Effect of Isolation on the Moults of *Parasitus* sp. Deutonymphs (Acarina: Mesostigmata)

Yasuhiro Ito

Laboratory of Rural Sanitation, National Institute of Agricultural Sciences, Kita-ku, Tokyo, 114 Japan

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The gamasid mite, *Parasitus* sp. is a common manure-inhabiting mite. Although crowded deutonymphs of this species developed into adults normally, the rate of moults of the isolated ones was quite low. The moults of these long-lived solitary deutonymphs was induced by crowding. The most successful emergence of adults was achieved by the combination of male and female deutonymphs, or of male adult and female deutonymph. However, without sufficient supply of food (nematode) for their development, most of the deutonymphs remained in this stage even when they were reared in a crowded state. It was therefore concluded that a sufficient nutritive condition was a primary necessity for inducing moults in these deutonymphs, and that some unknown stimuli produced by association with other individuals might also play a contributory role.

INTRODUCTION

The works on the life history of Acarina, hitherto carried out by many investigators, showed that their post-embryonic development could be completed regardless of rearing in isolation or in a crowded state.

A common free-living mite, *Parasitus* sp. (Parasitidae) collected from live-stock dung, has been successfully cultured for about 3 years (Ito, 1970, 1971). However, emergence of the *Parasitus* adults from deutonymphs could not be observed if they were reared in isolation with an exception of a few cases.

The purpose of the present experiment was to determine the nature of stimuli which affect the final moulting into adults of the deutonymphs reared in isolation.

MATERIALS AND METHODS

Parasitus sp. used in this study was collected from a swine manure, and was maintained with moistened wood dust in a round plastic container, 9 cm in diameter and 6 cm in depth, having a ventilated cover. Free-living nematodes, *Rhabditis elongata* (SCHNEIDER), were provided as food, together with an agar culture medium containing 10 per cent of powdered dry yeast for the maintenance of the nematodes. Oviposition was made on the medium or the wetted substance.

On the other hand, smaller plastic containers, 6 cm in diameter and 3.5 cm in depth, with plaster-charcoal substrata and with plastic covers, were used for the rearing of mites in isolation or for studying their life history. For the purpose of rearing mite in isolation, fertilized females were maintained singularly in the rearing container. Each egg deposited on the medium was transferred from oviposition sites to

fresh medium in a newly provided container. Rearing and observation of their life history were conducted at room temperature ranging from 26 to 28°C with 65 to 75 % RH.

RESULTS

Life history and effect of density on the emergence of adults of the isolated and crowded mites

There were 5 developmental stages in the life cycle of this species; i.e., egg, larva, protonymph, deutonymph, and adult.

Egg : The eggs were laid separately by the fertilized female adults on the surface of agar culture media or wetted substrata etc. The egg, round and translucent, was covered with a whitish and onion-shaped substance. The average dimensions of the eggs were 377 μ long and 298 μ wide. The incubation period was about 1 day.

Larva : The larvae were active moving, and fed on nematodes. The idiosoma was soft and glossy, and the average length and width were 555 μ and 338 μ , respectively. The average duration of this stage was about 1 day.

Protonymph : The protonymphs were pearl white in color, the average idiosomal length and width being 899 μ , and 560 μ , respectively. The average duration of this stage was about 1 day regardless of whether rearing in isolation or in crowd. The resting (quiescent) period at the end of each stage was short.

Deutonymph : The deutonymphs were active moving, fed vigorously on nematodes, especially after starving, and were capable to endure hunger. The average idiosomal length and width of matured male deutonymphs were 1173 μ and 773 μ , and those of females were 1371 μ and 878 μ , respectively. Gnathosoma, legs, and dorsal and sternal shields were tan and the other parts of idiosoma remained whitish light tan in color.

The average duration of the crowd-reared deutonymphal stage ranged from 2 to 20 days with a mean of 8 days (for 2 mites per container), or 3 to 16 days with an average of 9 days (for 3 mites per container). Moults of the solitary deutonymphs could not be observed for more than 50 days (Fig. 1, and Table 1). Some mites reared in

Fig. 1. Emergence of *Parasitus* sp. adults under 3 different densities.
 ○—○: 3 mites per container; ●—●: 2 mites per container; ●—●: 1 mite per container.

Table 1. EFFECT OF CROWDING ON EMERGENCE RATES OF *Parasitus* SP. ADULTS

No. of mites per container	No. of replications	No. of replications with adult emerged	Total No. of adults emerged
1	22	0 (0%)	0 (0%)
2	20	12 (60%)	22 (♂ 12, ♀ 10) (55%)
3	18	16 (89%)	37 (♂ 20, ♀ 17) (69%)

isolation developed regularly into adults as the crowded ones. The rate of moults in these normally grown solitary ones was quite low. For example, only 12 mites out more than 2000 individuals conditioned by isolation developed into adults.

Adult: The average idiosomal length and width of the male adults were 1200 μ and 776 μ , with a spur on the femur of leg II. They lived for 5 to 14 days with a mean of 10.0 days. The average idiosomal length and width of female adults were 1554 μ and 1005 μ . They mated immediately after emergence and the pre-oviposition period for fertilized females was within 1 day. Unfertilized females did not produce eggs. The fertilized females lived for 6.0 (3—12) days, and the unfertilized ones 7.4 (2—13) days. The oviposition period lasted for the first 3.1 days of this stage. The total egg production for each adult varied from 3 to 125 eggs with a mean of 66.8.

Effect of crowding on moult of solitary mites

As shown in the above experiment, the isolated-reared deutonymphs did not moult for more than 50 days, though most of the crowd-reared ones did so normally. Thus the influence of crowding on moulting of the solitary deutonymphs into adults was studied.

In the first experiment, each mite was reared in isolation for 10 to 48 days before they were used for the next experiment, in the small plastic containers at 27°C and supplied with nematodes as food together with the agar culture medium (Table 2, reared in isolation). The next experiment was followed for the purpose of examining the influence of crowding on moulting in these long-lived deutonymphs. The same aged solitary and sexually undivided deutonymphs were grouped in 2 to 4 individuals and each group was kept in a container along with the food (Table 2, reared in crowd).

The isolated-reared mites grew to the deutonymphal stage normally but remained in this stage until they were used for the next rearing experiment. Earliest occurrence of adults was observed within 24 hr after the grouping. The emergence rate of these gregarious mites varied from 58 to 100 per cent over the tests (Table 2).

Table 2. EMERGENCE OF *Parasitus* SP. ADULTS, BEFORE AND AFTER GROUPING OF ISOLATED-REARED DEUTONYMPHS

Expt.	Reared in isolation → grouping →				Reared in crowd		
	Days of rearing	No. of replications	No. of adults emerged	Days of rearing	No. of mites in group	No. of replications	Total no. of adults emerged
1	10	15	0	→ 4	3	5	12 (♂ 7, ♀ 5) (80%)
2	22	12	0	→ 6	3	4	7 (♂ 3, ♀ 4) (58%)
3	29	8	0	→ 8	4	2	8 (♂ 4, ♀ 4) (100%)
4	41	16	0	→ 9	2	8	11 (♂ 6, ♀ 5) (61%)
5	48	10	0	→ 6	2	5	7 (♂ 2, ♀ 5) (70%)

Effect of mixing of sexes on moult of isolated-reared deutonymphs

The following attempts were made since the mixing of sexes in a group of 2 deutonymphs seemed to affect the moult.

The male deutonymphs could be distinguished from the female ones on account of a carmine colored spot located ventrally and a little posterior to the coxae IV (Fig. 2). The pigmentation was recognized in the mature, more than 2- to 3-week-old male deutonymphs reared in isolation, and also in male adults developed from those deutonymphs. It accumulated in a limited part of a gland of the reproductive system. Hence the decision to combine sexes were made with about 3-week-old solitary mites according to the above differentiation.

Deutonymph-deutonymph combination : Two isolated-reared and sexually confined deutonymphs were kept in a glass tube, 4.5 cm long and 2.5 cm in diameter, together with food. Each end of the tube was covered with Parafilm. The combinations prepared were as follows : (1) 2 males (2) 1 male and 1 female, and (3) 2 females. Tubes were deposited in an incubator held at 27°C and was observed daily for 7 days. The daily emergence rates were calculated by the following formula: (daily number of mites emerged/total number of mites tested) $\times$ 100 %.

As shown in Table 3, the maximum emergence rate of 95.1 per cent was retained

Fig. 2. Ventral view of male deutonymph of *Parasitus* sp. Arrow indicates the part of pigmentation (see text).

Table 3. EMERGENCE RATES OF *Parasitus* SP. ADULTS IN THE SEVERAL COMBINATIONS OF THE ISOLATED-REARED DEUTONYMPHS

Combination	No. of replications	No. of adults emerged	Emergence rates Average ^a (min.-max.)
Two male deutonymphs	47	52	55.3 (21.4— 84.6%)
One male deutonymph and one female deutonymph	51	97 (♂ 50, ♀ 47)	95.1 (85.7—100.0%)
Two female deutonymphs	52	5	4.8 (0.0— 17.9%)
One male deutonymph and one male adult	47	27	57.4 (40.0— 81.3%)
One male deutonymph and one female adult	49	34	69.4 (62.5— 75.0%)
One female deutonymph and one male adult	51	48	94.1 (90.0—100.0%)
One female deutonymph and one female adult	49	34	69.4 (50.0— 87.5%)

^a Mean of 5 test. Fig. 3. Daily emergence rate curves of *Parasitus* sp. adults in each combination. ♂, ♀: male and female deutonymphs; ♂, ♀: male and female adults.

when 1 male and 1 female deutonymphs were coupled. The next high rate of 55.3 per cent was obtained with 2 males, though the mean of 5 tests varied largely ranging from 21.4 to 84.6 per cent. The lowest rate, a mean of only 4.8 per cent was obtained with the couple of 2 females. The daily emergence rate for the male-female combination reached a maximum on the first day and then declined rapidly. With other combinations, daily emergence rate was low and distributed on the first to third day without an obvious peak (Fig. 3A).

Deutonymph-adult combination: Each male and female deutonymph reared in isolation was grouped with either male or female adults.

More than 90 per cent of the female deutonymphs emerged into adults when they were paired with male adults. The highest emergence rate was obtained within 48 hrs after the onset of grouping (Fig. 3B). The average emergence rates over 5 tests for the other 3 combinations were lower than that of the female deutonymph-male adult combination. The peak of the daily emergence rates for these 3 combinations appeared on the third day or later.

Fig. 4. Effect of food on emergence of *Parasitus* sp. adults.

Effect of food on moulting of deutonymphs

As already shown, deutonymphs reared in isolation did not moult into adults even if they were fully supplied with the nematode as nutritive food. On the other hand, the nutritive condition also seemed to have some effect on the moulting of the crowd-reared deutonymphs because those deutonymphs remained in their stage for more than 1 month when they were not supplied with food.

Three runs of experiments were conducted to ascertain the influence of feeding for the moulting. First run : 2 deutonymphs of different sex, which had been reared in isolation, were put into a glass tube and supplied with nematode as food (Fig. 4A). Second run : 2 deutonymphs were held in the same tube and given with only agar media during the first 4 days, and then given nematode (Fig. 4B). Third run : 2 deutonymphs were reared without food during the first 8 days, and then given nematodes (Fig. 4C). Emergence rates of these 3 runs were compared.

In the first run, about 80 per cent of the deutonymphs moulted into adults within 2 days after crowding. The emergence rates of the latter 2 runs during periods of unfeeding were below 10 per cent, but after that period they rose rapidly to the same level of the first run.

DISCUSSION

Among the Acarina, some mesostigmatid mites have been known to require stimulus or some factors for their normal post-embryonic development such as moulting of deutonymphs into adults, or in some cases, producing progenies.

COSTA (1964, 1969) described that actively feeding deutonymphs of *Parasitus*

copridis Costa remained alive without moulting for periods exceeding 6 months. Same observations were made in *P. coleopterorum* L. (RAPP, 1959). Similar longevity of the deutonymphs of *Parasitus* sp. was observed in this experiment, e.g., moulting of the solitary deutonymphs into adults was not observed for periods over 50 days, while the deutonymphs reared in crowd were able to develop normally into adults.

Effect of isolation on the emergence rate of adults was clearly shown in this study using the groups of 1, 2, and 3 mites per container. Although, over a half of mites of the latter 2 groups moulted into adults, no adult appeared from the first group. COSTA (1964, 1969) suggested that high population density induced the *P. copridis* deutonymphs to moult into adults.

In this study, it was also found that sexual combination had a definite effect on raising the rate of moult in deutonymphs. If solitary female deutonymphs were paired with males, irrespective of whether deutonymphs or adults, a high emergence rate of adults was achieved, and the time necessary for the occurrence of adults was shortened.

The nutritive condition, regulated by food supply, markedly affected the moult, i.e., most of the deutonymphs held under a poor nutritional condition remained in their stage till when they were given sufficient nutritious food.

Preliminary experiments to determine the stimuli which probably influence the moult of the deutonymphs are being conducted. Results of the experiments show some deutonymphs respond to the stimuli such as moult skins, filter paper contaminated with crushed and extracted whole body fluid of the crowd-reared deutonymphs. COSTA (1969) obtained a high emergence rate of *P. copridis* with the rearing of long-lived deutonymphs together with the *Copris* beetle. RAPP (1959) observed that the *P. coleopterorum* deutonymphs were induced to moult into adults by supplying with fresh horse droppings or its filtrated fluid. These results indicate the necessity for further investigation about tactile and chemical stimulations for inducing the moult of this gamasid mite.

It may be concluded that sufficient nutritive condition is a primary factor necessary for initiating moult of isolated-reared *Parasitus* sp. deutonymphs, and tactile or chemical stimuli produced by associating with other matured individuals are also of a supporting nature.

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REFERENCES

- COSTA, M. (1964) Descriptions of the hitherto unknown stage of *Parasitus copridis* Costa (Acarina : Mesostigmata) with notes on its biology. *J. Linn. Soc. (Zool.)* **45** : 209-222.
- COSTA, M. (1969) The association between mesostigmatic mites and coprid beetles. *Acarologia* **11** : 411-428.
- ITO, Y. (1970) Preliminary surveys on macrochelid and some other mesostigmatid mites occurring in the experimentally deposited live-stock dungs as predators of muscid flies. *Jap. J. Sanit. Zool.* **21** : 205-208.
- ITO, Y. (1971) Predation by manure-inhabiting mesostigmatids (Acarina : Mesostigmata) on some free-living nematodes. *Appl. Ent. Zool.* **6** : 51-56.
- RAPP, A. (1959) Zur Biologie und Ethologie der Käuferrmilbe *Parasitus coleopterorum* L. 1758. (Ein Beitrag zum Phoresie-Problem.) *Zool. Jahrb. (Syst.)* **86** : 303-366.