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Vertical Changes of Dispersion Structure of *Carex kobomugi* Population in the Accumulating Habitat of Sand Dune

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In Hamasaka Sand Dune, Tottori Prefecture, San'in Region, we investigated the vertical changes of the distribution pattern of shoots of *Carex kobomugi* OHWI population buried in the sand. For an excavation survey, three plots were sampled from a quadrat of 4 m×4 m in size. Plot A of 1 m×1 m was dug to 70 cm in depth, Plot B of 0.5 m×1 m was to 40 cm and Plot C of 1 m×1 m was to 60 cm, respectively. In the former two plots, the location of shoots was mapped in every 10 cm layer, and plant materials were collected and their fresh weights were measured. In the last plot, only plant materials were weighted in every layer without mapping shoots.

Distrubtion pattern of shoots was analyzed by Iδ-biomass method. Contagious distribution with samll or large clump, in which intra-clump distribution is uniform, was detected from almost sand layers in Plot A and B, except for the most upper two layers of Plot B showing random distribution. There existed a trend that the larger is the biomass, the lower is the maximum Iδ-value of each layer. Contagiousness of shoot distribution of *C. kobomugi* population is the intrinsic property which may be represented constantly in time and space sequence.

Introduction

Carex kobomugi OHWI is one of the most representative psamophytes growing on the eroding and accumulating sand dune or the advance line of sandy beach in the warm-temperate zone of Japan. It can propagate with seeds, but its actual reproduction is chiefly due to the rhizome-tillering in the sand. Namely, the bulbous nodes covered with the leaf sheath, a nutritive storage organ, are formed at the base of shoots of the previous year, while new roots of the current year emerge from these nodes in the late spring (Fig. 1).

In the stand where the sand accumulates at the considerable quick rate, the rhizomes often elongate upward longer than one meter almost without lateral tillering. In the stand where the sand accumulates verly slowly, on the other hand, they grow laterally or obliquetly upward beyond 180 cm to 250 cm. The bulbous nodes are often reserved alive in the sand for the considerable long period, even if the rhizomes and

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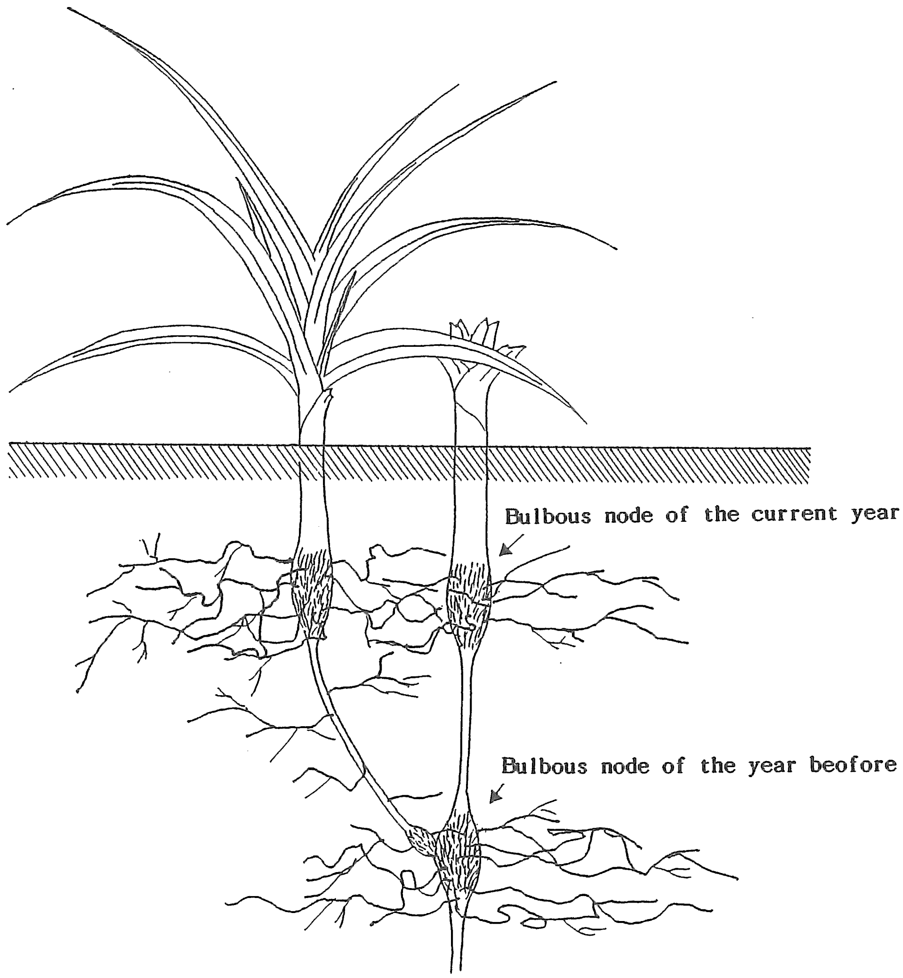

Fig. 1. Profile structure of *C. kobomugi* in the ground surface and the underground.

roots had vanished completely (Yano, 1983).

The seasonal trend of standing crop and the structure of the subterranean system of *C. kobomugi* were intensively investigated in Hamasaka Sand Dune (Yano, 1962, 1972). The distribution pattern of shoots was also analyzed by some workers (Numata & Nobuhara, 1952, Nobuhara, 1967, Tagawa, 1963, Miyata & Haramoto, 1986). The objective of this paper is to follow the process that the distribution pattern of shoots of *Carex kobomugi* changes vertically in the accumulating habitat of sand dune.

Study Area and Methods

We performed the field survey at Hamasaka Sand Dune in the suburb of Tottori

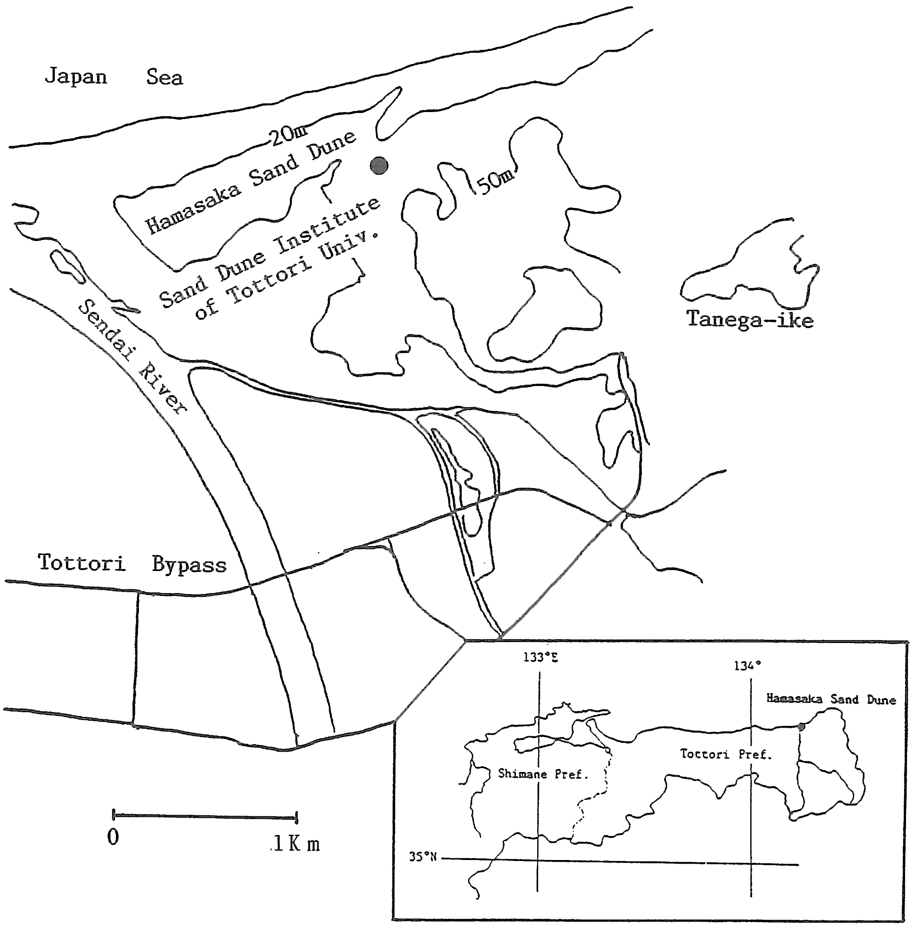

Fig. 2. Geographical map of Hamasaka Sand Dune in the suburb of Tottori City. Solid circle shows the *Carex kobomugi*-stand where an excavation survey was performed.

City, Tottori Prefecture, San'in Region, on the 5th to 8th of August, 1983 (Fig. 2). This sand dune is derived from the discharged sand by the Sendai River which flow through the Tottori field. The sand accumulated at the mouth of the river has been carried to land by wind resulting in the formation of the sand dune. The sand soil is weakly acid ranging from pH 5.0 to 6.0. The water content of the upper layer (0–70 cm) is below 1.0% on an average in summer (Yano, 1962).

According to Shimizu & Narita (1980), the vegetation of this area is classified into two groups: one is *Carex kobomugi* Alliance as the beach-typed vegetation, and the other is *Ischaemum anthephroides-Fimbristylis sericea* Alliance as the inland-typed one. For an excavation survey, a quadrat of 4 m×4 m in size was established within the former vegetation zone about 500 m distant from the beach line. The quadrat was subdivided into sixteen plots of 1 m×1 m in size. Out of them, the three were arbitorarily sampled. Furthermore, one of the three was subdivided into two grids of 1 m×0.5 m in size, and one of them was named Plot B. The rest two plots were named Plot A and Plot C.

Plot A was dug to 70 cm in depth, Plot C to 60 cm and Plot B to 40 cm, respectively. In Plot A, the location of shoots was mapped at interval of 10 cm untill 60 cm in depth, marking every shoots found in each layer, and in Plot B, mapping was made untill 40 cm in depth. In Plot C, the plant materials were collected from every 10 cm layer till 60 cm, but the mapping of shoots was not made. Plant materials were sorted into the leaf, leaf sheath, root, rhizome, stem (bulbous node), etc., and their

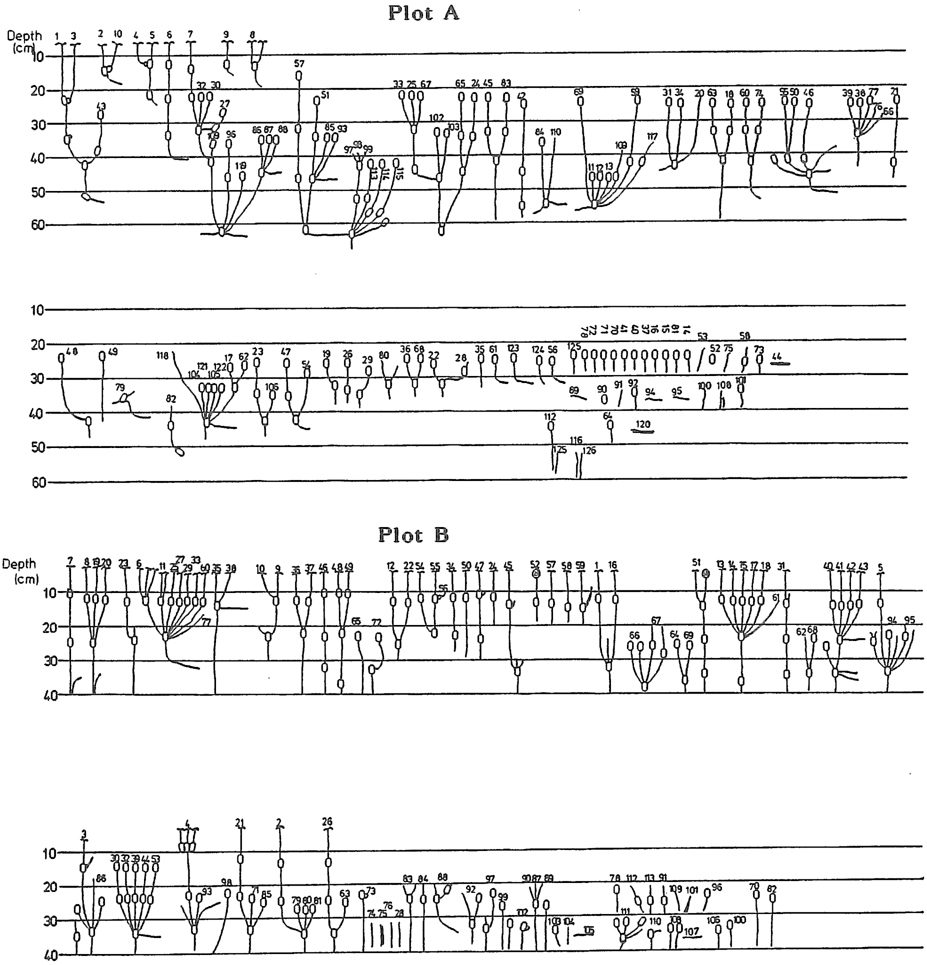

Fig. 3. Schematic figure of shoots, bulbous nodes and rhizomes of *C. kobomugi* populations in Plot A and Plot B. The numerical numbers in the figures represent the shoot number.

fresh and dry weights were measured. Distribution pattern of shoots was analyzed by I δ -method (Morisita, 1959a) and I δ -biomass method (Ono, 1965).

Results and Discussion

Fig. 3 shows schematically the vertical distributions of the rhizomes and bulbous nodes in Plot A and Plot B. We can find the good feature, i.e. vigorous upright elongation of rhizomes in the stand where the sand accumulates quickly. The vertical distributions of the fresh weights of live bulbous nodes, leaves including leaf sheaths, rhizomes including roots and dead organs in the three plots are given in Fig. 4. The fresh weight of bulbous nodes showed the maximum value between 40–50 cm layer in

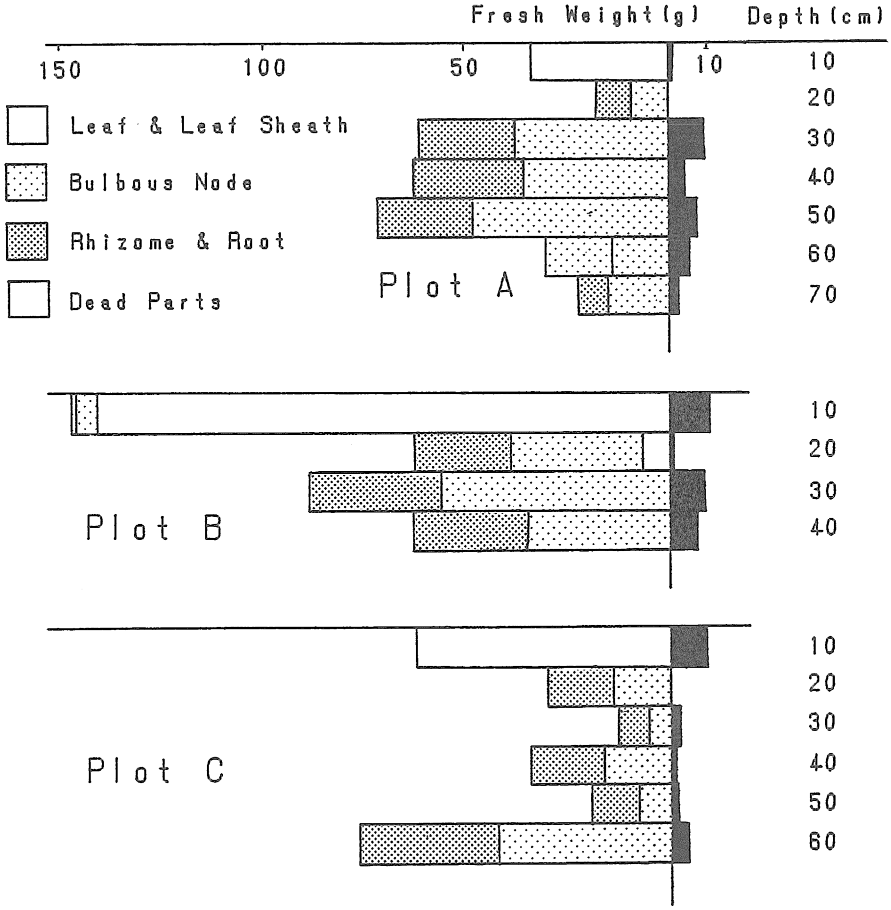

Fig. 4. Showing the vertical distributions of the fresh weights of leaves and leaf sheaths, bulbous nodes, rhizomes and roots. The left-side indicates the living organs and the right-side does the dead ones.

Plot A, between 20–30 cm layer in Plot B, and between 50–60 cm layer in Plot C, respectively.

In the previous paper, we reported the result of the excavation survey which was made in *C. kobomugi* populations growing on the sandy beach of Minatohara, Taisha-cho, Shimane Prefecture. Although the fresh weights of the rhizomes and roots were not measured, the relative percentage of their number for the soil depth showed the maximum in 20–30 cm layer (Miyata & Haramoto, 1986). General difference in the underground structure may be mainly due to the difference of the accumulation rate of the sand. Since such a difference occurrs at the comparatively near distance as in Plot A and Plot B, the micro-habitat conditions, i.e. soil moisture, pH, salinity, etc., may be also concerned with the difference. As the soil properties was not examined in this study, such a problem will be reserved for the further detailed investigation in the field.

There was recognized a statistically significant correlation between the fresh weight of the bulbous node and that of the leaf and leaf sheath (Fig. 5). This suggests that the fresh weight of the bulbous node could represent the amount of the leaf and leaf sheath of a given time in the past.

Fig. 6 shows the I-biomass curves of shoots in every snad layer in Plot A and Plot B. The total fresh weights of the bulbous nodes, rhizomes and roots in every layer was used as the biomass. The curves are obtained using the biomass per quadrat, instead of

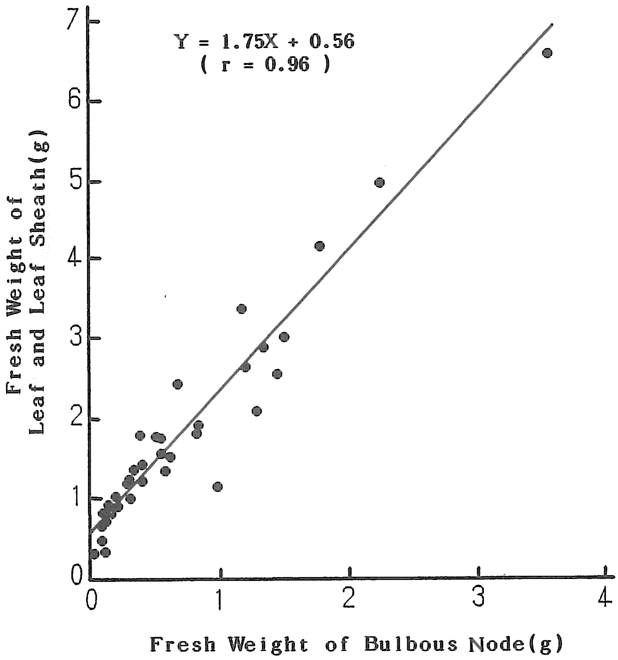

Fig. 5. The relationship between fresh weights of leaves including leaf sheaths and that of bulbous nodes.

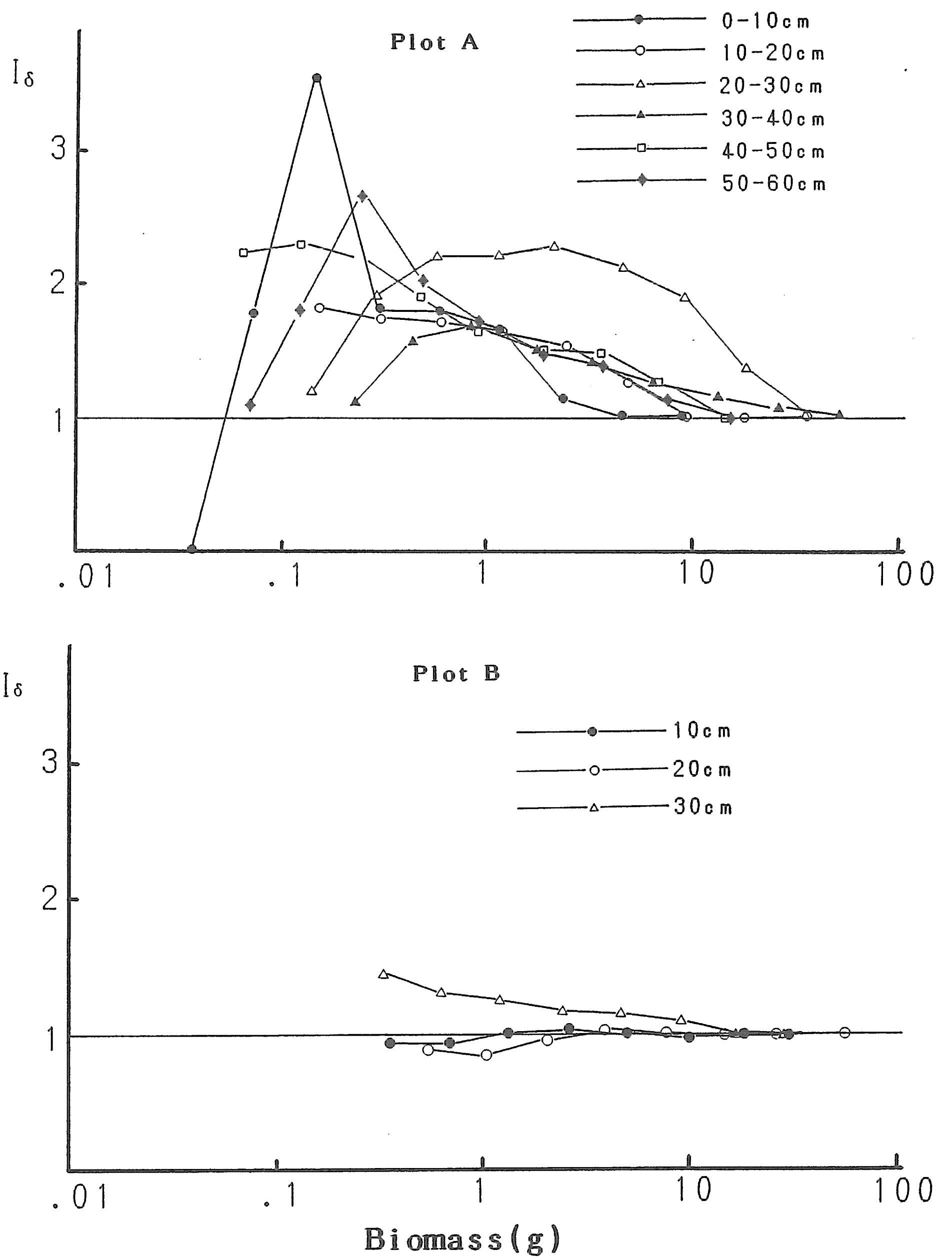

Fig. 6. Iδ-biomass curves in every depth-layer in Plot A and B. Instead of the quadrat size, biomass of live organs including leaves, leaf sheaths, bulbous nodes, rhizome, roots was used for abscissa.

the quadrat size. They make us clarify how the distribution pattern of shoots is affected by the biomass. As seen easily from Fig. 4, there exist only a few leaves and leaf sheaths in 0–10 cm layr of both plots, which there is lacking the bulbous nodes almost never. Thus, the location of shoots in this layer is largly determinted by the

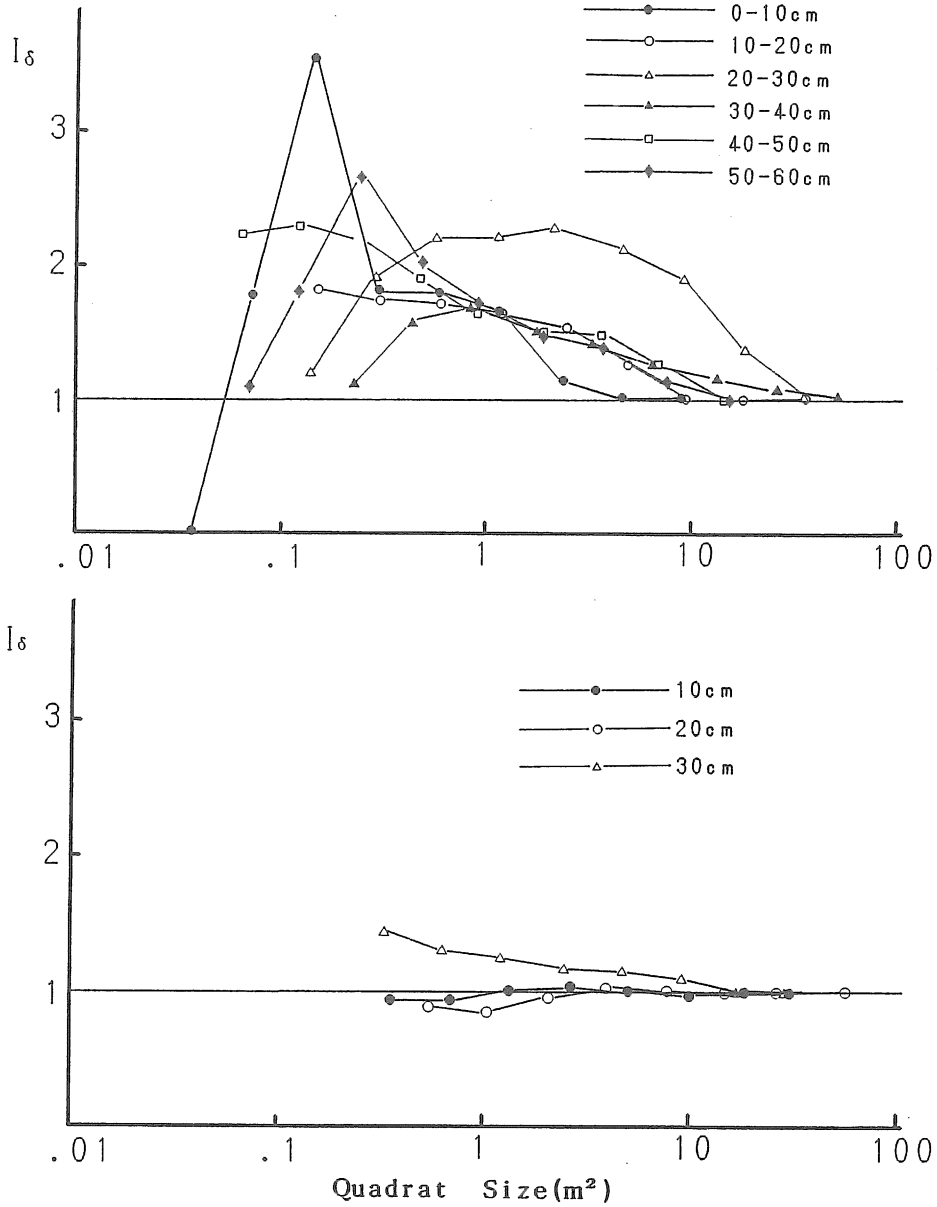

Fig. 7. Iδ(s)/Iδ(2s)-curves for detecting clump size in Plot A (upper) and Plot B. (lower).

bulbous nodes remained in 10–20 cm layer.

In Plot A, contagious distribution with samll clumps in which intraclump distribution is uniform was detected in all layers except for 10–20 cm layer where the contagious distribution with large clumps was found. In Plot B, on the other hand, the upper two layers indicated the random distribution and the most deep layer did the contagious distribution in which intraclump distribution is at random. In the previous paper, we reported the contagious distribution denoting statistically significant departure from randomness in all stands without exception. But, we could not detect small clumps which shoots distribution is uniform, because smaller grids sizes than those in this study were not adopted. If the samller grid size was used, we could get the same pattern of the contagious distribution mentioned above. It is difficult to elucidate the causal reason for random distribution of the upper two layers in Plot B. Decrease in $I\delta$-values may be partly due to larger biomass in Plot B than in Plot A. The ubiquitous attribute that *C. kobomugi* populations are distributed contagiously can be also verified in this study (Numata & Nobuhara, 1952, Tagawa, 1963, Miyata & Haramoto, 1986).

Fig. 7 represents the $I\delta(s)/I\delta(2s)$-curves to detect the clump size of every layer in Plot A and Plot B. In Plot A, clump sizes range from 1/64 m^2 to 1/4 m^2 in size. These clump sizes are also well accord with those reported in Shimane Prefecture (Miyata & Harmaoto, 1986). Since clump size below 1/64 m^2 was not detected, 1/64

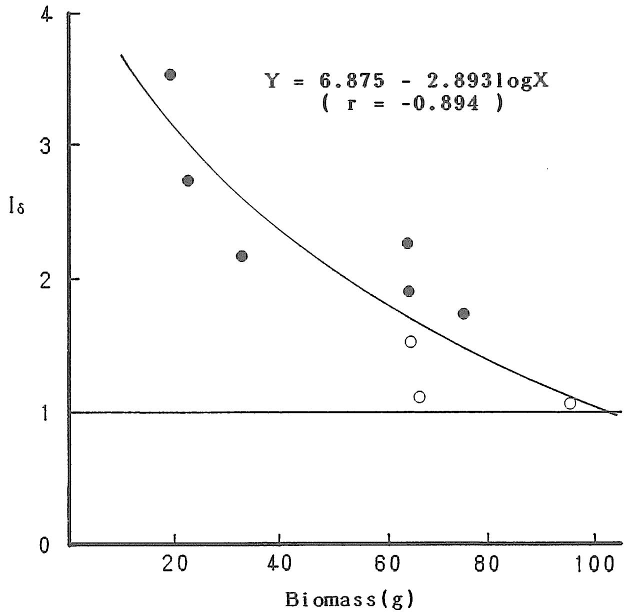

Fig. 8. The relationship between the maximum $I\delta$-values and biomass of sand layers. Open and solid circles indicate Plot A and Plot B, respectively.

m^2 might represent the minimum morphological pattern of *C. kobomugi.* Larger clump sizes than this scale may represent the social patterrn which is determined by such a biological agency as competition between shoot individuals (Kershaw, 1958, 1969). In Plot B, it was difficult to detect a definite clump size.

We can recognize the general trend that the larger is the biomass, the lower is the maximum Iδ-value of each layer. Fig. 8 shows the relationship between the maximum Iδ-value in every layer including the two plots and biomass excluding live leaves and leaf sheaths. It is well known in many plant populations that an increase in density or biomass makes its contagiousness of distribution lower (Tagawa, 1963, Miyata, 1977, Miyata & Haramoto, 1986). This trend is particularly strengthened in the species populations which propagate by the colonial growth of rhizome performance under a severe condition of habitat.

Although the accumulation rate of sand was measured directly, it was estimated to reach 10–15 cm per year from the average length of rhizome between the bulbous nodes. Under such an unstable habitat condition, rhizomes consume so much energies only for their upright growth that they may elongate hardly their lateral branches. Therefore, it is considered that shoots of *C. kobomugi* population have held their contagiouness of distribution all the time since their establishment in the habitat. Its contagiousness is a intrinsic property that would be represented constantly in space as well as in time.

Acknowledgement

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