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EFFECT OF THE NUMBER OF PARASITOID (*APANTELES KARIYAI*) EGGS [*HYM. : BRACONIDAE*] ON THE GROWTH OF HOST (*LEUCANIA SEPARATA*) LARVAE [*LEP. : NOCTUIDAE*]

Y. SATO & T. TANAKA

Department of Zoology, Faculty of Science, Kyoto University,
Kyoto 606, Japan.

The developmental interactions between a gregarious endoparasitoid, *Apanteles kariyai* Watanabe and its host, *Leucania separata* Walker, were investigated. The parasitoid laid more eggs in older hosts. Host size increased gradiently as the instar advanced, but the number of eggs laid per host did not increase accordingly.

The net weight of the host was correlated positively with the number of eggs laid and with the total weight of parasitoids, especially in cases of parasitization at 3rd (5th-instar type), 4th and early 6th instar where the correlation was significant at 1 % level. It follows therefore that the more parasitoids there are relative to their host size, the more they contribute to make the host size larger.

Endoparasitic hymenoptera frequently suppress growth of host larva (**Jones & Lewis**, 1971 ; **Smilowitz & Iwantsh**, 1973 ; **Vinson**, 1972 ; **Vinson & Barras**, 1970). Those parasitoids are all solitary ones. *Apanteles glomeratus,* a gregarious parasitoid, does not suppress growth of its host (*Pieris rapae*) larvae. If gregarious species require a large amount of food, as pointed out by **Smith & Smilowitz** (1976), host larvae containing more parasitoid eggs laid should grow larger (**Beckage & Riddiford**, 1978). Work reported in this paper was undertaken to examine the influence of the number of parasitoid eggs on the growth of host larvae.

MATERIALS AND METHODS

Leucania separata Walker larvae used in this study were descendants of larvae collected from corn fields in Kanoya City, Kagoshima.

Apanteles kariyai Watanabe adults were obtained from parasitized host larvae collected in Kanoya. The mated females were maintained in glass tubes (3 x 13.5 cm) in the dark at 10 °C and given diluted honey soaked in a cotton ball.

Host larvae in the moulting stage of each instar and 48 h after the 5th ecdysis were used for parasitization. The moulting stage here is regarded as Phase I as defined by **Dahlman** (1969). About 20 larvae in each stage were parasitized and reared separately on young corn plants in a 200 ml plastic cup at 25 °C and 16 h photoperiod. Each parasitized larva was weighed daily and the food plant leaf exchanged until the parasitoid's egression from the host body. The head

capsules were recovered and their width was measured microscopically. The host larvae from which the parasitoids had egressed were weighed, and dissected to count the number of parasitoid larvae remaining inside. The cocoon clusters were weighed and dissected to count the number of parasitoids.

RESULTS

EFFECT OF HOST STAGE ON THE NUMBER OF EGGS LAID

Almost parasitoid females avoided a host which was in the 1st moulting stage (2nd instar). Only 8 female wasps attacked host larvae in that stage and parasitoids egressed from only one of these. When attacking 3rd instar or older larvae, successful parasitization reached 80 % of attacked larvae (table 1). Average number of eggs laid were 42, 62, 58, 80 and 81 at the 3rd, 4th, 5th and 6th instar, before ecdysis and 2 days after ecdysis (early and late 6th instar), respectively. The number of eggs laid in the 3rd instar was significantly smaller ($P < 0.01$) than that in the 4th instar. The number of eggs laid in the 4th instar was the same as that in the 5th ($P > 0.05$) and this was significantly smaller ($P < 0.01$) than that in both the early and late 6th instar. No difference was found between the numbers of eggs laid in the early stage and in the late stage of the 6th instar ($P > 0.05$). The parasitoid laid more eggs in older hosts. The host size increased gradiently as the instar advanced, but the number of eggs laid per host did not increase accordingly (table 1). Therefore, the number of eggs laid did not depend on the size or weight of host. In fact the number of eggs laid did not correlate the weight of host at the time of oviposition even at 10 % level ($r = 0.217, 0.245, 0.103, -0.176$ and 0.0903 at the 3rd, 4th, 5th, early 6th and late 6th instar, respectively).

TABLE 1

Effect of host stage on parasitization by Apanteles kariyai *at the time of oviposition*

Instar (a)	n	% parasitoid's egression	% host's pupation	% host's death	No. of eggs laid per host $\bar{X} \pm$ S.D.	Host's weight at the time of oviposition $\bar{X} \pm$ S.D. (mg)
II	8	12.5	87.5	0.0	31	
III	22	77.3	0.0	22.7	41.9 ± 14.5 (c)	2.0 ± 0.4
IV	22	95.5	0.5	0.0	61.8 ± 19.0 (d)	11.0 ± 1.2
V	20	80.0	10.0	10.0	58.3 ± 23.0 (c)	46.2 ± 8.6
VI	20	90.0	0.0	10.0	80.3 ± 27.2 (d)	231.3 ± 17.4
VI (b)	20	85.0	10.0	5.0	81.4 ± 21.8	506.2 ± 65.1

(a) Parasitized in moulting stage except b.
(b) Parasitized 2 days after ecdysis.
(c) Significant at 1 % level of probability from value directly following it in the column.
(d) Insignificantly at 5 % level of probability from value directly following it in the column.

GROWTH OF PARASITOID

Parasitoid larvae egressed from the host in 9-9.5 days from oviposition irrespective of host age at the time of parasitization unless it was 2nd instar. When parasitizing 2nd instar, the parasitoid required 12 days from being laid to egression. Egression to adult emergence took 5.5 - 6 days. The developmental period of the parasitoid was not affected therefore by host age when parasitizing 3rd to 6th instar.

GROWTH OF HOST

Parasitized host larvae moulted every other day as did unparasitized larvae, but parasitized ones did not pupate. Hosts parasitized at 2nd instar did not enter 6th instar. When parasitized at 3rd instar, some host larvae did not enter 6th instar (5th-instar type). These larvae weighed more than 2.2 mg at the time of being attacked or contained less than 40 parasitoid eggs. The other larvae entered 6th instar (6th-instar type) and grew larger (fig. 1). All larvae parasitized later than 3rd instar entered 6th instar, except 1 larva parasitized at 4th instar. The number of eggs laid in that larva was 14. Unparasitized larvae pupated 6 days after 5th ecdysis.

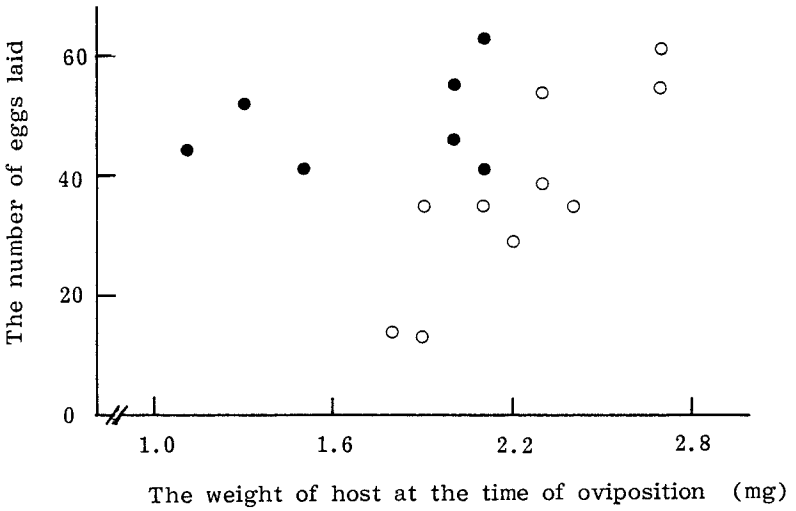

Fig. 1. When parasitized at 3rd instar, smaller host larvae in which more eggs were laid entered 6th and grew large, but larvae in which less were laid or larger one did not enter 6th instar. ○ : 5th-instar type ● : 6th-instar type.

Host larvae reached their maximum weight on 7 (5th-instar type) or 8 (6th-instar type) days when parasitized at 3rd instar, 7, 6 and 5 days, respectively, when parasitized at 4th, 5th and early 6 th instar, and 2 to 5 days when parasitized at late 6th instar.

In the final instar, the head capsule width was positively correlated with the maximum body weight, as shown in figure 2. The correlation was significant for larvae parasitized at 3rd instar (5th-instar type), 4th and 5th instar at 1 % level. When host larvae were parasitized at 6th instar, that is, the head capsule of the final instar had already formed at the time of being parasitized, correlation was insignificant at 5 % level.

RELATIONSHIP BETWEEN THE NUMBER OF PARASITOID EGGS LAID PER HOST AND THE WEIGHT OF THE PARASITOID LARVAE

The average weight of parasitoid larvae per host was negatively correlated with the number of parasitoid eggs laid. When parasitized at 3rd (5th-instar type), 4th, 5th, early and late 6th instar, correlation was significant at 1 % level ($r = -0.757$, -0.590, -0.882, -0.757 and -0.769, respectively). Only when parasitized at 3rd (6th-instar type) instar correlation was insignificant at 5 % level ($r = -0.496$).

RELATIONSHIP BETWEEN THE NUMBER OF PARASITOID EGGS LAID PER HOST AND THE GROWTH OF HOST

When host larvae reached maximum weight, the weight was positively correlated with the number of eggs laid. In cases of parasitization at 3rd instar (5th-instar type), 4th and early 6th instar, correlation was significant at 1 % level ($r = 0.916$, 0.915 and 0.707, respectively). In other cases, correlation was insignificant at 5 % level.

Since the weight measured here included the weight of the parasitoid inside the host, correlation between the number of parasitoid eggs laid and the net weight of the host larva was examined. When parasitized at 3rd (5th-instar type), 4th and early 6th instar, the weight of host larvae from which parasitoid larvae had just egressed was positively correlated ($P < 0.01$) with the number of eggs laid per host ($r = 0.911$, 0.904 and 0.656, respectively), and also positively correlated ($P < 0.01$) with the total weight of parasitoid larvae per host ($r = 0.937$, 0.916 and 0.720, respectively) (fig. 3-a). In other cases, correlation was also positive but insignificant at 5 % level (fig. 3-b).

DISCUSSION

The parasitized larvae were divided into 2 groups. 1) Those which were parasitized at 3rd (5th-instar type), 4th and early 6th instar contained more parasitoid eggs relative to their host size. 2) Those which were parasitized at 3rd (6th-instar type), 5th and late 6th instar contained fewer eggs.

When parasitized at 3rd (5th-instar type), 4th and early 6th instar, the number of eggs laid per host effected host growth significantly. The maximum weight of host was positively correlated with the number of eggs laid. The weight measured here included the weight of the parasitoids inside the host. If the host size is constant and independent of parasitization, the final net weight of host containing more parasitoid larvae should decrease and the net weight of host larvae should correlate negatively with the total weight of parasitoid. But in fact the correlation was positive, that is, when the host contained more parasitoid larvae, it grew larger ; showing that parasitoid larvae increase the host's size according to the number of eggs laid.

The final net host weight is related to the maximum size. The parasitized host reaches maximum size and then its weight begins to decrease due to cessation of feeding. The head capsule width of the final instar was positively correlated with the maximum weight of the host (fig. 2). Since the head capsule in the final instar is formed in the preceeding instar, the maximum size of the final instar is decided in the penultimate one. The head width of parasitized larvae was different from that of the unparasitized, as shown figure 2. From this it appears as though the parasitized host larvae grow large enough to feed the parasitoid.

Parasitoids grow at a definite rate like *Apanteles ruficrus* (Tagawa *et al.*, 1982), though the growth rate of the parasitoid is frequently influenced by host stage at the time of oviposition

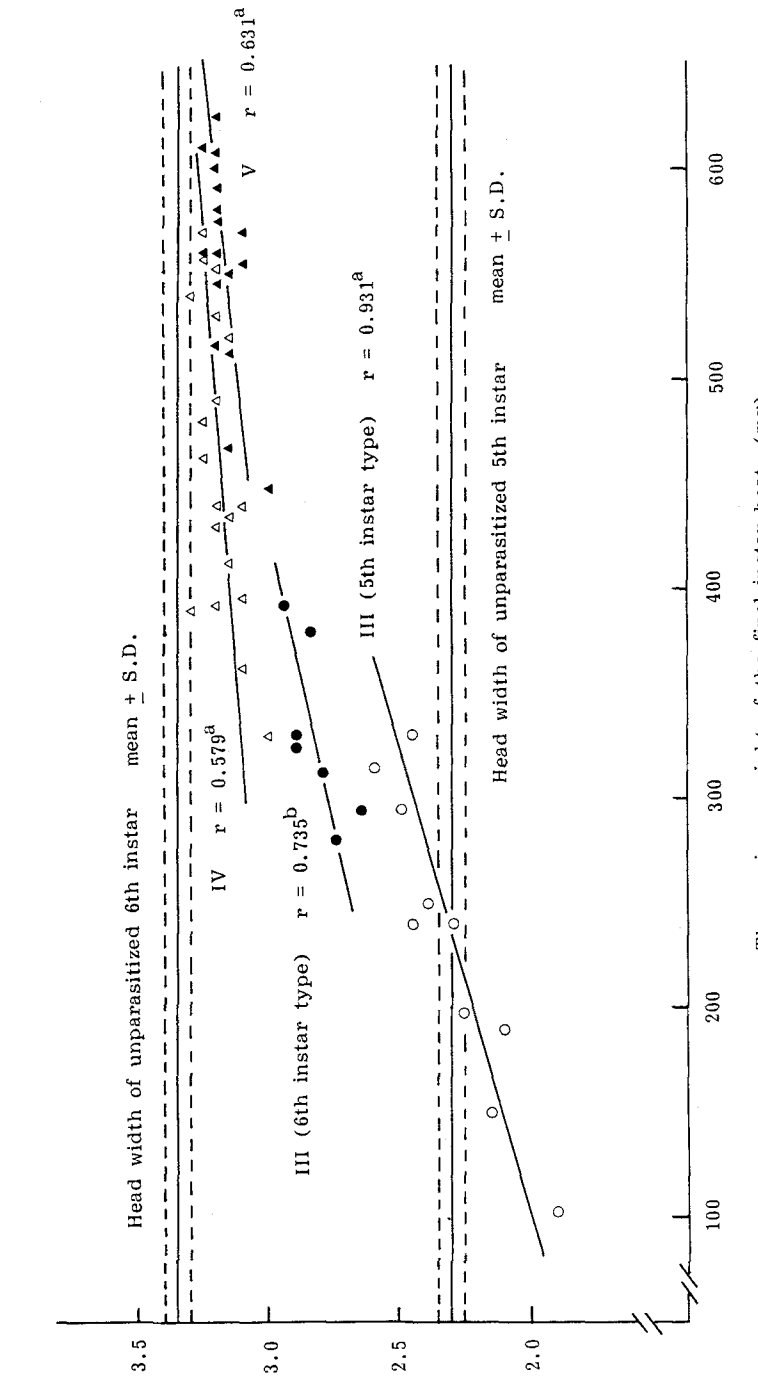

Fig. 2. The head capsule width as a parameter of the potential size of the final instar.
a : Significant at 1 % level
b : Insignificant at 5 % level.

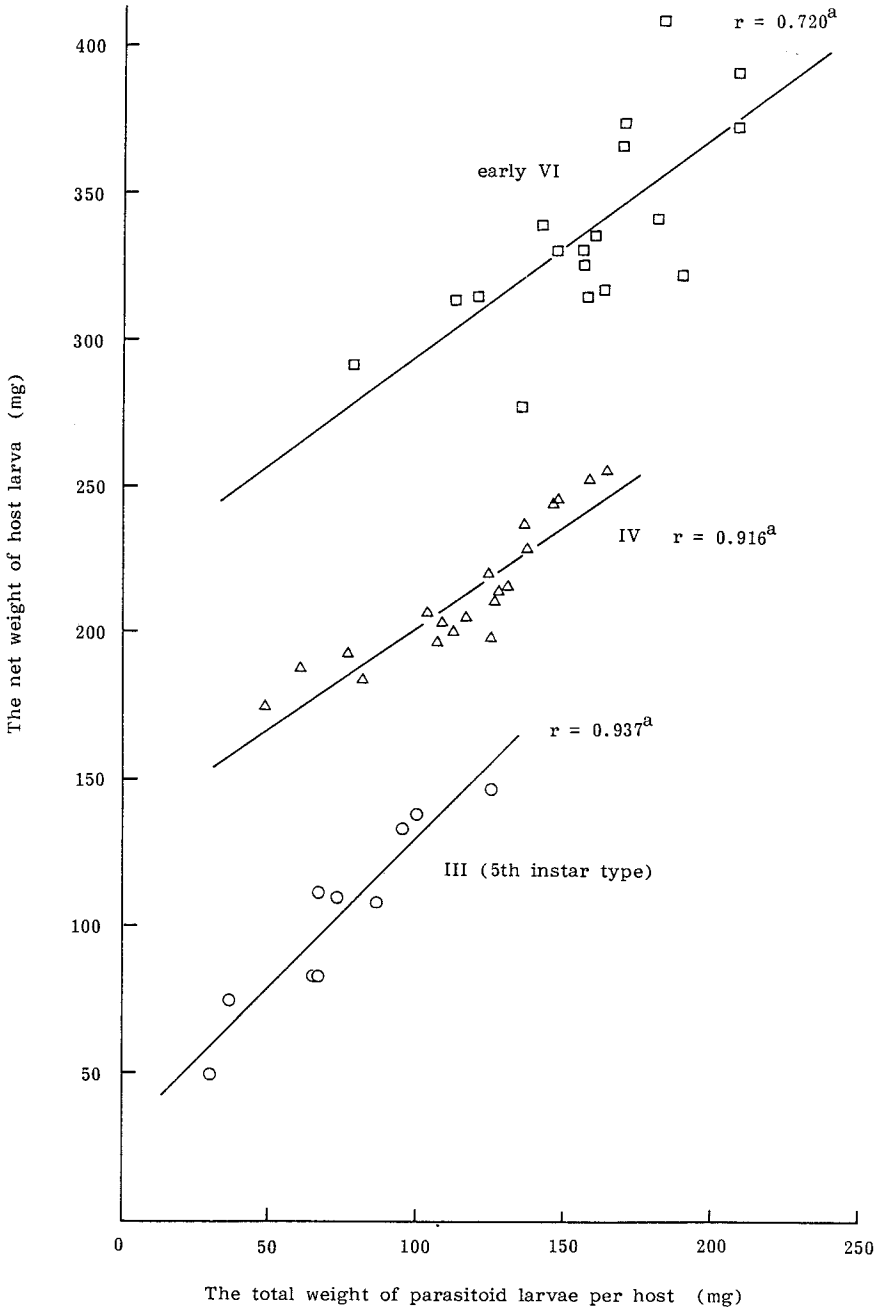

Fig. 3. Correlation between the total weight of parasitoid larvae and the net weight of host larvae from which parasitoid has just egressed.
a : Significant at 1 % level

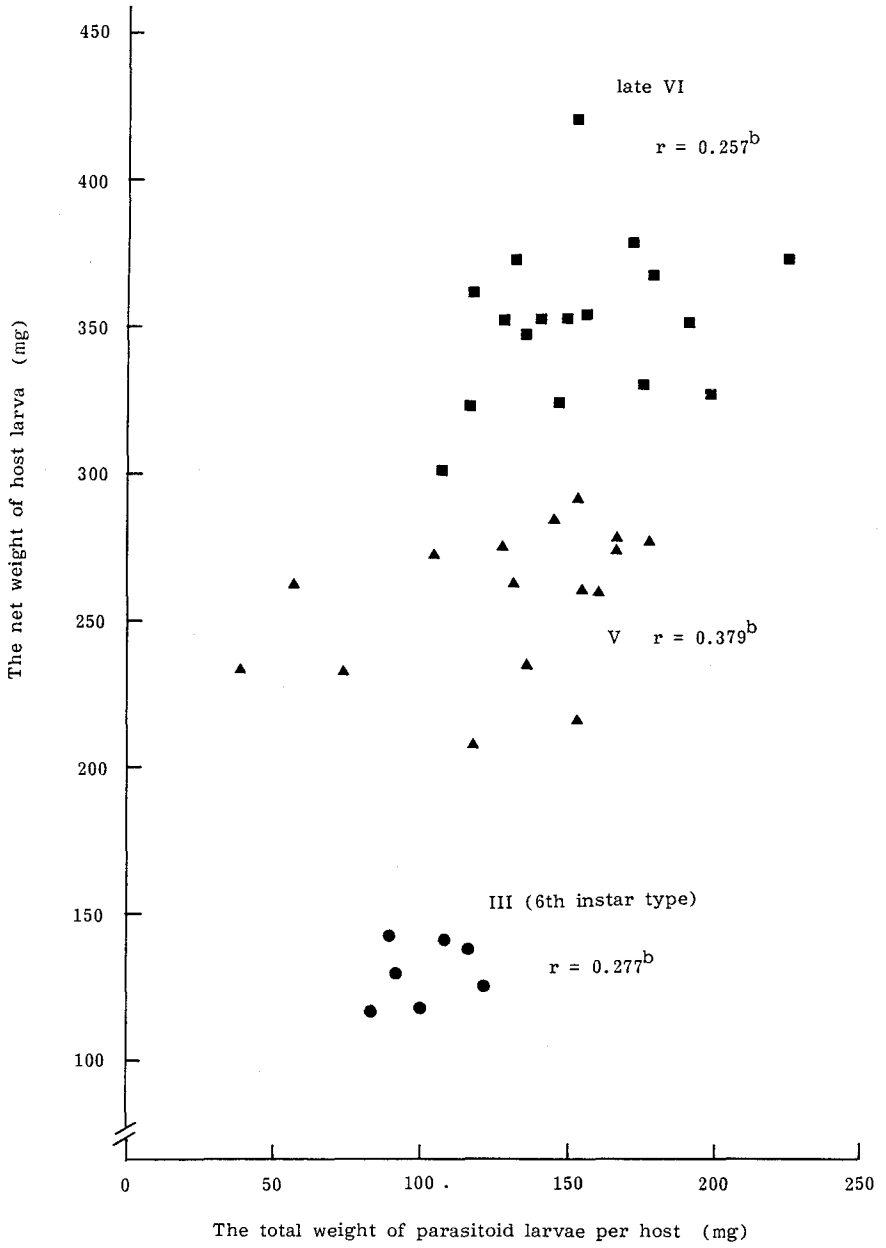

Fig. 3. Correlation between the total weight of parasitoid larvae and the net weight of host larvae from which parasitoid has just egressed.
b : Insignificant at 5 % level.

(**Jones & Lewis**, 1971 ; **Sato**, 1980 ; **Smilowitz & Iwantsh**, 1973 ; **Vinson**, 1972 ; **Vinson & Barras**, 1970). To maintain their growth rate, they not only inhibit host pupation prior to their egression but control the growth rate of the host itself.

It follows therefore that the parasitoid larvae control host growth in such a way that the more numerous they are relative to their host size, the more they contribute to the size of their host.

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RÉSUMÉ

Effet du nombre d'œufs du parasitoïde, *Apanteles kariyai* [*Hym. : Braconidae*] sur le développement des larves de l'hôte, *Leucania separata* [*Lep. : Noctuidae*]

Les interactions de développement entre un endoparasitoïde grégaire, *Apanteles kariyai* Watanabe et son hôte, *Leucania separata* Walker, ont été étudiées. Le parasitoïde a pondu un plus grand nombre d'œufs dans l'hôte plus âgé. La taille de l'hôte a montré une augmentation graduelle avec l'avancement du stade larvaire, mais l'augmentation en nombre des œufs pondus par le parasitoïde n'a pas été parallèle à l'augmentation graduelle de la taille de l'hôte. Le poids net de l'hôte a été en corrélation positive avec le nombre des œufs pondus par le parasitoïde ainsi qu'avec le poids total des larves du parasitoïde. Par conséquent plus les parasitoïdes sont en nombre, plus ils contribuent à l'augmentation de la taille de l'hôte.

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