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Bionomics of *Coccinula crotchi* in Hokkaido (Coccinellidae: Coleoptera)

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Abstract *Coccinula crotchi* showed a univoltine life cycle in Hokkaido, and the adults depended not only on small hemipterans as aphids but also on pollens of various flowers such as *Taraxacum officinale, Rumex acetosella,* and *Plantago lanceolata.* Ratio of adults observed on flowers was larger in post-hibernating adults (66%) than in newly emerged adults (29%). Although the larvae were also found occasionally on flowers, they could not develop at all with pollen food.

Key words: *Coccinula crotchi*; Coccinellidae; life cycle; pollen feeding.

Introduction

Coccinula crotchi (LEWIS) is a cool-temperate coccinellid species endemic to Japan, distributed in Hokkaido and northern-central Honshu (SASAJI, 1971, 1985). Its life cycle has not yet known as most species of Japanese Coccinellidae, though morphology of larvae had been described in detail (SASAJI and TSUBOKAWA, 1983). In the course of another census, I found some populations of the species with high densities, and observed their annual life cycle and food habits. Here I describe the bionomics of the ladybird there, with special stress on its food habits. This species shows a remarkable flower visiting behavior, as observed in some other ladybirds, *e.g. Coleomegilla maculata* (see HODEK, 1967) and *Propylea* spp.

Materials and Methods

I. *Field census*

A population in Toyotaki, Sapporo C. was periodically surveyed from May to September in 1978. Census area was about 7 m × 20 m in size, an openland with short grasses, and located by riverside of Toyohira River. In each two hours census, the following items were recorded: number of adults observed, site of each adult found (flower, leaves and stems of plants, and others), presence or absence of pre-imaginal stages, and notable adult behaviors. To prevent duplicate counting, adults found in each census were marked with lacquer paints.

II. *Dissection*

From another adjacent population some adults were collected and dissected to examine their gut contents and ovary development, under a binocular microscope. The results are given in Table 1.

III. *Rearing test*

To examine food suitability, larvae were reared with three kinds of food: (1) an aphid species from *Artemisia*, probably *Macrosiphoniella grandicauda*, (2) flowers of *Stenactis annuus*, and (3) flowers of *Poa* sp. Three pairs of adults collected on June 28, 1978 were reared in a laboratory, under a long day photoperiod, 16L 8D. They laid 38 egg-masses, which included 4 "masses" consisting of one egg, during July 2–August 11. Larvae hatched were reared with the above three kinds of food or a combination of them, under room condition in Sapporo. A part of larvae was fixed by KAHLE'S solution, stored in 70% ethanol, and later subjected to measurement of head width.

Results

I. *Field census*

Figure 1 summarizes the results of census and reveals the univoltine life cycle of *Coccinula crotchi* in Hokkaido. Post-hibernating adults appeared in early May and devoured pollens of *Taraxacum officinale*. Eggs were laid as a mass of 2–9 eggs on leaves or flowers of various small grasses at 5–30 cm height from mid(?) June to mid July. Larvae usually attacked aphids on various plants, but I observed twice pollen feeding on *Rumex acetosella* flowers. The pollen of this plant was utilized also by post-hibernating adults. Pupae were found on leaves of various plants. Until early July, the post-hibernating adults disappeared, and instead, newly emerged adults appeared in mid July. Although flower visiting behavior was not so remarkable in newly emerged adults, they were frequently observed on flowers of *Plantago lanceolata*, *Stenactis annuus*, and *Erigeron canadensis*. After short feeding time, they disappeared from the area observed, probably due to migration to hibernate. Copulation was not observed in newly emerged adults despite it was frequent in post-hibernating adults.

A few additional observations are described here: The seasonally latest observation of a feeding adult in Hokkaido was on Sept. 12, 1994 at Shiroishi, Sapporo on a *Taraxacum officinale* flower. Hibernation site for this species is unknown, but I had once found one adult under a stone of *ca.* 30 cm in diameter

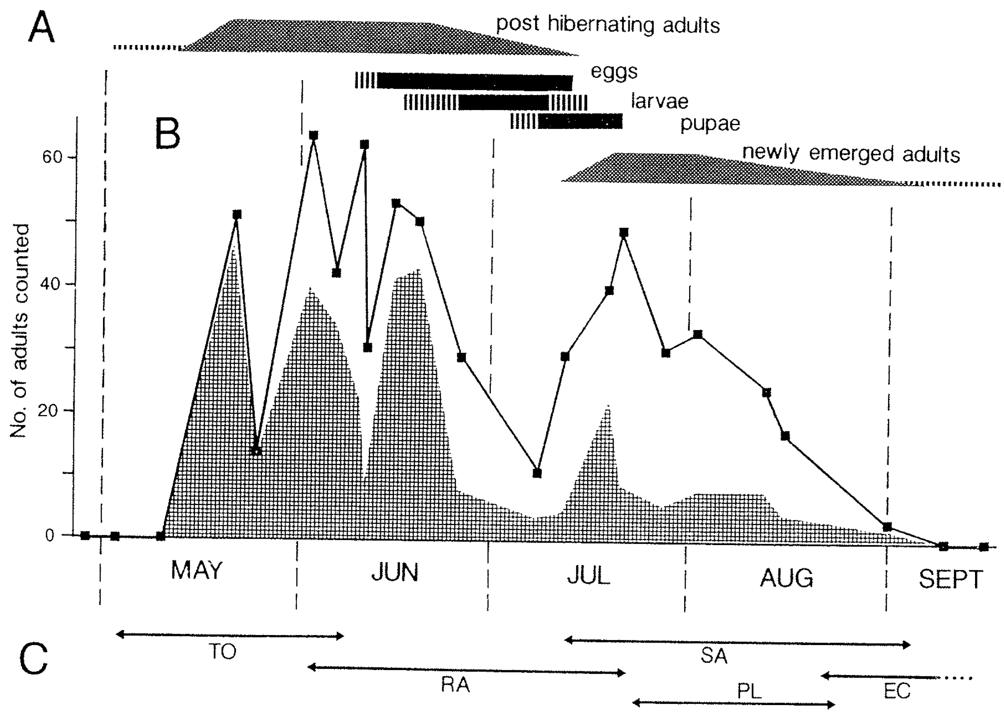

Fig. 1 Life cycle of *Coccinula crotchi* in Toyotaki near Sapporo, Hokkaido. A: an outlined annual cycle, B: changes in number of adults counted in each census. Area meshed shows adults found on flowers. C: Flowering season of plants visited by the ladybird at the census area. TO: *Taraxacum officinale,* RA: *Rumex acetosella,* PL: *Plantago lanteolata,* SA: *Stenactis annuus,* EC: *Erigeron canadensis.*

near the census area on April 21, 1979 among many individuals of another coccinellid, *Harmonia axyridis.*

The flower visiting trend of the ladybird was thus remarkable, though somewhat exaggerated in Fig. 1 because beetles on flowers were easy to find than those on other sites. Ratio of individuals found on flower was 66% for post-hibernaing adults and 29% for newly emerged adults. Although the ratio was unavailable for larvae, it should be far lower than those in adults.

Exact estimation of the adult population density using mark-recapture method was impossible, since marks with lacquer on elytron of the ladybird were easily lost. The losing rate was estimated as 12% of marks per a day by double marking method. A rough estimation using PETERSEN method after correction by the above losing rate gives 257±87 (SD) individuals of post-hibernating adult on June 10, and 322±125 newly emerged adults on July 19 in the census area of about 140 m^2. Lower recapture ratios in newly emerged adults might suggest active migration in this stage.

II. *Dissection*

Dissection of 64 adults demonstrated that a part of adults truly swallowed

Table 1. Gut contents and ovarian developmental stages of *Coccinula crotchi* in different seasons. Given as ratio of individuals. For gut contents an individual which contained both pollens and insects are counted as 0.5 individual in each.

Month[1)]	No. of individuals observed		Gut contents (%)				Ovarian stage (%)[2)]		
	♀	♂	pollens	insects	others	empty	I	II	III
June	15♀[3)]	7♂[3)]	54	14	14	18	13	—	87
July	7	8	10	33	37	20	72	14	14[4)]
August	2	10	17	13	62	8	—	100	—
September	7	8	66	17	10	7	100	—	—

[1)] Samples collected on the following date were monthly pooled: June 3, 5, 6, 10, 15, 19; July 8, 18; Aug. 2, 16; Sept. 1, in 1978.
[2)] I: ovary without developed oocyte, II: growth of oocyte recognized, III: full grown egg(s) recognized.
[3)] Each including one individual parasitized by a nematoda.
[4)] A post-hibernating female. Others in July are newly emerged.

the pollens (Tab. 1). Ratio of individuals which contained pollens in their gut was higher in spring and autumn (June and September), while lower in summer (July and August). As for gut contents in Table 1, "others" implies those of undefined amorphous masses greenish or brownish in color, probably derived from insect consumed. A female collected on June 6 contained in her gut a large amount of fibrous material probably being plant origin.

Ovaries of post-hibernating females were fully developed. One female of two undeveloped individuals in June (Tab. 1) was parasitized by a nematoda. Although newly emerged females might once start ovary development as shown in two females in August (Tab. 1), all seven females in September had undeveloped ovarioles. In most of September samples (12/15), colorless or whitish fat flowed over the body when dissection. Such large amount of fat was not observed in other samples except for one male collected on August 16.

It would be noted that sex ratio of the ladybird might differ between post-hibernating adults (16♀♀7♂♂; 69.6% female, 50.8–88.4% in 95% limits estimeted) and newly emerged adults (15♀♀26♂♂; 36.6%, 21.9–51.3%), though not significant at 95% confidence level, suggesting a selective mortality during hibernation or an early phase of active season.

III. *Rearing test*

Number of eggs per an egg-mass laid in the test was approximate to that in field condition; 5.32 ($\pm$2.71 SD; $n=34$) in average, ranging 1–10. A case of 20 eggs in a mass, which should be a combination of two egg-masses, was excluded from the above calculation. Size of an egg was larger relative to adult size; 1.32 mm in length and 0.63 mm in diameter. Period for egg stage was 5.68$\pm$0.60

Table 2. Mortality, developmental duration, and head width of *Coccinula crotchi* larvae reared with different food. Given as mean±SD.

Kind of food[1]	No. of larvae tested	No. of adults emerged	Larval period (days)	Head width in each instar (μ)[2]			
				1st	2nd	3rd	4th
A1	15	12	15.2±1.0	353±14	458±28	608±15	775±46
A1+P1	15	13	15.4±1.3	355±12	450±16	612±27	768±33
P1	21	0[3]	—	—	—	—	—
P2	24	0[3]	—	—	—	—	—

[1] A1: aphids on *Artemisis,* probably *Macrosiphoniella grandicauda,* P1: flowers of *Stenactis annuus,* P2: flowers of *Poa* sp.

[2] No. of larvae measured varied between 5-13 individuals.

[3] Died within 9 days for P1, within 13 days for P2, both without molting.

days (n=31). Hatching ratio in each egg-mass was 74.8±30.5% (n=28), and most of mortality was due to sib-carnivalism. Three egg-masses were fed by their own mothers, and the offspring-carnivalism was observed in August, the latest phase of oviposition period in the laboratory test.

Table 2 summarizes mortalities, periods required for development, and size of larvae represented by their head width. Among the three kinds of food offered, flowers of *Stenactis annuus* were observed to be visited by the adults during the above field census, while pollen feeding on *Poa* sp. has never been observed. Most of larvae given the aphids or the aphids plus flowers of *Stenactis annuus* as food were developed to adult. In contrast, those given only flowers of *Stenactis annuus* or *Poa* sp. were died within two weeks without molting, irrespective of occurrence of the sib-carnivalism at the time of hatching. No virtual difference was observed between larvae given the aphids only and those given the *Stenactis* flowers adding to the aphids. All pupae obtained emerged at 5.62±0.65 days after pupation (n=25).

Discussion

The life cycle of *Coccinula crotchi* in Hokkaido was univoltine, as obviously revealed by both results of the field census (Fig.1) and of the dissection (Tab. 1). The univoltinism should be defined by a reproductive diapause, which induced by a short-day photoperiod. Under field conditions in Sapporo, ovary of the newly emerged female might once start to develop in mid August (Tab. 1, about 14.5L 9.5D in photoperiodic condition), while ceased the development until early September (about 13L 11D). A conspecific population discovered recently in southwestern Honshu (Hoshikawa *et al.,* 1994), however, should be multivoltine as larvae were observed from May to September. As pointed out by Hodek (1967), voltinism in coccinellids is rather complicated. Further comparative studies are required for this disjunctive population.

In the Hokkaido populations, the beetles devoured pollens of various flowers, especially *Taraxacum officinale* and *Rumex acetosella,* during oviposition period. Ratio of flower visiting adults in post-hibernating adults attained to 66% by the field census or 54% by the dissection. To examine whether nectar was sucked by the ladybirds or not, sugar contents in gut of an adult collected on *Rumex acetosella* was analysed by gas chromatography (HOSHIKAWA, unpubl.). Small amounts of glucose, glycerol, and inositol were detected, but fructose or sucrose which characterize flower nectar was scarcely detectable as trace. Together with abundance of anemophilous flowers in those visited by the beetle (RA, PL, and EC in Fig. 1), it could be appreciated that the beetle visits flowers to take pollens but not nectar.

Flower visiting behavior of the adults was distinct not only in oviposition period but also pre-hibernating period (Tab. 1). This suggest that pollens were utilized as a subsidiary food when the hemipterous insect food is in shortage. For the larval growth, on the other hand, as indicated by the rearing test (Tab. 2), pollens are completely inadequate food. And the inadequacy may imply that pollen feeding in *Coccinula crotchi* should be a derived food habit for the essentially entomophagous beetles.

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