The Science Reports of the Kanazawa University, Vol. VII, No. 1, pp. 85—105, June, 1960.

Characeous Vegetation Study of Lake Kizaki, Japan***

By

Kozo IMAHORI* and Hidefumi SUGA**

(Received)

Introduction

No available data are known for long range succession by Charophyta. Fortunately a detailed ecological study of the Lake Kizaki, Japan, was made by Dr. Harufusa NAKANO in 1927, and although his main object was the ecology of higher aquatic plants, some valuable information is available on the Characeae.

Two studies of the region were made by the writers, one from October 26 to October 29, 1956, and the second in the summer of 1957. The present paper is based upon a comparison of the results of both expeditions and the data from Dr. H. NAKANO's study of 30 years ago.

Description of Habitat

The lake is situated almost in the middle of Honshu, Japan, at the foot of the Japanese Alps. It is considered to be a fault lake. The surface area is 1,413 km², the coast line 6,515 m. and the altitude 745 m. above sea level. The lake is elongated to the north and south, and both ends connect with small rivers, the Upper Nogu and the Lower Nogu. The bottom is mainly mud in the central deeper parts, and sand or sandy mud in the shallow parts. The west shore is steep and rather rocky while the east shore has a gradual slope and is muddy. The latter bottom is covered with an abundance of biotic sediments.

Methods

a) Nakano's method :

The main research was made from September 7 to September 12, 1937, assisted by Mr. T. Oka. Using a plant hook of almost the same type as that used by the present writers', he dredged hydrophytes from a motor boat. Though his study covered almost all parts along the lake shore, the main ecological study was done at the east shore near Uminokuchi where the present writers selected as the Station 6.

No methods are mentioned in his paper regarding the chemical or physical analysis.

* Formerly : Laboratory of Systematic Botany and Phytogeography of the Fuculty of Science, University of Kanazawa, Isikawa-ken, Japan. Present : Bot. Dept., Osaka Univ., Toyonaka, Osaka, Japan.

** Instructor of the Junior High school of Azuma, Nagoya, Japan.

*** Contribution from the Laboratory of Systematic Botany, Fuculty of Science, University of Kanazawa, no. 27.

b) The writers' method :

Eight stations which appeared to exhibit typical vegetation of this lake were selected for the main investigation. (Fig. 1)

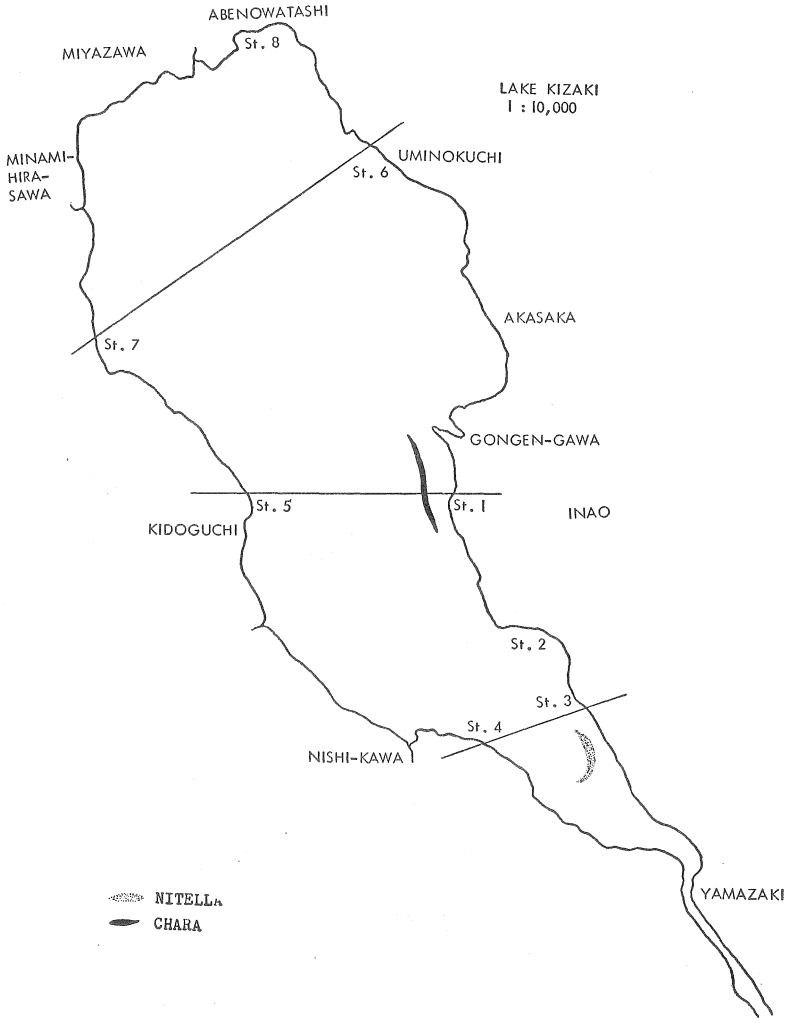

Fig. 1. Distribution of Chara zone in Sept. 1927, and also showing the present authors' stations.

More stations were established on the eastern shore, because the vegetation was more developed on that side.

Collecting was done from a row boat using anchor (cf. Imahori, 1954 : 43, as a heavy plant hook). Determination of pH were made by color indicators, Brom-Thymol Blue being the most useful. The Eckman's reversing water bottle and its reversing thermometer were used for obtaining water sample and for measuring temperatures at various depths. The belt transect method of about 1 m. width was adopted for study of the aquatic vegetation.

Data

a) Nakano's results :

i) Species found :

Two species of Characeae were collected, one of which was a *Chara* and the other one was a *Nitella*. No species were determined in his paper, though the present writers prefar them to be *Chara braunii* and *Nitella flexilis* since these species were commonly found in this lake in 1956–57.

ii) Aspect of the characeous vegetation :

As has been mentioned above, the main ecological study was made at only one station, almost the same place which the present writer called Station 6. Nakano distinguished the following 5 strata at the station, though the last one was not developed :

1. Phragmitetum·····Phragmite-Salix Association; ranging amphibious part.
2. Zizanietum ·····Zizania-Assoc; to 1 m depth.
3. Trapetum·····*Trapa natans* L. var. *Koonibishi* Makino being dominant, *Nymphoides peltatum, Nymphaea tetragona* or *Nuphar japonicum* being mixed; ranging 1–5 m. depth. This stratum takes the place of Nupharetum which is the typical Association in lakes found in Japan.
4. Potamogetonetum ··· Hydrilla verticillata-Ceratophyllum demerosum-Assoc.; ranging 5–8.5 m. depth.
5. Charetum·····Uudeveloped.

Regarding the Charophytes vegetation, Nakano stated that some scanty Charas were growing at the northern part of 'Soro-kaku' and near 'Inao-mura' (St. 2 and 4 of fig. 1), as a component of the fourth stratum (Potamogetonetum) and never developed as an independent zone so-called "Chara bed". He stated, however, that a somewhat depressed Chara zone might exsist at an area near Daigaku (St. 3 of fig. 1), since twice he dredged up several branchlets of *Nitella* from depths of 11.5–13 m. around this area. The distribution of the Charophyte vegetation in 1927 is assumed to be that shown in fig. 1.

b) Writers' results :

i) Species found :

Three species of Characeae were collected, of which two are cosmopolitan and one is endemic. The latter is a new species.

Genus *Chara*

C. braunii Gmelin (pl. 2) A common Japanese *Chara* of world wide distribution. It was common, though not abundant, along the margin of the lake, generally at a depth of 5 m. It did not form a pure community but was mixed with higher aquatic plants, especially *Ceratophyllum demersum* L., *Hydrilla verticillata* Presl. and *Nitella flexilis* Ag.

Genus *Nitella*

N. flexilis Agardh var. *longifolia* Braun (Pl. 3) The dominant plant of this lake. As shown in the figures 8 and 9, the bottom near the shore at depths of 5–10 m., especially on

the eastern shore, is covered with a consociation of this species, forming a so-called "Chara zone–Charetum" or even a "Chara bed".

N. minispora IMAHORI et SUGA (pl. 4) Only one mass of this species was found at the station 6, in water 1–2 m. deep, mixed with *Chara braunii, Hydrilla verticillata, Potamogeton perfoliatus* and *Vallisneria asoatoca.*

ii) Analysis of characeous vegetation :

As shown in the following tables, 1–8 and figures 2–7, Charas in this lake usually occur between 1–2 m. and 12–13 m. deep. *Chara braunii* is generally limited to shallower water and *Nitella flexilis* is most frequent in the deeper area. The former species is generally a subdominant or found as a fragment of association, whereas the latter is a dominant or even forms consociations. In the latter case, the plant is so vegetatively vigorous that it usually produces no gametangia. This stand, of course, exhibits a typical 'Charetum', since only this species can endure the extremely weak light. *Chara braunii,* on the other hand, lives in a more illuminate zone than does *Nitella flexilis,* and it grows, accordingly, in competitive association.

The following detailed explantation of characeous vegetation of each station may be helpful in understanding the tables 1–8 and figures 2–7.

Station 1. This area has the typical slope and substratum of the east shore of the lake. *Nitella flexilis* appears at a depth of 4 m., apparently as a subdominant species of the *Ceratophyllum-Hydrilla-Assoc.* At the depth of 7–9 m., *Nitella flexilis-Association* occurs, forming a Chara bed. This pure stand disappears abruptly at 10–11 m. deep, and is quite absent at depths exceeding 13 m. (fig. 2)

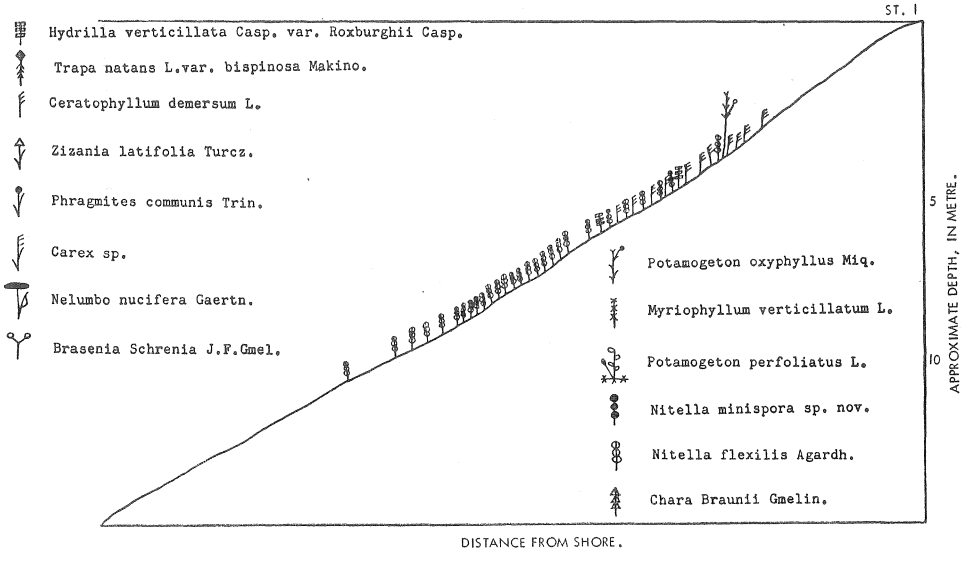

Fig. 2. Diagram of the vertical distribution of hydrophytes at the Station 1.

Table 1. Vertical distribution of species at St. 1.

Depths (m) \ Species	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillatus*	*Potamogeton oxyphyllus*	Edaphic Conditions
0	−	−	−	−	−	Sands & stones
1	−	−	−	−	−	Sandy mud
2	−	−	−	−	−	〃
3	−	−	+	−	−	〃
4	+	−	4	−	1	〃
5	1	−	3	1	−	〃
6	1	−	2	2	−	Muddy
7	5	−	−	−	−	〃
8	5	−	−	−	−	〃
9	5	−	−	−	−	〃
10	1	−	−	−	−	〃
11	±	−	−	−	−	〃
12	−	−	−	−	−	〃

Station 2. The slope here is similar to that at station 1, though the vegetation is more advanced. The dominant species in shallower littoral region is *Hydrilla verticillata* accompanying with *N. flexilis* as a subdominant. This association is gradually replaced by the latter species. At the 5–6 m. depth a *Nitella-Hydrilla-Assoc.* is accompanied by *Chara braunii* and *Ceratophyllum demersum.* In deeper water *Nitella flexilis* becomes the prevailing species. A "Chara bed" of *N. flexilis* appears at a depth of 7–8 m. and disappears at 9-10 m.

Table 2. Vertical distribution of species at St. 2.

Depths (m) \ Species	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillates*
1	−	−	−	−
2	−	−	−	−
3	−	−	−	+
4	1	−	−	4
5	3	+	+	2
6	4	+	+	1
7	5	−	−	−
8	5	−	−	−
9	2	−	−	−
10	−	−	−	−
11	−	−	−	−

Station 3. The slope is also as in Station 1. The vegetation is most advanced and nearest to the climax. A pure stand of *Hydrilla verticillata* appears at 3–4 m. and disappears suddenly at 5 m., being replaced by *N. flexilis Myriophyllum-Assoc.* A "Chara bed" of *N. flexilis* is found between 7 and 10 m. and at 10 m. it suddenly disappears. (Fig. 3)

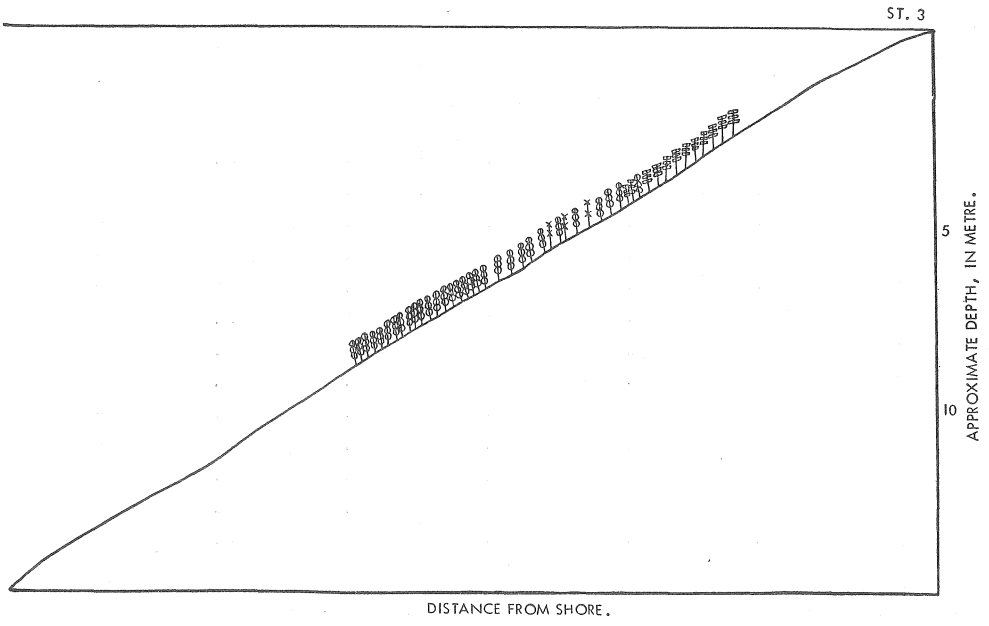

Fig. 3. Diagram of the vertical distribution of hydrophytes at the Station 3.

Table 3. The vertical distribution of species at St. 3.

Depths (m) \ Species	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillatus*	*Myriophyllum spicatum*
0	—	—	—	—	—
1	—	—	—	—	—
2	—	—	—	—	—
3	—	—	—	5	—
4	—	—	—	5	—
5	4	—	—	—	1
6	4	—	—	—	1
7	5	—	—	—	—
8	5	—	—	—	—
9	5	—	—	—	—
10	—	—	—	—	—
11	—	—	—	—	—

Station 4. This station is situated on the western shore and has a steep and sandy bottom. Vegetation is most advanced and nearest to climax of any of the west shore stations. No aquatic plants were found except *N. flexilis* which appears at a 8 m. depth and forms a "Chara bed" between 9 and 12 m.

It is to be noted that the southern area of both shores (Stat. 3 & 4) have the most advanced vegetation in this lake. (Fig. 4)

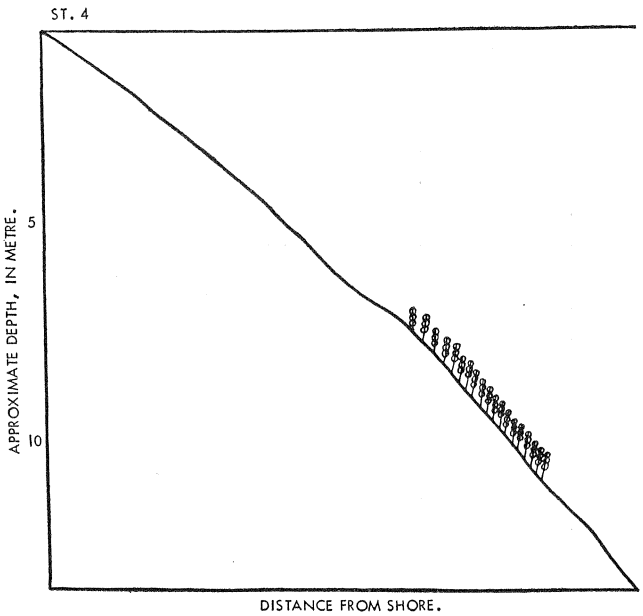

Fig. 4. Diagram of the vertical distribution of hydrophytes at the Station 4.

Table 4. The vertical distribution of species at St. 4.

Depths (m) \ Species	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillatus*
0	—	—	—	—
1	—	—	—	—
2	—	—	—	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	2	—	—	—
9	5	—	—	—
10	5	—	—	—
11	5	—	—	—
12	5	—	—	—
13	—	—	—	—
14	—	—	—	—

Station 5. This area lies opposite Station 1. It has a very steep bottom covered with large and small rocks. As is usual under such topographic conditions, the aquatic vegetation is poorly developed. A sparse *Chara-Hydrilla-Assoc.* appears at a depth of 5 m. A "Chara zone" occurs between 7 and 11 m. deep forming an open association.

Table 5. The vertical distribution of species at St. 5.

Species / Depths (m)	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillatus*	Edaphic conditions
0	—	—	—	—	Stony
1	—	—	—	—	〃
2	—	—	—	—	〃
3	—	—	—	—	〃
4	—	—	—	—	〃
5	—	1	—	±	〃
6	—	—	—	—	Stony Sand
7	±	±	—	—	〃
8	1	—	—	—	〃
9	+	—	—	—	〃
10	+	—	—	—	〃
11	±	—	—	—	〃
12	—	—	—	—	〃

Station 6. Topographic condition of this area is similar with those of Station 1, 2 and 3. The vegetation is, however, the most primitive along the eastern coast. That is to say, the vegetation is composed largely of species which are forming an opening association. A *Phragmites-Salix-Association* first appears, being replaced by a *Potamogeton-Ceratophyllum-Chara Assoc.* dominated by *Ceratophyllum demersum* at a depth of 1–2 m. A depths exceeding 5 m. only *N. flexilis* occurs and it is rather sparse, not forming a so-called Chara bed. This vegetation is apparently in a young stage of succession. (Fig. 5)

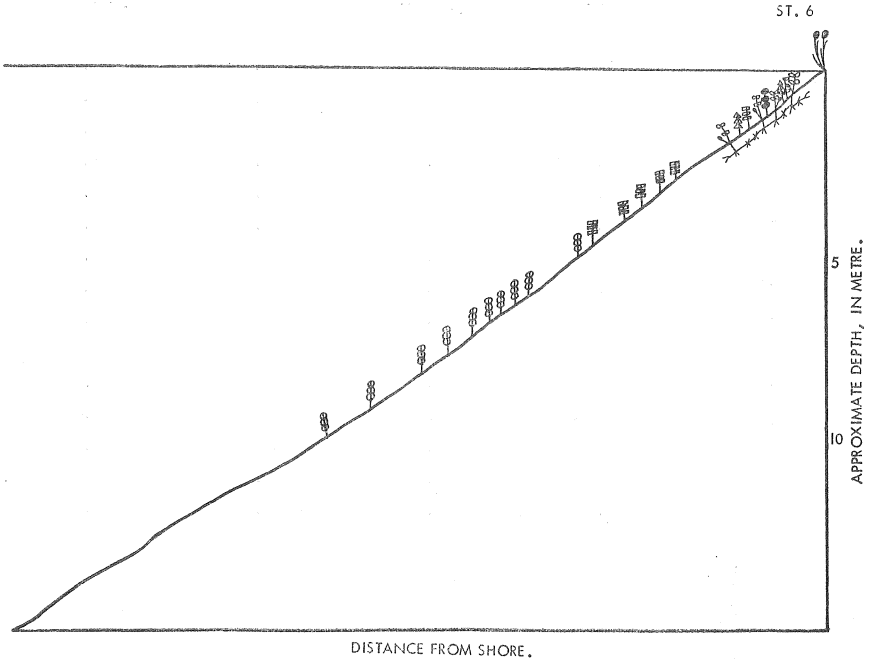

Fig. 5. Diagram of the vertical distribution of hydrophytes at the Station 6.

Table 6. The vertical distribution of species at St. 6.

Depths (m) \ Species	*Nitella flexilis*	*Nitella minispora*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillata*	*Zizania latifolia*	*Phragmites communis*	*Salix integra*	*Potamogeton perfoliatus*	*Potamogeton distinctus*	*Najas major*	*Vallisneria asiatica*
0	—	—	—	—	—	—	4	1	—	—	—	—
1	—	±	1	—	1	—	—	1	3	—	—	±
2	—	—	1	—	1	—	—	—	3	+	+	±
3	—	—	—	—	2	—	—	—	—	—	—	1
4	—	—	—	—	2	—	—	—	—	—	—	1
5	+	—	—	—	—	—	—	—	—	—	—	—
6	3	—	—	—	—	—	—	—	—	—	—	—
7	3	—	—	—	—	—	—	—	—	—	—	—
8	1	—	—	—	—	—	—	—	—	—	—	—
9	+	—	—	—	—	—	—	—	—	—	—	—
10	+	—	—	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—	—	—	—

Station 7. The slope is the steepest of this lake, and the bottom is covered with sand and rocks with very poor biotic sediments. Correspondingly, the aquatic vegetation is poor and exhibits a younger succession stage than that of station 6. *Nitella flexilis* is distributed diffusely and widely between 2 and 11 m. depths. (Fig. 6)

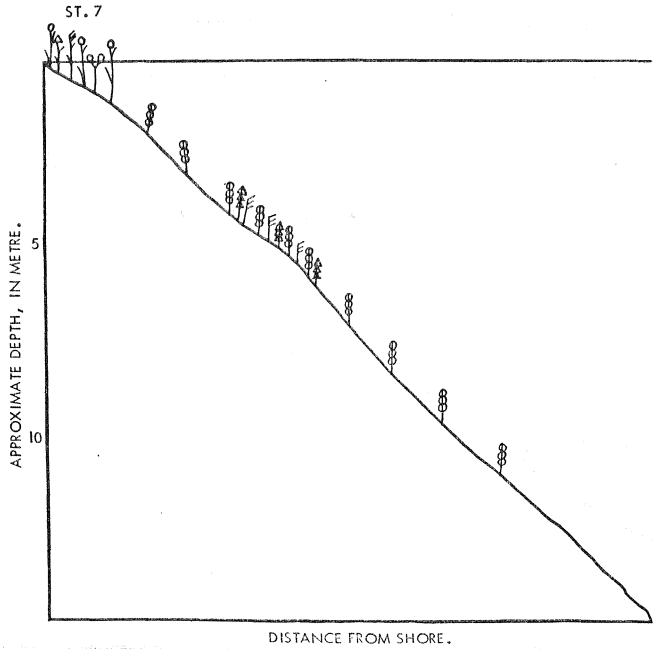

Fig. 6. Diagram of the vertical distribution of hydrophytes at the Station 7.

Table 7. The vertical distribution of species at St. 7.

Depths (m) \ Species	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demerum*	*Hydrilla verticillata*	*Phragmites communis*	*Salix integra*	*Calex* sp.	*Zizania latifolia*	*Potamogeton oxyphyllus*	*Brasenia Schreberi*	*Wisteria floribunda*
0	—	—	—	—	1	+	1	+	1	1	+
1	—	—	—	—	1	+	1	+	1	1	—
2	±	—	—	—	—	—	—	—	—	—	±
3	+	—	±	—	—	—	—	—	—	—	—
4	1	±	—	—	—	—	—	—	—	—	—
5	1	±	—	—	—	—	—	—	—	—	—
6	1	±	—	—	—	—	—	—	—	—	—
7	+	—	—	—	—	—	—	—	—	—	—
8	+	—	—	—	—	—	—	—	—	—	—
9	+	—	—	—	—	—	—	—	—	—	—
10	±	—	—	—	—	—	—	—	—	—	—
11	±	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—

Station 8. The slope is gradual and its water is rather eutrophic. *Nelumbo nucifera* is planted and cultivated in the amphibious zone. The bottom is muddy and rich in biotic sediments. The vegetation has numerous species but their coverage ratio are rather low as shown in the table 8. *N. flexilis* is widely distributed between 3 and 8 m. deep, but it does not form a "Chara bed". The vegetation is, accordingly, primitive. (Fig .7)

The outline of the distribution of characeous vegetation as found in 1956 and 1957 is shown in the following figures. (Fig. 8 & 9)

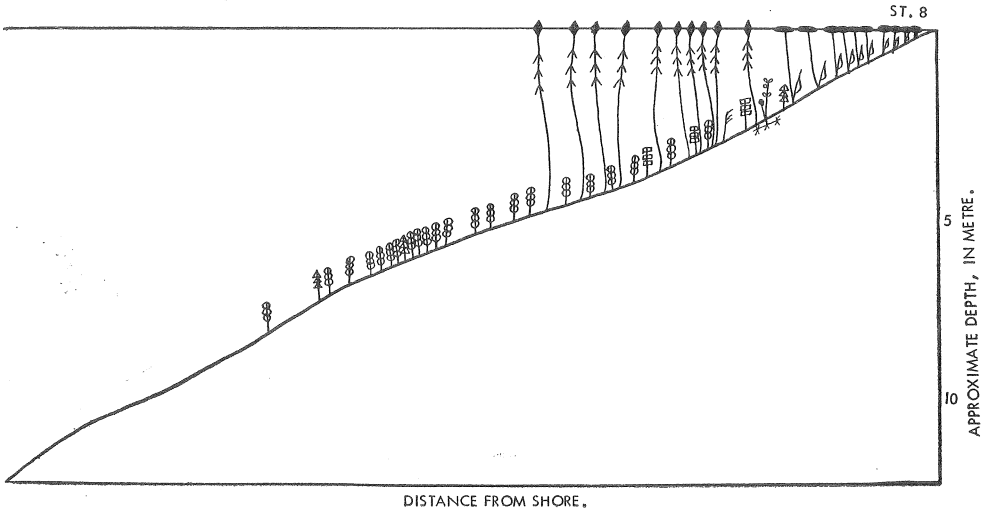

Fig. 7. Diagram of the vertical distribution of hydrophytes at the Station 8.

Table 8. The vertical distribution of species at St. 8.

Species / Depths (m)	*Nitella flexilis*	*Chara braunii*	*Ceratophyllum demersum*	*Hydrilla verticillata*	*Potamogeton perfoliatus*	*Trapa bispinosa*	*Nelumbo nucifera*	*Basin Condition*
0	—	—	—	—	—	—	—	Muddy
1	—	—	—	—	—	—	5	〃
2	—	±	—	1	1	1	2	〃
3	1	—	—	+	—	4	—	〃
4	2	—	—	+	—	3	—	〃
5	3	—	—	—	—	2	—	〃
6	4	+	—	—	—	—	—	〃
7	2	±	—	—	—	—	—	〃
8	+	—	—	—	—	—	—	〃
9	—	—	—	—	—	—	—	〃
10	—	—	—	—	—	—	—	〃

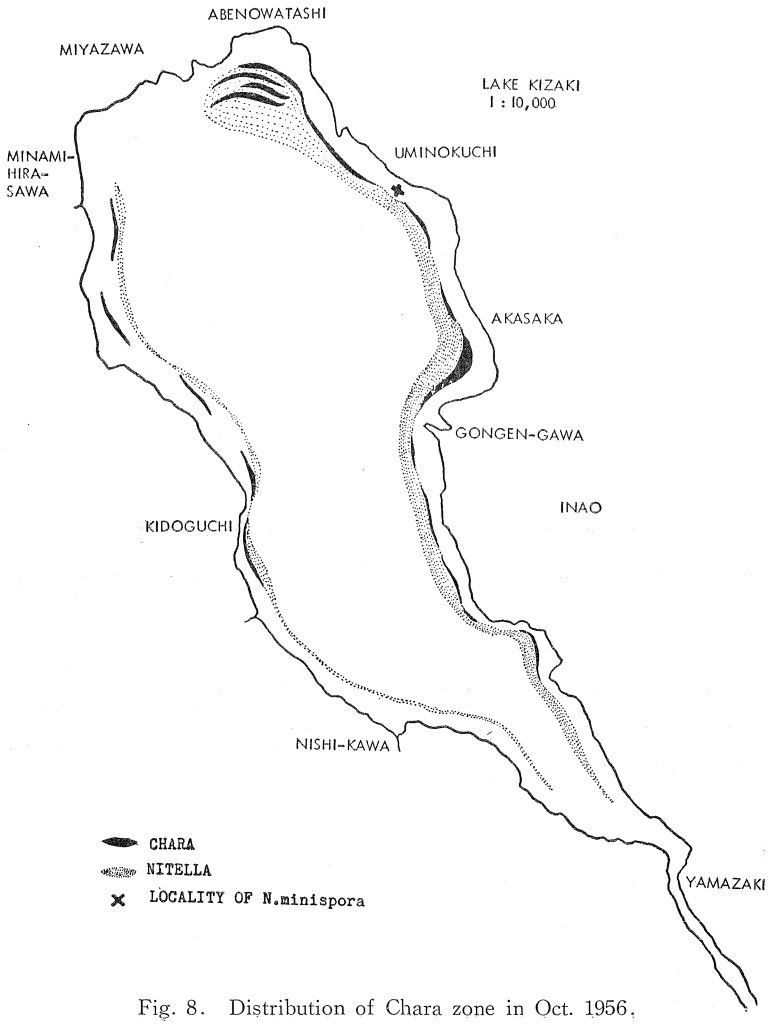

Fig. 8. Distribution of Chara zone in Oct. 1956.

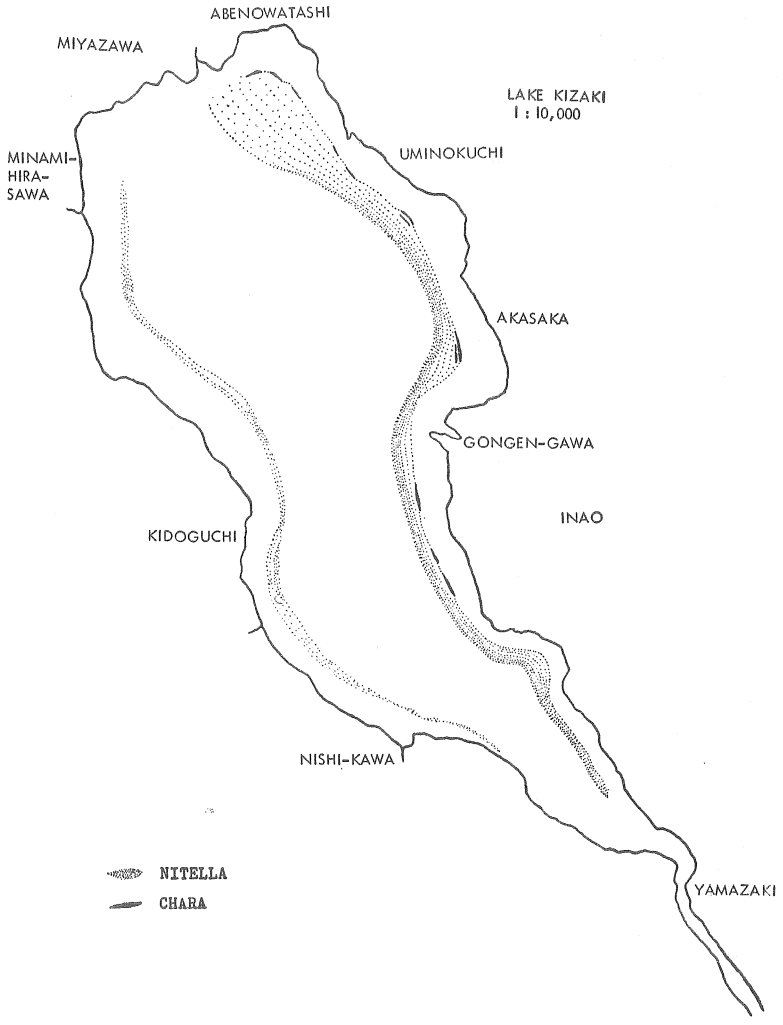

Fig. 9. Distribution of Chara zone in Aug. 1957.

The otherwise continuous "Chara zone" is broken both at the north and south ends. This fact may be caused by the rather rapid movement of water as the areas are near rivers.

Generally, the northern part of the lake had more species than does the southern part. The coverage ratio of each species of the northern vegetation was lower than that of the southern vegetation. These two data seem to explain that the southern hydrophytia is nearer to the climax than the northern one.

Conclusions :

Our analysis of this lake was made just 30 years after Dr. Nakano's investigation. In the meantime no work on Characeae has been done in this lake. It may prove naive to draw conclusions on the bases of Dr. Nakano's and the present writers' data, because some serious and unexpected changes could have occurred during these decades.

It appears likely, however, that the vegetation changes have been gradual during these years, and that no serious unexpected changes have occurred. This seems probable because on comparing the vegetation of our stations it is found that the vegetation which was most near to climax in 1956 is found at the area where the most advanced vegetation occurred in 30 years ago. That is to say, 30 years ago *Nitella flexilis* was found only at the station 3, and now this station has the most vigorous "Chara bed" in this lake. Moreover, no serious topographic changes have been reported in this lake during these years.

a) Changes occurred in vegetation :

On comparing the vegetation of 1927 and of 1957, it is found that marked succession has occurred during 3 decades. "Chara zone" or "Chara bed" developed along almost all shore lines between 5 and 12 m. deep, as is clearly seen by comparing figures 1 and 8 or 9. It can be concluded that the vegetation of eastern littoral area is now that of a typical widely distributed "Chara bed", though very scanty bed were found only in the small area around the Station 3, 30 years ago. No Charas were found at the western littoral zone in 1927, but now a belt of Chara bed is covers this zone, though the vegetation is not so vigorous as that of the eastern shore. It is also an interesting fact that the Chara zone has been getting shallower.

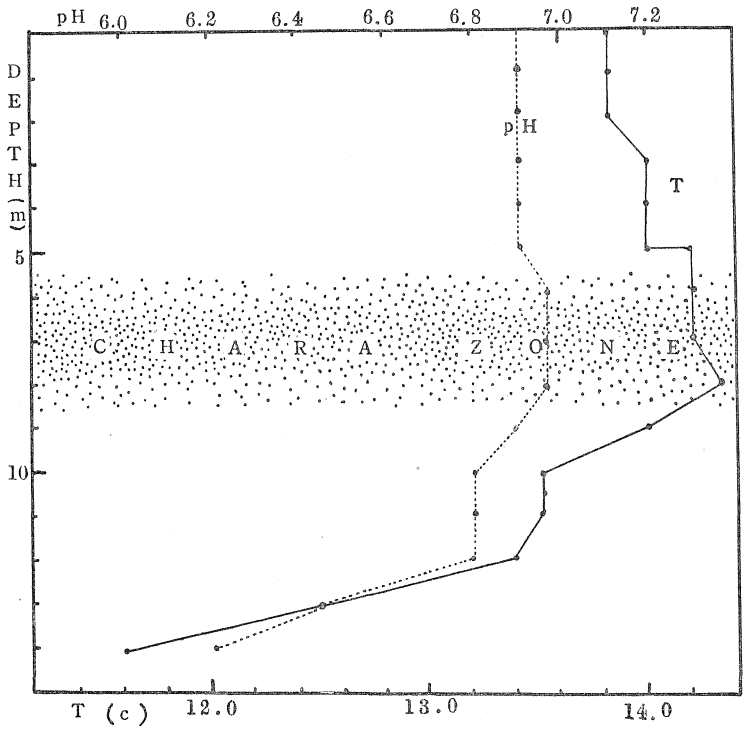

Fig. 10. Vertical distribution of pH, temperature and Chara zone at the Station 6, in Oct. 1956.

b) Changes in chemical-physical factors :

Regarding the chemical-physical factors of this lake, very valuable and detailed data appeared in the contribution by Viscount A. Tanaka (1930) in which he reviewed numerous data during several decades. On the other hand, it is regrettable that the present writers' investigation were limited to only pH, temperature and transparency. The following tables show the changes of factors during 30 years or more.

Table 9. Decrease of the Transparency at Lake Kizaki

Date	Transparency (m)
Oct. 23, 1909	10.0
Aug. 18, 1918	7.0
Aug. 23, 1924	7.2
Aug. 21, 1926	7.2
Aug. 4, 1927	6.3
Aug. 6, 1957	4.0

Table 10. Thermal and pH Zonation in Lake Kizaki

	St. 6 (East shore) Imahori et Suga Oct. 28, 1956		St. 7 (West shore) Imahori et Suga Oct. 29, 1956		Center of the lake Nakano et Oka December 1927	
Depth (m)	Temperature (C°)	pH	Temperature (C°)	pH	Temperature (C°)	pH
0	13.8	7.1	12.5	6.9	7.4	6.8
1	13.8	6.9	13.1	6.9	—	—
2	13.8	6.9	13.1	6.9	—	—
3	14.0	6.9	13.6	6.9	—	—
4	14.0	6.9	13.7	6.9	—	—
5	14.0	6.9	13.8	6.9	7.7	6.8
6	14.2	7.0	13.6	6.9	—	—
7	14.2	7.0	13.3	6.9	—	—
8	14.3	7.0	13.4	6.9	—	—
9	14.0	6.9	13.5	6.9	—	—
10	13.5	6.8	13.4	6.9	7.7	6.8
11	13.5	6.8	13.4	6.9	—	—
12	13.4	6.8	13.2	6.9	—	—
13	12.5	6.5	13.0	6.7	—	—
14	11.6	6.2	12.6	6.4	—	—
15	—	—	—	—	7.6	6.7
20	—	—	—	—	7.6	6.7
30	—	—	—	—	7.5	6.6

Table 11. The depths of Chara zone of *Nitella flexilis* and its hydrotherm and pH at each station in 1956.

Station	Depths (m)	pH		(C) Temperaturess		Date	Whether
		surface	Charetum	surface	Charetum		
1	7– 9	7.0	6.6	11.6	13.3	Oct. 26	Cloudy
2	7– 8	—	—	—	—	—	—
3	7– 9	7.0	6.8	12.0	14.6	Oct. 26	Cloudy
4	9–12	—	—	—	—	—	—
5	8	6.8	6.8	10.9	13.2	Oct. 26	Cloudy
6	6– 7	7.1	7.0	13.8	14.2	Oct. 28	Clear
7	4– 6	6.9	6.9	12.5	13.6	Oct. 29	Rainy
8	6	—	—	—	—	—	—
AVERAGE	6.8–8.2	7.0	6.8	12.2	13.8		

From these tables no remarkable changes are found regarding the temperatures and pH. Concerning the transparency, however, it is apparent that the value have decreased markedly. The decrease is, of course, the result of the increase of the organic products.

c) Factors seem to have caused the change of vegetation :

It is not possible to resolve all of the factors which caused this remarkable succession. One of the main factors which is apparent, however, is the decrease of transparency of the water. The decrease of transparency apparently caused the peculiar succession of the whole vegetation of this lake. That is to say, the habitat succeeds to the shallower parts in the course of diminishing the light available by submerged plants.

The second important factor in this succession is the increase of the production of organic matter in the lake. The unsuccessful hydrophytes would decomposed and acumulated on the bottom where a prevailing *Nitella* vegetation occurred. Such increasing eutrophic condition would caused a more vigorous growth resulting in a "Chara bed".

The third factor which can be point out is the depth of the Chara zone which is in the range of temperature within which only *N. flexilis* can grow vigorously. Regarding this range of temperature two phases are related, one is the water temperature in autumn when the Charophytes are in the growing and reproductive stage, and the other concerns the seasonal fluctuation of the water temperature. As shown in Fig. 10, the highest water temperature in the autumn is found at the zone between 5 and 9 m. deep where the Chara bed is developing. The latter phase is explained in the following figure. (Fig. 11) This figure shows the seasonal fluctuation of water temperature at different depths, from November 1924 to December 1927. These data are based on the Tanaka's contribution and cite only the water temperatures during the seasons in which the Charophytes were growing in the lake, from April to December. According to this figure, the zone between 0 and 5 m. depths show the great fluctuation in temperature which is presumed to be adverse for the Charophytes vegetation. The low temperatue at the zone between 15 and 20 m. depths, which does not exceed 9°C. even in the mid summer, is not adequate for the development

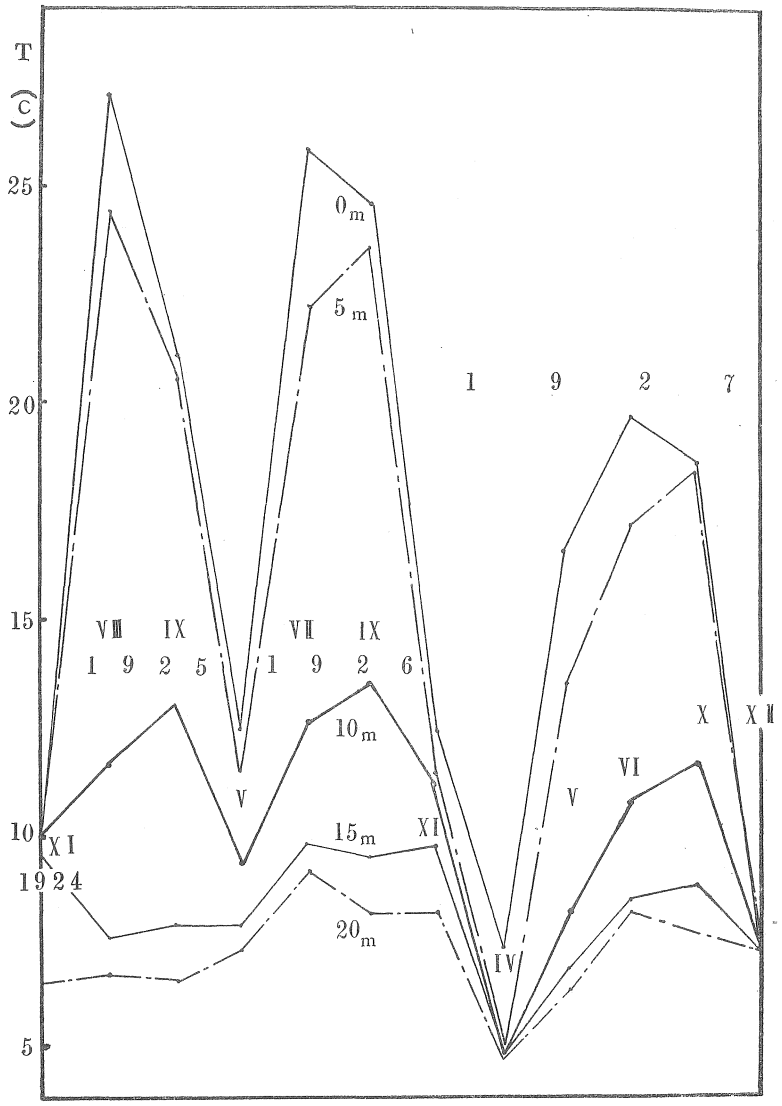

Fig. 11. Seasonal fluctuation of hydrotherm at different depths, from November 1924 to December 1927.

of the Chara bed, though the fluctuation of temperature is very small. The 10 m. zone, however, shows the small fluctuation and usual moderate temperature suitable for Charophyte vegetation.

These factors mentioned above are, of course, interrelated. That is to say, eutrophic conditon of water effects on the water transparency, which relates with light intensity in water. The vegetation itself effects on the water temperature. Anyhow, it seems that the Chara bed is now well developed in this lake since 6–9 m. deep zone is now in the optimum condition for growing Charophytes.

It is well known, however, that many characeous vegetations fluctuate and are hardly

stable. Therefore, the succession of the present lake might be more complicated or more or less different from the way the present writers have pictured. They need, therefore, a more lengthy investigation of this problem lasting many years, to complete their work.

Acknowledgment :

The authors are deeply indebted to Dr. Richard D. Wood, Professor of Botany, University of Rhode Island, for his valuable criticism and suggestion.

Summary

1. An ecological investigation of Characeae in the Lake Kizaki was made to determine the probable succession during a long period.

2. Eight stations (5 on the east and 3 on the west shore) were selected for investigation of the vegetation and enviroment.

3. The western stations have rather poor vegetation, limited mainly by topographic conditions. The eastern stations have the rather typical hydrophytia as found in other lakes.

4. Generally, the northern part of the lake has more species than does the southern part. The southern hydrophytia is nearer to the climax than is the northern one.

5. The vegetation has changed tremendously during 30 years. *Nitella flexilis*, which seems to have formed a poor vegetation belt 30 years ago, is now abundant and forms a wide "Chara bed".

6. The Chara zone is becoming more shallow.

7. Biotic and abiotic factors were analyzed in an attempt to explain the succession of this lake during 3 decades.

8. It is concluded that transparency, water temperatures and eutrophic conditons are the main factors which influenced the succession.

References

CORILLION, R. 1957 : Les Charophycees de France et d'Europe Occidentale. 1–497.

IMAHORI, K. 1954 : Japanese Charophyta. Maruzen. 1–234.

IMAHORI, K. et H. Suga, 1958 : Preliminary note on the succession and distribution of Characeae in the Lake Kizaki, Japan. Journ. Jap. Bot. 33 (8) : 16–20. (in Japanese with English summary).

NAKANO, H. 1930 : The vegetation of Lakes and swamps in Japan. 5 Report. Lake Kizaki, Nakatsuna, and Aoki. in Tanaka's Contribution on the lakes and swamps of northern Japan Alps. 572–609. (in Japanese)

TANAKA, A. 1930 : Contribution on the lakes and swamps of northern Japan Alps. 1–1036. (in Japanese)

WOOD, R. D. 1950 : Stability and zonation of Characeae. Ecology, 31 (4). 642–647.

WOOD, R. D. 1952 : An analysis of ecological factors in the occurrence of Characeae of the Woods Hole Region, Mass. Ecology 33 (1). 104–109.

Plate I. Photos of the Lake Kizaki

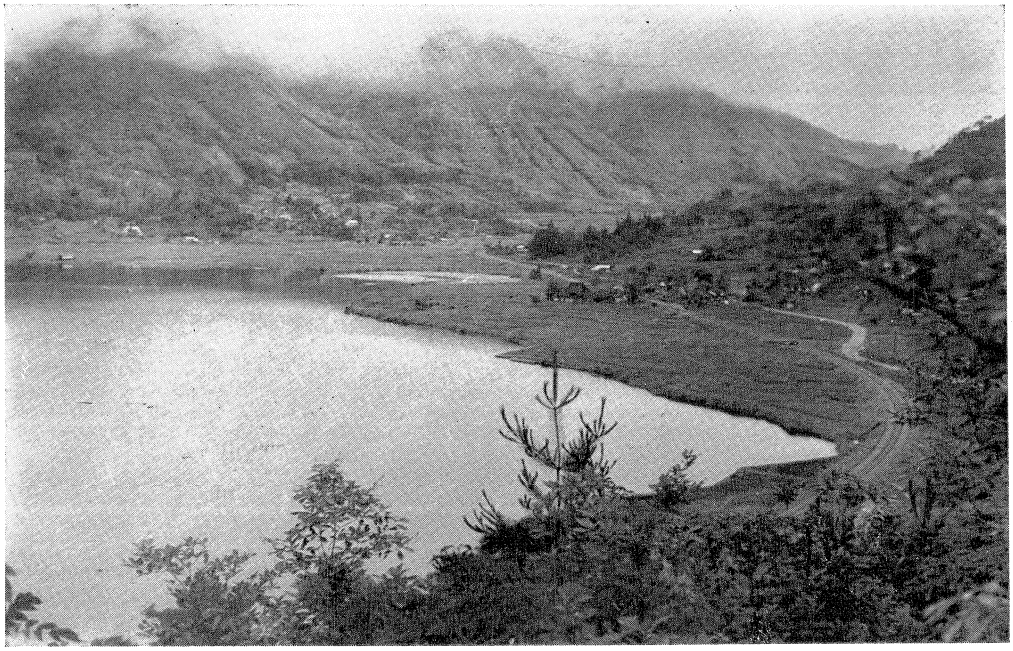

Photo 1. Northern shore, showing Station 8 at the left, Station 6 at the right hand

Photo 2. Vegetation near the Station 7.

Plate II. Habit of *Chara braunii* Gmelin

Plate III. Habit of *Nitella flexilis* Agardh var. *longifolia* Braun

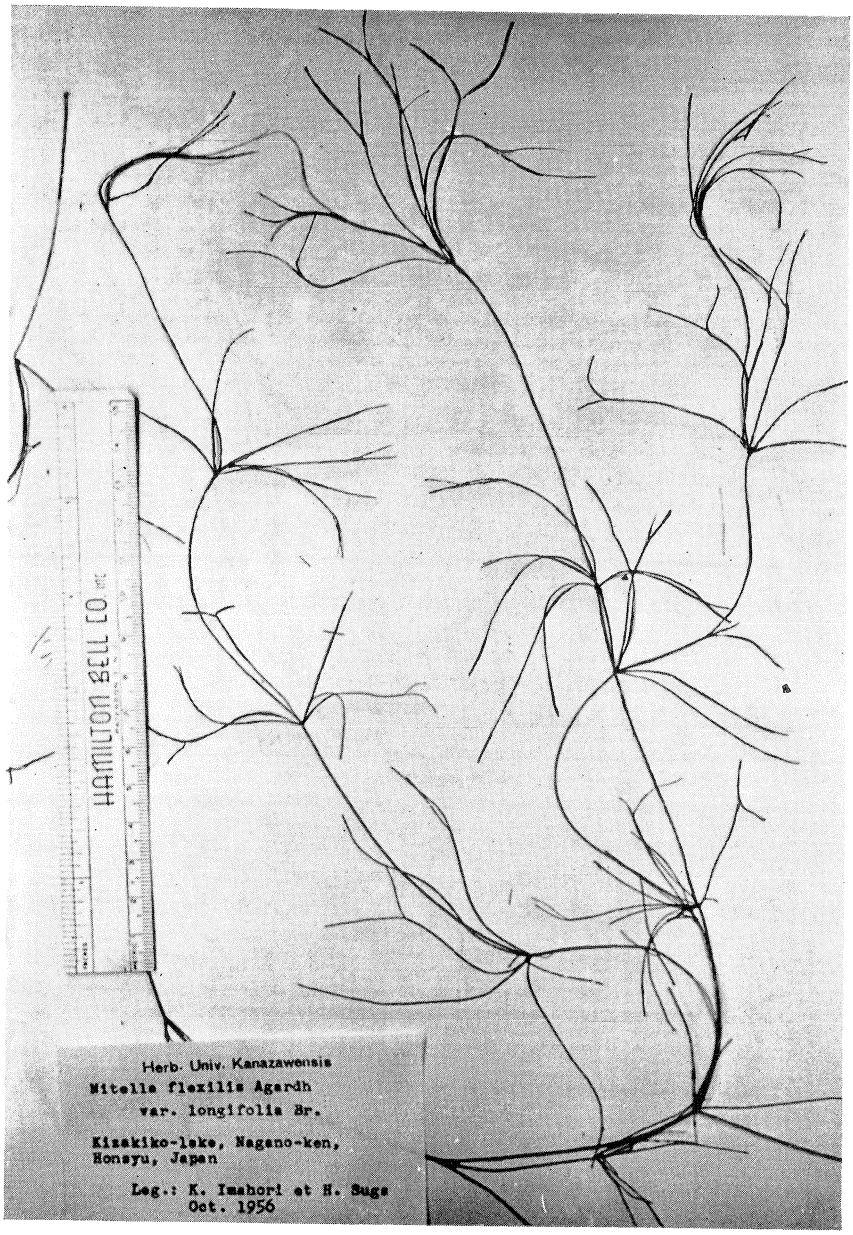

Plate IV. Habit of *Nitella minispora* Imahori et Suga