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Spatial Distribution of Oribatid Mites in Small Areas II. The Distribution Pattern of Some Oribatid Species

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The spatial distribution of 11 oribatid species obtained from forest and grassland was analyzed using IWAO's ρ-index. Ten species were distributed contagiously. Colonies were loosely distributed in forest plots, but many were compact and small in grassland plots. Two species, *Oppia nova* and *Tectocepheus velatus* were found in all eight plots examined, and their degree of aggregation was higher in forest than in grassland plots. In the *Picea*-moss forest, degree of aggregation was lower in early winter than in spring, despite an increase in population density in early winter.

INTRODUCTION

Studies on the spatial distribution of oribatid mites are considered important for the clarification of their ecology, and determination of the optimum quadrat unit and sample size for estimating population density. Up to date, there have been some attempts to apply mathematical models for the distribution of oribatid mites which have revealed that the distribution of most oribatid mites is contagious and approximated by the negative-binominal (BERTHET and GERARD, 1965; CERNOVA and CUGUNOVA, 1967; HARTENSTEIN, 1961; IBARRA et al., 1965). Recently, IWAO (1968) advanced a regression method for analyzing the spatial pattern using the parameter, "mean crowding" ($\overset{*}{m}$), proposed by LLOYD (1967). This method is advantageous over other methods including the parameter k of the negative-binominal distribution, the I_δ index of MORISITA (1959) and the parameter C_A(KUNO, 1968), in that it reflects the contagiousness inherent among the species (i.e. the basic component of the distribution) and indicates how the basic components are spatially distributed. IWAO and KUNO (1970) showed that this method was applicable to the analysis of the spatial pattern of oribatid mites based on BERTHET & GERARD's data (op. cit.). The present author attempted to apply the unit-size $\overset{*}{m}$-m method with the ρ-index, which was proposed by IWAO (1972) for contiguous quadrat analysis, to detect the spatial pattern of some oribated species (FUJIKAWA, 1974a). In the present paper, the spatial pattern of the eleven oribatid species is analyzed using this method.

MATERIALS AND METHODS

Eleven oribatid species were selected among more than 80 which were extracted from 1,200 soil samples representing the following eight plots: plot Zg set in a *Zoysia* type natural grassland, plot Mg in a *Miscanthus* type natural grassland, plot Gx in a natural mixed forest of *Picea glehni*, *P. jezoensis*, *Abies sachalinensis* and *Betula ermani*,

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plot Gs in a *P. glehni*-sasa forest, and plots (GmA, GmB, GmC and GmD in a *P. glehni*-moss forest. In the *P. glehni*-moss forest, two plots were set out in spring (GmA and GmB) and in early winter (GmC and GmD), respectively. The remaining four were surveyed in spring. The average density in each of 11 species was more than 1.0 in any plot, as described in the previous report (FUJIKAWA, 1975). Of these 11 species, the $\overset{*}{m}$-m relations of two species, *T. velatus* and *O. nova* were analyzed in all plots; those of five species, *Cultroribula lata*, *Cyrthermannia parallela*, *Eohypochthonius gracilis crassisetiger*, *Pergalumna duplicata nipponica* and *Scheloribates latipes*, in only two plots of grassland; and those of the remaining four species, *Chamobates pussilus*, *Melanozetus meridianus*, *Oppia* sp. and *Rostrozetes foveolatus*, in each plot where present.

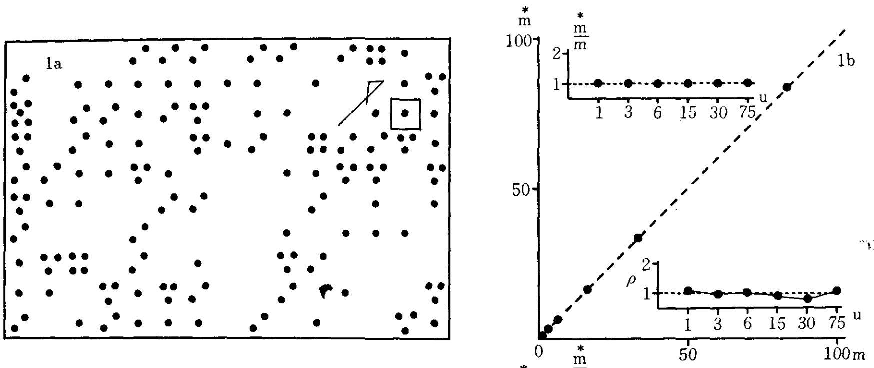
The ρ-index (IWAO, 1972) is expressed as:

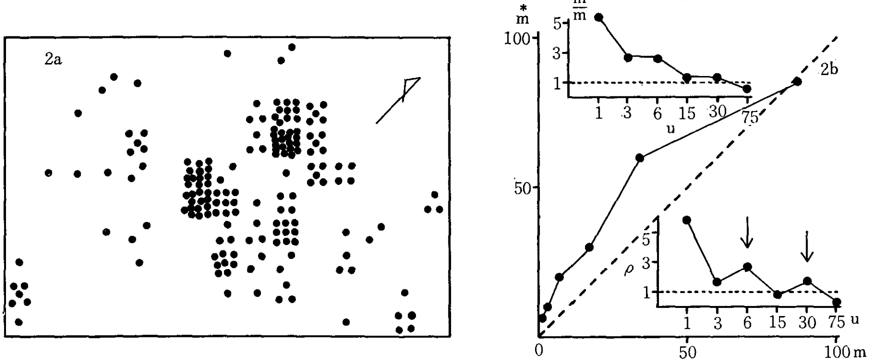
$$\rho_i=\frac{\overset{*}{m}_i-\overset{*}{m}_{i-1}}{m_i-m_{i-1}},\quad \text{where } m=\frac{\sum_{j=1}^{Q} x_j}{Q},\quad \overset{*}{m}=\frac{\sum_{j=1}^{Q} x_j(x_j-1)}{\sum_{j=1}^{Q} x_j},$$

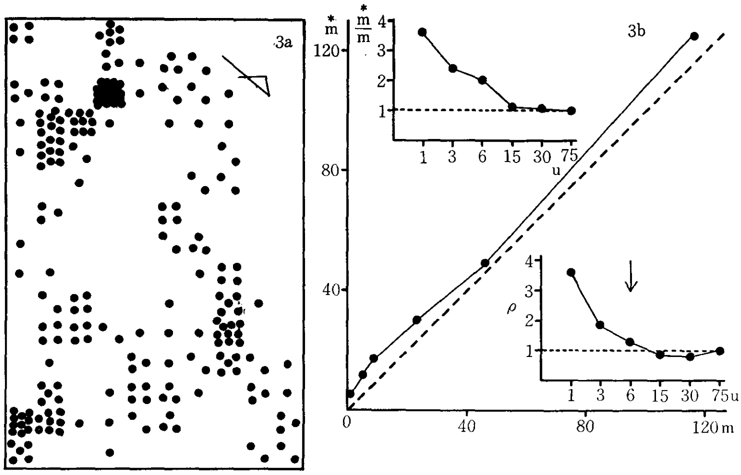
and i stands for the ascending order of quadrat sizes (u), Q is the total number of the quadrat in the area, x_j the individual number in the jth quadrat ($j=1, 2, \ldots, Q$). The ρ value equals unity for the case where no spatial correlation exists between adjacent quadrats, and values larger or smaller than unity express positive or negative correlation. When the basic component of the distribution is either a compact or loose colony, the $\overset{*}{m}_u$- on -m_u regression for the population with changing quadrat size is either parallel with the Poisson line or curvilinear, respectively. In random or aggregated distribution of territorial individuals and compact colonies, ρ_i will take the value of zero for the quadrat sizes smaller than the territory or colony size, and it will assume unity or a value greater than unity for a larger quadrat size, with the exception that ρ_1 is larger than ρ_2 for the distribution of compact colonies. In random or aggregated distribution of loose colonies, ρ_i will be expressed by values larger than unity for a quadrat size smaller than the colony area. The index is superior to the $I_\delta(s)/I_\delta(2s)$ value (MORISITA, 1959) and the τ_h index (IWAO, 1972) for the analysis of contiguous quadrat data, because it indicates the spatial pattern of clumps and the spatial correlation among neighbouring quadrats, and allows for comparison of ρ values even when quadrat size increases successively with different ratios. (For further explanation of ρ index and its relation to spatial pattern, see IWAO, 1972). Distribution of mites in plots having an area of 3,000 cm^2 were analyzed using 6 different quadrat sizes; namely, 20 ($u=1$; $i=1$), 60 ($u=3$; $i=2$), 120 ($u=6$; $i=3$), 300 ($u=15$; $i=4$), 600($u=30$; $i=5$) and 1500 cm^2 ($u=75$; $i=6$). Furthermore, in the case of the species with the data on several populations, the values of α and β in the series $\overset{*}{m}$-m relations for respective quadrat sizes are able to be obtained. The relation is expressed as: $\overset{*}{m}=\alpha+\beta m$, where α reflects the contagiousness inherent to the species, and β the manner in which individuals or groups of individuals distribute themselves in their habitat with change in the mean density (IWAO, 1968; IWAO and KUNO, 1971). In the present work, α and β were calculated for only two species, *T. velatus* and *O. nova*.

RESULTS AND DISCUSSION

Chamobates pussillus (BERLESE) (Fig. 1): This species was collected only from







Figs. 1 to 5. Analysis of distribution patterns of five species.

Fig. 1. *Chamobates pusillus* (BERLESE) in plot Gs (m = 1.10/100 ml; $\sigma^2 = 1.26$).

Fig. 2. *Oppia* sp. in plot GmC (m = 1.15/100 ml; $\sigma^2 = 7.66$).

Fig. 3. *Melanozetes meridianus* SELLNICK in plot GmD (m = 1.55/100 ml; $\sigma^2 = 7.86$).

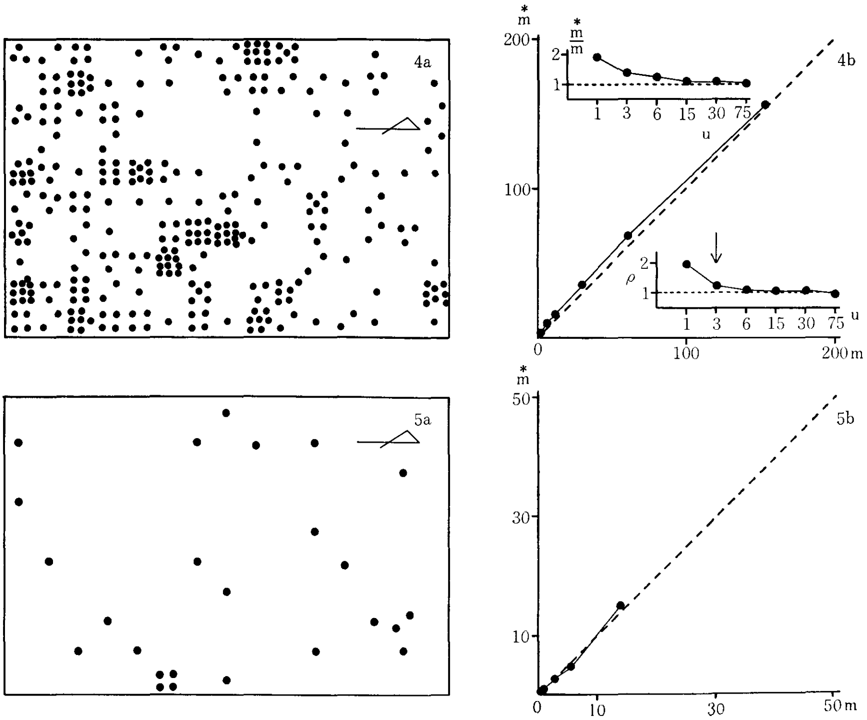


Fig. 4. *Rostrozetes foveolatus* SELLNICK in plot Zg ($m=2.04/100$ ml; $\sigma^2=6.00$).
Fig. 5. *R. foveolatus* SELLENICK in plot Mg ($m=0.18/100$ ml; $\sigma^2=0.23$).
(a) Distribution map. Rectangle indicates the standard quadrat size ($u=5\times 4$ cm^2). (b) The unit-size $\overset{*}{m}$-m relation; The ρ index plotted against quadrat sizes; Arrow in the ρ-graph indicates the colony area, and the degree of aggreagation ($\overset{*}{m}/m$) plotted against quadrat size.

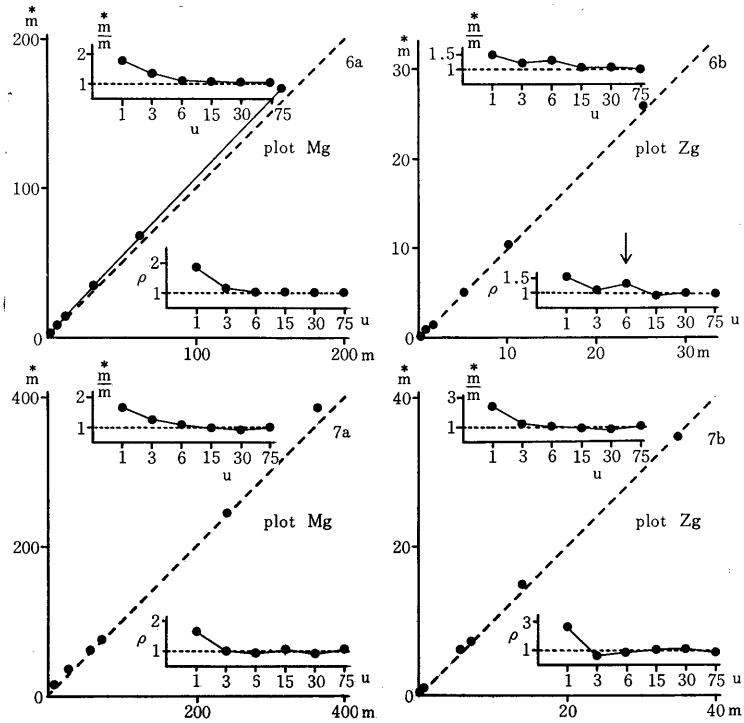
plot Gs. No significance could be assigned to $\overset{*}{m}/m>1$ ($p>0.01$) showing that individuals of this species were distributed nearly at random.

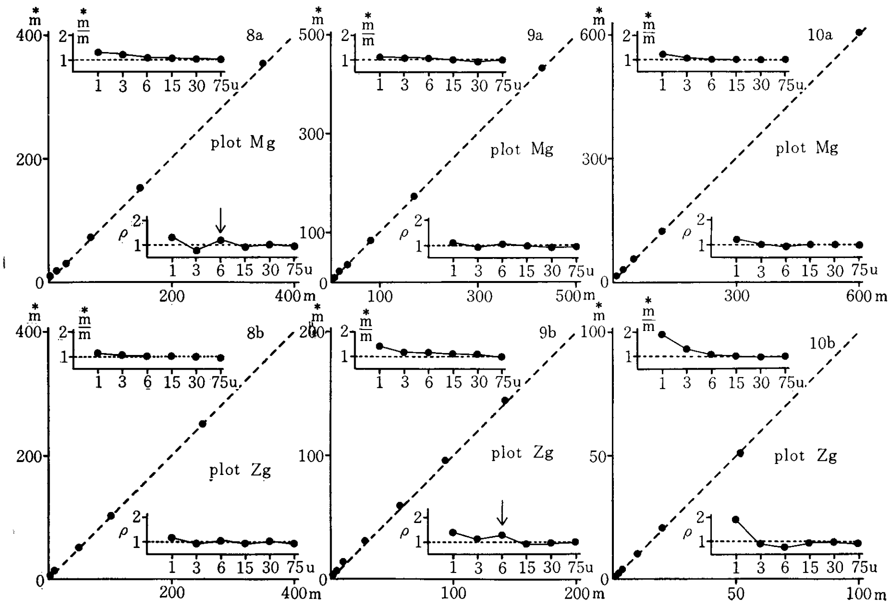
Oppia sp. (Fig. 2): This species was collected only from plot GmC. The $\overset{*}{m}$-m relation indicated a double-clumped distribution where small colonies were distributed randomly or rather regularly within large clumps.

Melanozetes meridianus SELLNICK (Fig. 3): This species was collected only from plot GmD. The $\overset{*}{m}$-m relation with changes of quadrat sizes showed a contagious distribution of loose colonies with random disposition of individuals within colonies. It is suggested that the area of colony was about 120 cm^2.

Rostrozetes foveolatus SELLNICK (Figs. 4 and 5): This species was collected from plots Zg and Mg. The number of individuals was abundant in plot Zg but very scarce in plot Mg (average density 0.18). In plot Zg, the $\overset{*}{m}$-m relation showed the random distribution of small and loose colonies.

Cyrthermannia parallela (AOKI) (Fig. 6): The $\overset{*}{m}$-m relation showed the weakly contagious distribution of loose colonies in plot Mg and the random distribution of compact colonies in plot Zg.


6a
plot Mg
6b
plot Zg
7a
plot Mg
7b
plot Zg


8a
plot Mg
9a
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10a
plot Mg
8b
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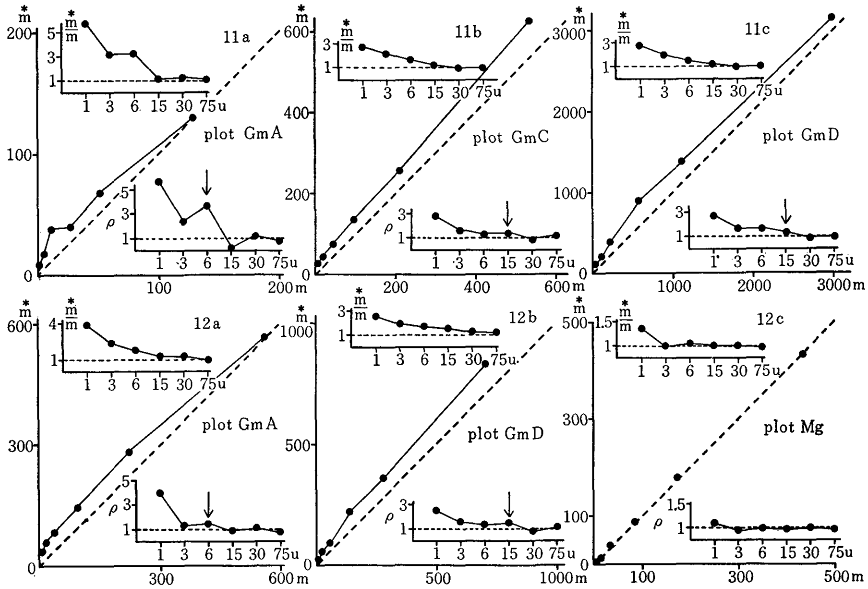


Figs. 6 to 12. Analysis of distribution patterns of seven species.

Cyrthermannia parallela (Aoki) in plots Mg (Fig. 6a : m=2.09/100 ml; σ^2=5.79) and Zg (Fig. 6b : m=0.34/100 ml; σ^2=0.39).

Eohypochthonius gracilis crassisetiger Aoki in plots Mg (Fig. 7a : m=4.82/100 ml; σ^2=20.30) and Zg (Fig. 7b : m=0.47/100 ml; σ^2=0.82).

Cultroribula lata Aoki in plots Mg (Fig. 8a: m=4.78/100 ml; σ^2=13.46) and Zg (Fig. 8b: m=3.4/100 ml; σ^2=6.8).

Pergalumna duplicata nipponica Aoki in plots Mg (Fig. 9a : m=5.76/100 ml; σ^2=11.60) and Zg (Fig. 9b: m=1.9/100 ml; σ^2=3.67).

Scheloribates latipes (C. L. Koch) in plots Mg (Fig. 10a : m=8.11/100; σ^2=22.39) and Zg (Fig. 10b : m=0.69/100 ml; σ^2=1.13).

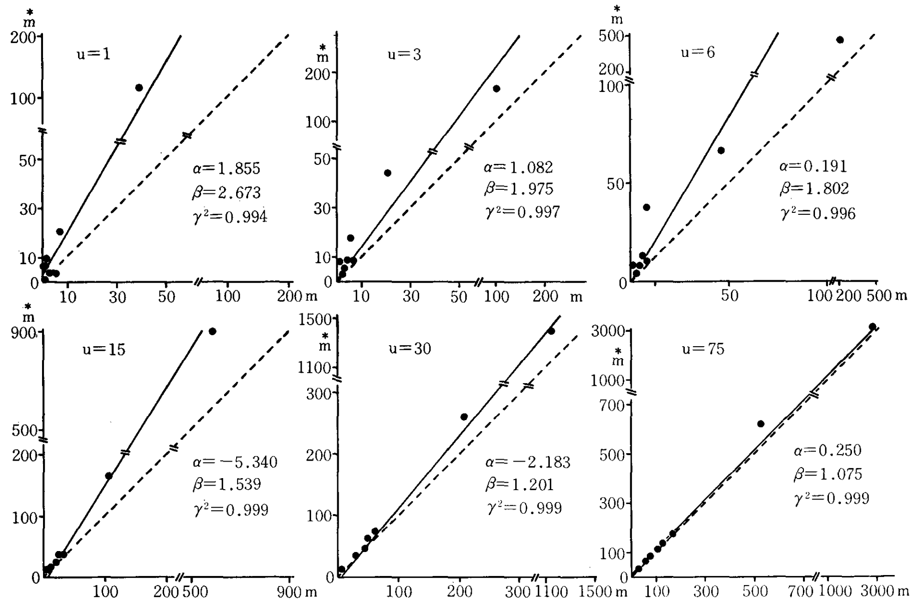
Oppia nova (Oudemans) in plots GmA (Fig. 11a : m=1.71/100 ml; σ^2=15.71), GmC (Fig. 11b : m=7.14/100 ml; σ^2=99.62) and GmD (Fig. 11C : m=39.23/100 ml; σ^2= 2682.48).

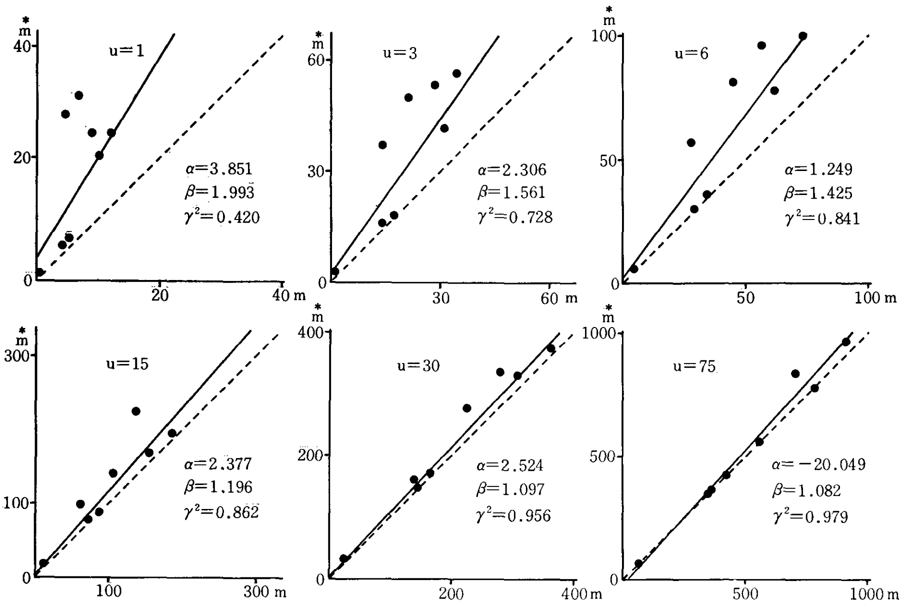
Tectocepheus velatus (Michael) in plots GmA (Fig. 12a : m=7.56/100 ml; σ^2=181.29), GmD (Fig. 12b : m=9.37/100 ml; σ^2=147.00) and Mg (Fig. 12C : m=5.80/100 ml; (σ^2= 11.69).

Eohypochthonius gracilis crassisetiger Aoki (Fig. 7): The $\overset{*}{m}$-m relations showed the random or weakly contagious distribution of compact colonies comprizing few individuals in plots Zg and Mg, respectively.

Cultroribula lata Aoki (Fig. 8), *Pergalumna duplicata nipponica* Aoki (Fig. 9) and *Scheloribates latipes* (C. L. Koch) (Fig. 10): The $\overset{*}{m}$-m relations of these three species showed random or uniform distribution of loose colonies in both plots Mg and Zg.

Oppia nova (Oudemans) (Fig. 11): In all eight plots examined, the $\overset{*}{m}$-m relations showed the presence of colonies with random disposition of individuals within colonies. The colonies were compact in plots Mg and Zg but loose in the remaining six plots. The distribution pattern of colonies was contagious in plot GmC, and nearly at random





Figs. 13. and 14. The series $\overset{*}{m}$-m relations for respective quadrat sizes of two species. *Oppia nova* (Fig. 13); *Tectocepheus velatus* (Fig. 14).

in the four plots, GmB, GmD, Mg and Zg. In the other three plots, GmA, Gx and Gs, on the other hand, it was more or less uniform. The degree of aggregation ($\overset{*}{m}/m$) for u = 1 showed the highest value in plot Gx. Individual number of this species was most abundant in plot GmD where the largest individual number per unit sample (100 ml) was 408.

Tectocepheus velatus (MICHAEL) (Fig. 12): The $\overset{*}{m}$-m relations of this species, as in the case of *O. nova*, showed the presence of colonies with random disposition of individuals within colonies in all the eight plots examined. The colonies were compact in plots GmA, GmB, Gs, Mg and Zg, but loose in the remaining three plots. The distribution pattern of colonies were contagious in plot GmD but random in the remaining seven plots. The degree of aggregation was higher in plots GmA and GmB than in the remaining plots.

As described above, the result of analysis of the $\overset{*}{m}$-m relations indicates that all but *C. pussilus* have colonial structure. These results are in accord with those reported by HARTENSTEIN (1961), BERTHET and GERARD (1965), IBARRA et al. (1965); CERNOVA and CUGUNOVA (1967), (op. cit.). The only species, *C. pussilus*, was distributed randomly. But the calculation of α and β in the $\overset{*}{m}$-m relation was impossible because this species was obtained from only one plot. In the previous study (FUJIKAWA, 1974b), however, this species was obtained from various places in the same forest although the sampling season was different from those of the present work, and further survey is necessary to ascertain whether or not this random distribution is characteristic to the species.

Among the ten species of which the basic components were colonies, *C. parallela* and *E. g. crassisetiger* had the contagious distribution of colonies in plot Mg. Two abundant species in all the plots, *O. nova* and *T. velatus*, showed different $\overset{*}{m}$-m relations for respective quadrat sizes (Figs. 13 and 14). The correlation coefficient (r^2) of the former was always greater than 0.9 regardless of unit size, but a high value ($\geqq$0.8) for the latter was found at the unit sizes larger than 30. To eliminate the effect of sampling season on $\overset{*}{m}$-m relation, the coefficient of correlation was calculated from the data excluding those of the November sampling, which produced the result that the high r^2 value ($\geqq$0.8) for both species was obtained when the unit was 6 or larger. This indicates, to some extent, that the colony of each plot sampled on May has a peculiar size or area. For example, the size of colony was below 5.80 in the grassland plots and 0.84–45.36 in the forest plots. The area of colony was 1 u in the grassland plots and 1–15 u in the forest plots. In case of *O. nova*, the value was always 0.9 when the data of November and May samplings were used for the calculation of correlation coefficient. This seems to depend upon the high population densities obtained from November sampling of GmC and GmD.

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