STUDIES ON THE DAILY RHYTHMIC ACTIVITY AND FOOD HABIT OF *CARABUS YACONINUS* BATES (COLEOPTERA : CARABIDAE)

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Many investigations have been made on the day rhythms and activities of insects. Most of them, however, have been made only in limited seasons. Activities of insects in the field vary greatly according to the time-zone allotted for the main part of their life. The daily rhythmic activity of carabid beetles was studied by Park (1935), Williams (1959) and Greenslade (1963). They suggested that there were ectogenous rhythms that depended on light, temperature, and other factors, as well as endogenous rhythms. Most carabid beetles are usually nocturnal as stated by Bulduf (1935) and Thiele (1977).

Carabus yaconinus BATES is a kind of carabid beetle which is common in Okayama prefecture. Carabid beetles are carnivorus, and known as natural enemies for agricultural and forest pest insects. The present investigation was carried out to analyze the data of daily rhythmic activity of *C. yaconinus* BATES throughout the year and intended to make a list of the animals which were directly observed being eaten by this beetle in the field.

MATERIALS AND METHODS

The study was made from 1975 to 1976 on the west slope of Mt. Fukuyama in the Asabara region about 4km north of Kurashiki city. There were many broad-leaved trees covering the ground of a valley.

Two methods, an automatically timed trapping method and direct observation were used to obtain data about the daily rhythm in the field. The trap consisted of a main container and a transparent-plastic funnel to the tip of which was attached an infrared sensor (Fig. 1). When the beetle slipped into the trap, the sensor (infrared beam) was obstructed and a pulse was produced, the pulse being recorded by the electro-magnetic counter. The trap was sunk in the ground with the rim level 2cm above the surface of the ground, so as to prevent other animals' falling in and rain invasion. The data disturbed by rare invasions such as by hornet, centipede etc., were ommited. The water way near the trapping site was about 50m long. The water way was under a precipice, the active beetles falling over the precipice. The number of beetles caught in the water way was counted every one hour. Trapping was done for about 10 days every month from July to October in 1975 and from April to August in 1976. The direct observation was made in 12hour. systems for 2 days from May to November in 1975 and for 1 day from April to August in 1976.

Guts of the beetles caught were dissected and their contents were examined.

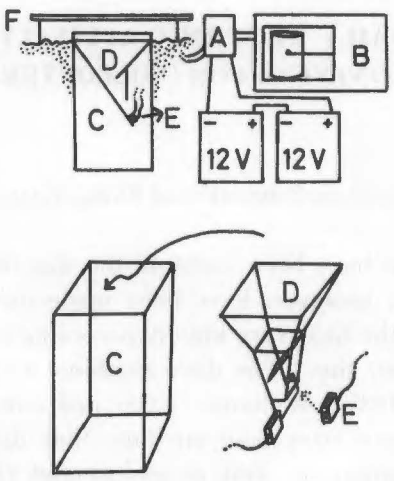

Fig. 1. Component parts and external appearance of an automatically timed t[illegible].
A. photo swich B. electro-magnetic counter
C. main container (12×12×24cm) D. funnel
E. sensor (infrared beam) F. transparent plastic cover

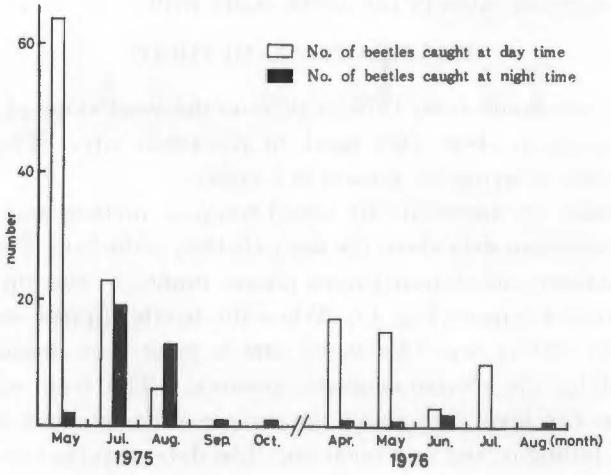

Fig. 2. Result obtained by the direct observation from 1975 to 1976.

RESULTS AND DISCUSSION

Fig. 2 shows the result of direct observation from 1975 to 1976. If the beetles were diurnal-nocturnal insects, the number of the beetles caught in the day and night should be in the ratio between the lengths of day and night.

Table 1 shows the result by the χ^2 test on the data in Fig. 2 obtained on the above assumption. As shown in Fig. 2 and Table 1, during the spring season, activity of the beetle is distinctly diurnal with the peaks at April and May. After the spring, however, the activity gradually shifted from diurnal to diurnal-nocturnal, the number of active beetles being smaller than in the spring. In the autumn, none of the beetles was trapped nor walking in the water way. It was sometimes observed, however, that carabid beetles lived under the fallen leaves or stones from August to October. The beetles were more active in the night, namely nocturnal, though they seldom walked on an open area in the daytime. They crept into the ground and decayed wood and hybernated at these places. Fig. 3 shows the result by the trapping method from 1975 to 1976. The

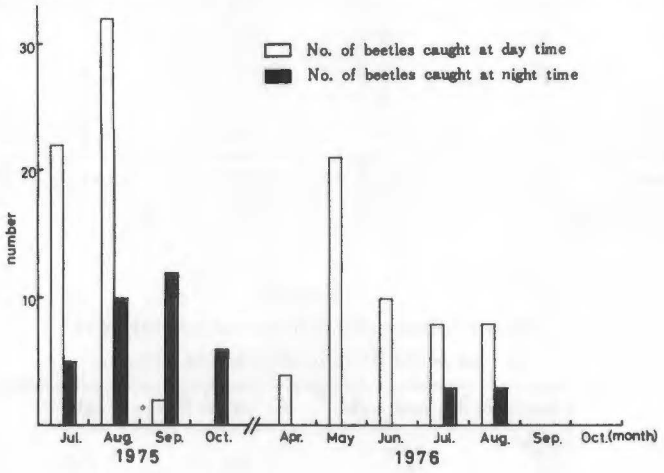

Fig. 3. Result obtained by the trapping method from 1975 to 1976.

result in Table 2 was obtained from the data in Fig. 3 in the same way as in the case of Table 1. In conclusion, these results indicate that the beetles have diurnal activity in spring, and their activity shifts to diurnal-nocturnal thereafter, becoming nocturnal in autumn.

The black odoreous ant, *Lasius fulginosus* (Yamauchi and Hayashida, 1968), and the tenebrionid beetle, *Onymacris plana*, etc. (Holm and Edney, 1973) are known to be insects changing their activity throughout the year. In the case of these insects, temperature is the most dominant factor affecting the activity shift. In summer, the activity of insects is observed only in the night because of the high temperature in the afternoon, while in spring and autumn the activity can be seen both in the evening and afternoon. In winter, the insects are active only in the warm afternoon.

Chiba (1976) stated that *Diestrammena japonica* BLATCHLAY is a kind of camel cricket, its activity being closely related with the growth and oviposition periods. He described that immature females weighing from 400 to 900mg showed nocturnal activity, but mature females weighing from 1,000 to 1,500mg

TABLE 1

Relation between change of seasons and activity of *C. yaconinus* BATES by direct observation.

Month		Lengths of day and night		No. of the beetles caught		χ^2	P
		day* (hr.)	night (hr.)	day	night		
1975	May	15	9	64	2	33.46	< 0.01
	July	15	9	23	19	1.83	
	August	14	10	6	13	5.59	< 0.02
	September	13	11	0	1		
	October	11.5	12.5	0	1		
1976	April	14.5	9.5	17	1	8.72	< 0.01
	May	15	9	15	1	6.67	< 0.01
	June	15.5	8.5	3	2		
	July	15	9	10	0	6.00	< 0.02
	August	14	10	0	1		
	Total	142.5	97.5	138	41	23.31	< 0.01

* +1 hour(twilight)

TABLE 2

Relation between change of seasons and activity of *C. yaconinus* BATES by the trapping method.

Month		Lengths of day and night		No. of the beetles caught		χ^2	P
		day* (hr.)	night (hr.)	day	night		
1975	July	15	9	22	5	4.15	< 0.05
	August	14.5	9.5	32	10	4.37	< 0.05
	September	13	11	2	12	8.97	< 0.01
	October	12	12	0	6	6.00	< 0.02
1976	April	14.5	9.5	4	0	2.62	
	May	15	9	21	0	12.60	< 0.01
	June	15.5	8.5	10	0	5.48	< 0.02
	July	15	9	8	3		
	August	14.5	9.5	8	3		
	Total	129	87	107	39	11.17	< 0.01

* +1 hour(twilight)

had diurnal activity. Males and females of *C. yaconinus* BATES collected in the field each month from 1975 to 1976 showed similar tendencies in their development of genital organs. The number of mature eggs found in females (which showed the remarkable variation), had a peak in April and May. Most of the copulations were observed in the field from April to July especially in April and May from 1975 to 1976. These results are in agreement with

TABLE 3
List of food animals of *C. yaconinus* BATES.

Phylum	Order	Species
ARTHROPODA	Coleoptera	*Anomala testaceipes* MOTSHULSKY
		Maladera castanea ARROW
		Popillia japonica NEWMANN
		Adoretus tenuimaculatus WATERHOUSE
		Melolontha japonica BURMEISTEA
		Mimela splendens GYLLENHAL
		Actenicerus pruinosus MOTSCHULSKY
		Apriona japonica THOMSON
	Lepidoptera	*Erebus crepuscularis* LINNE
		Spilosoma nivea MENETRIES
		Agrotis fucosa BUTLER
		Xylena formosa BUTLER
		Arcte coerulea GUENEE
		Marumba gaschkewitschii BOISDUVAL
		Neope goschkevitschii MENETRIES
		Pelopidas mathias oberthuri EVANS
	Aranea	*Heteropoda forcipata* KARSCH
ANNELIDA	Neoligochaeta	*Pheretima communissima* GOTO et HATAI
MOLLUSCA	Stylommatophora	*Incilaria bilineata* BENSON
		Acusta despecta SOWERBY
VERTEBRATA	Urodela	*Heteropoda forcipata* KARSCH
	Anura	*Hyla arborea japonica* GUNTHER

the observation of Chiba (1976). It may be concluded that diurnal activity of the beetle coincides in season with mating and oviposition, nocturnal natures being in other seasons.

None of the data was obtained from the examination of the gut contents. The guts were filled with the brown liquid, and no broken solids were observed in them. This is presumably due to digestion system of the beetles. Davies (1953) described that *Carabus violaceus* LINNE and *C. nemoralis* MUELLER practised pre-oral digestion, taking their food into gut in only liquid state. Table 3 shows the list of the animals upon which *C. yaconinus* BATES preyed at the Asabara region from 1975 to 1976. We observed the beetle preying upon animals of 22 species in 4 phylums. Among the 22 species, 16 species belonged to insects. *C. yaconinus* BATES may be important as natural insect pest controller because of its highly predatory habit. In the laboratory, *C. yaconinus* BATES showed omnivorous, but such food habit was not obsreved in the field.

SUMMARY

The daily rhythmic activity and food habit of *Carabus yaconinus* BATES were investigated by the direct observation and the automatically timed trapping methods. The result of examinations proved that the beetle was diurnal rather than nocturnal in spring and this activity changed with the season. The activity also closely related with the oviposition periods.

C. yaconinus BATES ate many kinds of animals, including 16 species of insects, in the field. It may be an important insect controller.

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