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Studies of Polysety in *Pseudobryum speciosum* (Mniaceae, Musci)

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Abstract Polysety in *Pseudobryum speciosum* was investigated based on material from three localities in central Japan. The frequency of polysety is discussed. In the material studied over 80% of the fertile shoots were polysetous. The number of setae in a shoot varied from one to eight, and two or three was the most common. A comparison of the number of sporophytes per shoot and its correlation to shoot length is described, but no definite correlation was found.

Key words: polysety, *Pseudobryum speciosum*, moss, shoot length.

The development of more than one sporophyte from a single gametoecium, each from separate archegonium, is known as polysety (cf. Magill, 1990). Polysety is distinguished from polyembryony, which is the development of more than one sporophyte from a single archegonium, as reported in *Sphagnum* (Lyon, 1905). As a result, sporophytes share a single calyptra in polyembryony, while each has its own calyptra in polysety. Usually more than one archegonium are formed in a gametoecium. It is quite possible that several archgonia may be fertilized, and more than one embryo begin to develop. Most bryophytes, however, typically show monosety, that is, a sporophyte develops in only one archegonium in each gametoecium. It is interested that this is also true in pteridophytes, in which a sporophyte usually develops from a prothallium (cf. Campbell, 1905). Thus polysety does not occur often or in every group of bryophytes. For example, Longton (1962) noted that polysety had been recorded in 66 British mosses (more than 10% of the British moss flora).

Polysety has been recorded and investigated in several species of bryophytes (Györffy, 1931; Svihla, 1942; Sowter, 1948; Lowry, 1949; Lacey, 1950, 1951; Dalby, 1959; Longton, 1962; Chopra & Rashid, 1967; Koponen, 1968; Egunyomi, 1978; Hughes, 1979, 1980; Ono, 1980; Higuchi, 1993, 1997), but the factors causing polysety are unknown.

Pseudobryum speciosum (Mitt.) T. Kop. (Mniaceae) is robust moss and endemic to Japan, and it grows on forest litter in montane and subalpine forests. Male and female gametoecia are separately formed on the apical part of the stems. Polysety in this species has been reported by several authors, in which they described the number of setae (e.g., Noguchi (1989) noted "Setae usually 2–3, rarely to 10 from each perichaetium"). However, there is no quantitative study on polysety in this species.

Observations in the field and the laboratory have been made to better understand the nature of polysety in *Pseudobryum speciosum*.

Materials and Methods

Plant material with sporophytes was obtained from three localities situated in central Honshu, Japan (Fig. 1).

(1) Gifu-ken, Masuda-gun, Kosaka-cho, Mt. Ontake, Nigorigo Spa, 1800 m alt. (35°55′N, 137°28′E), 29 July 1996.

(2) Nagano-ken, Minamisaku-gun, Koumi-cho, Mts. Yatsugatake, Lake Shirakoma, 2250 m alt. (36°3′N, 138°22′E), 30 July 1996.

(3) Tochigi-ken, Nikko-shi, Mt. Shiranesan, Lake Yunoko, 1500 m alt. (36° 47′N, 139°25′E), 31 July 1997.

On Mt. Ontake the material was sampled from the continuous population, while on Mts. Yatsugatake and Mt. Shiranesan it was taken from populations dispersed over a small area (ca. 10×10 m). Observations in the laboratory were made for plant material from each locality as follows.

Frequency of polysety. On material from each of three localities the numbers of monosetous and polysetous shoots were counted, and the percentage of each type was calculated.

Measurements of shoot length. In bryophytes the development of sporophytes is more or less dependent on the gametophytes. The vitality of the gametophytes of a polysetous species may have some influence on the number of the sporophytes. The number of setae is expected to rise proportionately with the increase in the size of gametophytes. In order to ascertain whether any morphological differences exist among the gametophytes with different numbers of setae, the length of all fertile shoots was measured.

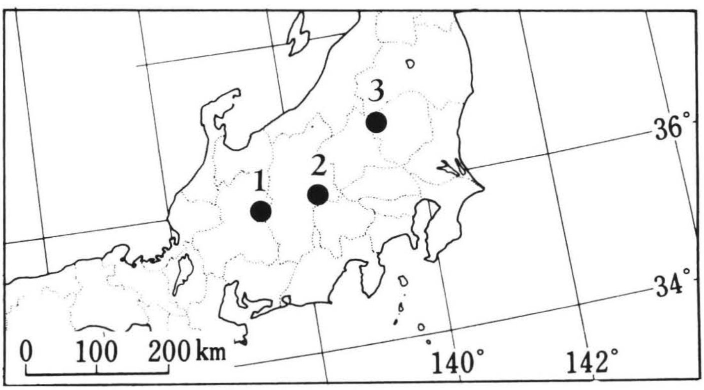

Fig. 1. Map showing study sites. 1. Mt. Ontake. 2. Mts. Yatsugatake. 3. Mt. Shiranesan.

Maturity of sporophytes. The stages of development of sporophytes were recorded on all material examined.

The voucher specimens are deposited in the herbarium of the National Science Museum, Tokyo (TNS).

Results

Table 1 shows the frequency of polysety in *Pseudobryum speciosum*. In each locality over 80% of the fertile shoots were polysetous. The highest number of setae seen in a single gametoecium was six in Mt. Ontake, seven in Mt. Shiranesan and eight in Mts. Yatsugatake. The most frequent number of setae per gametoecium was two in Mt. Ontake and three in Mts. Yatsugatake and Mt. Shiranesan, which is in accord with the description by Noguchi (1989). A χ^2-test shows that the differences

Table 1. Number of shoots with 1~8 setae in *Pseudobryum speciosum*.

Number of setae	1	2	3	4	5	6	7	8	Total of shoots
Mt. Ontake	19	31	23	17	10	5	—	—	105
%	18.1	29.5	21.9	16.2	9.5	4.8			
Mts. Yatsugatake	93	186	217	116	47	19	3	1	682
%	13.6	27.3	31.8	17.0	6.9	2.8	0.4	0.2	
Mt. Shiranesan	69	104	155	128	43	17	2	—	518
%	13.3	20.1	29.9	24.7	8.3	3.3	0.4		

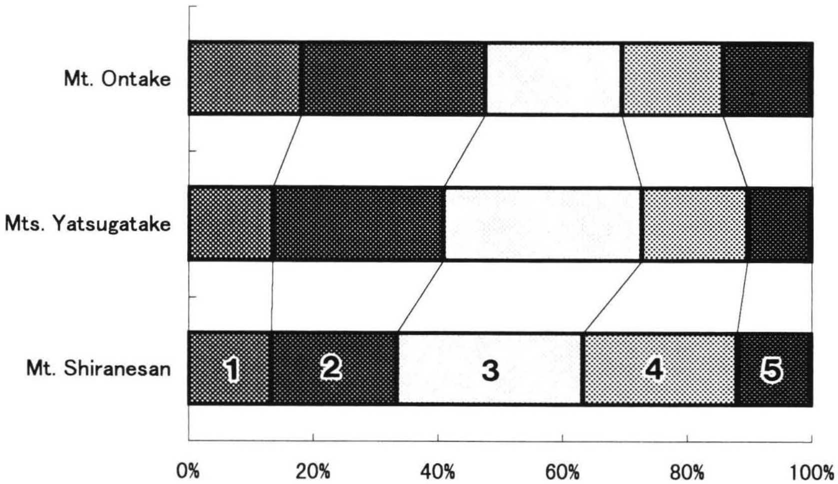

Fig. 2. Histograms of the proportion of the number of shoots in *Pseudobryum speciosum* based on Table 1. 1: shoots with one seta, 2: shoots with two setae, 3: shoots with three setae, 4: shoots with four setae, 5: shoots with five or more setae.

among the proportion of the number of setae in each locality were not significant (P=0.05) (Fig. 2). This means that there seems to be no geographical difference in the frequency of polysety in this species.

Measurement of shoot length is given in Fig. 3. The mean value of shoot length was different among three localities. However there is no significant difference between the length of monosetous shoots and polysetous ones in any locality. In Fig. 3 the mean value for shoots with more than four setae per shoot was more or less different than others, which may be due to low sample size. The results suggest that the size of gametophytes, at least shoot length, has no influence on the number of sporophytes in this case.

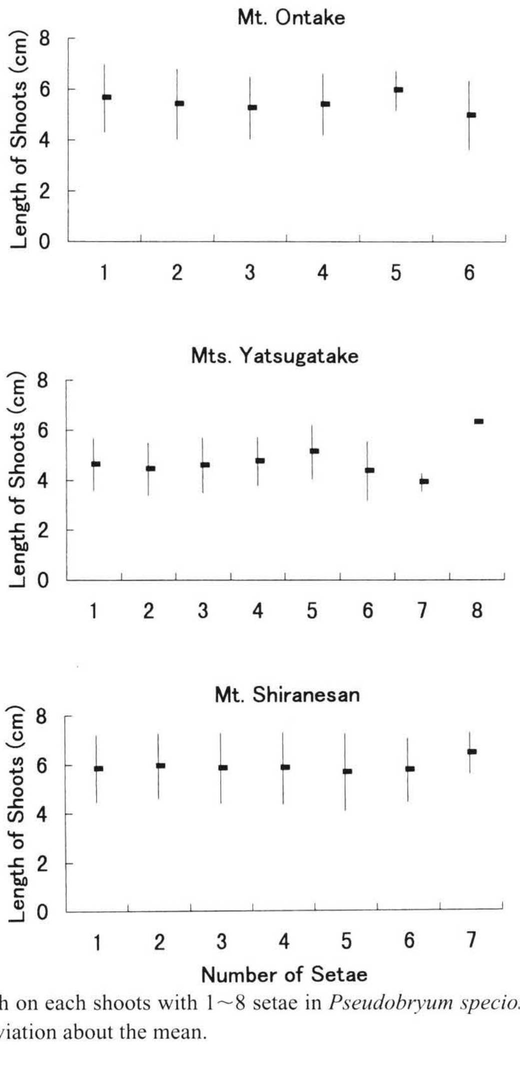

Fig. 3. Shoot length on each shoots with 1~8 setae in *Pseudobryum speciosum*; bars represent ± one standard deviation about the mean.

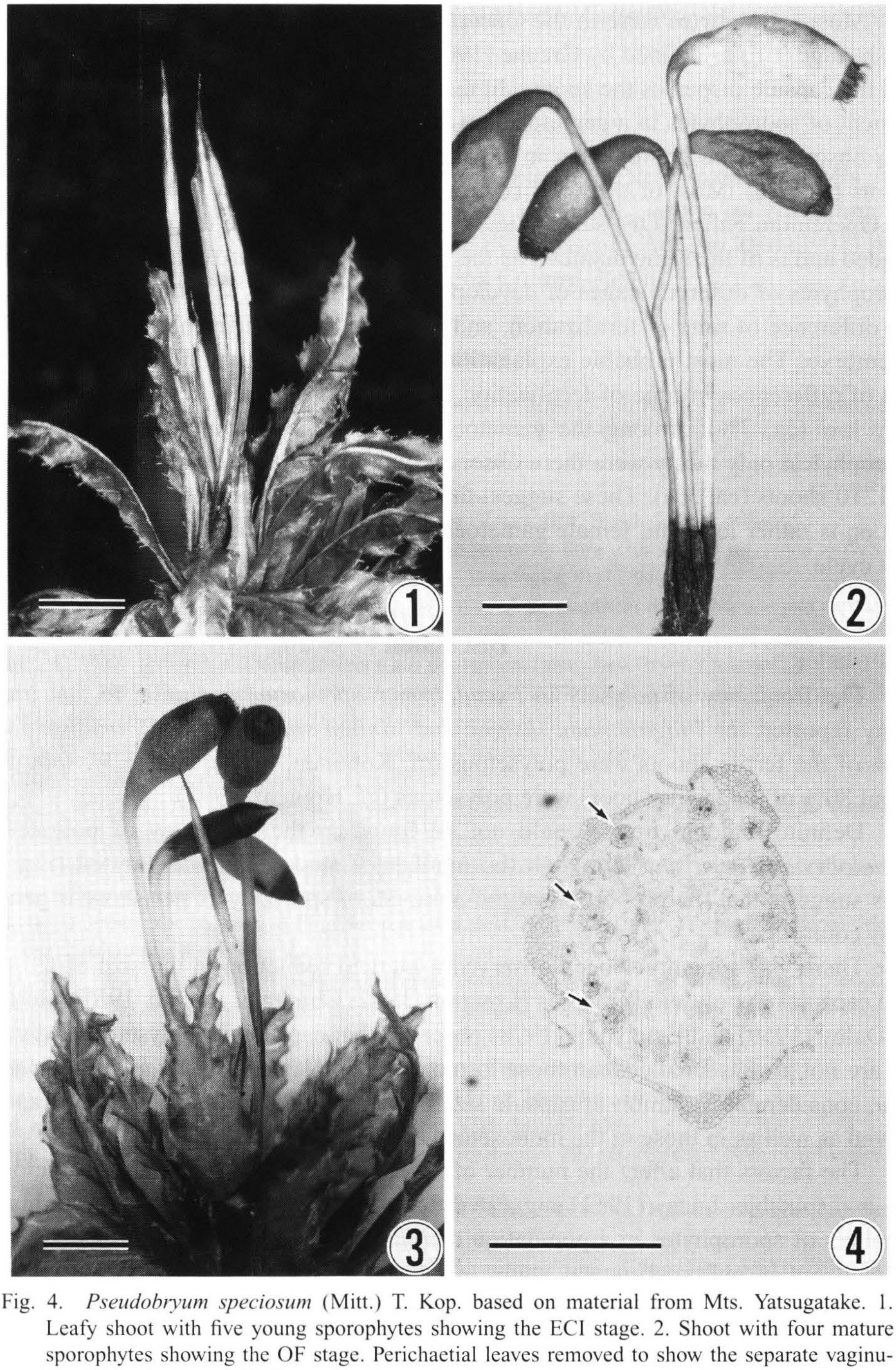

Fig. 4. *Pseudobryum speciosum* (Mitt.) T. Kop. based on material from Mts. Yatsugatake. 1. Leafy shoot with five young sporophytes showing the ECI stage. 2. Shoot with four mature sporophytes showing the OF stage. Perichaetial leaves removed to show the separate vaginulae. 3. Leafy shoot with five sporophytes showing the ECI stage to the OF stage. 4. A cross-section of sterile female gametoecium. Thirty eight archegonia (arrows) and a number of paraphyses are surrounded by four perichaetial leaves. (Scale bars, 1–3: 0.5 cm, 4: 0.5 mm.)

Most sporophytes were in the Operculum Fallen stage (OF) and the Empty and Fresh stage (EF) as defined by Greene (1960). In the OF stage the operculum is fallen and the capsule disperses the spores. In the EF stage the capsule is empty. The development of sporophytes in a gametoecium was usually synchronous (Fig. 4: 1, 2), but also observed were sporophytes in different stages of development in 95 of 1305 shoots (ca. 7%). Most of them varied from the Early Calyptra Intact (ECI) stage to the Operculum Fallen (OF) stage (Fig. 4: 3). In the ECI stage the capsule is not expanded and is of the same diameter as the seta. Two reasons are considered to explain sporophytes of different stages of development within a single gametoecium. One is the difference of time of fertilization, and the other is the difference of development of embryo. The most probable explanation is that differences in development are result of differences in time of fertilization, because the number of such instances was very low (ca. 7%). Among the gametoecia showing synchronous development of sporophytes, only rarely were there observed those in the ECI stage (Fig. 4: 1), in 38 of 1210 shoots (ca. 3%). These suggest that in this species the period of active fertilization is rather long and female gametoecia can be fertilized several times in a current cycle.

Discussion

The frequency of polysety in *Pseudobryum speciosum* is similar to that previously reported for *Plagiomnium insigne* and *Mnium spinosum*. In *P. insigne* about 90% of the fertile shoots were polysetous (cf. Koponen, 1968), and in *M. spinosum* about 80% of the fertile shoots were polysetous (cf. Higuchi, 1997).

Definite regional trends could not be found in the frequency of polysety in *Pseudobryum speciosum*, although the number of study sites was limited (Fig. 2). This suggests that the proportion of the numbers of sporophytes per shoot is genetically controlled.

There was sometimes been observed a marked reduction in the size of the mature capsules in polysetous mosses (Longton, 1962; Chopra & Rashid, 1967). However, Dalby (1959) and Egunyomi (1978) observed that capsules in polysetous individuals are not always smaller than those in monosetous plants. In *Pseudobryum speciosum*, considerable variation in capsule size in plants in polysetous condition was observed as well as in those in the monosetous condition.

The factors that affect the number of sporophytes developed in each gametoecium is disputable. Lacey (1951) suggested that high rainfall might have led to higher numbers of sporophytes in a population of *Mnium undulatum*, while Hughes (1979) pointed out in an experimental study of *Phascum cuspidatum* that the number of sporophytes per gametoecium was found to increase with increase in the number of archegonia. In *Pseudobryum speciosum*, as shown in Fig. 4: 4, more than 30 archegonia are usually formed in a female gametoecium. The ability to produce many archegonia in a gametoecium may be correlated with whether the species shows polysety or monosety.

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