tors of the respiratory enzyme such as hydrocyanic or hydrazoic acid gas (KEILIN, 1936).

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Respiration and Glycogen Contents in the Adult Life of the *Coccinella septempunctata* MULSANT and *Epilachna vigintioctopunctata* FABRICIUS (Coleoptera : Coccinellidae)[1]

In Aichi Prefecture in Japan, entomophagous coccinellid, *Coccinella septempunctata* and phytophagous coccinellid, *Epilachna vigintioctopunctata* live together in the fields from spring to early autumn. However, the life cycles of both coccinellids differ from each other, such as the aestivation of entomophagous coccinellids in the summer season and the diapause of the phytophagous ones in the winter season. When related to the synchronized control of agricultural pests, the cmparison of each life cycle in both the beneficial and harmful coccinellids may be valuable. Accordingly in the present paper, for the detailed comprehension of the behavior of Coccinellidae, the changes of respiration and glycogen contents during the adult life of *C. septempunctata* and *E. vigintioctopunctata* were studied.

MATERIALS AND METHODS

The adults of *C. septempunctata* and *E. vigintioctopunctata* were taken from the fields of Anjo City from 1964 to the following year. Then the changes of the respiration and glycogen contents in them were measured monthly.

The respiration was measured by the WARBURG respirometer for 1 hr at 30°C; in this temperature, the most active movement of the coccinellids was observed. Five heads of adults were held in The WARBURG flask, and produced CO_2 by respiration was absorbed into 20% KOH in the well. The respiratory rate was expressed as $\mu l\ O_2$/mg wet weight/hr.

After the measurements of the respiration were taken, the insects were used for the analysis of the glycogen. The glycogen contents were determined following the method used by YAMASHITA and HASEGAWA (1964). The coccinellids were homogenized in a glass homogenizer with the addition of 80% ethanol, then the homogenates were centrifuged. Precipitated glycogen was reextracted in 5% trichloroacetic acid, and its contents were surveyed by the anthrone method (MOKRASCH, 1954).

RESULTS AND DISCUSSION

C. septempunctata adults of the first generation emerged in May and entered into aestivation in July and August. In early autumn, these adults were released from aestivational restriction and behaved in the mating conduction in the fields. *C. septempunctata* adults of the second generation emerged in October, and actively ate victims in the fields till early winter. While in *E. vigintioctopunctata*, overwintered adults appeared in the fields in April, and then produced 2 or 3 genera-

[1] Appl. Ent. Zool. **4** (1): 55-57 (1969)

tions till September. In late autumn, *E. vigintioctopunctata* adults could not be found in the fields due to their migration to the place of hibernation.

The seasonal changes of the respiration in both coccinellids are given in Fig. 1. In *C. septempunctata*, the respiratory rate in newly emerged adults in May was diminishing with the elapse of the season, then decreased to the lowest level from July to September. The second generation adults of *C. septempunctata* which emerged in October kept a high respiratory rate through the winter season from November to the next March, though a little descent was observed. In overwintered *E. vigintioctopunctata*, the respiratory rate in April increased

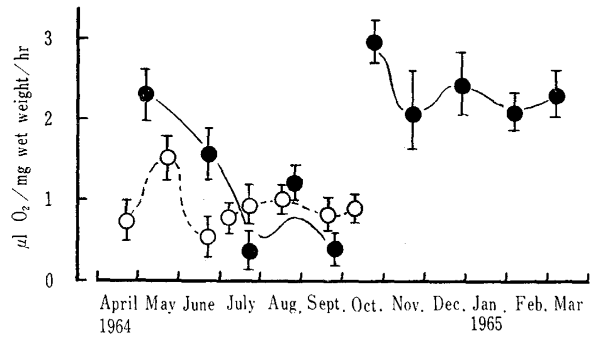

Fig. 1. Seasonal changes of the respiratory rate in the adults of *C. septempunctata* (●), and *E. vigintioctopunctata* (○). In *C. septempunctata*, the values from May to September correspond to the first generation, and October to March belong to the second generation, while in *E. vigintioctopunctata* April to June belong to the overwintered generation. Vertical lines in each circle show the standard deviation.

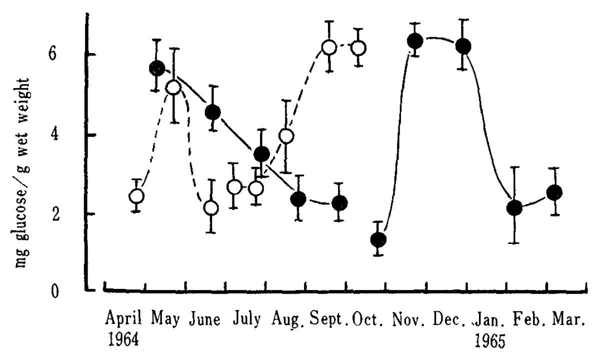

Fig. 2. Seasonal changes of the glycogen contents in the adults of *C. septempunctata* (●), and *E. vigintioctopunctata* (○). Vertical lines in each circle show the standard deviation.

towards May, then decreased. The coccinellids emerged in July, kept nearly the fixed level of respiration till October.

The seasonal changes of glycogen contents in both coccinellids are shown in Fig. 2. *C. septempunctata* adults of the first generation showed a gradual decrease of glycogen from May to September. This trend in glycogen shown during the aestivation agreed with the change of respiration. In the second generation of *C. septempunctata* adults, the glycogen contents increased from November to December, then decreased towards the next February. The adults eating their victims kept a high respiratory rate in spite of the low contents of glycogen in October.

In overwintered *E. vigintioctopunctata* adults, the glycogen contents formed a pattern similar to that shown for respiration; that is, the increase in May accompanied the decrease in the next month. In these adults emerged in July, a gradual increase of the contents was observed.

The low rate of the respiration and glycogen contents in *C. septempunctata* adults in summer may indicate the metabolic change by the aestivation. On the lipid contents of *C. septempunctata* adults in the aestivation, similar changes as in glycogen were also reported by TAKEDA et al. (1965). Withstanding the decrease of glycogen contents, *C. septempunctata* kept a high rate of respiration through winter. This trend may point out active utilization of glycogen for the energy source to sustain high vitality as estimated from respiration. Actually *C. septempunctata* adults showed active movements on the plants infested with their victims even in mid-winter.

In overwintered adults of *E. vigintioctopunctata*, the increment of respiration and glycogen contents in May indicates the physiological state of the reproduction in the fields. The fixed low level of respiration of *E. vigintioctopunctata* through the summer season, is supported by the dull feeding behavior of those observed in the fields. Such a suppressed feeding behavior of *E. vigintioctopunctata*, may be caused by the high temperature in the summer season, and is much like the case reported by HUKUSIMA (1947). After late autumn, *E. vigintioctopunctata* entered into diapause in the fields. MIYAKE and TAMURA (1943) reported that the diapause of this coccinellid was induced by the short-day photoperiod during its adult life.

The rate of the respiration and glycogen contents determined in the present study may be used as the index indicating the physiological state of both coccinellids in the fields; the respiration clearly demonstrates the vital state of coccinellids, while the glycogen contents express the rate of deposition and utilization of the energy source.

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Exceptional Cases of the Emergence of Two Parasite Species (Hymenoptera) from a Single Individual Host, *Pseudococcus comstocki* (KUWANA)[1] (Hemiptera : Pseudococcidae)

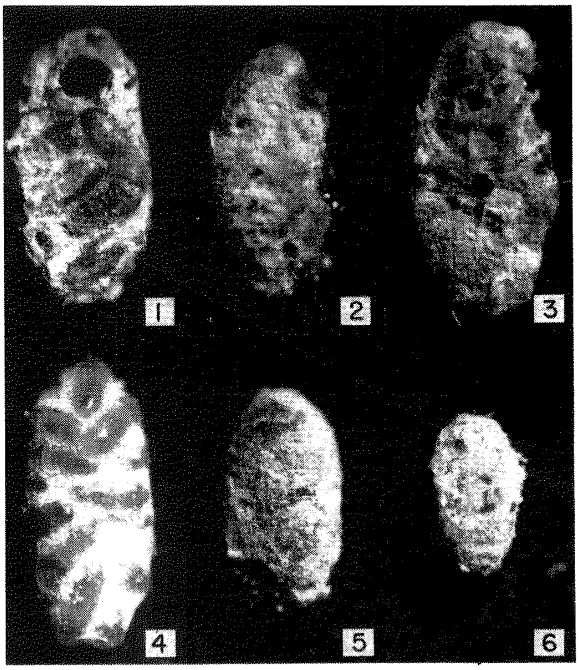
The interspecific relation among the parasites of an insect pest is perhaps one of the most important problems in biological control. When the different species of specific parasites attack a common host simultaneously, the emergence of the different parasites from a single host is thought either possible or impossible.

Among the three species of parasites recorded as the common parasites of a mealybug, *Phenacoccus pergandei* COCKERELL in Japan, two encyrtid parasites, *Anagyrus schoenherri* (WESTWOOD) and *Aphycus apicalis* (DALMAN), parasitize gregariously the adult female of the host and the adults of both parasites often emerge simultaneously from a single host in their spring generation. Two explanations were given for the phenomenon of such multiple parasitism. First, the host is large enough to support many individuals of both parasites. Second, these parasites avoid interspecific competition with each other by means of a kind of habitat segregation within a host body (MURAKAMI, 1963). Thus, these two parasites are able to coexist in a single host individual.

On the other hand, five common parasites of another mealybug, *Pseudococcus comstocki* (KUWANA) are known in Japan (MURAKAMI, 1965), and it has not been observed that two or more species of these primary parasites emerged simultaneously from a single host. So, it has been believed that the multiple parasitism does not occur among them.

DISCOVERY OF A CASE OF MULTIPLE PARASITISM

The junior author collected 271 parasitized



Figs. 1—6. Parasitized mummies of *P. comstocki*. 1—3: Parasitized by *A. subalbipes* and *A. burrelli* simultaneously (a larger hole in Fig. 1 is an exit hole of the former and the smaller ones in Fig. 3 are of the latter). 4: Normal gregarious mummy parasitized by *A. burrelli*. 5 and 6 : Normal solitary mummies parasitized by the female (Fig. 5) and the male (Fig. 6) of *A. subalbipes*.

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