The Science Reports of the Kanazawa University, Vol. III, No. 1, pp. 93—99, March, 1955.

Phytogeographical survey on *Charophyta*-flora in the Ryukyu Islands.

By

Kozo IMAHORI

(Received October 7, 1954)

The Ryukyu Islands (including Okinawa and Amami Islands) are a very interesting region from the standpoint of phytogeography as well as that of zoogeography. The distributional research on vascular cryptogamic and flowering plants has been done and made clear by some authorities, e. g. Dr. E. D. MERRILL (1923, '26) and Dr. Genkei MASAMUNE (1931, '33). They pointed out that this region shows the remarkable characteristic of the Paleotropical floral zone, although it is situated at the boundary line between the Paleotropical and Holoarctic floral zones.

The phytogeographical remarks of lower plants, on the other hand, do not always agree with those of higher plants, because one group of the lower plants is different from another in its dispersal factor. It is very regrettable that the study of the cryptogamic flora of the present region is considerably incomplete, and that of the algal flora, above all the *Characeae*, has been left almost untouched from the viewpoint of Phytogeography. Very recently, however, the present author has investigated the *Charophyta* flora in this region and reported the following 11 species in a few papers.

Table 1. Charophyta found in the Ryukyu Islands.

Species name	Japanese name
Chara Braunii GMELIN	Syazikumo
C. corallina WILLDENOW	Oh-syazikumo
C. Benthamii A. BRAUN	Kenaga-syazikumo
C. gymnopitys A. BRAUN	Ito-syazikumo
C. vulgaris L.	
ssp. *euvulgaris* ZANEVELD	Sekkai-syazikumo
ssp. *squamosa* ZANEVELD	Timba-syazikumo
C. zeylanica WILLDENOW	Hadasi-syazikumo
C. sejuncta A. BRAUN	America-syazikumo
Nitella acuminata A. BRAUN	Togari-hurasumo
N. Horikawae IMAHORI	Horikawa-hurasumo
N. axilliformis IMAHORI	Miru-hurasumo
N. pseudoflabellata A. BRAUN	Husa-hurasumo

According to his investigation, no endemic species is found in the region, but 6 species are common with the Philippine Islands, 8 species with Formosa, 10 species with

Contribution from the Laboratory of Systematic Botany of the Faculty of Science, Kanazawa University, no. 20 (1955)

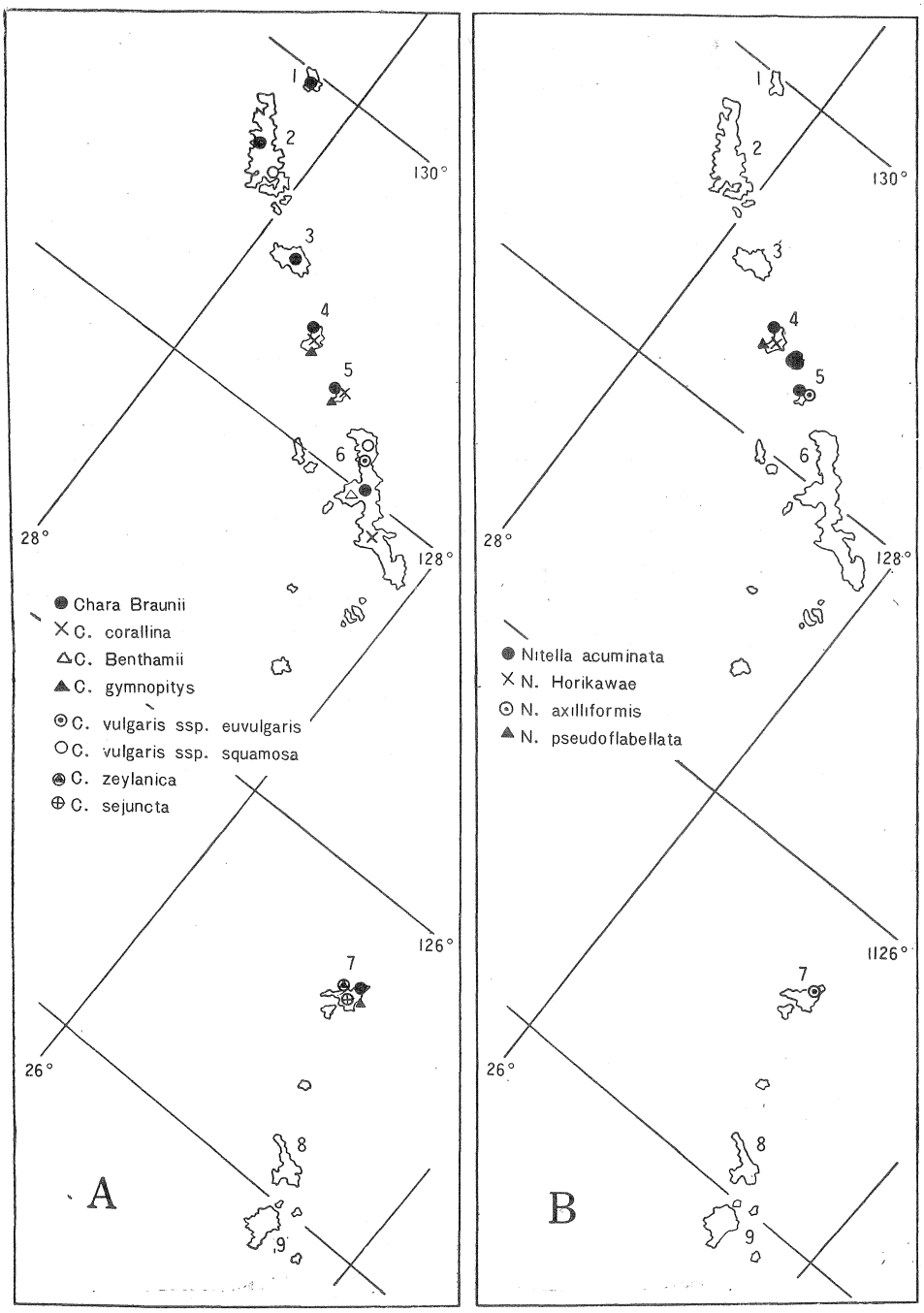

Fig. 1. Distribution map of Charophyta in the Ryukyu Islands.
A. Distribution of *Chara*. B. Distribution of *Nitella*.
1. Kikai-sima 2. Amami-Ohsima 3. Tokuno-sima
4. Okierabu-sima 5. Yoron-sima 6. Okinawa-sima
7. Miyako-sima 8. Isigaki-sima 9. Iriomote-sima.

Japan-Hondo, and only 1 species is common with Hokkaido.

In order to show the phytogeographical feature of the Ryukyus more clearly, the author indicates in Table 2, all the indigenous species which are found in the Ryukyus and their adjacent regions, together with their distribution.

Table 2. The distribution of Charophyta in neighbouring regions of the Ryukyu Islands.

	Philipp.	Formosa	Kyusyu	Sikoku	Honsyu	Hokkaido
Chara Braunii	+	+	+	+	+	+
C. corallina	+	+	+	+	+	−
C. Benthamii	+	+	+	+	+	−
C. gymnopitys	+	+	+	+	+	−
C. vulgaris euvulgaris	−	−	−	−	−	−
C. vulgaris squamosa	−	+	−	−	−	−
C. zeylanica	+	+	+	+	+	
C. sejuncta	−	−	+	+	+	−
Nitella acuminata	+	+	+	+	+	
N. Horikawae	−	−	+	−	+	−
N. axilliformis	−	+	+	−	+	−
N. pseudoflabellata	−	−	+	+	+	−
No. of common spp.	6	8	10	8	10	1
No. of spp. comprised in the region	9	19	35	29	52	9
% of common spp.	67.7	42.1	28.6	27.6	19.2	11.1
Average % of common spp. in floral zones	54.9		21.6			

This table shows that the Philippines' flora has 9 species, in which 6 (67.7%) species are common with the flora of the Ryukyus : Formosan flora has 19 species, in which 8 (42.1%) are common with that of the Ryukyus : Kyusyu flora has 35 species, in which 10 species (28.6%) are common with that of the Ryukyus ; Sikoku flora has 29 species, in which 8 (27.6%) are common with that of the Ryukyus ; Honsyu flora has 52 species, in which 10 (19.2%) are common with that of the Ryukyus ; and Hokkaido flora contains 9 species in which only 1 species (11.1%) is common with that of the Ryukyus. The average percentages of common species in Formosa and Philippines (Paleotropical) are 54.9% and those of Japan Hondo and Hokkaido (Holoarctic) are only 24.5%.

From the inspection of these data, one can see that the Ryukyu Islands are closely allied phytogeographically with Formosa and Philippines, and it is clear that they belong to the paleotropical floral zone, while Japan-Hondo and Hokkaido are phyto-geographically far from the Ryukyu Islands though they are very closely situated geographically.

But in the present writer's opinion, it is unreasonable and dangerous to depend only

upon these values, because these regions are extremely different from one another in the number of species which compose their florae. In order to make up for this deficiency, the author adopted the following method. Let 'a' be the total number of the indigenous species in A-Province flora and let 'b' be the total number of the species found in B-Province flora. And let 'c' be the number of the common species between A- and B-Provinces. Now, the value of affinity between A- and B-florae (V) is represented by the following formula :

$$V=\frac{c}{2}\left(\frac{1}{a}+\frac{1}{b}\right)\times 100$$
$$=50\ c\left(\frac{a+b}{ab}\right)$$

Here, the author obtains Table 3, which shows the affinities of the relation between the Ryukyus' flora and their neighbouring florae of *Charophyta*, compared with the affinities in *Phanerogames*.

Table 3. The affinity of relation between the Ryukyus and any adjacent region.

	Charophyta		*Phanerogames*
Philippines	$50\times 6\left(\frac{20}{9\times 11}\right)\fallingdotseq 60.6$	59.1	72
Formosa	$50\times 8\left(\frac{30}{19\times 11}\right)\fallingdotseq 57.5$		76
Kyusyu	$50\times 10\left(\frac{46}{35\times 11}\right)\fallingdotseq 59.6$	54.9	
Sikoku	$50\times 8\left(\frac{40}{29\times 11}\right)\fallingdotseq 50.0$		67
Honsyu	$50\times 10\left(\frac{63}{52\times 11}\right)\fallingdotseq 55.1$		
Hokkaido	$50\times 1\left(\frac{20}{9\times 11}\right)\fallingdotseq 10.1$		32

Contraly to his expectation, this table indicates that the Ryukyus are most affinitive to the Philippine Islands, while Kyusyu is next in affinity, and Formosa, which is closest geographically, is far from the Ryukyus phytogeographically. That is, Wataseline which separates the paleotropical and Holoarctic floral zones, is almost nonsense so far as the *Charophyta* flora is concerned, though a slight trace can be found in the average values of Paleotropics and Holoarctics.

Besides these data, in order to make clear the situation of the Ryukyu Islands flora, the author wants to present the following tables which indicate the affinities of relation between one region and another. These tables were obtained in the same way that was adopted in the last table.

The tables 4, 5 and 7 show that Ryukyu is intimate with Paleotropics, but table 6 indicates that Japan-Hondo is closest to Ryukyu. In short, it seems that *Charophyta* flora of Ryukyu has no evident feature of the Paleotropical floral zone. Then, we reach a doubtful result.

Table 4. The affinity of relation between the Philippines and any adjacent region.

	Charophyta	*Phanerogamia*
Formosa	$\left(\frac{9+19}{9\times19}\right)\times50\times7\fallingdotseq57.3$	66
Ryukyu	$\left(\frac{9+11}{9\times11}\right)\times50\times6\fallingdotseq60.6$	72
Japan Hondo	$\left(\frac{56+9}{56\times9}\right)\times50\times7\fallingdotseq45.1$	45
Hokkaido	$\left(\frac{9+9}{9\times9}\right)\times50\times1\fallingdotseq11.1$	36

Table 5. The affinity of relation between Formosa and any adjacent region.

	Charophyta	*Phanerogamia*
Philippines	$\left(\frac{9+19}{9\times19}\right)\times50\times7\fallingdotseq57.3$	66
Ryukyu	$\left(\frac{11+19}{11\times19}\right)\times50\times8\fallingdotseq57.5$	76
Japan Hondo	$\left(\frac{56+19}{56\times19}\right)\times50\times13\fallingdotseq45.8$	66
Hokkaido	$\left(\frac{9+19}{9\times19}\right)\times50\times3\fallingdotseq24.5$	47

Table 6. The affinity of relation between Japan-Hondo and any adjacent region.

	Charophyta	*Phanerogamia*
Philippines	$\left(\frac{56+9}{56\times9}\right)\times50\times7\fallingdotseq45.1$	45
Formosa	$\left(\frac{56+19}{56\times19}\right)\times50\times13\fallingdotseq45.8$	66
Ryukyu	$\left(\frac{11+56}{11\times56}\right)\times50\times10\fallingdotseq62.5$	67
Hokkaido	$\left(\frac{9+56}{9\times56}\right)\times50\times9\fallingdotseq58.1$	73

Table 7. The affinity of relation between Hokkaido and any adjacent region.

	Charophyta	*Phanerogamia*
Philippines	11.1	36
Formosa	24.5	47
Ryukyu	10.1	41
Japan Hondo	58.1	73

Now, the author analyzes each distribution of Ryukyu flora to solve the problem. Ryukyu is the northernmost limit in the distribution of only one species—*Chara vulgaris*, while it is the southernmost limit of three species, i. e., *Nitella pseudoflabellata*, *N. Horikawae* and *Chara sejuncta*. This datum shows also that the Watase line seems absurd for the *Charophyta* distribution. But the following detailed investigation makes this supposition a little more doubtful. He adopted a macrofrequency method, that is if any species was found in only two islands in the 10 surveyed islands, the value of macrofrequency is $2/10 \times 10 = 2$.

Table 8. The macrofrequency of Charophyta in Ryukyu Islands.

Species	No. of islands found the sp.	Macrofrequency
Chara Braunii	7	10
C. corallina	3	4
C. Benthamii	1	1
C. gymnopitys	3	4
C. vulgaris	3	4
C. zeylanica	1	1
C. sejuncta	1	1
Nitella acuminata	2	3
N. Horikawae	1	1
N. axilliformis	2	3
N. pseudoflabellata	1	1

Seven islands, namely Kikai-Sima, Amami-Ohsima, Tokuno-Sima, Okierabu-Sima, Yoron-Sima and Miyako-Sima, are surveyed by the author, and each flora is shown in Figure 1. Inspecting the macrofrequency of each species which is shown in Table 8, it is clear that *Chara Braunii*, *C. corallina*, *C. gymnopitys* and *C. vulgaris* are ancient species in this region, while *Chara Benthamii*, *C. zeylanica*, *C. sejuncta*, *Nitella Horikawae* and *N. pseudoflabellata* are recent species. That is to say, all the southernmost species in these islands are recent ones, while the northernmost species are ancient. The ancient species have been indigenous to the region, while the recent ones were afterward dispersed mainly by migratory water fowl. In fact, there are some fowl which migrate from the Philippines and Formosa to Japan-Hondo via Ryukyu Islands, such as snowy herons, night-herons and snipes.

Now, the writer considers that in past time, the Watase line was distinct in the *Charophyta* distributions as well as in the *Phanerogames*, but the peculiar dispersal factor of *Charophyta* made the line indistinct afterward.

Finally, the author wants to express his sincere thanks to Dr. Siro KITAMURA, Professor of Botany in Kyoto University and Dr. Masaji HONDA, Professor of Botany in Tokyo University, who kindly gave facilities for the writer to see many valuable specimens

which were preserved in the herbaria of these universities. He is also grateful to Mr. Tosio SHIN, Assistant Professor in University of Kagosima Prefecture, who has kindly collected and sent many specimens to him.

Summary

1. The author identified 11 species from the Ryukyu Islands flora.

2. Some data show that the Watase line is almost nonsensical so far as the *Charophyta* distribution is concerned.

3. But more detailed research leads to the following conclusion that the line had been distinct in past time, but became gradually indistinct by the peculiar dispersal factors of *Charophyta*.

References

GROVES, H. & J. 1912 : *Characeae* from the Philippine Islands. Philipp. Journ. Sci. Bot. **7**, pp. 69—70.

IMAHORI, K. 1948 : Miscellaneous papers on the east Asiatic *Charophyta* 1. Journ. Jap. Bot. **22**, pp. 40—45.

—— 1950 : Notes on the Asiatic *Charophyta* 2. Bot. Mag. Tokyo, **63**, pp. 260—264.

—— 1951 : Studies on the *Charophyta* in Formosa 1. Sci, Rep. Kanaz. Univ. **1**, pp. 201—221.

—— 1953 : Studies on the *Charophyta* in Formosa 2. Sci. Rep. Kanaz. Univ. **2**, pp. 121—135.

—— 1953 : Miscellaneous papers on the east Asiatic *Charophyta* 3. Journ. Jap. Bot. **28**, pp. 11—16.

—— 1954 : Similarity between the *Characeae* of Formosa and Philippine Islands, Acta Phytotax. Geobot. **15**, pp. 123—128.

—— 1954 : Miscellaneous papers on the east Asiatic *Charophyta*, 5. Journ. Jap. Bot. **29**, pp. 153—159.

—— 1954 : Ecology, phytogeography and taxonomy of the Japanese *Charophyta*, pp. 1—234. Maruzen, Tokyo.

MASAMUNE, G. 1931 : A table showing the distribution of all the genera of flowering plants, which are indigenous to the Japanese Empire. Ann. Rep. Taihoku Bot. Gard. **1**, pp. 51—92.

—— 1933 : Phytogeographical position of Japan concerning indigenous genera of vascular cryptogamic plants. Jap. Journ. Bot. **6**, pp. 307—314.

MERRILL, E. D. 1923 : Die Pflanzengeographische Scheidung von Formosa und den Philippinen. Engler Bot. Jahrb. **58**, pp. 599—604.

MIGULA, W. 1930 : Ueber einige japanische *Characeen*. Hedwigia **70**, pp. 211—215.

WHELDEN, M. 1947 : A note on a *Chara* new to the Philippine Islands. Farlowia **3** (1), pp. 67—71.