Development of the Immature Stages of *Ascogaster reticulatus* 
WATANABE (Hymenoptera: Braconidae), an Egg-Larval 
Parasitoid of the Smaller Tea Tortrix Moth, *Adoxophyes* sp. 
(Lepidoptera: Tortricidae)

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*Ascogaster reticulatus* WATANABE is a solitary egg-larval endoparasitoid of the smaller tea 
tortrix moth, *Adoxophyes* sp. Most of the parasitoid eggs hatched within two days after being 
laid in the host eggs, and became 1st-instar larvae with brown, falcate-shaped and sclerotized 
mandibles. The parasitoid larvae grew slowly, becoming 2nd-instar larvae when the host 
was in the 4th-instar and reaching 3rd-instar immediately before their egression from the host. 
The mandibles of the 2nd-instar parasitoid larvae were transparent and feebly sclerotized; 
however, they were again sclerotized and serrated in the 3rd instar. After its egression, 
the 3rd-instar parasitoid larva consumed the host larva completely from the outside, and then 
spun a cocoon for pupation.

INTRODUCTION

*Ascogaster reticulatus* WATANABE is a solitary egg-larval endoparasitoid of the smaller tea 
tortrix (STT) moth, *Adoxophyes* sp. (Lepidoptera: Tortricidae) which does great 
damage to the tea plant in Japan, and has 4 generations a year in Shizuoka Prefecture. 
The development of this parasitoid well synchronizes with that of STT, having the same 
number of generations a year (TAKAGI, personal communication). This parasitoid is 
also reported to parasitize seven tortricid species other than STT, including the summer 
fruit tortrix (*Adoxophyes orana fasciata* WALSINGHAM) and *Choristoneura diversana* HÜBNER 

The oviposition behavior and kairomone have already been investigated on *A. reticulatus* (KAINOH and TAMAKI, 1982; KAINOH et al., 1982). However, little is yet 
known about the development of *A. reticulatus* within the host. There are several reports 
on the immature stages of *Chelonus* spp. belonging to the same subfamily, Cheloniinae 
(BROODRYK, 1969; RECHAV and ORION, 1975; JACKSON et al., 1978; HAFEZ et al., 1980). The present study was thus perfomed to describe the morphological changes of *A. reticulatus* during the egg-larval stages of the host.

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380
Larval Development of *Axogaster reticulatus*

MATERIALS AND METHODS

*Insects.* The host insects (STT) were originally obtained from the stock culture maintained in the National Institute of Agro-Environmental Sciences (NIAES), while the parasitoids were collected at Kanaya in Shizuoka Pref. Both species were reared at 24 ± 1°C under a 16L-8D photoperiodic condition in a manner similar to that described in Kainoh and Tamaki (1982). For the oviposition of the parasitoid, a 2- to 4-day-old female was introduced into a 15-ml sample vial containing a 1- to 6-day-old STT egg mass and allowed to oviposit for 1 to 1.5 hr; this length of time was considered enough for maximum oviposition for one female parasitoid (Kainoh and Tamaki, 1982).

*Dissection.* The dissection of parasitized host larvae was performed with a dark-field stereomicroscope (10–50×). Development of the parasitoid living in a host egg was easily observed when the host egg mass darkened (6–7 days following deposition). Egg and larval size were measured with an ocular micrometer. The mouth parts of parasitoid larvae were observed on prepared specimens of larval heads, because morphological changes of the mouth parts are criteria distinguishing the instars.

RESULTS

*Development of parasitoid in the host egg*

Most of the parasitoid eggs deposited in host eggs (Fig. 1) hatched within two days and became 1st-instar larvae (Fig. 2-1, Table 1). Significant changes did not occur in size or morphology of 1st-instar larvae in host eggs.

*Developmental changes of a parasitoid larva in the host larva*

The parasitoid larva was slow growing and at day 10 after host eggs hatched (4th-instar host larva), its length and width had increased about 7 times and 4 times, respectively, over its just-hatched size. However, no noticeable changes were observed in the head capsule size. Not only did an anal vesicle develop as a part of the larval development, but also the number of body segments increased from 8 to 12, 10 days after hatching. Though the just-hatched parasitoid larva was transparent, the color gradually became creamy white (Fig. 2-1, 2-2), and a small, pointed caudal appendage appeared. There was no noticeable change in size or morphology of the brown, falcate-

![Fig. 1. Egg of *A. reticulatus* newly laid in an *Adoxophyes* sp. egg.](image-url)
Fig. 2. Larval growth of *A. reticulatus*. 1: 1st-instar larva soon after hatching, 2: 1st-instar larva before molt to the 2nd-instar larva, 3: 2nd-instar larva, 4: 3rd-instar larva after leaving its host, a.s: anal segment, a.v: anal vesicle, h: head.

Table 1. Development of *A. reticulatus* in the eggs of *Adoxophyes* sp.¹

<table>
<thead>
<tr>
<th>Time after oviposition (days)</th>
<th>No. host eggs examined</th>
<th>No. parasitoids</th>
<th>Hatchability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Eggs</td>
<td>1st-instar larvae</td>
</tr>
<tr>
<td>1</td>
<td>399</td>
<td>399</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>53</td>
<td>197</td>
</tr>
<tr>
<td>3</td>
<td>418</td>
<td>31</td>
<td>387</td>
</tr>
<tr>
<td>4</td>
<td>390</td>
<td>20</td>
<td>370</td>
</tr>
<tr>
<td>5</td>
<td>556</td>
<td>2</td>
<td>554</td>
</tr>
<tr>
<td>6</td>
<td>894</td>
<td>1</td>
<td>893</td>
</tr>
</tbody>
</table>

¹ Parasitized egg masses were dissected immediately before hatching (6-7 days old).

shaped and sclerotized mandibles (Fig. 3, Table 2). The 1st-instar parasitoid larva was often found around the Malpighian tubules near the boundary between the midgut and hindgut in the 1st- to 2nd-instar host larva. Thereafter, the parasitoid molted in the 4th-instar host larva, and the head became oval (Fig. 2-3). The mandible of the 2nd-instar larva was transparent and feebly sclerotized, but it was again sclerotized and serrated when the parasitoid reached the 3rd-instar or immediately before its eggression from the host larva.

**Developmental changes in a parasitoid larva after eggression from the host**

After a parasitized 4th-instar host larva formed a cocoon, the 3rd-instar parasitoid larva without an anal vesicle (Fig. 2-4) left the host (except for its last segment which remained inside). This parasitoid larva fed externally on the host larva by curving its
body and then spun a cocoon. The mouth parts of the parasitoid larva including the mandibles, became brown and well-sclerotized after the egression (Fig. 4). The residual head capsule and cuticle of the host larva attached to the parasitoid cocoon. Inside the cocoon, the larva became a prepupa, then pupated after gut purge (Fig. 5).
DISCUSSION

A detailed dissection of parasitized host egg masses revealed parasitoid eggs in all stages of the masses, as had been seen earlier in the rearing of the parasitized eggs (Kainoh and Tamaki, 1982). This suggested that all stages of the host can be regarded as suitable for the parasitoid egg development. Similarly, successful ovipositions were obtained in all ages of host eggs in other egg-larval parasitoids (Broodryk, 1969; Paul et al., 1980).

Lack of noticeable developmental changes of a newly-hatched parasitoid larva within a host egg may indicate the necessity of host development for the larval development of the parasitoid. This suggests that the nutrients and/or hormone in host larvae might be important factors in the development of 1st-instar parasitoid larvae.

An apparent increase in the number of larval segments of the parasitoid may be due to the undifferentiated larval body segments immediately before hatching, which can be seen in another egg-larval parasitoid, Chelonus spp. (Broodryk, 1969; Rechav and Orion, 1975).

In this study, the larval development of the parasitoid in a host egg was observed when the egg mass darkened (6–7 days old). Therefore, the relationship of the embryonic development between the host egg and the parasitoid was no certain. In the case of well-developed host eggs, the parasitoid may oviposit directly into the embryo as occurs in Chelonus inanitus (Rechav and Orion, 1975).

When the host larva was in the 1st to early 4th instars, the parasitoid consistently remained in the 1st instar stage, as evidenced by there being no morphological change in the mandibles; but its body length and width greatly increased (Table 2). Sequential changes of the mandibles were observed in relation to the development of later stages of the parasitoid, i.e., from sclerotized, falcate-shaped to feebly-sclerotized structure. Finally, the mandibles were again sclerotized and serrated before egression from the host larva, as can be seen in another endoparasitoid, Apanteles solitarius (Hagen, 1964). In addition, morphological changes in the mandibles and head capsule are closely related to the larval instars in other egg-larval parasitoids (Rosenberg, 1934; Broodryk, 1969; Rechav and Orion, 1975; Jackson et al., 1978; Hawlitzky, 1979). From these accounts, it is concluded that a 1st-instar larva of A. reticulatus becomes 2nd instar in a 4th-instar host larva (Fig. 2-3), then 3rd-instar (final instar) immediately before egression. The sclerotized and serrated mandibles seemed to be used by the 3rd-instar to egress from the host and the notable sclerotization of mouth parts makes them suitable for external feeding by a parasitoid larva.

Within the family of Braconidae, different species have a different number of instars (Hagen, 1964). The braconid egg-larval parasitoid, Ascoscapter quadridensatus, has 3 instars (Rosenberg, 1934), and in Chelonus curvicaudatus, molt to the 2nd instar occurs in the host instar when the parasitoid egresses (Broodryk, 1969). In view of these phenomena, an A. reticulatus larva is thought to pupate after going through 3 larval instars. In the egg-larval parasitoid, Chelonus inanitus, Rechav and Orion (1975) observed 3 instars, whereas Hafez et al. (1980) identified 4 instars based on the degree of sclerotization of a 1st-instar larva described by the former authors.

A. reticulatus could normally complete development using as host another tortricid species, Adoxophyes orana fasciata, and egressed from 4th-instar host larvae under laboratory
Larval Development of *As cogaster reticulatus* 385

rearing conditions (25°C, 16L:8D photoperiod) (Kawakami, unpublished). Since *A. orana fasciata* enters larval diapause in autumn (Oku, 1970), the effect of host diapause on the parasitoid development is an interesting aspect for study.

*As cogaster reticulatus* can be reared easily, because the development of the parasitoid well synchronizes with that of the host. This may be due in part to a certain control of host development by the parasitoid, as suggested by the concept of host regulation (Vinson, 1975). The effects of parasitism by *A. reticulatus* on host development and growth and other pathological aspects must be studied in future.

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REFERENCES


