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Salicornia europaea communities in salt marshes in Lake Komuke, eastern Hokkaido, Japan

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北海道東部コムケ湖の塩湿地に於けるアッケシソウ群落

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Summary

S. europaea communities in salt marshes of Lake Komuke located in the northeastern coast of Hokkaido were studied plant-ecologically. Three lakes consisting Lake Komuke were named tentatively Lake I, II and III from east to west. The communities were observed in Lake I and II. In Lake I, the communities existed in three stations: the western shore of lake-mouth (3 sites), the southern shore (7 sites) and the western shore (1 site). The largest community in Lake I was found in the site of the southern shore, which area measured about 2.7ha. The coverage of *S. europaea* in each of the 11 sites was in the range of 10% to 30%, and the mean plant-height was from 8.4cm to 15.3cm. Five community sites were observed in Lake II. The largest community was found in a sandbar developing from the northeastern shore and measured about 4.0ha in area. The coverage of *S. europaea* in each of the 5 sites was in the range of 25% to 40%, and the mean plant-height was from 3.5cm to 10.6cm. *S. europaea* accompanied *Glaux maritima* var. *obtusifolia*, *Spergularia marina*, *Triglochin maritimum*, *Puccinellia kurilensis* and *Atriplex gmelinii* in some sites, while in others some of these species were missing. Although the height and the branch-number of *S. europaea* varied from site to site, the average was 10.5cm and 9.6 respectively in all the sites in Lake Komuke.

Key words: *Salicornia europaea*, salt marsh, halophyte, Lake Komuke, eastern Hokkaido

Introduction

Salicornia europaea belonging to Chenopodiaceae is an annual plant and has a worldwide distribution, i.e. in Europe, Asia and North America. This species is a typical halophyte that grows in salt marshes that develop along the coasts of tidal seas and the shores of inland salt lakes (Flowers, 1934; Chapman, 1960; Ungar, 1965; Tiku, 1975; Ohwi, 1978).

S. europaea was first discovered by Sugiyama at Kakijima in the Akkeshi district in Japan. The Japanese name Akkeshiso originated from the name of the district. Later, the plant was discovered at several locations: Notsuke Cape, Onnetou, Lake Furen, Lake Saroma, Lake Notoro and Lake Komuke (Iwamoto, 1932; Ito, 1963).

The description of *S. europaea* communities in Lake Komuke was first reported by Ito in 1963. However, the plant ecological survey was restricted only to the river-mouth site of Akihira River. No reports on the communities in all the shore of Lake Komuke have been described.

In this paper, we will report the exact locations and areas

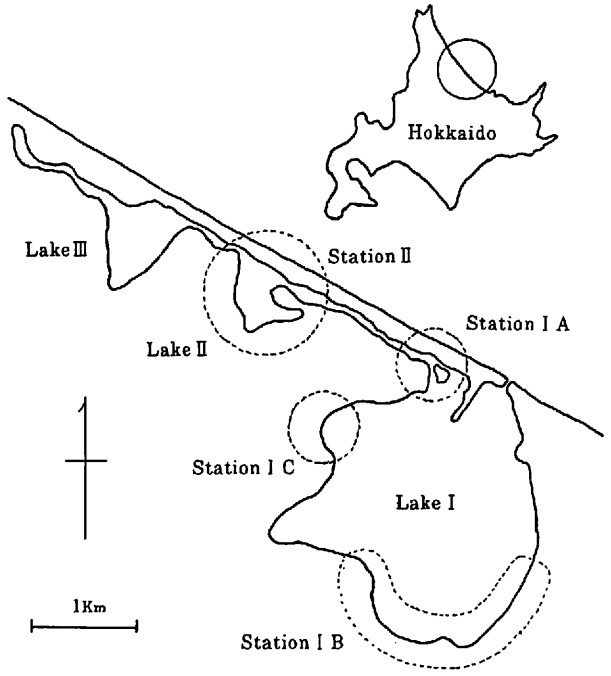

Fig. 1 Survey stations of *S. europaea* communities in Lake Komuke.

of *S. europaea* communities in Lake Komuke. We also report the percentage of the coverage of this species and other accompanying plants in each community for the purpose of making a standard for assessment of the changing state of the areas of *S. europaea* communities in the future.

Study stations and Methods

Lake Komuke, which lies about 15km southeast of Monbetsu City along the coast of Okhotsk Sea in eastern Hokkaido, consists of three lakes covering the area of 5.81km^2. The maximum depth of the lake is 3.8m. Since these three lakes had no names, we tentatively named the largest one locating in eastern side Lake I, and the other two lakes westward were named Lakes II and III respectively in this paper (Fig. 1).

The study was carried out from August 1st to October 31st in 2000. The plant communities with *S. europaea* were found mainly at 4 stations: the western shore of the lake-mouth of Lake I (Station IA), the southern shore of Lake I (Station IB), the western shore of Lake I (Station IC) and the shore around Lake II (Station II) (Fig. 1). No community with *S. europaea* was found in Lake III.

All the areas of *S. europaea* communities in these stations were surveyed together with the coverage of *S. europaea* and other accompanying plant species. The heights of these species were measured and the branch-number of *S. europaea* was counted.

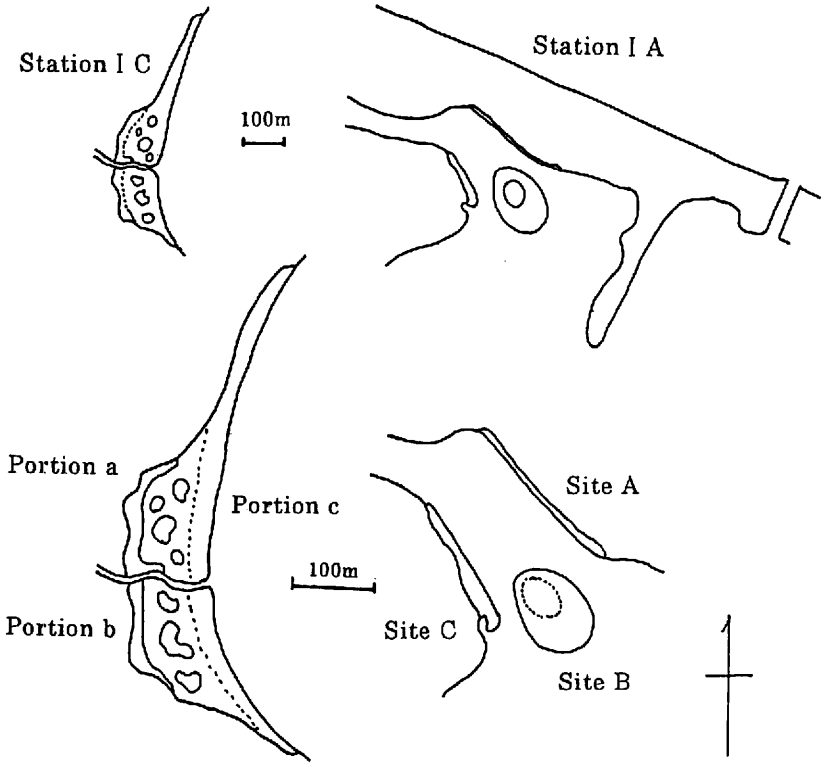

Fig. 2 Station IA : The western shore of the lake-mouth and Station IC : The western shore of Lake I.

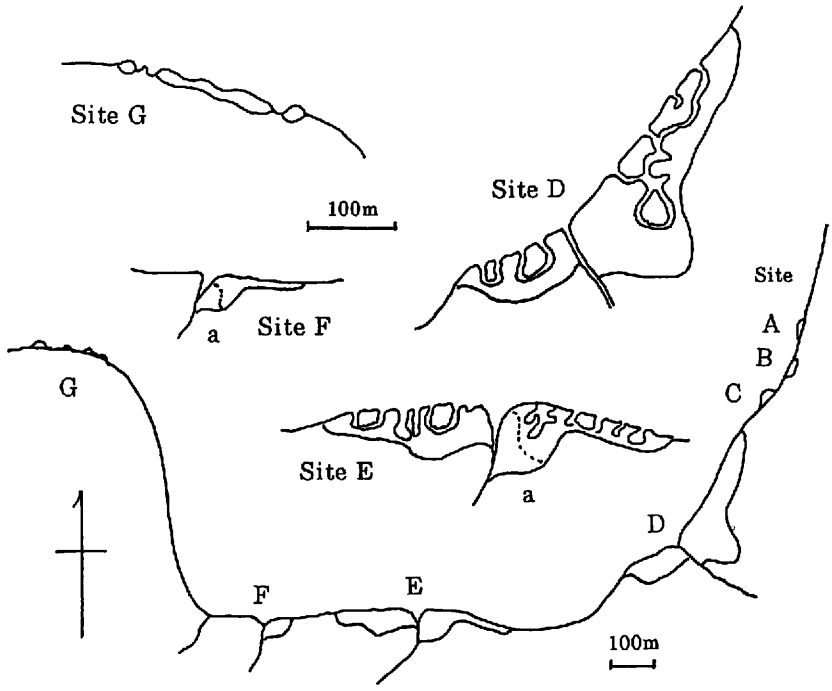

Fig. 3 Station IB : The southern shore of Lake I.

Results and Discussion

1. Station IA : the western shore of the lake-mouth of Lake I

Plant communities including *S. europaea* were observed at three sites : A, B and C in the station (Fig.2).

Site A : This site is located in the northern shore of river-mouth where a stream from Lakes III and II flows into Lake I, and it is a belt-shaped community (2-5×150m, 530m^2). *Spergularia marina* was dominant and mixed with *S. europaea* in site A. The coverage of both species was 40% and 15%, and these mean plant-height (abbreviated to MPH) were 7.8cm and 8.4cm, respectively. Mean branch-number (abbreviated to MBN) of *S. europaea* was 6.7 (Tables 1,2). There were some small colonies (10-30×10-30cm) of *Glaux maritima* var. *obtusifolia* all over the site. *Triglochin maritimum* was also observed in the central portion of the site forming pure colony (3×3m). This coverage in the site was 10% (MPH 9.9cm) and 10% (MPH 37cm), respectively. The area north of the site is sandy land growing *Rosa rugosa*, *Artemisia arctica*, *Elymus molis* and other seaside plants.

Site B : A sandbar (50×70m) located in the river-mouth consists of two areas : a central sandy plateau (19×38m) and its surrounding sandy mud where *S. europaea* community lies. *S. europaea* and *S. marina* were dominant in site B, and these coverages were both 30%. MPH of the former was 9.6cm, and the letter 6.8cm. MBN of *S. europaea* was 5.3 (Table 2). In this site, twenty or more colonies (0.5-1.0×0.5-1.0m) of *G. maritima* var. *obtusifolia* were found from place to place all over the site, and *T. maritmum* was scattered in the site. This coverage was both below 1%, and MPH was 9.1cm and 36cm, respectively (Table 1). The area where *S. europaea* grows was estimated about 0.2ha. *A. arctica*, *E. molis*, *Senecio pseudo-arnica*, *Atriplex gmelinii* and other seaside plants vegetated in the central sandy plateau.

Site C : A belt-shaped muddy land (2-25×145m) is situated in the southern shore of the river-mouth, where *S. europaea* community was observed. *S. europaea* and *S. marina* were dominant in this site, and this coverage was both 25%. MPH of these two species was relatively high compared to those in Sites A and B, and was 14.9cm (MBN 20.9) and 11.9cm, respectively. Whereas, of *T. maritimum*, MPH was lower (16.6cm) than that in Sites A and B, and the coverage was 10% (Table 1).

Southern area behind Site C was covered with *Phragmites australis* community (100-150cm in height), and *S. europaea*, *G. maritima* var. *obthsifolia*, *S. marina* and *Potentilla egedei* var. *groenlandica* were sparsely found underneath.

Table 1 Coverage and mean plant-height of some species in Station IA, IB, IC and II

Species	Station I A			Station I B					Station I C				Station II							
	A[1]	B	C	A	B	D	Ea[2]	Fa	G	a[3]	b	c	A	B	Cb	D	Ea	Eb	Ec	Ed
Salicornia europaea	15*	30	25	25	20	25	10	10	15	10	15	5	40	40	30	30	30	25	25	25
	8.4	9.6	14.9	15.3	10.2	8.7	12.9	10.8	11.2	12.1	10.6	9.1	8.3	10.6	7.2	7.7	3.5	6.4	8.5	5.3
Glaux maritima var. *obtusifolia*	10	<1	<1	—	—	<1	50	40	<1	—	—	—	—	—	—	—	—	—	—	—
	9.9	9.1	9.5			8.0	12.4	12.4	10.8											
Spergularia marina	40	30	25	20	15	15	<1	<1	10	5	40	—	10	10	15	5	—	15	15	15
	7.8	6.8	11.9	8.9	7.0	6.6	8.5	9.2	8.8	8.3	7.6		6.0	7.1	5.8	5.7		4.5	7.3	4.2
Triglochin maritimum	10	<1	10	20	10	5	20	15	5	5	—	—	5	2	10	15	—	—	—	3
	37	36	16.6	26.8	23.2	14.2	16.8	15.0	18.1	17.4			15.7	23.4	21.4	18.8				12.5
Puccinellia kurilensis	—	—	—	10	20	20	15	15	15	20	5	—	20	20	—	10	—	10	5	5
				12.8	12.3	10.3	12.3	11.7	12.2	12.2	11.9		12.7	10.6		12.4		6.4	7.2	7.0
Atriplex gmelinii	—	—	—	—	—	—	—	—	<1	5	—	—	—	—	—	—	—	—	—	—
									12.2	13.5										
Area (ha) of *S. europaea*	0.05	0.2	0.2	0.02	0.05	2.7	0.2 / 1.3**	0.04 / 0.14	0.2	0.4	0.3	1.4	0.06	0.2	0.1	0.2	0.6	0.4	1.4	1.6
											2.1				0.6			4.0		

[1]Site, [2]Portion a in Site E, [3]Portion a

*Coverage (%) , small letter shows mean plant-height of each species

**Area (ha) of site

2. Station IB : the southern shore of Lake I

Seven *S. europaea* communities of Site A to G were observed on the southern shore of Lake I (Fig.3). The shore extended 2.6km from east to west, and the area behind those communities were covered with *Calamagrostis epigeios* community mixed with *P. australis* and *Juncus gracillimus* .

Site A : A half-moon shaped muddy land (10×28m, 185m^2) located in the eastern end of the station. *S. europaea*, *S. marina* and *T. maritimum* were dominant species in this site with 25% (MPH 15.3cm, MBN 18.4), 20% (MPH 8.9cm) and 20% (MPH 26.8cm) of coverage, respectively. *P. kurilensis* was mixed in those species with 10% (MPH 12.8cm) of coverage (Table 1). The mean plant-height of these species was the highest among those of all sites in the station except *S. marina* (Tables 1,2).

Site B : A belt-shaped muddy land (10×72m, 530m^2) lies next to Site A. Dominant species in this site were *S. europaea* (MPH 10.2cm, MBN 17.1) and *P. kurilensis* (MPH 12.3cm) with 20% of coverage, respectively. Among these species, *S. marina* and *T. maritimum* were scattered with the coverage of 15% (MPH 7.0cm) and 10% (MPH 23.2cm), respectively (Table 1).

Site C : *S. europaea* community was observed in a part of semicircle muddy land (13 × 20m, 190m^2) near Site B. However, since the coverage of each plant was all less than 15% and partial plants loss presumably by surge was recognized, plant survey on this site was eliminated from this study. Small colony (30 × 30cm) of *G. maritima* var. *obtusifolia* was observed in the community.

Site D : On both sides of a narrow river (2.0m in width), muddy shores ran 300m to the northeast and 150m to the west. The maximum distance of the land was 150m. *S. europaea* community spread all over the muddy land although there were some puddles where *S. europaea* grew sparsely, and its coverage was 25% (MPH 8.7cm, MBN 10.4) of the site. *S. marina* and *P. kurilensis* also mixed in the community with the coverage of 15% (MPH 6.6cm) and 20% (MPH 10.3cm), respectively (Table 1). A belt-shaped colony (0.5×5m) of *G. maritima* var. *obtusifolia* (MPH 8.0cm) was observed along the river. The distribution area of *S. europaea* measured about 2.7ha.

Site E : A narrow river of 2.0m in width divides muddy shore into two areas, each of which was 200m long shore eastward and westward, respectively. The maximum muddy distance of the land is 65m. A carpet of *G. maritima* var. *obtusifolia* mixed with *T. maritimum* covered a portion (Portion Ea, 65×65m, 20a) of eastern site of the river with the coverage of 50% (MPH 12.4cm) and 20% (MPH 16.8cm), respectively. At this portion, *S. europaea* and *P. kurilensis* were also mixed to those species with the coverage of 10% (MPH 12.9cm, MBN 15.7) and 15% (MPH 12.3cm), respectively (Table 1). Aside from this portion, *S. europaea* distributed sparsely all over Site E where some puddles, canals and low plateaus growing *S. europaea, S. marina, T. maritimum* and *P. kurilensis* were found, and total area of Site E was estimated about 1.3ha.

Site F : On the muddy land of the eastern side of a narrow river (1m in width), *S. europaea* community was observed. The total area of Site F was estimated about 0.14ha, and in a portion of this site, a carpet of *G. maritima* var. *obtusifolia* (40% of coverage, MPH 12.4cm) was found (Portion Fa). It had similar appearance to the portion Ea in Site E and was mixed with *S. europaea* (MPH 10.8cm, MBN 15.6), *T. maritimum* (MPH 15.0cm) and *P. kurilensis* (MPH 11.7cm). The coverage of these three species in the portion Fa was 10%, 15% and 15%, respectively (Table 1). The area of the portion Fa was calculated to be 420m^2.

Site G : In the western end of Station IB, a belt-shaped muddy land (15×220m) exists. *S. europaea* (MPH 11.2cm, MBN 15.3) and *P. kurilensis* (MPH 12.2cm) were dominant in this site with the coverage of 15%, respectively. *S. marina* and *T. maritimum* also scattered in the community with the coverage of 10% in the former (MPH 8.8cm) and 5% in the latter (MPH 18.1cm) (Table 1). Estimated area of Site G was about 0.2ha.

3. Station IC : The western shore of Lake I

Some pasture grounds extend in the western area of Lake I From there, a narrow river (1m in width) flows into the Lake forming a large muddy alluvial fan in the river-mouth, which extends for 350m along the shore and the maximum width of the land was 65m (Fig.2). *S. europaea* community was observed all over the station and its area measured about 2.1ha. Since the density and accompanying species of *S. europaea* were not the same all over the station, it was divided into three portions : a, b and c, and plants survey was conducted.

Portion a : A belt-shaped land of 10m in width elongated between muddy land and the rear area where *C. epigeios-P. australis* community developed. The dominant species of this portion was *P. kurilensis* (MPH 12.2cm) with 20% of coverage, and *S. europaea* (MPH 12.1cm, MBN 13.9), *S. marina* (MPH

Table 2 Distribution of plant-height and mean blanch-number of *S. europaea* in survey Sites and Portions.

Plant-height	Station I A			Station I B						Station I C			Station II						
(cm)	A[1]	B	C	A	B	D	Ea[2]	Fa	G	a[3]	b	c	A	B	Cb	D	Ea	Eb	Ec	Ed
<2.5	–	–	–	–	–	–	–	–	–	–	–	2*	–	–	–	–	12	–	–	–
												0					0.3			
2.6– 5.0	14	4	–	–	–	10	–	–	–	3	3	7	9	–	14	12	33	17	8	28
	0	0				6.0				0.8	0.5	1.2	1.2		1.0	0.7	1.5	1.3	1.0	1.3
5.1– 7.5	13	16	3	2	3	13	–	5	3	6	10	8	13	8	15	20	5	21	8	15
	1.9	0.2	10.0	6.0	8.0	9.0		8.5	8.7	3.5	4.1	4.8	5.2	5.5	3.8	2.8	5.0	4.9	6.8	6.6
7.6–10.0	17	9	4	7	21	11	7	9	8	5	12	15	19	16	12	9	–	12	18	7
	4.1	1.0	11.2	11.3	15.7	13.4	14.2	14.5	13.8	9.5	8.9	9.6	10.6	6.3	8.9	7.0		10.2	10.6	9.5
10.1–12.5	6	21	9	6	19	6	11	13	15	10	8	14	4	17	7	5	–	–	12	–
	7.3	6.6	17.3	15.0	19.5	15.5	16.1	16.3	15.2	11.2	13.1	12.2	14.0	11.3	13.0	7.5			16.0	
12.6–15.0	4	10	6	12	4	7	23	8	9	8	7	5	5	9	2	4	–	–	4	–
	17.0	14.4	17.6	19.8	20.2	10.4	15.0	17.2	15.6	20.5	18.5	15.5	17.3	17.3	21.0	12.5			22.0	
15.1–17.5	3	–	12	2	–	–	3	7	5	8	8	–	–	–	–	–	–	–	–	–
	28.0		22.5	20.0			19.0	18.5	19.0	21.5	21.2									
17.6–20.0	–	–	15	9	–	–	2	1	2	3	1	–	–	–	–	–	–	–	–	–
			27.8	22.0			21.0	18.0	20.5	22.0	21.0									
20.1<	–	–	–	5	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
				26.8						28.0										
Mean plant-height	8.4	9.6	14.9	15.3	10.2	8.7	12.9	10.8	11.2	12.1	10.6	9.1	8.3	10.6	7.2	7.7	3.5	6.4	8.5	5.3
of *S. europaea***	6.7	5.8	20.9	18.4	17.1	10.4	15.7	15.6	15.3	13.9	11.7	8.6	8.5	9.9	6.2	4.3	1.6	5.0	10.7	4.0

[1]Site, [2]Portion a in Site E, [3]Portion

* Number of *S. europaea*, small letter shows mean blanch-number of *S. europaea* ** Small letter shows mean blanch-number of *S. europaea*

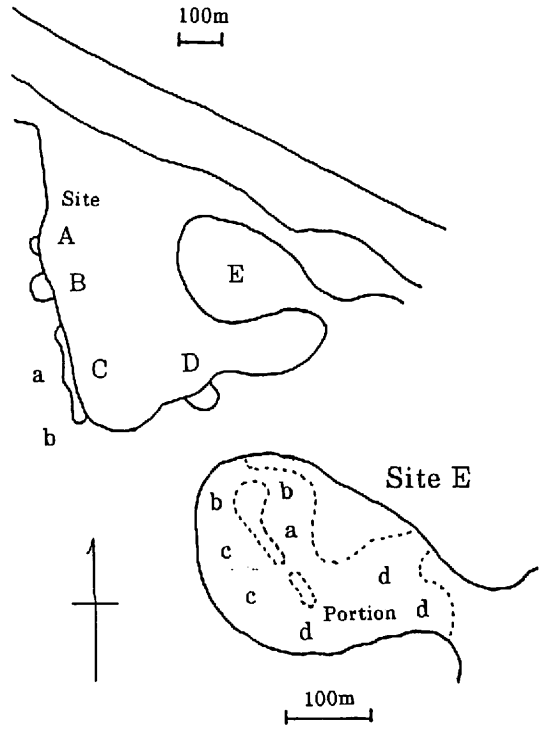

Fig. 4 Station II : The shore around Lake II.

8.3cm) and *T. maritimum* (MPH 17.4cm) mixed in it with the coverage of 10%, 5% and 5%, respectively (Table 1). *Atriplex gmelinii* (MPH 13.5cm) was also found in this portion. Estimated area of the portion was calculated to be about 0.4ha.

Portion b : Several low plateaus scattered in the central area of Station IC which often flooded. All plateaus were covered with *S. marina* (MPH 7.6cm) with the coverage of 40%, and *S. europaea* (MPH 10.6cm, MBN 11.7) and *P. kurilensis* (MPH 11.9cm) were mixed with it with the coverage of 15% and 5%, respectively (Table 1). The sum area of plateaus measured about 0.3ha.

Portion c : In sandy mud land, which flooded frequently, only *S. europaea* (MPH 9.1cm, MBN 8.6) grew scarcely with the coverage of 5% (Table 1). The mean plant-height was low compared to those in Portion a and b, and the area where *S. europaea* was growing measured about 1.4ha.

4. Station II : The shore around Lake II

Lake II is located between Lake I and Lake III and it is the smallest one of the lakes consisting Lake Komuke. Five *S. europaea* communities of site A to E were observed around the lake (Fig.4). The area at the back of those sites was covered with *P. australis* community mixed with *C. epigeios* and *J. gracillimus*.

Site A : *S. europaea* community developed well in a semicircular land (30 × 23m) measured 550m^2 with the coverage of 40%, and MPH and MBN of this species were 8.3cm and 8.5, respectively. *S. marina* (MPH 6.0cm), *T. maritimum* (MPH 15.7cm) and *P. kurilensis* (MPH 12.7cm) were also found in this community with the coverage of 10%, 5% and 20%, respectively (Table 1).

Site B : A semicircular land (50×45m) with similar appearance to Site A was covered with *S. europaea* (MPH 10.6cm, MBN 9.9), *S. marina* (MPH 7.1cm), *T. maritumum* (MPH 23.4cm) and *P. kurilensis* (MPH 10.6cm). This coverage was 40%, 10%, 2% and 20%, respectively (Table 1), and the community measured about 0.2ha in area.

Site C : Several different plant colonies were observed in a belt-shaped muddy land (20-25×250m). From the north end to the south end of this site, there were colonies of *Scirpus* sp., *S. europaea-T. maritimum* (Portion Ca), *Scirpus* sp., *T. maritimum-G. maritima* var. *obtusifolia* and *S. europaea-S. marina-T. maritimum* (Portion Cb), successively. The coverage of *S. europaea* and *T. maritimum* in Portion Ca were 30% and 15%, and those of *S. europaea* (MPH 7.2cm, MBN 6.2), S. marina (MPH 5.8cm) and *T. maritumum* (MPH 21.4cm) in Portion Cb were 30%, 15% and 10%, respectively (Table 1). In the rest of the portions, *S. europaea* scattered scarcely with below 5% of coverage. The area of Site C measured about 0.6ha including Portions Ca (550m^2) and Cb (1100m^2).

Site D : *S. europaea* community spread over a semicircular land (58×45m) accompanied with *T. maritimum* and *P. kurilensis*. The coverage was 30% of *S. europaea* (MPH 7.7cm, MBN 4.3), 15% of *T. maritimum* (MPH 18.8cm) and 10% of *P. kurilensis* (MPH 12.4cm) (Table 1). Some circular colonies (1-2×1-2m) of *J. gracillimus* were also found in the site. Estimated area of the community was about 0.2ha.

Site E : A large sand bar (5.3ha in area) develops at the northern margin of the east shore of Lake II. In the northern and the central areas of this sand bar, *P. australis* communities accompanied with *J. gracillimus, P. kurilensis, P. egedei* var. *groenlandica* and *G. maritima* var. *obtusifolia* were found. In all over the sand bar except the area of *P. australis* communities, *S. europaea* community spread accompanied with other species. The area was estimated to be about 4.0ha. Based on the differences in height and the coverage of accompanying species, the community was divided into four portions of Ea to Ed for plant-ecological survey.

Portion Ea : Pure *S. europaea* community was observed in muddy sand land of 0.6ha in area. The plants were of the

smallest not only in all portions of Site E but in all sites of Lake I and II (Table 2), and the MPH and MBN were 3.5cm and 1.6, respectively (Table 2). The coverage was 30%.

Portion Eb : Beside Portion Ea, *S. europaea* community mixed with *S. marina* (MPH 4.5cm) and *P. kurilensis* (MPH 6.4cm) spread over about 0.4ha in area. The coverage of *S. europaea* (MPH 6.4cm, MBN 5.0) was 25%, and those of the other two species were 15% and 10%, respectively (Table 1).

Portion Ec : Next to Portion Eb, the community having similar appearance to Portion Eb was observed over about 1.4ha in area. The coverage of *S. europaea* (MPH 8.5cm, MBN 10.7) and S. marina (MPH 7.3cm) were the same as those in Portion Eb, although that of *P. kurilensis* (MPH 7.2cm) was small (5%) compared to that in Portion Eb (Table 1). The mean heights of the plants composing this portion were the highest in Site E (Table 2).

Portion Ed : In the community spreading over the southeast of Portion Ec, *T. maritimum* (MPH 12.5cm) was scattered (Portion Ed). The coverages of *S. europaea* (MPH 5.3cm, MBN 4.0), *S. marina* (MPH 4.2cm) and *P. kurilensis* (MPH 7.0cm) were 25%, 15% and 5%, respectively, and 3% for *T. maritimum* (Table 1).

5. Distribution of plant-height and branch-number of *S. europaea* in the survey sites and portions

The findings about the distribution of MPH and MBN of *S. europaea* are summarized in Table 2. The plant-height varied from below 2.5cm to over 20.1cm, and MPH in the twenty survey sites and portions were in the range of 3.5cm to 15.3cm. The average was 10.5cm. On the other hand, the distribution of MBN in the sites and portions was within the limits of 1.6 to 20.9. The average was 9.6.

From the findings in Table 2, some differences in the plant-height distribution are observed in survey place to place. Relatively low plants spread in Site E of station II which is a sandy land, while high plants were observed in Site A of Station IB and in Portion a of Station IC which are muddy lands. The investigation of the soil components and conditions, which will influence the growth of S. europaea, would be necessary.

The location of the communities and their areas as well as the survey of the coverage and height of the plant will be essential information to evaluate the succession of *S. europaea* communities from the past to the future. The findings shown in this paper would be a standard for assessment of the changing state of *S. europaea* communities in Lake Komuke.

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References

Chapman, U.J. 1960. Salt marshes and salt deserts of the world. Leonard Hill, London.

Flowers, S. 1934. Vegetation of the Great Salt Lakes region. Bot. Gaz., **15**: 353-418.

Ito, K. 1959. *Salicornia europaea* community of the Okhotsk side in Hokkaido, Japan. Jap. J. Ecol., **9**: 21-27 (in Japanese).

Ito, K. 1963. Study on the vegetation of the salt marshes in Eastern Hokkaido, Japan. Sapporo Bulletin of the Botanic Garden, **1**: 1-101 (in Japanese).

Iwamoto, H. 1932. Akkesiso, a new habitat. J. Jap. Bot., **8**: 144-149 (in Japanese).

Ohwi, J. 1978. Flora of Japan. Shibundo Co., Tokyo (in Japanese).

Tiku, B.L. 1975. Ecophysiological aspects of halophyte zonation in saline sloughs. Plant and soil, **43**: 355-369.

Ungar, I.A. 1965. An ecological study of the big salt marsh. Stafford County, Kansas Univ. Kansas Sci. Bull., **1**: 1-99.