28 | — | 26 | 41 | 26 | 11 | 10 |
| IV | 14 | — | 22 | 34 | 12 | 16 | 12 |
| V | 22 | — | — | 50 | 23 | 27 | 24 |
| VI | — | — | — | — | 14 | 8 | 10 |
| VII | — | — | — | — | — | — | 17 |
| VIII | — | — | — | — | — | — | 15 |
| Total no. of eggs/female | 137 | 166 | 105 | 182 | 122 | 91 | 140 |

1-7* Individual females of *S. nipponicus*

TABLE II
*Length of adult life span of* ***S. nipponicus***

| Season | Average of room temperature in C | Females | | | Males | | |
|---|---|---|---|---|---|---|---|
| | | Shortest life (days) | Longest life (days) | Average of 7 indiv. (days) | Shortest life (days) | Longest life (days) | Average of 7 indiv. (days) |
| Spring | 21 | 54 | 87 | 75.3 | 3 | 13 | 7.7 |
| Summer | 30 | 24 | 64 | 41.0 | 5 | 10 | 7.0 |
| Autumn | 25 | 52 | 126 | 83.7 | 9 | 20 | 14.7 |
| Winter | 18 | 50 | 100 | 72.8 | 6 | 11 | 7.5 |

In general, adults of *S. nipponicus* exhibited a longer life span during the colder weather.

*Development of the immature stages:* Eggs were laid on the surface of the cerambycid larva. Development was rapid at 30 C and after three days, the embryos were well formed. The length of egg stage with respect to temperature is shown in TABLE III. During the embryonic development, the color of the egg gradually changed from transparent white to bright yellow. When the central part of the egg became yellow in color, the chorion broke longitudinally on the dorsum of the egg and the larva emerged to attack the host.

The larvae fed on the host fluid. The young larvae fed on the surface of the

TABLE III
*Length of egg stage of* ***S. nipponicus***

| Season | Average of room temperature C | Shortest period (days) | Longest period (days) | Average of 100 indiv. (days) |
|---|---|---|---|---|
| Spring | 21 | 4 | 12 | 7.3 |
| Summer | 30 | 2 | 4 | 3.1 |
| Autumn | 25 | 3 | 8 | 5.3 |
| Winter | 18 | 10 | —* | —* |

* Eggs did not develop because of the cold temperature.

host during the second to the fifth day of the larval life. They also punctuated the surface and fed on host tissue. The head and thoracic segments gradually became embedded in the host, while the larva grew. After larvae were fully grown, they left the host and spinned the cocoon. spinning was completed within 16 to 20 hours at 25–30 C. Soon after the cocoon was completed, the fully grown larvae moulted to the pupal stage.

The period of development of the larval stage varied according to the temperature of the different season (TABLE IV). Development of the larval stage was delayed by temperature below 18 C. A high mortality occurred in January and February when the temperature occasionally fell to 11 C.

After the larvae have pupated, temperature had little effect aside from prolonging the pupal stage. The length of the pupal stage is shown in TABLE V.

TABLE IV

*Length of the larval stage of* ***S. nipponicus***

| Season | Average of room temperature C | Shortest period (days) | Longest period (days) | Average of 100 indiv. (days) |
|---|---|---|---|---|
| Spring | 21 | 5 | 12 | 9.1 |
| Summer | 30 | 4 | 10 | 7.0 |
| Autumn | 25 | 5 | 10 | 7.2 |
| Winter | 18 | 13 | —* | —* |

* Most larvae did not develop because of cold temperature.

TABLE V

*Length of the pupal stage of* ***S. nipponicus***

| Season | Average of room temperature C | Shortest period (days) | Longest period (days) | Average of 100 indiv. (days) |
|---|---|---|---|---|
| Spring | 21 | 11 | 24 | 17 |
| Summer | 30 | 10 | 13 | 11 |
| Autumn | 25 | 11 | 20 | 15.8 |
| Winter | 18 | 20 | 51 | 38.7 |

The cocoon turned from white to dark grey. The mandibles of the adult aided in emergence of the adult.

Development of the egg and larval stages was influenced by the presence of the ventricose mites, *Pyemotes ventricosus* (Newports) (11) at temperature above 28 C. The mortality of these two stages of *S. nipponicus* was, therefore, increased by the damage of the ventricose mites at the temperature.

*Effects of parasitism: S. nipponicus* attacks not only the larval stages of cerambycid beetles, but also the pupal stage. The female and the young larva are haemophagous sucking the body fluid through the cuticle of the host, and do not feed on the fat body. Protein substances were possibly absorbed through the cuticle with the juice as reported by Schneider (12) for Ichneumonids. The mature larvae however consume the fat body and also the haemolymph of the host. The head of the larva and its anterior body segments become embedded in the body of the host as shown in *Fig. 11.* The larvae never shift their place on the host until they are fully grown.

The host was injured by feeding of the parasitic adult and appeared irritable (*Fig. 10*). Most of the hosts however

were paralyzed by the oviposition. The host never survived after it was attacked by *S. nipponicus*. The parasitic larvae absorbed all the body content of the host. By the time when the parasitic larvae were fully grown, all that remained of the host were the head and the cuticle.

*III. Importance as a control agent:*

According to this observation *S. nipponicus* appears to have several important attributes as an agent for controlling cerambycid population. One important characteristic is the ability to undergo parthenogenesis. Cerambycid larvae live individually in wood or the stems of the plants and never leave the plants through holes made by their strong mandibles. Females of *S. nipponicus* are small, very active wasps. They can seek the host with their antennae and reach it through clefts in the wood or small holes left by oviposition of the host adult. In addition, due to the high fecundity of *S. nipponicus*, the parasitic species needs not be abundant to achieve a high incidence of parasitism; once the host larvae are attacked by the parasitic females, their development immediately ceases. This attribute, therefore, is an important factor in the reduction of the host population.

The adults of *S. nipponicus* can tolerate cold temperature and are non-specific in the choice of the larval or the pupal stages of cerambycids as the host. The parasite can survive and propagate by attacking other Coleopterous or Lepidopterous larvae when the cerambycid hosts are lacking. Furthermore, *S. nipponicus* appears to be easily reared in the laboratory without expensive equipment.

Thus, the results of this observation indicate that this species could serve as an effective control agent for cerambycids.

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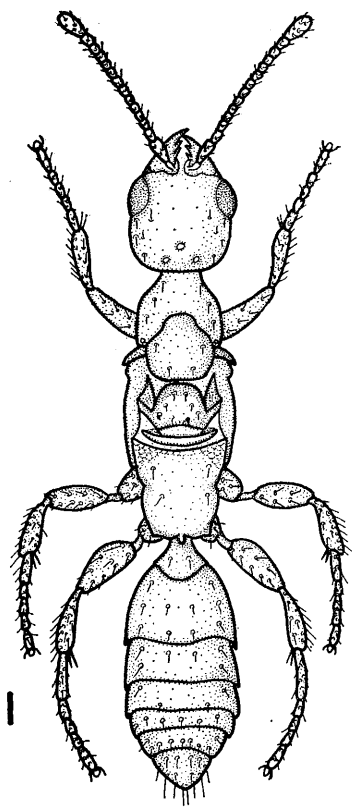
*Fig. 1.* Dorsal aspect of *Sclerodermus nipponicus* male, wings removed.
*Fig. 2.* Dorsal aspect of *S. nipponicus* female, wingless form.
*Fig. 3.* Dorsal aspect of right wing of male.
*Fig. 4.* Lateral aspect of thorax of male.
*Fig. 5.* Lateral aspect of thorax of wingless female.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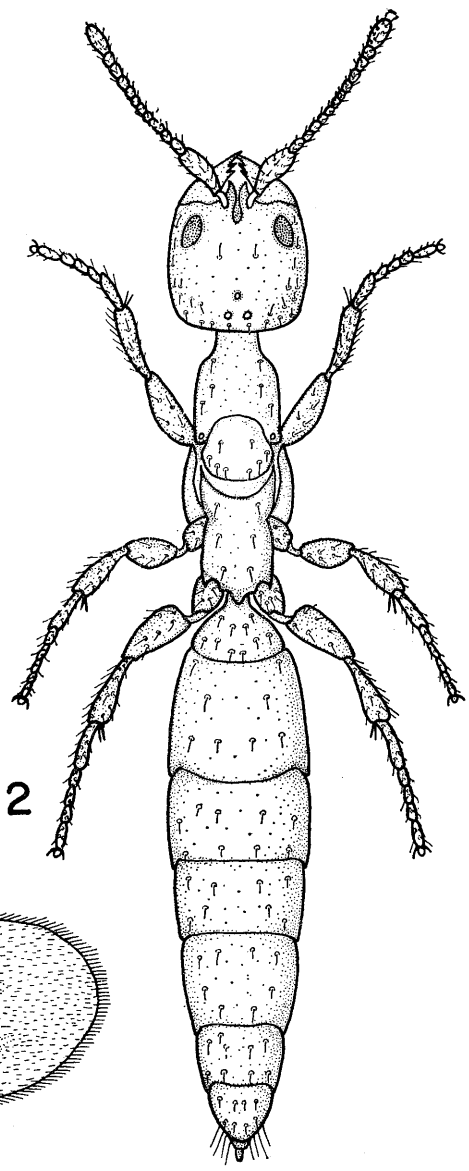
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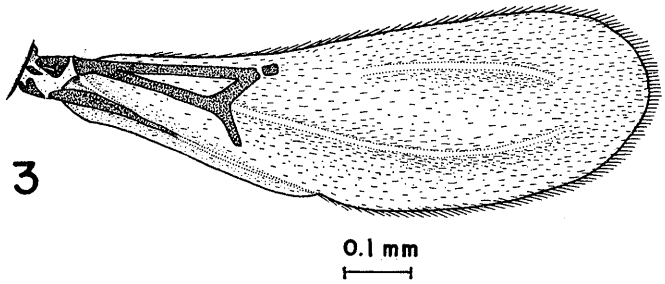
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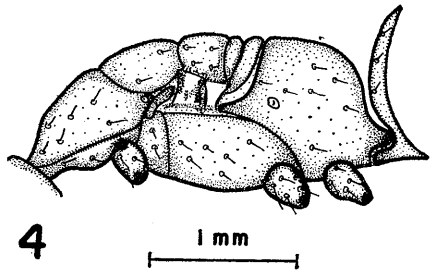
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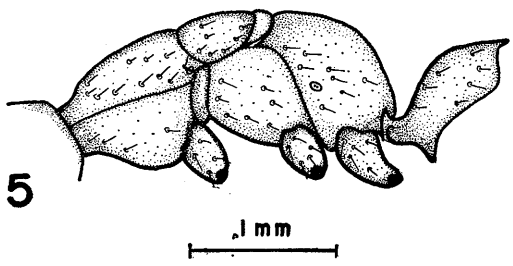
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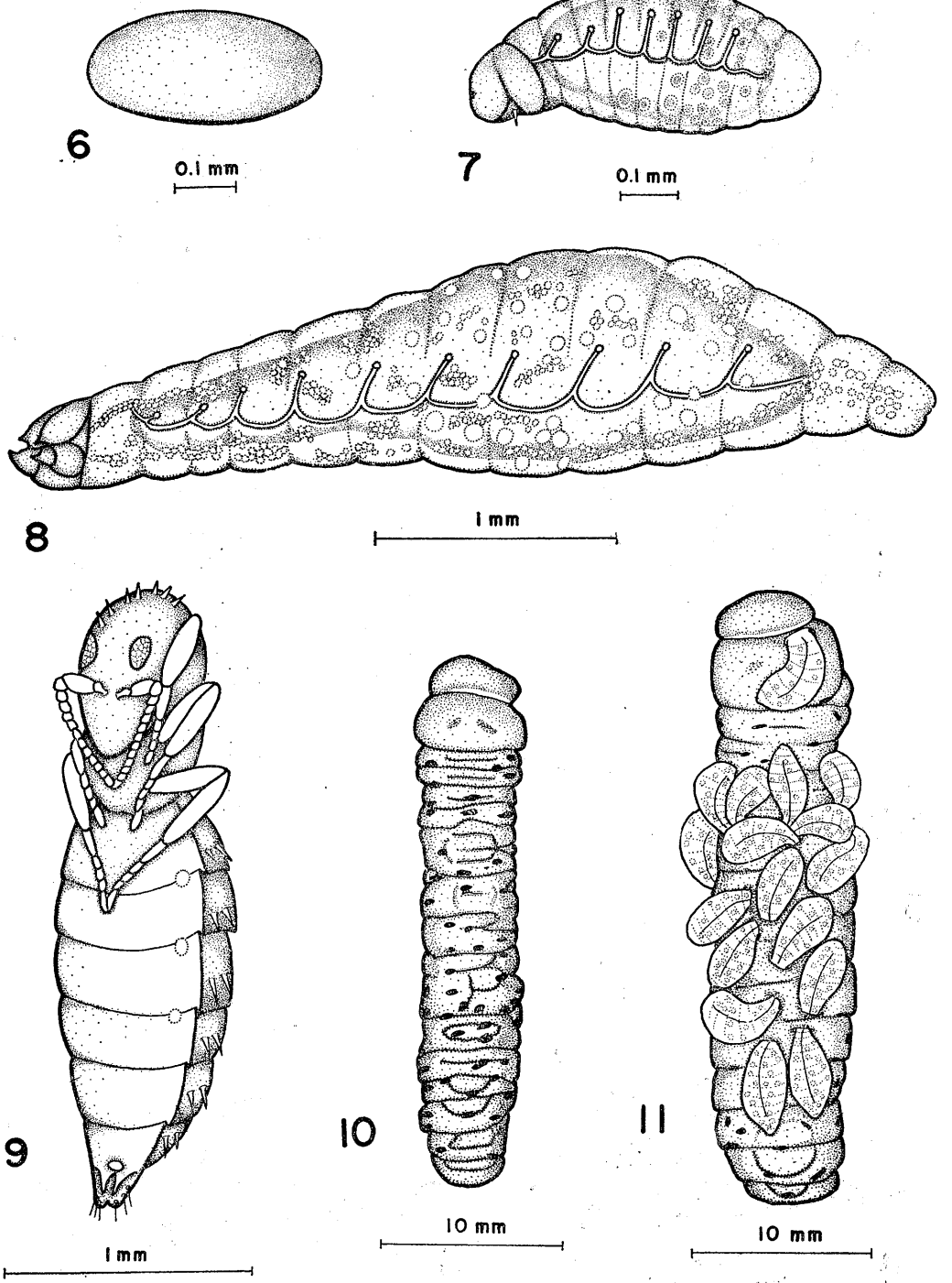
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*Fig. 6.* Lateral aspect of *S. nipponicus* egg.
*Fig. 7.* Lateral aspect of *S. nipponicus* young larva.
*Fig. 8.* Lateral aspect of *S. nipponicus* mature larva.
*Fig. 9.* Ventral aspect of *S. nipponicus* pupa.
*Fig. 10.* Cerambycid larva injured by the parasitic female of *S. nipponicus.*
*Fig. 11.* Mature larvae of *S. nipponicus* parasite on the host of cerambycid larva.