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Studies of the Fresh-water Plankton of Central China, I.

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Introduction

In spite of the richness of various inland waters, our present knowledge of the fresh-water plankton of Central China is still very narrowly limited. Although excellent works have been published by several authors, *viz.*, G. O. SARS (1903), LEMMERMANN (1907), BREHM (1909, 1930), BURCKHARDT (1913, 1924), UÉNO (1927, 1932), and TUGE, KOKUBO and IMAI (1939), these studies were based on more or less fragmentary materials, most of the localities of their materials being limited to the coastal region. Recently, MIYADI and UÉNO of the University of Kyoto made a survey of the inland waters in the coastal region of Sekiang Province (the Yangtse delta), the results of which were investigated by many authors and published in the form of "Reports on the Limnological Survey for Central China" (in Japanese) in 1944.

During the last war, the present writer spent about three years (1940 to 1943) in Central China as a soldier and was happy enough to make a number of plankton collections in the area extending from Kiu-kiang to Lake Tung-ting-hu along the Yang-tse-kiang. The present report is the result of his studies on these materials. It is very regrettable to the writer that considerable parts of the materials have been lost because of extremely unfavourable conditions of their preservation and transportation.

In carrying out the present work the writer is indebted to many persons for their kindness and aid. First, it is the writer's pleasure to record here his hearty thanks to ex-Colonel T. YUNOKAWA and ex-Major Dr. M. YAMADA for their kindness without which the collection of these materials by a mere soldier in such a wide area and in various seasons as will be mentioned, might have been impossible. The writer also wishes to express the sense of gratitude he feels towards Mr. R. HOSHINO for his aid, through which the collection of Tung-ting-hu plankton was successfully made. To late Prof. Dr. S. HÔZAWA and Dr. S. KOKUBO of the Tôhoku University and Dr. M. UÉNO of the University of Kyoto, the writer wishes to express his sincere thanks for their kind and helpful advice rendered in his study. Further, the writer is greatly indebted to Mr. K. YAMAMOTO and Mr. H. YAMAGUCHI of the University of Kyoto who kindly rendered helpful aid in identifying the rotifers and diatoms, respectively. Finally, the writer expresses his gratitude to Prof. S. HIBINO and Prof. K. MIYAMURA of the Kanazawa University for their kindness in reading the original manuscript.

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Material

The material treated in the present study consists of 232 samples which were collected during the period of about three years (1940—1943) by the writer at about 33 localities in the following regions:

A. Wu-han[1] region, 18 localities: ponds, swamps and lakelets secattered in the surrounding area of the city of Han-kow[2] and Wu-chang.[3]

B. Yo-yang (Yo-chow)[4] region, 4 localities: 3 ponds near the railroad station of Yo-yang and Lake Ta-chiao-hu,[5]

C. Yang-tse-kiang,[6] 3 stations.

D. Lake Tung-ting-hu,[7] 1 station, off Yo-yang.

E. Young-long-tung[8] and Chao-li-chao[9] region, 10 localities: ponds and swamps near the town of Young-long-tung and Chao-li-chao.

F. Chi-kung-shan[10] region. 5 localities: a pool and springs on Mt. Chi-kung-shan and ponds near the town of Hsin-tien.[11]

G. Kiu-kiang[12] region, 10 localities: Lake Nan-men-hu,[13] Lake Kan-tang-hu.[14] small ponds near the city of Kiu-kiang, small ponds and springs near the village of Lien-hwa-tung[15] which lies at the foot of Mt. Lu-shan.[16]

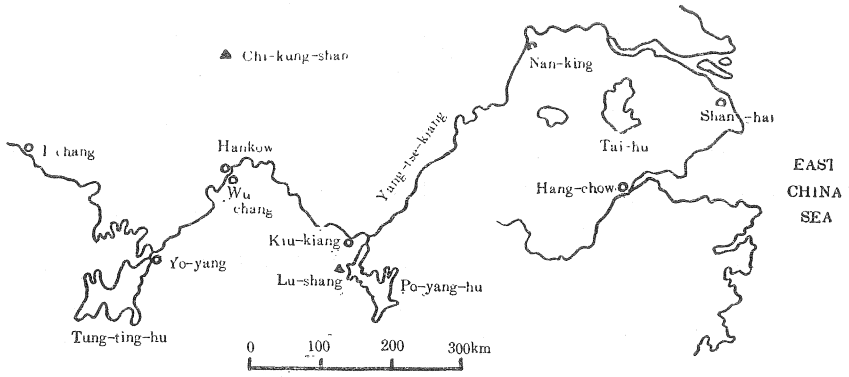


Fig. 1.

General Remarks on the Plankton Collected

The plankton organisms identified by the writer are as follows:

Copepoda

Sinocalanus mystrophorus BURCKHARDT, *Eodiaptomus sinensis* (BURCKHARDT), *Neodiaptomus handeli* (BREHM), *N. yangtsekiangensis*, sp. nov., *Sinodiaptomus sarsi* (RYLOV), *Pseudodiaptomus forbesi* (POPPE et RICHARD), *Cyclops* (*s. str.*) *vicinus* (ULJANIN), *Eucyclops* (*s. str.*) *serrulatus* (FISCHER), *Mesocyclops leuckarti* (CLAUS), *Thermocyclops hyalinus* (REHBERG), *Th. taihokuensis* (HARADA).

1) 武漢, 2) 漢口, 3) 武昌, 4) 岳陽 (岳州), 5) 大橋湖, 6) 揚子江, 7) 洞庭湖, 8) 羊樓峒, 9) 趙李橋, 10) 雞公山, 11) 新店, 12) 九江, 13) 南門湖, 14) 甘棠湖, 15) 蓮花洞, 16) 盧山

Cladocera.

Sida crystallina (O. F. MÜLLER), *Diaphanosoma brachyurum* (LIEVIN), *D. b.* var. *leuchtenbergianum* FISCHER, *Latonopsis australis* G. O. SARS, *Daphnia pulex* (DE GEER), *D. longispina* O. F. MÜLLER *hyalina* (LEIDIG), *D. carinata* KING, *Scapholeberis kingi* G. O. SARS, *Simosa vetula* (O. F. MÜLLER), *S. vetuloida* (G. O. SARS), *Ceriodaphnia laticaudata* P. E. MÜLLER, *C. rigaudi* RICHARD, *Moina macrocopa* STRAUS, *M. dubia* DE GUERNE et RICHARD var. *parva* RAMMNER, *Bosmina longirostris* (O. F. MÜLLER), *B. fatalis* BURCKHARDT, *Bosminopsis deitersi* RICHARD, *Macrothrix rosea* (JURINE), *Chydorus sphaericus* (O. F. MÜLLER), *Dunhevedia crassa* KING, *Alona rectangula* G. O. SARS, *A. costata* G. O. SARS, *A. karua* KING, *Pleuroxus trigonellus* (O. F. MÜLLER), *Leptodora kindtii* (FOCKE)

Rotifera

Asplanchna brightwellii GOSSE, *A. sieboldii* (LEIDIG), *Synchaeta sp.*, *Filinia terminalis* (PLATE), *Tetramastix opoliensis* ZACHARIAS var. *brevispina* AHLSTROM, *Polyarthra euryptera* WIERZ., *P. trigla* (EHRBG.), *Trichocerca bicristata* (GOSSE), *T. cylindrica* (IMHOF), *T. tetractis* (EHRBG.), *Trichotria intermedia* (BGDL.), *Scaridium eudactylotum* GOSSE, *Mytilina ventralis* (EHRBG.), *Euchlanis dilatata* EHRBG., *E. piriformis* GOSSE, *Lecane luna* (O. F. MÜLLER), *L. ungulata* (GOSSE), *Monostyla bulla* GOSSE, *M. lunaris* (EHRBG.), *Lepadella ovalis* (O. F. MÜLLER), *Testudinella patida* (HERMANN), *Pompholyx complanata* GOSSE, *Brachionus angularis* GOSSE, *B. forficula* WIER., *B. falcata* ZACH., *B. urceus* L., *B. caliciflorus* PALLAS, f. *amphiceros*, f. *spinosus*, f. *anuraeiformis*, f. *dorcus*, *B. quadridentatus* HERMANN, *Schizocerca diversicornis* DADAY, *S. d.* var. *homoceros* WIERZ., *Platyias patulus* (O. F. MÜLLER), *P. quadricornis* (EHRBG.), *Keratella cochlearis* (GOSSE), *K. c.* var. *tecta* (GOSSE), *K. valga* (EHRBG.), f. *asymmetrica*, f. *tropica*, *K. quadrata* (O. F. MÜLLER), *Anuraeopsis fissa* GOSSE, *Pedaria mira* (HUDSON.).

Protozoa

Ceratium hirundinella O. F. MÜLLER. *Peridinium sp.*, *Volvox aureus* EHRBG., *Difflugia corona* WALLICH, *D. biwae* KAWAMURA, *Dinobryon sertularia* EHRBG.

Generally speaking, this plankton fauna of Central China shows very remarkable features, containing many endemic or characteristic forms such as *S. mystrophorus*, *Eo. sinensis*, *Neo. heandeli*, *Neo. yangtsekiangensis*, n. sp., *Sino. sarsi*, *Lat. australis*, *B. fatalis*, *Dunh. crassa*, *Scaph. kingi*, *Ceriod. rigaudi*, *Moina dubia* and *D. longispina* f. *galeata* ect. It may be a noticeable tendency that in Cladocera the tropical or subtropical forms are generally abundantly seen, while in copepod fauna, especially in Calanoida, the endemic or highly characteristic forms are dominant.

Attention must be drown to the fact that the distribution of the plankton organisms of Central China seems to be closely related, directly or indirectly, with the great river,

the Yangtse-kiang. Most of the numerous waters now widely scattered in the drainage area of the Yangtse-kiang valley are considered to have had more or less connection with the river itself and nearly all of the large-shaped ones among them are supposed to be the remains or "lobes" of the meanderings of this river. The plankton organisms of these lakes, swamps and ponds must have been all mixed up owing to the repeated floods which occurred during the past ages. From this point of view, the plankton fauna of Central China may rightly be called the Yangtse-kiang fauna.

According to UÉNO's studies (1937, 1940), the Manchurian plankton, especially the Cladocera fauna, seems to be closely related with that of Central China, having a considerable number of chracteristic or southern elements in common, *e. g.*, *B. fatalis*, *C. rigaudi*, *Sc. kingi*, *M. dubia* and *Dunh. crassa*. For such a wide distribution of southern elements of Cladocera, in the writer's opinion, the two great rivers, the Yangtse-kiang and the Hwang-ho, have been responsible in affording them a chance to advance northward from Central China. The Hwang-ho, the greatest river in North China, is well-known for the repeated changes of its course. Several years ago, indeed, the Hwang-ho at flood made a surprisengly great move of its course and had its new mouth open more than 650 km. away southward, actually causing the river to join the Yangtse-kiang near its mouth. From this point of view, the southern elements of the Manchurian plankton may be regarded as an extension of the fauna of Central China or the Yangtse-kiang fauna.

Concerning the Yangtse-kiang fauna, there is another interesting problem: the process of adaptation of the plankton animals from sea to inland waters. Cosmopolitanism seems, in general, to be a unique character of the fresh-water plankton. Calanoid copepods of inland waters, however, may be taken as one of the remarkable exceptions, because each species has more or less its own limited distribution. This peculiarity of the Calanoid copepods may be due to the fact that their adaptation or migration from sea to inland waters is considered to have been made in an age comparatively recent.

HERRICK who established the genus *Pseudodiaptomus* called attention to this genus as a "missing link connecting the fresh-water genus *Diaptomus* with its fellows of the sea." Later, TOLLINGER (1911) and BURCKHARDT (1913) maintained that its migration took place from sea to fresh-water but not from fresh-water back to sea.

The opinion of these two authors is now generally accepted to be true. Twentytwo species are hitherto known to belong to this genus, among them 4 species being found in the sea, 2 in the sea as well as in brackish-water, 3 in brackish-water and fresh-water (*P. lobipes* GURNEY, *P. inopinus* POPPE et RICHARD, *P. japonicus* KIKUCHI), and 2 in fresh-water (*P. poppei* STINGELIN, *P. forbesi* BURCKHARDT). Two important species, *P. inopinus* and *P. forbesi*, of these twenty-two have been described as coming from the Yangtse-Kiang and its neighbourhood. The former species was afterwards reported from several other localities, namely, the River Suifun which flows into Peter the Great Bay (SMIRNOV, 1929), Lake Kasumigaura which lies near the Pacific coast of Central Japan (BREHM, 1925), Lake Koyama-ike which lies near the coast of the Sea of Japan

(KIKUCHI, 1928, 1936) and several other brackish-water lakes in Japan. Recently this species was collected by TUGE, KOKUBO and IMAI (1939) from the lower part of the Yangtse-kiang, but the present writer could not find it among his collections which were made in the upper reaches of Kiukiang. Considering these records, the distribution of this species seems to be limited to the waters which are near the sea and have some connection with it, if not necessarily the brackish-waters. The latter species, *P. forbesi*, was afterwards reported by KIKUCHI (1928) from Shibayama-gata, a lake in Japan, which is situated near the coast of the Sea of Japan. This is the only record of its presence anywhere except in the original locality. Since, in the case of the writer's collections, a large number of this species was often found in the Yangtse-kiang and some other localities, its distribution in Central China is supposed to cover a much wider area, reaching farther up the stream, than in the case of the preceding species. This fact leads the writer to presume that *P. forbesi* had adapted itself to fresh-water earlier than *P. inopinus* did. It may also be a very interesting fact that, as mentioned above, *P. forbesi* is very narrowly limited in its distribution, while *P. inopinus* is to be found widely in many brackish and fresh-water lakes in the coastal regions of Japan and Siberia. *Sinocalanus mystrophorus* is the most characteristic copepod in the Yangste-kiang fauna, and has never been recorded from other regions. Though BURCKHARDT (1913) mentioned that the distribution area of this species is limited to the fresh-waters adjacent to the sea, the present writer found a large number of this species even in such an inland region as Tungting-hu situated about 1,000 km. away from the river mouth.

A very closely allied species, *S. tenellus*, which was first described by KIKUCHI (1928) as a variety of *Limnocalanus sinensis*, is known to have a wide distribution in Japan, Siberia, Sakhalin and the Kuril Islands. It is interesting to note that in most cases *S. tenellus* is found in brackish-waters, while *S. mystrophorus* is a species living only in pure fresh-waters and even in such a far inland region as mentioned above.

From the Yangtse-kiang, BURCKHARDT described two additional noticeable Cyclopoid copepods, *viz.*, *Oithona* (*Limnoithna*) *sinensis* and *Cyclops* (*Halicyclops*) *aquoreus* which afterwards by KIEFER (1925) were revised and described as *Limnoithna sinensis* and *Halicyclops sinensis*, respectively. Since these species did not occur not only in the writer's collections, but also in those of TUGE and others, their distributions are supposed to be limited to the lowermost part of the Yangtse-kiang.

From these facts we may be able to arrange the order of their adaptation to inland waters as follows:

L. sinensis and *H. sinensis*⟶*P. inopinus*⟶*P. forbesi*⟶*S. mystrophorus*

In regard to the distribution of *Pseudodiaptomus*, BREHM (1931) gave a noteworthy opinion as follows:

"Bei der grossen Neigung zur Artenzersplitterung innerhalb der Gattung *Diaptomus* scheint es mir unwahrscheinlich, dass hier eine polytope Entstehung aus je einer marinen Stammform vorliegt. Ich meine, es wäre plausibler, anzunehmen, dass die Arten *Forbesi*

und *inopinus* schon vor der Abtrennung der japanischen Inselguirlande existierten und ihr heute zerstückeltes Wohngebiet besiedelt hatten, was ja auch bezüglich der Arten der *denticornis*-Gruppe in der Gattung *Diaptomus* anzunehmen wäre."

BREHM's opinion may apply also to the cases of some other copepods which possess, if not directly, more or less close relation with the sea. In the early stage of its formation, the Sea of Japan must have remained in a brackish-water condition for a considerably long period. The adaptation from sea to brackish-water (on rare occasions, from fresh-water to brackish-water) is supposed to have taken place in some copepods such as *Pseudodiaptomus*, *Sinocalanus* and *Paracyclopina*, during this period. On the structural completion of the Sea of Japan, their habitats must have been isolated at some particular areas as seen at present. And some of these forms are presumed to have made further adaptation to inland waters, with more or less morphological changes. The general tendency may be that the earlier the adaptation to inland waters, the more progress in morphological differentiation. The following table showing the present distribution of several noteworthy copepods may give an interesting suggestion.

Table 1.

species	Central China	Siberia	Japanese Islands
S. mystrophorus	+	−	−
S. tenellus	−	+	+
E. sinensis	+	−	−
E. japonicus	−	−	+
Ps. inopinus	+	+	+
Ps. forbesi	+	−	+
Paracyclopina nana	−	+	+

Here the writer wishes to note a new interesting fact that the point-headed form of *D. longispina* occurred at Hankow St. 5 even in the winter season. All the specimens of this species collected by the writer in Central China are regarded as belonging to subspecies *hyalina* (LEYDIG), which has delicate hyaline shell and a long spine, almost all of them being point-headed, or of *galeata* form.

The localities where the specimens were collected are as follows: a lakelet in the northern vicinity of Hankow (St. H 5), Tungting-hu (May 18, 1941) and a pond behind the railroad station of Yo-yang (May 18, 1941). Among these localities the lakelet of Hankow was the only locality where somewhat serial collections in various seasons were made and matured parthenogenetic females were abundantly obtained. In spite of the occurrence of some male specimens here, no female with ephippial egge was found. In other localities the specimens obtained were always young forms, though in every locality they abundantly occurred.

Table 2.

date	1941								1942
	20/II	24/III	28/IV	14/IX	21/IX	12/X	1/XI	9/XII	18/I
Water temperature	9.5	—	20.0	21.0	23.2	22.5	—	—	4.5
Occurrence of animal	r	—	cc	—	—	—	r	c	cc

The seasonal distribution of the animal, and the conditions of the water in the lakelet of Hankow (H 5) were such as shown in Table. 2. It is very regrettable for the writer to have been unable to make any collection in midsummer at this station. It may be necessary to note, however, that in the Hankow region it is so warm even in May that the atmospheric temperature sometimes rises as high as 35°C or more.

In this lakelet, in February, 1941, a small number of young specimens was found, in March they disappeared, and in April a large number of young ones was again collected. In September and October of the same year none of the animals was found. In November, some young forms and a comparatively small number of females bearing parthenogenetic eggs made their second appearance. In December these parthenogenetic females with elongated and acutely pointed heads abruptly increased in number. In January, 1942, a small number of matured females with bluntly pointed head and only one specimen of round-headed female were found among a large number of typical *galeata* forms.

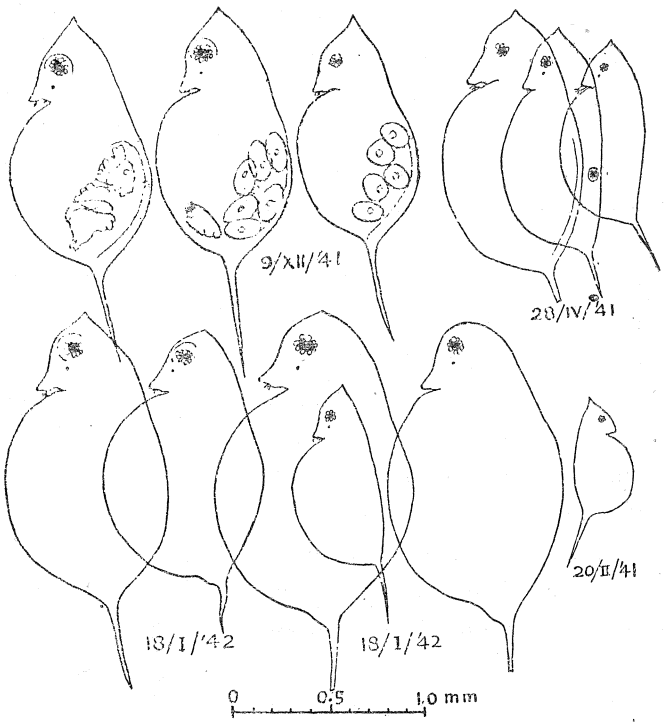


Fig. 2. Seasonal change of the body form of *Daphnia longispina* at Hankow St. 5 (H5).

In Eastern Asia, *galeata* form of *D. longispina* has hitherto been known in the summer period from Manchuria, Sakhalin, Kurile Islands and Hokkaido. In Honshu, the main island of Japan, however, none of this form has hitherto been found except for one

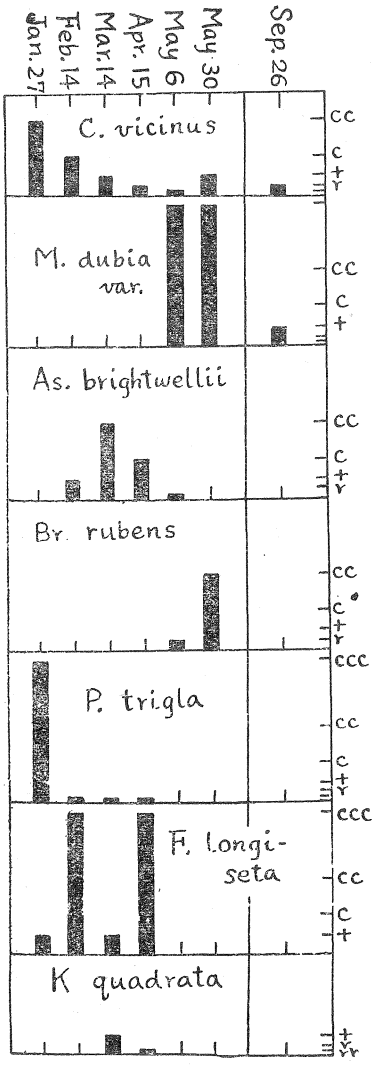
specimen which was collected by UÉNO from the deep layer of Lake Kizaki.

The seasonal change of the form of the body in *Daphnia* as well as many other plankton organisms has long been an object of interest to many investigators. WESENBERG-LUND offered an explanation that these phenomena were caused by the changes in the density of water in which they lived, due to the seasonal changes of water temperature. OSTWALD is also of the opinion that the physicochemical changes of the water, especially those in the viscosity, may be the main stimulant for producing the seasonal variations of body form. The interpretation of these authors is what we call the buoyancy theory. WOLTERECK, however, is of opinion that the thermal stratification of water is the cause of form changes. He (1932) states as follows:

"It seems that they have this kind of shape (form without any elogation of the head) in all lakes, hot or cold, when they are living and migrating within a thick layer of water, but they develop elongated, procurved or retrocurved heads only in lakes where they have to live and migrate in a distinctly stratified medium and within rather narrow layers of water. The effect of these elongations and curved rudders seems to be that the originally steep direction of swimming (jumping) becomes more or less horizontal."

In either case, the common premise may be that the elongation of heads takes place in the summer time, whether it may be caused by he change of buoyancy or thermal stratification of water, but, in Central China, the writer observed the occcrrence of the phenomenon in the winter period. Although the water temperature is not so cold in winter in Central China as shown in the table, it is inconceivable that so steep a thermocline still remains in December and January or already is in existence in April.

It may also be an interesting fact that in Japanese Islands *galeata* form is found only in the northern region in the summer period, while in Central China it appears in the winter, spring and early summer seasons



Fig, 3. Seasonal distribution of the plankton at Hankow St. 1.

Remarks on the Principal Localities

In various localities, especially in the surround-

ing area of the city of Hankow, the plankton collections of the writer worked out more or less successively. Most of them were surface collections by hauling a net along the coast. It may be undeniable, therefore, that the results thus obtained would not always show the exact or sufficient features of the seasonal distributions of plankton in each locality.

(1) **Hankow St. 1. (H-1).** A large pond in front of the Kiang-hang High School.

This pond consists of the main square part and a long, narrow creek-like part (about 40×30m., 5×200m., respectively). The plankton collections at this station were made during the period from the winter to the early summer of 1941. The principal species obtained at this station are such as shown in Figure 3.

It may be a remarkable phenomenon at this station that the predominant forms of the plankton are alternated from month to month, at least during the period from January to May as seen in the figure. In January, a large number of *Polyarthra trigla* was found to be accompanied by a considerable number of *Cyclops vicinus*. In February, *P. trigla* almost entirely disappeared and another species of rotifer, *Filinia longiseta*, took the place of the former species, the number of *C. vicinus* also decreasing as compared with that in the preceding month. The dominant species in March was *Asplanchna brightwellii*, a small number of which had already been seen in February, while other forms mentioned adove were found remarkably diminished. In April, *F. longiseta* markedly increased again and *A. brightwellii* decreased in number. At the begining of May, a characteristic cladoceran, *Moina dubia* var. abruptly increased, keeping its predominance through this month, but nearly all of the other species disappeared. And at the end of the same month, another rotifer, *Brachionus rubens*, markedly increased.

The fact that the plankton fauna is always represented by one or two markedly dominant species with a regular alternation from one to another during a comparatively short period as described above will presumably deserve our attention.

The occurrence of *Brachionus quadrata* at this station and Hankow St. 3 is noteworthy, because this rotifer is regarded as a conspicuous cold-water form, which is not to be seen in the summer period even in the southern plain of Manchuria (YAMASAKI, 1938). In Hankow St. 3, this species was found only in January, while its closely related species, *K. valga*, which is regarded as a warm-water form, was never found in the winter period. It seems somewhat curious, however, that at the present station *B. quadrata* was rather commonly found in March and even in April though not abundantly, but never in January and February.

The species found at this station are as follows:

Cyclops vicinus, Thermocyclops hyalinus, Moina dubia var., *Asplanchna brightwellii, Brachionus caycifiorus*, f. *dorcus*, f. *amphiceros, Keratella cochlearis* var. *tecta, K. quadrata, K. rubens, Schizocerca diversicornis, Filinia longiseta, Polyarthra trigla.*

(2) **Hankow St. 3. (H-3).** A large pond (or lakelet) in the northern vicinity of the

city of Hankow (about 50×300m.). The depth is not exactly known, but it is supposed to be no less than 5 meters. The water is rather clear and submerged plants are very scanty throughout the year. The southern part of the lakelet forms a shallow lotus pond.

Table 3. Seasonal distribution of the principal plankton at St. H-3.

Date (1941—1942)	15 III	22 IV	6 V	31 V	28 VI	14 VIII	10 IX	16 X	1 XI	17 XI	7 XII	13 I
Water temperature°C	—	28	22.5	28	30.5	32	23	—	—	—	—	—
pH	—	—	—	—	7.5	—	—	—	—	—	—	—
N. handeli (adult)	—	+	—	—	—	rr	—	—	c	rr	+	—
〃 (young)	rr	—	—	rr	r	r	r	r	c	c	c	—
C. vicinus	rr	—	—	—	—	—	—	—	—	—	rr	—
Th. taihokuensis	rr	—	—	rr	rr	r	r	+	rr	+	—	rr
D. brachyurum var. *leuchtenbergianum*	—	r	—	rr	—	rr	r	+	+	r	—	—
B. fatalis	—	—	—	—	—	—	+	rr	+	rr	rr	—
B. longirostris	—	cc	rr	—	rr	—	—	rr	r	r	r	c
As. brightwellii	—	c	—	—	—	rr	r	+	c	r	r	+
Br. forficula	—	—	—	—	+	+	—	—	—	—	—	—
Br. calyciflorus	r	—	—	—	—	—	—	—	—	—	—	+
K. cochlearis	cc	+	—	—	—	—	—	r	+	c	c	c
K. c. var. *tecta*	+	rr	—	—	+	r	r	+	r	rr	r	r
K. valga	—	—	—	—	+	—	+	r	r	—	—	—
K. quadrata	—	—	—	—	—	—	—	—	—	—	—	r
Sch. diversicornis	—	—	—	—	+	+	+	+	r	rr	rr	—
P. trigla	—	—	—	—	r	r	+	c	r	rr	—	—
C. hirundinella (with 3 post. spines)	—	—	—	rr	—	—	—	—	—	rr	—	—
C. hirundinella (with 2 post. spines)	r	—	—	—	+	rr	+	r	rr	—	rr	—

The plankton collections were successively made from March 1941 to January 1942. Among copepods, *Neodiaptomus handeli* and *Thermocyclops taihokuensis* were found. The former was seen to increase in the spring and in the late autumn, and the latter to be most abundant in the autumn, at least in the case of surface collection. One of the most noteworthy facts at this station is that this is the only locality in which the two species of *Bosmina*, *B. fatalis* and *B. longirostris* were found at the same time. The latter, *B. longirostris* was found to be most abundant in April and to be next in abundance in January while the former, *B. fatalis*, was seen to be common in the autumn, but absent, at least at this station, in the spring. This characteristic *Bosmina*, however, occurred very abundantly in the midsummer in the Yangtse-kiang as was mentioned before. Thus it may be safe to presume that this form is distributed in large-shaped waters in the summer period too.

In any case, the fact that *B. fatalis* was seen to co-exist with *B. longirostris* at this station may be due, from the limnological point of view, to the condition of the water being intermediate between the *fatalis* type and *longirostris* type. The seasonal distribution of rotifers at this station is also a matter of interest. The southern elements such as *Brachionus forficula*, *Schizocerca diversicornis* and *Keratella valga* were distinctly predominant in the summer period but absent in the winter period, while *K. quadrata* which is decidedly a cold-water form as already mentioned was seen only in January.

The species identified at this station are as follows: *Neodiaptomus handli*, *Pseudodiaptomus forbesi*, *Cyclops vicinus*, *Thermocyclops taihokuensis*, *Sida crystallina*, *Diaphanosoma brachyurum* var. *leuchtenbergianum*, *Bosmina fatalis*, *B. longirostris*, *Bosminopsis deitersi*, *Chydorus sphaericus*, *Asplanchna brightwellii*, *Brachionus calyciflorus*, *Br. forficula*, *Br. rubens*, *Keratella cochlearis*, *K. c.* var. *tecta*, *K. valga* f. *asymmetrica*, *K. quadrata* f. *divergens*, *Schizocerca diversicornis*, *Mytilia ventralis*, *Trichocerca cylindrica*, *Filinia longiseta*, *Tetramastix opoliensis* var. *brebispina*, *Polyarthra euryptera*, *Pedalia mira*, *Ceratium hirundinella*.

(3) **Hankow St. 5. (H-5).** A more or less round-shaped lakelet on the north-western margin of the city of Hankow. Depth, about 10 meters. Limnologically this lakelet seems to be in a compratively young stage. No emergent vegetation is to be seen there, *Myriophyllum spicatum* which is commonly found in the littoral region being the only submerged vegetation found in this lake.

In this station the plankton collections were made during the period from February to April, 1941, and from September 1941 to January 1942. The principal features of the results obtained are shown in Table 4. Most of the collections were those of the surface by hauling the net along the coast. When a boat was available the vertical or deeper layer collections as well as the surface ones were made at the central part of the lake. Judging from these results, the plankton component involves considerable differences between the surface and the deeper layer collections, especially in the case of such copepods as *N. handeli*, *C. vicinus* and *Th. taihokuensis*. In the vertical collection, *Asplanchna brightwellii* was also found much more abundantly than in the surface collection made on February 20. It seems, therefore, difficult to decide, making use of the present data, the seasonal distribution of the plankton at this station. Generally speaking, however, the characteristic forms of this lake seems to be able to be classified into three types according to their seasonal occurrences. First comes the type which shows its predominance in the period from the autumn to the spring, including such species as *N. handeli*, *C. vicinus*, *D. longispina hyalina* and *Asplanchna brightwllii*. The second is the type which seems to have its maximum occurrence in the period from the summer to the early autumn, including those forms which are regarded to be the southern elements, *e. g.*, *Th. taihokuensis*, *B. fatalis*, *Br. calyciflorus* and *Sch. diversicornis*. The third is the type with its predominant occurrence during from the autumn to the

Table 4. Seasonal distribution of the principal plankton at H-5.

Date (1941—1942)	20/II	*	24/III	28/IV	14/IX	21/IX	12/X	1/XI	17/XI	9/XII	**	18/I	*
Water temp. °C	9.5		—	20	21	23	22.5	—	—	—		—	
N. handeli	rr	+	r	r	—	rr	—	—	+	r	c	r	+
C. vicinus	cc	c	c	+	—	—	—	—	r	+	cc	c	+
Th. taihokuensis	—	—	rr	—	r	c	rr	—	c	r	r	—	—
copepodids	cc	c	c	r	+	c	r	r	cc	+	+	c	+
nauplii	—	c	rr	+	c	+	+	c	rr	c	+	c	c
D. brachyurum	—	—	—	—	rr	rr	rr	r	+	—	—	—	—
D. longispina	—	r	—	cc	—	—	—	—	rr	cc	c	ccc	ccc
B. fatalis	—	—	—	rr	+	r	—	—	—	—	—	—	—
As. brightwellii	—	c	c	+	—	—	—	—	—	cc	+	c	+
Br. calyciflorus	—	—	—	r	cc	—	—	—	—	—	—	—	rr
K. cochlearis	—	—	—	rr	—	—	—	—	rr	rr	r	—	rr
K. c. var. *tecta*	rr	rr	—	rr	—	—	r	r	r	cc	c	—	r
K. valga	—	—	—	—	r	+	—	—	—	—	—	—	—
K. quadrata	—	—	+	—	—	—	—	—	—	—	—	rr	rr
Sch. divcrsicornis	—	—	—	—	+	—	—	—	—	—	—	—	—
P. complanata	—	—	—	—	—	—	c	—	—	—	—	—	—
C. hirundinella (3 p. spines)	—	—	r	—	—	rr	—	—	—	—	—	—	—
〃 (2 p. spines)	—	—	—	c	—	rr	+	+	r	r	r	—	—
Dif. corona	—	—	—	—	rr	+	rr	rr	r	—	—	—	—
M. granulata	—	—	—	—	—	—	cc	+	c	cc	cc	c	c

* vertical collection; ** collection of 5—6 meters layer

winter, as seen in the case of *Melosira granulata.*

The seasonal change of the body form of *Ceratium hirundinella* in this lake was also very distinctly observed. The specimens found in the spring were always of large forms with three long posterior spines (f. *robstum*), while those found in the autumn had two posterior spines (f. *gracilis*). And in the early autumn a large number of transitional specimens with two long posterior spines and a short, often rudimentary one, was found.

The most noteworthy fact observed at this station was, as already mentioned, the occurrence of *Daphnia longispina hyalina* with pointed head in the winter season. This species was abundantly found during the period from the late autumn to the winter and in the spring, and almost all of the specimens obtained were of point-headed forms except only one individual found in January.

The species obtained at this station are as follows:

Sinocalanus mystrophorus, Neodiaptomus handeli, Cyclops vicinus, Thermocyclops taihokuensis, Diaphanosoma brachyurum, Daphnia longispina hyalina, Bosmina fatalis, Pleuroxus aduncus, Chidorus sphaericus, Asplanchna brightwellii, Brachionus

calyciflorus f. *amphiceros*, *B. forficula*, *Keratella cochlearis*, *K. c.* var. *tecta*, *K. valga* f. *asymmetrica*, *K. quadrata*, *Euchlanis dilatata*, *Schizocerca diversicornis*, *Trichocerca cylindrica*, *Filinia longiseta*, *Polyarthra eurypteraa*, *Pompholyx complanata*, *Trichotria tetractis*, *T. bicristata*, *Ceratium hirundinella*, *Difflugia corona*, *Pediastrum simplex*, *P. pertusum*, *Melosira granulata*.

(4) **Nanmen-hu** and **Kantang-hu**

These two lakes which lie on the southern side of the city of Kiukiang are much of a size and face each other with a road between them, and have a short canal at the eastern side as their connection. The collections were made twice in these lakes, on August 31 and October 6, 1941.

Apparently, the plankton constituents of these lakes have marked similarity, with several characteristic forms in common, but in detail somewhat remarkable differences can be observed as shown in Table 5. Two species of Diaptomidae were found here, *viz.*, *Neodiaptomus handeli* and *N. yangtsekiangeensis*, sp. nov. These twe copepods can easily be distinguished from each other in the male but they are very difficult to distinguish in the case of the female. It may be an interesting fact that these species seem to concentrate in either of the lakes, at least at some particular seasons of the year.

Table 5.

Principal plankton of Nanmen-hu and Kantang-hu

Locality	Kantang-hu		Nanmen-hu	
Date (1941)	31 VIII	6 X	31 VIII	6 X
N. handeli	–	+	+	–
N. yantsekiangensis	–	–	r	–
Mes. leuckarti	r	c	–	+
Th. taihokuensis	c	r	c	–
Eu. serrulatus	r	–	rr	–
copepodids (Diaptomidae)	r	+	rr	+
〃 (Cyclopidae)	+	c	r	r
nauplii	+	+	c	+
Dia. brachyurum	r			r
B. fatalis	+	r	c	+
C. rigaudi	–	+	r	r
M. dubia	+	r	rr	–
Sc. kingi	r	–	+	–
As. sieboldii	r	–	rr	rr
Br. forficula	r	r	rr	+
K. cochlearis	–	rr	–	–
K. c. var. *tecta*	r	c	rr	+
C. hirundinella (2 post. spines)	rr	c	+	r

In Kantang-hu, *Moina dubia* was somewhat commonly found, containing a considerable number of males and females with ephippial eggs. *Bosmina fatalis* was also found in some abundance, and it is a remarkable fact that the specimens collected in Kantang-hu were much larger than those found in Nanmen-hu in both cases of the collections which were made in August and October. It is also a noteworthy phenomenon that, in both of those collections, all the specimens of *Ceratium hirundinella* in these lakes were the forms which had two slender posterior spines, while in other localities most specimens of this species generally had three posterior spines in the period from summer to early autumn.

Among the phytoplankton, a diatom of spiral form, *Melosira granulata* var. *angustissima*, two species of *Anabaena* and *Microcystis sp.* were found in marked abundance. Of the two species of *Anabaena*, one is a species forming a spiral colony and the other is that forming a sheaf-shaped one and both of them were found to be predominant exclusively in Kantang-hu but not in Nanmen-hu.

The species found in these lakes are as follows:

Neodiaptomus handeli, *N. yangtsekiangensis*, *Eucyclops serrulatus*, *Mesocyclops leuckarti*, *Thermocyclops taihokuensis*, *Diaphanosoma brachyurum*, *Bosmina fatalis*, *Ceriodaphnia rigaudi*, *Moina dubia*, *Scapholeberis kingi*, *Alona rectangula*, *A. costata*, *Chydorus sphaericus*, *Asplanchna sieboldii*, *Brachionus forficula*, *Br. calyciflous* f. *amphiceros*, f. *spinosus*, var. *dorcus*, *Br. capsuliflorus* var. *brevispinus*. *Keratella cochlearis*, *K. c.* var. *tecta*, *K. angularis*, *K. valga* f. *asymmetrica*, f. *monostrosa*, *Lecane ungulata*, *L. ludwigii*, *Euchlanis dilatata*, *Schizocerca diversicornis*. *Pompholyx sulcata*. *Monostyla quadridentata*, *M. lunaris*, *M. bulla*, *Testudinella patina*, *Mytilina ventralis*, *Diurella stylata*, *Trichocerca cylindrica*, *Filinia longiseta*, *Polyarthra trigla*, *Tetramastix opoliensis* var. *brevispina*, *Difflugia corona*, *Ceratium hirundinella*, *Peridinium sp.*, *Eudorina elegans*, *Melosira granulata*, *M. g.* var. *angustissima* f. *spiralis*, *Anabaena spp.*, *Microcystis sp.*

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