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BIOLOGY OF TECTOCEPHEUS VELATUS (MICHAEL) 
AND T. CUSPIDENTATUS KNÜLLE

by Tokuko FUJIKAWA *

SUMMARY: As nature farming progressed, Tectocepheus velatus (Michael) and T. cuspidentatus Knülle showed higher ability of reproduction, increase of individual number and expansion of the spatial distribution.


RÉSUMÉ: À mesure que progressait l'agriculture naturelle, Tectocepheus velatus (Michael) et T. cuspidentatus Knülle montrèrent une capacité de reproduction plus élevée, un accroissement du nombre des individus et une extension de leur distribution spatiale.

In the previous paper (FUJIKAWA, 1988), the author has described the morphological feature of two species belonging to the genus Tectocepheus, namely, T. velatus (Michael, 1880) and T. cuspidentatus Knülle, 1954, collected from a nature farm at Nayoro in northern Japan. In the present paper, discussion will be made on their biological features.

INVESTIGATED FARM AND METHODS

Farming in the Nayoro Nature Farm: The word "nature farming" used in the present paper and in a series of the author's work was advocated firstly in 1935 and given the definition in 1950 by M. OKADA (1882-1955) who was the founder of the Church of World Messianity (The Church of World Messianity, 1950 & 1982). The Nayoro Nature Farm is situated in the northernmost Japan and one of experimental farms established by the Church of World Messianity, in order to confirm the principle of nature farming scientifically. At the farm, inorganic mineral fertilizers and pesticides had been used until 1975 by other farmers. But, since 1976, when the farm was established as the Nayoro Nature Farm by the Church of World Messianity, manure made from excreta, inorganic mineral fertilizers and any pesticides have never

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been used. Only plant materials like green manure, crops themselves and litter and humus from forest floor have been used at the investigated area in the Nayoro Nature Farm.

**Methods**: The surveyed area, the sampling schedule and the sampling method have been detailed in the previous papers (Fujikawa et al., 1979 & Fujikawa, 1985). In short, the surveyed field (2,000 m² in area) was divided into 1,000 blocks (each 2 x 1 m²), from which four blocks were selected at random at each sampling time. In each block, one sampling plot consisting of 16 continuous quadrats was laid out (one quadrat : 5 x 4 cm² and 5 cm in depth). The soil sample from each quadrat was taken by means of a rectangular metal sampler, and animals were extracted using a modified Tullgren apparatus in the laboratory of the field. Every year from 1976 to 1986, the soil samples were taken at four seasons, namely, s : spring (May 21 to July 10), su : summer (July 11 to August 20), a : autumn (September 21 to October 31) and m : mid-winter (November 21 to March 30), and these abbreviated words, namely, s, su, a and m, were used in the figures.

**RESULT**

1. *Tectocepeheus velatus* (Michael, 1880)

A total 6,519 adult specimens were collected during 10 years (1976 to 1986). All were females and male was not found.

1) Seasonal occurrence (Fig. 1): The average individual number per 100cc soil varied from 0.04 ± 0.02 to 16.84 ± 1.65. In spring and summer of 1979 and autumn of 1985, the values were significantly larger than one of the first sampling time, spring of 1976 (P = 5%). The number had an increasing tendency from spring to summer, except for 1976 and 1984. Since 1982, the number showed an increasing tendency in mid-winter, especially the number collected in mid-winter of 1986 was significantly larger than those of other sampling times. Of all samples collected since 1976 the largest individual number was 57 of the sample (100cc) collected in summer of 1979.

2) Spatial distribution of the individuals and the relative precision (Figs. 2 & 3): The spatial distribution and the relative precision, when the same total area was sampled by different quadrat sizes, were analyzed for plot with m (the average individual number per 100cc soil) > 1.0 using the *m-m* method proposed by Llyod (1967) and advanced by Iwao (1968 & 1972). As shown in Fig. 2 changes of the values α and β reflect that *T. velatus* (Michael) in the Nature Farm aggregated as loose colonies which were distributed almost "randomly" in 3 years (spring of 1978 to mid-winter of 1980 and spring of 1983 to mid-winter of 1984), "uniformly" in the last year (spring of 1985 to mid-winter of 1986), and "contagiously" in the remaining 6 years.
FIG. 2: The values, $x$, $\beta$ and $r^2$ in the series $m - m$ relations for respective quadrat sizes in case of T. velatus (Michael). The number asterisked means number of plots with $m > 1.0$.

$m = \pi + 2m,$

Where $m = \frac{Q}{\sum_{j=1}^{Q} x_j (x_j - 1)}$, $m = \frac{Q}{\sum_{j=1}^{Q} x_j}$

$Q$ is the total number of the quadrat in the area, $x_j$ is the number of individuals in the $j$-th quadrat ($j = 1, 2, 3, \ldots, Q$).

At the smallest unit size ($u = 1 = 20 \text{ cm}^2$), individuals of T. velatus (Michael) was distributed independently in 2 years, namely, spring of 1977 to mid-winter of 1978 and spring of 1980 to mid-winter of 1981, and aggregatively in the remaining 8 years.

The value of $Du/D$, (Fig. 3) was less than 1 in 3 years, (spring of 1979 to mid-winter of 1980, spring of 1981 to mid-winter of 1982, and spring of 1984 to mind-winter of 1985), however, it was more than 1 in the remaining 7 years.

3) Succession of percentage of gravid females and non-gravid females (Fig. 4): Although gravid females were not collected in mid-winter of 1977 and 1978, they appeared in all seasons since 1979. Until 1978, percentage of gravid females was 50% in total and more numerous in summer than in
FIG. 3: The relative precision when the same total area was sampled by two different quadrat sizes in case to *T. velatus* (Michael).

(According to Iwao (1972)).

\[
D_i = \frac{\sqrt{x_i + 1 + (b_i - 1) u \cdot m_i}}{x_i + 1 + (b_i - 1) m_i}
\]

where \( D \) is the standard error/mean. The size \( u \) is better if \( D_u / D_i < 1 \).

spring and autumn. Since 1979, however, percentage of gravid females in summer was less than those in spring or autumn. Percentage of gravid females in spring or autumn since 1981 was more than 50% in total.

4) Succession of body size and number of eggs (Fig. 5): Body length was about between 300 and 330 µm, and body width about between 180 and 200 µm. Body size was very valuable in 1976 and 1977 and a little small in the next two years. Since 1982, gravid female showed a tendency to be larger than non-gravid female although no significance could be attached to this correlation except for a few seasons. Variance of body size of gravid female was large in mid-winter since 1981 compared with that of the other seasons. Most of gravid females had 1 egg and the others had 2 eggs. Only one female collected in summer of 1982 had 3 eggs.

5) Variation in some characters (Figs. 6-9 & Table 1): Abnormality in the number of anal setae was found every year, and the rate was less than 5% in total (Fig. 6). One specimen completely lacking anal seta was collected in autumn of 1979. Abnormality in number of genital setae was found every year except for 1981 and 1984 (Fig. 6). Rate of examples of increase in the setal number was less than 2.5%, and rate of examples of decrease was
Examples of abnormality (1:2)(2:1)(0:0)
(3:2)(3:3)(3:3)(1:3)

(7:6)(7:7)(6:7)

Genital setae (86)

Anal setae (right: left, normally 2:2)

Rate of abnormality in total examined specimens (%)

10% in summer of 1977 and almost 15% in mid-winter of 1980. T. velatus (Michael) from the Nayoro Nature Farm showed three forms in both sensillus and cuspis (Fig. 7). As nature farming progressed, rate of certain form increased in both sensillus and cuspis. Only in summer of 1980, specimens having glabrous and spiniform sensilli appeared, however, in other specimens sensillus was verrucose and licheniform. Adanal lyrifissure iad of T. velatus (Michael) showed very many kinds of variation (Fig. 8). A large kinds of variation of iad appeared in 1979 and 1980 (Table 1). As nature farming progressed, percentage of specimens having A-type of iad increased (Fig. 9).

II. — Tectocepheus cuspidentatus Knüll, 1954 (Figs. 10-13)

A total 272 adult specimens were collected during 10 years and all the specimens were female. T. cuspidentatus Knüll was seldom collected until 1979, especially it was not collected at all in 1978 (Fig. 10). In spring of 1982, however, the average individual number per 100cc soil was significantly larger than one of first sampling time (P = 5%).
Table 1. — Succession in occurrence of variation of adanal lyrifissure ind of T. relatus (Michael) shown in Fig. 8.

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Table 2. — The values, $s$, $g$, and $r^2$ in the series $m-m$ relations for respective quadrat sizes in case of T. cuspidatus Knülle. (only 2 plots with $m > 1.0$).

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Fig. 10: Seasonal occurrence of T. cuspidatus Knülle in soil.

The $m-m$ relation was analyzed in 2 years, spring of 1982 to mid-winter of 1983 and spring of 1984 to mid-winter of 1985 (Table 2). Individuals of T. cuspidatus Knülle aggregated as loose colonies which were distributed "uniformly" in the year, spring of 1982 to mid-winter of 1983, and "contagiously" in the year, spring of 1984 to mid-winter of 1985. Gravid female was not collected at all in
mid-winter (Fig. 11). Body length was about between 275 and 325 μm and body width about between 150 and 200 μm (Fig. 12). No significant difference in body size appeared between gravid and non-gravid females. Most of gravid females had 1 egg, and the others 2 eggs. Any specimen holding more than 2 eggs was not found (Fig. 12). Sensillus varied in form, especially, specimens having glabrous and spiniform sensilli appeared only in summer of 1980 (Fig. 13). Abnormality in situation of adanal lyrifissure iad like Fig. 8 D appeared in spring 1981.

Abnormality in the number of setae appeared like (2-3), (3-2), (2-1) and (1-2) on anal plates in spring and autumn of 1982 and in summer and autumn of 1984, and like (6-5) on genital plates in spring of 1982.

III. Interspecific correlation between *T. velatus* (Michael) and *T. cuspidentatus* Knüll (Figs. 14 & 15).

In most of years, *T. velatus* (Michael) appeared more numerous than *T. cuspidentatus* Knüll. Since 1982, however, rate of individuals of *T. cuspidentatus* Knüll increased somewhat. It was more 50% in spring of 1982. The value of $R$ proposed by MORISITA (1959) was calculated for measuring the
correlation between two species, *T. velatus* (Michael) and *T. cuspidatus* Knülle. As shown in Fig. 15, slightly positive correlation was recognized between two species in spring and summer of 1982, and slightly negative correlation in autumn of 1979, 1983 and 1984 and summer of 1984.

**DISCUSSION**

Of two species belonging to the genus *Tectocephus* inhabiting the Nayoro Nature Farm, *T. velatus* (Michael) is somewhat larger in body size and more numerous in individual number than *T. cuspidatus* Knülle except for summer of 1982. The former reproduced throughout the year since 1979 and the latter did not reproduce in winter. Both of them lay 1 or 2 eggs and are distributed as loose colonies. Appearance of exceptional and common form in sensilli of these species in summer of 1980 let us suppose that these species might have been influenced by some meteorological condition, because the air temperature was unusually low in the season (Fujikawa, 1985). According to some phenomena appeared in these species as nature farming progressed, the followings are considered: (1). The ability of reproduction increased as shown in some phenomena, namely, the increase of rate of gravid females in total individual number, the increase of reproductive seasons, the appearance of gravid females holding 3 eggs and two peaks of rate of gravid females in a year, and (2). The increase of the ability of reproduction caused increase of individual number and the expansion of the spatial distribution as shown in the phenomena, namely, the appearance of the years when the individual number was significantly more numerous than in the first year, the increase of individual number in winter and the change from independent distribution of individual into aggregative distribution and the appearance of uniformal distribution of colonies.

As summarized by Luxton (1981b & c), number of generation of *T. velatus* (Michael) varies from one to three in case of field works in Europe. Luxton (1981a), also, recorded *T. velatus* as the most strongly aggregated species at a pure beach forest in Denmark. Variation found about *T. velatus* (Michael) reminds of the suggestion by Berthet & Gerard (1965), that is, *T. velatus* was distributed in particularly heterogenous manner, and this fact might reflect the degree of specialisation different from other species distributed in other kinds of manner.

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