

Record of a Freshwater Planarian, *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958, from the Bottom of Lake Kussharo-ko in Hokkaidô, Japan, with a Corrective Overview of the Previous Records of Japanese Lake-dwelling Planarians

By

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Introduction

Lake Kussharo-ko is located at about 12 km NW of Lake Mashû-ko in the eastern part of Hokkaidô (the Akan National Park) at an elevation of 121 m (Figs 1 and 2). Both these caldera lakes in the Kussharo Caldera were formed in the Holocene (less than 0.01 million years ago; cf. Minato, 1973; Kawakatsu, Murayama, Nishino & Ohtaka, 1999: 89). The former is about 10.7 km long and about 7 km (or more) wide. It has a 57 km shoreline, a 79.9 square km area, and a maximum depth of 117 m. The transparency of the lake was reported as 20 m in 1917 (ca. 14.5 m in recent years) (Shiroishi, 1972). The pH of the lake water ranged from 5.0 to 6.2.

Ohtaka, a specialist on aquatic oligochaetes, collected several species of a brown-colored planarian species with its cocoons from the deep bottom of Lake Kussharo-ko in the summer of 2008. These samples fixed on the spot were examined.

The present web article gives our tentative data on this planarian together with a corrective overview on the previous records of lake-dwelling planarians reported from Japanese lakes.

Samples Examined and Methods

Benthonic animals of Lake Kussharo-ko were taken by Ohtaka and Mr. Ogasawara on August 1, 2008, with a 15 cm × 15cm Ekman Dredge. Planarians were obtained from the Stations 1 and 2 in the lake (Fig. 2). The collected specimens were fixed with 5% formalin solution on the spots. For the samples examined, Kawakatsu's Specimen Lot Numbers (KSL Nos) were given. For the 2 specimens of them were deposited in the Division of Biological Science, Graduate School of Science, Hokkaido University (ZIHU). All of the collection data (including non-registered samples) are the followings.

1). *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958. Several specimens and cocoons were collected off the northern shore of Lake Kussharo-ko (43°39'N, 144°20'E; Station 1, depth 39 m); Aug. 1, 2008; collected by Ohtaka and Mr. Ogasawara (Fig. 2). Due to an undesirable preserved condition of the samples from the St. 1, they were not used for a detailed examination of the present study.

2). KSL No. 2438-a (ZIHU No. 3454). *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958. A single sexual(?) specimen (5.2 mm long and 1.4 mm wide in the preserved condition) collected off the Wagoto (Wakoto) Peninsula of Lake Kussharo-ko (43°36'N, 144°17'E; St. 2, depth 49 m); Aug. 1, 2008; collected by Ohtaka and Mr. Ogasawara (Fig. 2; Pl. I, fig. A). Photo of the preserved specimen (Ohtaka's File: P81, dorsal view); photo of the whole mount specimen (Ohtaka's File: PA14).

3). KSL No. 2438-b (ZIHU No. 3455). *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958. A single, small, sexual specimen (3.8 mm long and 1.9 mm wide in the preserved condition) collected off the Wagoto (Wakoto) Peninsula of Lake Kussharo-ko (43°43'N, 144°17'E; St. 2, depth 49 m); Aug. 1, 2008; collected by Ohtaka and Mr. Ogasawara (Fig. 2; Pl. I, Figs B and C). Photos of the whole-mount specimens (Ohtaka's File: FA17, ventral view) and the head with sucker (Ohtaka's File, FA18, ventral view).

4). KSL No. 2439. *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958. Two cocoons (1.1 mm and 0.6 mm in diameter, respectively) collected off the Wagoto (Wakoto) Peninsula of Lake Kussharo-ko (43°36'N, 144°17'E; St. 2, depth 49 m); Aug. 1, 2008; collected by Ohtaka and Mr. Ogasawara (Fig. 2; Pl. I, Figs D and E). Photos of preserved cocoons (Ohtaka's File: FA16).

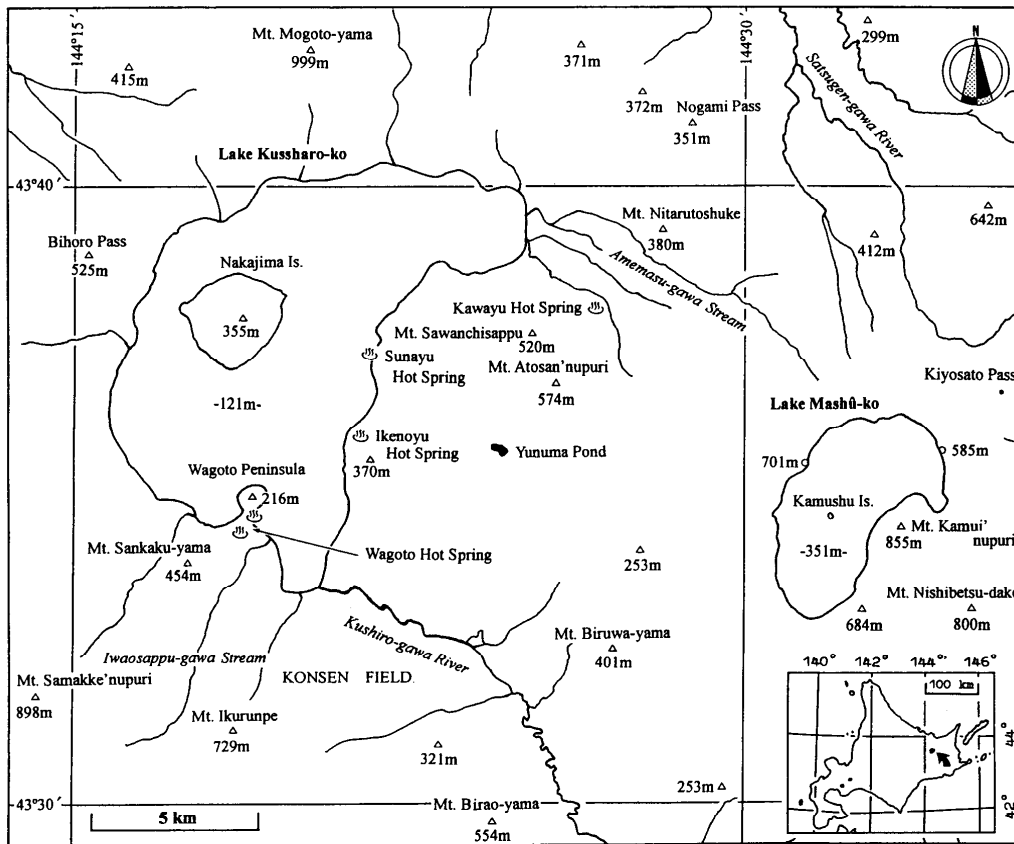


Fig. 1. A sketch-map of the Kussharo Caldera area showing the location of Lake Kussharo-ko and Lake Mashû-ko, the Akan National Park, Hokkaidô.

In the quantitative samples from Lake Kussharo-ko, 2 each specimens of *Den. ezensis* were collected in three each Ekman bottom samples, both in the St. 1 and St. 2 (Fig. 2).

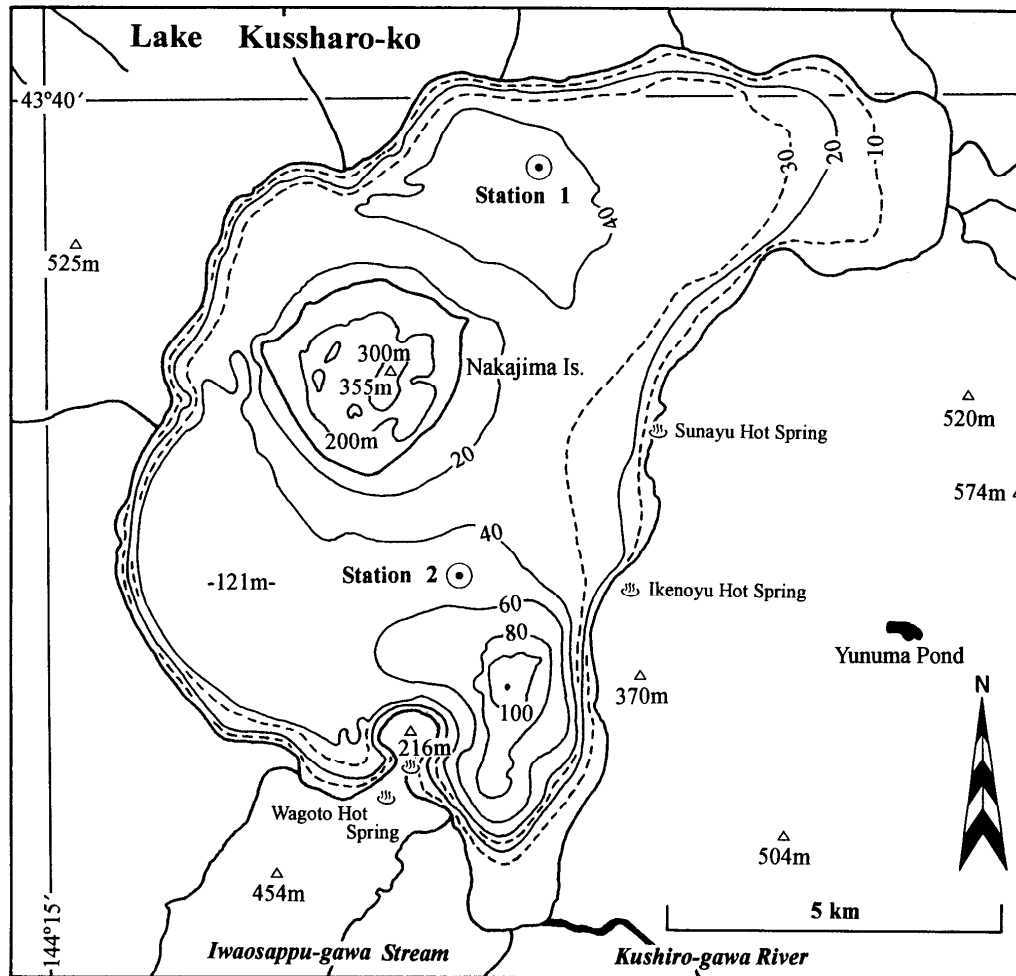


Fig. 2. A lake-basin figure of Lake Kussharo-ko [modified from a part of the 1: 200,000 Geographical Map of <Shari> (GSI) and Shiraishi (1972)]. Two stations surveyed on August 1, 2008 are shown: Station 1, 39 m in depth; Station 2, 49 m in depth).

Taxonomic Observation

Class “Turbellaria”

Order SERIATA Bresslau, 1933

Suborder Tricladida Lang, 1884

Infraorder Paludicola Hallez, 1892

Family Dendrocoelidae Hallez, 1892

Genus *Dendrocoelopsis* Kenk, 1930

Dendrocoelopsis ezensis Ichikawa et Okugawa, 1958

External Appearance. The external appearance of 2 preserved specimens of *Den. ezensis* collected from the St. 2 of Lake Kussharo-ko is shown in Pl. I (Figs A and B). They are very small in size (3.8-5.2 mm long and 1.4-1.9 mm wide) with a pair of large eyes each surrounded by a clear non-pigmented ocular area. Both the dorsal and ventral surfaces of the body are a uniform reddish brown coloration. The pharynx is located at a slightly posterior level of the body. The genital pore that located at the slightly posterior level of the mouth opening is clear in the specimen of KSL No. 2438-b (Pl. I, Fig. B). A sucker consisting of weak longitudinal folds can be seen at the ventral side of the head (Pl. I, Fig. C).

Ohtaka's observation on the external morphology of the bottom-dwelling samples of planarians from Lake Kussharo-ko is coincident with the original description given by Ichikawa & Okugawa (1958; cf. Fig. 3 a-c in the present web article).

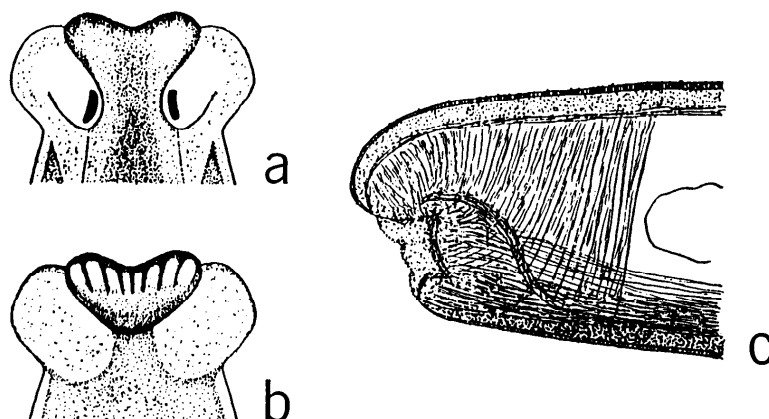


Fig. 3. Sketch figures of the head (a), sucker (b) and the sagittal section of the head showing musculatures of the sucker (c) of *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958. Reproduced from the paper by Ichikawa & Okugawa (1958: 13, figs 3 and 4); modified.

Note. Kawakatsu made the original sketches of the head of live specimens of *Den. ezensis* printed in the original paper according to the request of the late Dr. K. I. Okugawa (December in 1957 in Kyôto).

According to Ohtaka's observation on the spot, living specimens of *Den. ezensis* collected from the lake bottom were larger in size (10 mm long or more and 2 mm wide) with paler coloration than those of the preserved specimens.

Cocoons of *Den. ezensis* collected from the bottom of Lake Kussharo-ko are spherical in shape (0.6-1.1 mm in diameter) and without a stalk (Pl. I, Figs D. and E).

Taxonomic and Distributional Remarks

The type locality of *Dendrocoelopsis ezensis* is a brooklet on the campus ground of Hokkaido University, Sapporo, Hokkaidô (cf. Ichikawa & Okugawa, 1958: 12-17). This brooklet disappeared in the middle of the 1960's (cf. Kawakatsu, Sluys & Sasaki, 2004: 10). *Den. ezensis* was subsequently found in slow running streams and brooklets in plains of central, northern and eastern areas of Hokkaidô (cf. Kawakatsu, 1969: 84-85, fig. 19, pl. VIII on p. 91, fig. 18; see also Sasaki, 2002 a and b).

Den. ezensis is essentially an epigean, stream-dwelling planarian species. It is sometimes found in spring-fed streams. Usually, large and sexual specimens in life are measured up to 25 mm long and 3.5 mm wide. The anterior end of the head is concave. The antero-ventral sucker is a shallow, concave depression with inner muscle fibers (see Fig. 3 A-C). This organ is, however, less-developed than the sucker of the other 3 Japanese dendrocoelid species: *Dendrocoelopsis ichikawai* Kawakatsu, 1977 (cf. Kawakatsu, Asai & Yamada, 1977); *Bdellocephala brunnea* Ijima et Kaburaki, 1916 (cf. Ijima & Kaburaki, 1916; Kaburaki, 1922; Teshirogi, Sasaki & Kawakatsu, 1981) and *Bdellocephala annandalei* Ijima et Kaburaki, 1916 (cf. Ijima & Kaburaki, 1916; Kaburaki, 1922; Kawakatsu, Sluys, Timoshkin, Naumova, Nishino & Takai, 2001).

Ecology and life cycle of *Den. ezensis* was reported by Yamada (1965a, b), Kawakatsu, Yamada & Iwaki (1967) and Kawakatsu (1974: 318-326). In the previous serial studies of distributional ecology of Japanese freshwater planarians by the Kawakatsu's team, *Den. ezensis* was not recorded in the Akan National Park (cf. Yamada & Kawakatsu, 1966). The occurrence of this species was, however, reported from the base of the Shiretoko Peninsula (ca. 50 km NE of Lake Kussharo-ko) in the Shiretoko National Park (cf. Kawakatsu & Yamada, 1966). Moreover, Kawakatsu had a chance to examine a few number of live specimens of *Den. ezensis* collected from a stream at Bihoro-chô (ca. 25 km N of Lake Kussharo-ko) by Mr. K. Hasebe, on May 12, 1981 (the preserved samples were registered in Kawakatsu's Fixing Notebook as KSL No. 1658; now preserved in the Zoölogisches Museum, Universiteit van Amsterdam). (Cf. Sluys, Kawakatsu & Bleeker, 2006.) The collector of that sample said that the Bihoro locality had a considerable large population of *Den. ezensis*.

Although the histological examination of the copulatory apparatus of the bottom-dwelling planarian samples from Lake Kussharo-ko is not studied, the samples examined are undoubtedly assigned to *Den. ezensis* in their external morphology. The authors may, therefore, reasonably conclude that the bottom population of *Den. ezensis* in Lake Kussharo-ko is considered as a very recent immigrant from epigean waters around the lake.

Corrective Overview of the Previous Records of Japanese Lake-dwelling Planarians

The first taxonomic study of lake-dwelling planarian species in Japan was made by Ijima & Kaburaki (1916: 157-159, figs 6-8), who described *Bdellocephala annandalei* from Lake Biwa-ko based upon the material: "Locality: - Lake Biwa, on muddy bottom at

a depth of 3-45 fathoms. Collected by Dr. N. Annandale and Mr. T. Kawamura, Oct. 1915.” See also Annandale (1922).

During the posterior half of the 1920's to the 1930's, several limnobiological surveys of the bottom fauna of Japanese lakes have been made by Dr. D. Miyadi and Dr. M. Uéno of Kyoto Imperial University (now Kyoto University). Occurrence records of lake-dwelling planarians in 10 Japanese lakes were found in Miyadi's publication. An overview of the previous records of lake-dwelling planarians will be given in this Section. Although there are several records of freshwater planarians from the shore of Japanese lakes located in plains and mountains, those epigeal water records are not mentioned as a rule in the present web article.

1). Lake Kussharo-ko

For the topography and geological history of the Lake Kussharo-ko, see the foregoing Section of the present web article.

Note. The compound palaeogeographical maps of the Old Japanese Islands (8 sheets, 100 million years ago – 0.02 million years ago) are available in a paper by Kawakatsu, Oki, Tamura, Ogren, Yamada & Murayama (1990: 113-16, figs. 22-29). They are useful for the understanding of the geological history of the Japanese Islands.

Miyadi (1932b: 238, 251, table 19) reported the occurrence of “*Planaria gonocephala*” from the 4 bottom stations (50, 79, 84 and 90 m in depth, respectively) of Lake Kuttyaro-ko (*i.e.*, the Ainu pronunciation of Lake Kussharo-ko). The population density of planarians in these 4 stations was reported as 52-104 individuals per a square meter (July 29, 1931).

Dugesia gonocephala (Dugès, 1830) (synonym: *Planaria gonocephala*) is a species distributed only in Europe, North Africa and Western Asia (?) (cf. Kenk, 1974: 24). In the original descriptive paper of *Dugesia japonica* Ichikawa et Kawakatsu, 1964, these authors pointed out as follows:

“ The species described and recorded from Japan, the Loochoo Islands, Korea, Kwantung, South Manchuria and China under the name *Dugesia* (= *Planaria*; = *Euplanaria*) *gonocephala* (Dugès) is a synonym of the present new species.” Cf. Ichikawa & Kawakatsu (1964: 187).

Dugesia japonica is a commonest species inhabiting epigeal water of Japan, Taiwan, Korea and China. Although this species has been recorded from shallow underground water in wells and caves (cf. Kawakatsu, 1960, 1999; Kawakatsu & Kim, 1967; Kawakatsu & Mack-Firă, 1975; Mack-Firă & Kawakatsu, 1972), it is not a lake-dwelling species. It is highly probable that Miyadi's (1932a) record of “*Planaria gonocephala*” from the bottom of Lake Kuttyaro-ko is an uncertain species due to a misidentification.

In the epigeal streams around Lake Kussharo-ko, the occurrence of 2 (or 3) species of stream-dwelling planarians have been reported. They are: *Phagocata vivida* (Ijima et Kaburaki, 1916); *Polycelis sapporo* (Ijima et Kaburaki, 1916) and/or *Seidlia akkeshi*

(Ichikawa et Kawakatsu, 1963) (cf. Yamada & Kawakatsu, 1966: 68, fig. 1). Since both *Pol. sapporo* and *S. akkeshi* are white species with numerous small eyes, they are not separable externally at the occasion of field surveys.

Note. *Seidlia akkeshi* was at first described as a new species *Polycelis akkeshi* Ichikawa et Kawakatsu, 1963. Since the Eurasian genus *Polycelis* Ehrenberg, 1831 is not homogeneous, it was separated into 3 subgenera, i.e., *Polycelis* Ehrenberg, 1831, *Seidlia* Zabusov, 1911 and *Ijimia* Bergendal, 1890 (cf. Kenk, 1953). Then, the subgenus *Seidlia*, characterized by an extraordinarily thick muscular zone surrounding the male genital antrum, should be recognized at the rank of genus which it was elevated by Zabusova (1936). Cf. Kawakatsu & Mitchell (1995, 1998). See also Kawakatsu, Oki, Tamura, Takai, Yamamoto, Nishino, Timoshkin, Kuznedelov & Sluys (1996).

The reasonable scientific names of 4 Japanese “*Polycelis*” species are as follows:

Polycelis sapporo (Ijima et Kaburaki, 1916); *Seidlia auriculata* (Ijima et Kaburaki, 1916); *Seidlia akkeshi* (Ichikawa et Kawakatsu, 1963); *Seidlia schmidtii* (Zabusov, 1916). Cf. Kawakatsu, Sluys & Sasaki (2004: 7-8). See also Kawakatsu, Yamada, Murayama & Naoki (1991); Kawakatsu & Timoshkin (1998).

2). Lake Mashû-ko

This caldera lake is located in the Akan National Park in Hokkaidô (Fig. 1; Pl. II) (43°32'-43°36'N and 144°50'-144°35'E). Its elevation is 351 m and is about 6.7 km long and about 2.7 km wide. It has a 20 km shoreline, a 20 square km area, and a maximum depth of 212 m (Pl. III, top-left). Its transparency was reported as 41.6 m in 1931 (cf. Shiraishi, 1932; Kawakatsu, Murayama, Nishino & Ohtaka, 1999).

The benthic animals of Lake Mashû-ko were collected by Ohtaka and Dr. Nishino in September, 1999. Two neorhabdocoelid species were found in their bottom samples taken from the profundal zone of the lake. They are: *Mesostoma?* sp. (KSL No. 2348; ZIHU No. 3452) (210 m in depth) and *Gyratrix?* sp. (KSL No. 2349; ZIHU No. 3453) (150 m in depth) Cf. Kawakatsu, Murayama, Nishino & Ohtaka, 1999: 89-90, figs 9 and 10).

In the epigeal streams around the Lake Mashû-ko, *Phagocata vivida* (Ijima et Kaburaki, 1916) is found (cf. Yamada & Kawakatsu, 1966: 68, fig. 1).

3). Lake Usoriyama-ko

This caldera lake is located in the Osoreyama Volcanic area in the Shimokita Peninsula, Mutsu City, Aomori Prefecture, the northernmost part of Honshû (Pl. II) (41°18'-41°19'N. and 141°04'-141°06'E). Its elevation is 351 m and is about 1.6 km long and about 1.7 km wide. It has a 12.5 km shoreline, a 2.5 square km area, and a maximum depth of 15.8 m (Pl. III, top-right). Its transparency is 4.2 m; the pH value of the lake water ranges from 3.1 to 3.7 (especially at the northwestern part of the lake) (cf. Shiraishi, 1972; Teshirogi, Sasaki & Kawakatsu, 1981).

The benthic animals of Lake Usoriyama-ko (Osorezan-ko) were studied by the members of Nara Women's University in 1972 and 1973. They reported the occurrence of “*Phagocata kawakatsui*” (lapus calmi of the generic name) from 4 bottom stations of the

Lake: Off the mouth of the Ôzukushi-gawa Stream (3.4-6.8 m in depth) and near the center of the Lake (7.65 m in depth) (cf. Watanabe, Kamijô, Morishita, Shinya & Mashiko, 1973: 48-49, table 6). However, its occurrence record of a freshwater planarian, *Phagocata kawakatsui* Okugawa, 1956, is doubtful because this species is not distributed in the northern part of the Tôhoku Region in Honshû (cf. Kawakatsu, 1961b, 1969: 56-57, fig. 5; Kawakatsu, Teshirogi & Tsushima, 1970; Teshirogi, Sasaki & Kawakatsu, 1981: 84 and 96).

A detailed report of the limnobiological and taxonomic studies of freshwater planarians inhabiting in Lake Usoriyama-ko and streams in its vicinity was published by Teshirogi, Sasaki & Kawakatsu (1981). A considerable number of specimens of *Bdellocephala brunnea* Ijima et Kaburaki, 1916 were collected from 4 bottom stations of the southern and northeastern parts of the Lake (4.5-7 m in depth; cf. Teshirogi, Sasaki & Kawakatsu, 1981: 86-91, figs 2 and 4, table 1; see also Table III, bottom). It is emphasized that *Bd. brunnea* is common in the small epigeal streams that runs into the northwestern shore of Lake Usoriyama-ko (cf. Teshirogi, Sasaki & Kawakatsu, 1981: 89, fig. 5).

In the other epigeal streams around Lake Usoriyama-ko, 4 species of freshwater planarians have been found. They are: *Dugesia japonica* Ichikawa et Kawakatsu, 1964; *Phagocata vivida* (Ijima et Kaburaki, 1916); *Seidlia auriculata* (Ijima et Kaburaki, 1916); *Polycelis sapporo* (Ijima et Kaburaki, 1916). Habitats of the last-mentioned species, *Pol. sapporo*, are limited since its main geographical distribution range is Hokkaidô (cf. Teshirogi, Sasaki & Kawakatsu, 1981: 86, fig. 2; see also Kawakatsu, 1961b; Kawakatsu, Teshirogi & Tsushima, 1970).

4). Lake Towada-ko

This large caldera lake is located at the boundary of Aomori and Akita Prefectures, Tôhoku Region, Honshû (the north-central part of the Towada-Hachimantai National Park)(40°24'-40°30'N and 140°49'-140°58'E). Its elevation is 401 m and is about 10 km long and about 9.5 km wide. It has a 46.2 km shoreline, a 59 square km area, and maximum depth of 334 m (Pls. II, IV, top). Its transparency is 12-15.5 m; the pH of the lake water ranges from 7.0 to 7.6 (cf. Shiraiishi, 1972; Kawakatsu, Teshirogi & Tokui, 1976: 481).

Miyadi (1929: 68, 75, table XIV) was the first researcher who reported the occurrence of "*Planaria*" from 2 bottom stations of Lake Towada-ko (80 m and 305 m in depth). Their population density was reported as 51.2 and 153.6 individuals per square meter, respectively (September 7-8, 1928). Later, Miyadi (1932c: 270, 285, table 29) reported the same data cited above in his English paper; the samples were listed under the name of "*Planaria gonocephala*". For this misidentified Japanese *Dugesia* species, see the Section <Lake Kussharo-ko> of this web article. Cf. Kawakatsu, Teshirogi & Tokui (1976: 481).

Okugawa (1947) reported the occurrence of *Phagocata vivida* (Ijima et Kaburaki, 1916) in deep bottom of Lake Towada-ko and Lake Tazawa-ko (60-100 m in depth). This short Japanese article was published as an item of the Illustrated Encyclopedia of the Fauna

of Japan published by the Hokuryû-kan Publisher (1947: 1487, fig. 4190). Nearly the same Japanese items about *Ph. vivida* from bottoms of those 2 lakes written by Dr. Okugawa were also found in 2 different editions of the Illustrated Encyclopedia of the Fauna of Japan: 1965 (p. 319, fig. 33) and 1979 (p. 118, fig. 411). In the recent Reprint Edition of the 1967 book published in 2004, the above-mentioned Okugawa's item is also found (p. 319, fig. 33). Kawakatsu, Teshirogi & Tokui (1976: 481) pointed out that the taxonomic description of the late Dr. Okugawa's samples of *Ph. vivida* was not published (see also Kawakatsu, 1978: 7-8).

The occurrence of *Polycelis* sp. from 10 bottom stations of Lake Towada-ko was reported by Kitagawa (1974: 162-165, tables 2 and 3). Those stations are: Off Ôkawatai (8 stations, 73-94 m in depth; June 24, 1973) and Off Yasumiya (2 stations, 31-35 m in depth; June 25, 1973). According to the collector (loc. cit.), the population density of *Polycelis* sp. was 52-520 individuals per a square meter.

Kawakatsu, who studied Dr. Kitagawa's preserved samples of *Polycelis* sp. from the bottom of Lake Towada-ko, identified the species as *Polycelis sapporo* (Ijima et Kaburaki, 1916) (cf. Kawakatsu Teshirogi & Tokou, 1976). (See Pl. IV, top). Since *Pol. sapporo* is found sporadically in epigeal streams in Aomori Prefecture (see the Section Lake Usoriyama-ko in the present web article), the lake-dwelling populations of *Pol. sapporo* in Lake Towada-ko is considered as a recent immigrant from the epigeal waters. For a more detailed discussion about this problem, see Kawakatsu, Teshirogi & Tokui (1976: 481-482). Additionally, Lake Towada-ko is now known as the southern limit of geographical distribution of *Pol. sapporo* (cf. Kawakatsu, Teshirogi & Tsushima, 1970).

The 3 common species of freshwater planarians are found in the epigeal streams around Lake Towada-ko. They are: *Dugesia japonica* Ichikawa et Kawakatsu, 1964; *Phagocata vivida* (Ijima et Kaburaki, 1916); *Seidlia auriculata* (Ijima et Kaburaki, 1916). Cf. Kawakatsu (1961a: 62, fig. 2); Kawakatsu, Teshirogi & Fujiwara (1970: 129, fig. 1); Kawakatsu, Teshirogi, Ishioka & Kasahara (1968: 252, fig. 1); Teshirogi, Kon-no, Fuji-i & Kawakatsu (1978: 57, pl. III). See also Kawakatsu (1978: 7, fig. 12).

5). Lake Tazawa-ko

This caldera lake is located in the east-central part of Akita Prefecture, Tôhoku Region, Honshû (39°41'-39°45'N and 137°52'-137°57'E). Its elevation is 250 m and is about 6 km long and about 5.8 km wide. It has a 20km shoreline, a 25.7 square km area, and a maximum depth of 425 m (Pls. II, IV, bottom-left). Its transparency is 14.5 m; the pH of the surface lake water is 6.5 (cf. Shiraishi, 1972).

Miyadi (1929: 74, table XIII) reported the occurrence of "*Planaria*" from a single bottom station of Lake Tazawa-ko (25 m in depth). Its population density was reported as 51.2 individuals per a square meter (June 4 and 5, 1928). In his English paper, Miyadi (1932c: 281 and 285, tables 25 and 27) reported the same data cited above; the sample was listed under the name of "*Planaria gonocephala*". For the misidentified Japanese *Dugesia* species, see the Section Lake Kussharo-ko of this web article. See also items of *Ph. vivida* by Okugawa (1947, 1965, 1979, 2004) mentioned in the foregoing Section, Lake Towada-ko.

After the year 1940, acidic water of the Tama-gawa River was led into Lake Tazawa-ko. Thus, no benthic animals have been found since then from the deep bottom of Lake Tazawa-ko (cf. Kitagawa, 1974: 165; see also Kawakatsu, 1978: II, p. 8).

The 3 common species of freshwater planarians are found in the epigean streams around Lake Tazawa-ko. They are: *Dugesia japonica* Ichikawa et Kawakatsu, 1964; *Phagocata vivida* (Ijima et Kaburaki, 1916); *Seidlia auriculata* (Ijima et Kaburaki, 1916). Cf. Teshirogi, Kon-no, Fuji-i & Kawakatsu (1978: 55, table II).

6). Lake Numazawa-ko

This caldera lake is located in the western part of Fukushima Prefecture (near the boundary of between Fukushima and Nîgata Prefectures), Tôhoku Region, Honshû (37° 26'-37°28'N and 139°34'-139°35'E). Its elevation is 474 m and is about 2 km long and 2.4 km wide. It has a 5.8 km shoreline, a 3.1 square km area, and a maximum depth of 96 m (Pl. II & Pl. IV, bottom-right). Its transparency is 7.9-16 m; the pH of the lake water ranges from 5.8 to 6.5 (cf. Shiraishi, 1972).

Miyadi (1932c: 281, table 25) reported the occurrence of "Planarians" from a single bottom station of Lake Numazawa-ko (85 m in depth). Its population density was reported as 52 individuals per a square meter (November 17, 1940). No scientific name of the sample planarians was given.

7). Lake Motosu-ko

This dammed lake is located at the northwestern foot of Mt. Fuji (alt. 3776 m), the southern part of the Yamanashi Prefecture, Chûbu Region, Honshû (35°27'-35°28'N and 138°34'-138°37'E.). Its elevation is 902 m and is about 2.8 km long and about 3 km wide. It has a 10.4 km shoreline, a 4.8 square km area, and a maximum depth of 126 m (Pl. II & Pl. V, top-left). Its transparency is 11-12.5 m (cf. Shiraishi, 1972).

Miyadi (1932a: 94, tables 19-20) reported the occurrence of "*Planaria gonocephala*" and "*Planaria*" sp. one each from bottom station of Lake Motosu-ko (60 m and 117 m in depth, respectively). Both population densities were reported as 52 individuals per a square meter (July 26, 1929). For the misidentified Japanese *Dugesia* species, see the Section Lake Kussharo-ko of this web article.

In the epigean streams in the vicinity of the Lake Motosu-ko, *Dugesia japonica* Ichikawa et Kawakatsu, 1964 is common. *Phagocata vivida* (Ijima et Kaburaki, 1916) and *Seidlia auriculata* (Ijima et Kaburaki, 1916) are also found in the mountainous area (cf. Kawakatsu & Nîmura, 1977, pl. I).

8). Lake Aoki-ko

This is one of the three tectonic (or depression) lakes --- so-called the Nishina Three Lakes --- located at the northern part of Nagano Prefecture, Chûbu Region, Honshû (36°30'-36°37'N and 137°51'-137°52'E). It has a 6.7 km shoreline, a 1.86 square km

area, and a maximum depth of 62 m (Pl. II & Pl. V, top-right). Its transparency is 8.6-14 m (cf. Shiraishi, 1972).

Miyadi (1928: 8-9, table XVIII) reported the occurrence of “*Planaria*” from the 4 bottom stations of Lake Aoki-ko (16, 26, 27 and 29 m in depth). Their population densities were reported as 51.2-102.4 individuals per a square meter (June 27, 1928). In his English paper, Miyadi (1931: 203, figs 1 and 2, table 13 and 15) reported the same data cited above, with the additional data: “*Planaria gonocephala*” from 2 bottom stations (28 m and 40 m in depth; 102.4 individuals per a square meter; November 3, 1928). For the misidentified Japanese *Dugesia* species, see the Section Lake Kussharo-ko of this web article.

In three epigeal streams in the vicinity of the Lake Aoki-ko, *Dugesia japonica* Ichikawa et Kawakatsu, 1964 and *Phagocata vivida* (Ijima et Kaburaki, 1916) are common (cf. Ni-imura, 1984: 965-969, fig. 65).

9). Lake Kizaki-ko

This is one of the Nishina Three Lakes located about 4 km south of Lake Aoki-ko (36°32'-36°34'N and 137°50'-137°51'E). Its elevation is 764 m and is about 2.7 km long and about 1 km wide. It has a 6 km shoreline, a 1.41 square km area, and a maximum depth of 29.5 m (Pl. II & Pl. V, bottom-left). Its transparency is 4.8-10 m (cf. Shiraishi, 1972).

Miyadi (1931: 209, table 17) reported the occurrence of “*Planaria gonocephala*” from 2 bottom stations of Lake Kizaki-ko (8 and 9 m in depth). Their population densities were reported as 102.4-153.6 individuals per a square meter (April 25, 1928). For the misidentified Japanese *Dugesia* species, see the Section Lake Kussharo-ko of this web article.

Dugesia japonica Ichikawa et Kawakatsu, 1964 and *Phagocata vivida* (Ijima et Kaburaki, 1916) are common in the epigeal streams around the Lake Kizaki-ko (cf. Ni-imura, 1984: 965-969, fig. 65).

10). Lake Biwa-ko

This is the largest lake in Japan located in Shiga Prefecture, Kinki Region, Honshū (34°58'-35°30'N and 135°52'-136°12'E). Its elevation is 85.6 m and is about 63.5 km long and about 22.8 km wide. It has a 235.2 km shoreline, a 607.4 square km area, and a maximum depth of 103.6 m (Pl. II & Pl. V, bottom-right). Its transparency is 3-16 m (cf. Environ. Div. Shiga Pref. Govern., 1991; see also Shiraishi, 1972; Kawakatsu & Nishino, 1993: 877, 100-102, pls III-V).

According to Horie (1984), this tectonic lake is about 0.4 million years old. It is therefore known as one of the ancient lakes in the world (cf. Kawakatsu & Nishino, 1993). Up to the present, 2 described and a single undescribed lake-dwelling planarian species are known from Lake Biwa-ko. They are as the followings.

a. *Phagocata kawakatsui* Okugawa, 1956. This is a small planarian with grayish coloration found in springs, spring-fed streams and shallow wells in Honshû (from Okayama Prefecture in the Chûgoku Region to Fukushima Prefecture in the Tôhoku Region) and Shikoku (only found in Takamatsu City in Kagawa Prefecture), in Central Japan (cf. Okugawa, 1956: Kawakatsu, 1969: 56-57, text-fig. 5, 89, pl. VII, fig. 4; Kawakatsu & Iwaki, 1967). See also Sasaki (2002a, b; Kawakatsu, Sluys & Sasaki, 2004: 5).

Although *Ph. kawakatsui* is not usually considered a true lake-dwelling species, the occurrence of lake-dwelling populations of this species was recorded from the southern part of the Northern Basin of Lake Biwa-ko after the year 1989 (depth, 3-70 m). Cf. Kawakatsu, Oki, Tamura, Takai, Yamamoto, Nishiono, Timoshkin, Kuznedelov & Sluys (1996: 7-8, 10-11, figs 6A and B, 7, 12 top, 13A); Kawakatsu, Nishino, Tamura, Takai, Oki, Kuznedelov & Timoshkin (2000); Oki, Tamura, Nishino, Takai, Kuznedelov, Timoshkin & Kawakatsu (1998). See Pl. V, bottom-right in the present web article.

Usually, *Ph. kawakatsui* is an inhabitant of small springs and spring-fed streams in lowland area in Central Japan (cf. Kawakatsu & Iwaki, 1967; Kawakatsu, Nishino, Tamura, Takai, Oki, Kuznedelov & Timoshkin, 2000). Therefore, the lake-dwelling populations of *Ph. kawakatsui* is considered as immigrants from surrounding epigeal waters.

b. *Bdellocephala annandalei* Ijima et Kaburaki, 1916. This is an endemic dendrocoelid planarian inhabiting the muddy bottom of the Northern Basin of Lake Biwa-ko (20-103 m in depth). Cf. Ijima & Kaburaki (1916: 157-159, figs 6-8); Kaburaki (1922: 3-8, figs 1-2, pl. I, fig. 1); Kawakatsu, Sluys, Timoshkin, Naumova, Nishino & Takai (2001); Kawakatsu & Sasaki (2002: 7-9, second plate). See also the following papers including photographs and/or sketch-figures of *Bd. annandalei*. They are: Kawakatsu (1964: 32-35, figs 1-5; 1968a: cover photo, 41, 43, fig. 16; 1968b: 80-81, fig. 17-a, -b, 91, pl. VIII, fig. 16; 1974: 30, top-right photo; 1978, II, 6, figs 9 and 10A); Murayama & Kawakatsu (1973: 163-165, fig. 4); Kawakatsu & Nishino (1993: 98, pl. I, figs A-F); Nishino (1993, III, 17, fig. 16 and photos; 2000: 2 pages including a color photo of *Bd. annandalei*; 2006: 56, color photos 537-538); Sasaki (2002a, b); Kawakatsu, Sluys & Sasaki (2004: 9).

For the recent ecological, taxonomic and karyological studies of *Bd. annandalei*, see the following papers: Kawakatsu (1964, 1978b); Kawakatsu, Oki, Tamura, Takai, Yamamoto, Nishino, Timoshkin, Kuznedelov & Sluys (1996: 7-11, figs 6 C-D, 7, 8-9, 11, 12 bottom, 13 B-D); Oki, Tamura, Nishino, Takai, Kuznedelov, Timoshkin & Kawakatsu (1998); Kawakatsu, Sluys, Timoshkin, Naumova, Nishino & Takai (2001); Nishino & Ohtaka (2002: 1-2). For the other various papers on *Bd. annandalei*, see Kawakatsu & Nishino (1993, 1994).

c. *Dendrocorlopsis?* sp. of Lake Biwa-ko. Kawakatsu (1966: 57, figs 11 and 12). Two specimens of this undescribed species were collected by Dr. K. I. Okugawa from the bottom of Off the Tsuzurao-zaki Cape, the northern part of the Lake Biwa-ko (2 stations, 40 m and 50 m in depth, respectively); July 24, 1959. The largest live specimen measured 25 mm long and 4 mm wide; the head has a subtruncated form with a gentle frontal curve and a pair of rounded auricles; with 2 adjacent eyes; pale brown coloration on

the dorsal surface of the body; without an adhesive organ on the ventral side of the head.

At that time, two sets of serial sections of the samples fixed with Bouin's fluid were prepared (KSL No. 278-a and -b). Unfortunately, those sections kept in the late Dr. Okugawa's office of Kyoto Gakugei University were lost.

For the other data of this undescribed species. see the following publications. They are: Kawakatsu, Ôgawara & Tarui (1967: 114, fig. 2); Kawakatsu (1978, II: 6-7, figs 9, 10B); Kawakatsu & Nishino (1993: 97-98, pl. I, figs G and H); Kawakatsu, Oki, Tamura, Takai, Yamamoto, Nishino, Timoshkin, Kuznedelov & Sluys (1996: 8, fig. 7); Oki, Tamura, Nishino, Takai, Kuznedelov, Timoshkin & Kawakatsu (1998: 316, fig. 1). See also Pl. V, bottom-right figure in the present web article.

Epigeal waters and Lake Yogo-ko

Dugesia japonica Ichikawa et Kawakatsu, 1964 is common in the epigeal streams around Lake Biwa-ko. In many mountain streams of the Hira Mountains located along the western shore of Lake Biwa-ko, both *D. japonica* and *Phagocata vivida* (Ijima et Kaburaki, 1916) are common (cf. Kawakatsu, Ôgawara & Tarui, 1967: 113, fig. 1). In the Suzuka Mountains located on the eastern side of the Lake, both *D. japonica* and *Ph. vivida* are also common (cf. Kawakatsu, Kanezaki & Ôgawara, 1968).

The occurrence of *D. japonica* from the shore of Lake Biwa-ko (a gravel bottom of the southern part of the Lake; 0.2-0.5 m in depth) was reported by Tsuda (1945). For the "microturbellarian" fauna of Lake Biwa-ko, see Okugawa (1930, 1953); Kawakatsu & Nishino (1993, 1994); Timoshkin, Grygier & Kawakatsu (2004: 1288-1295, figs 8-13; 1301-1302). See also the following web articles. They are: Yamamoto, Sasaki & Kawakatsu (2003) and Sasaki (2003). A color photograph of a live specimen of *Macrostomum kawamurai* Okugawa, 1930 from Lake Biwa-ko is found in Dr. Faubel's Homepage: <http://www.rrz.uni-hamburg.de/benthos> (taxonomy - Macrostomida).

Additionally, Lake Yogo-ko (Elevation 134 m, 1.6 square km area, and a maximum depth of 14.5 m) is a small lake located about 1 km NE of Lake Biwa-ko. The Yogo River from the southern shore of Lake Yogo-ko runs into the northeastern shore of Lake Biwa-ko. No lake-dwelling planarian was found from Lake Yogo-ko (cf. Murayama, Takahashi & Kawakatsu, 1974).

Summary

1). Occurrence of the bottom populations of a paludicolan planarian species, *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958, was reported from Lake Kussharo-ko located in the Akan National Park in Hokkaidô, Japan. Both sexual and asexual specimens and cocoons of this species were obtained from 2 bottom stations (39 m and 49 m in depth). Since this caldera lake was formed in the Holocene (less than 0.01 million years ago), the bottom populations of *Den. ezaensis* is considered as a very recent immigrant from epigeal waters around the Lake Kussharo-ko.

2). Corrective overview of the previous occurrence records of Japanese lake-dwelling planarians was given. Those discussed are 6 caldera lakes (Lake Kussharo-ko reported in the present web article, Lake Mashû-ko, Lake Usoriyama-ko, Lake Towada-ko, Lake Tazawa-ko, Lake Numazawa-ko), 1 dammed lake (Lake Motosu-ko) and 3 tectonic lakes (Lake Aoki-ko, Lake Kizaki-ko and Lake Biwa-ko). See Pl. II.

3). According to the accurate and trustworthy data of the bottom populations of the paludicolen planarians (Triclad) in Japanese caldera lakes, the following 2 species are reliable. They are: *Polycelis sapporo* (Ijima et Kaburaki, 1916) from Lake Towada-ko (31-94 m in depth) and *Bdellocephala brunnea* Ijima et Kaburaki, 1916 from Lake Usoriyama-ko (4.5-7 m in depth).

4). The previous occurrence records of bottom populations of “*Planaria gonocephala*” and “*Phagocata vivida*” from several caldera lakes are undoubtedly erroneous due to misidentifications of the other species. The occurrence records of “*P. gonocephala*” is not consider as a misidentification of *Dugesia japonica* Ichikawa et Kawakatsu, 1964, a commonest Japanese freshwater planarian species that erroneously known as *Dugesia* (= *Planaria*, = *Euplanaria*) *gonocephala* (Dugès, 1830) until the year 1964.

5). “*Planaria gonocephala*” and “*Planaria*” reported from 2 tectonic lakes, Lake Aoki-ko and Lake Kizaki-ko, are erroneous due to misidentification. See Item 4 in the present Summary.

6). Lake Biwa-ko, a tectonic lake and one of the ancient lakes on the earth, is about 0.4 million years old. The 3 lake-dwelling paludicolen planarians are now known. They are: *Phagocata kawakatsui* Okugawa, 1956 (only known from the southern part of the Northern Basin, 3-70 m in depth); *Bdellocephala annandalei* Ijima et Kaburaki, 1916 (the Northern Basin, 20-103 m in depth); *Dendrocoelopsis?* sp., an endemic, undescribed species (Off the Tsuzurao-zaki Cape of the Northern Basin, 40-50 m in depth)

7). Taxonomic study of bottom-dwelling species of “microturbellarians” in Japanese lakes is incompleteness. Only *Mesostoma?* sp. (210 m in depth) and *Gyratrix?* sp. (150 m in depth) were reported from the profundal zone of Lake Mashû-ko in the Akan National Park in Hokkaidô.

Recently, the following “microturbellarian” species of the Prorhynchidae Hallez, 1894, in the Order Lecithoepitheliata Reisinger, 1924, was reported from Off Kitakomatsu (Northern Basin) of Lake Biwa-ko. It is: *Prorhynchus stagnalis biwaensis* Timoshkin, Grygier et Kawakatsu, 2004.

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Addition

The following paper contains occurrence records of “Turbellaria” obtained from the bottoms of Lake Tôya-ko and Lake Mashû-ko in Hokkaidô. Due to a bad preserved condition of the samples from the former, species identification was impossible. For the samples from the latter, see Kawakatsu, Murayama, Nishino & Ohtaka (1999).

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Explanation of Plates I-V

Plate I. *Dendrocoelopsis ezensis* Ichikawa et Okugawa, 1958 from the bottom of Lake Kussharo-ko, Japan. Photos by Ohtaka.

Fig. A: Whole mount specimen. Dorsal view. KSL No. 2438-a (ZIHU No. 3454). Loc.: Off the Wagoto Peninsula, St. 2 (49 m in depth). Aug. 1, 2008. Scale (black): 1 mm.

Fig. B: Whole mount specimen. Ventral view. KSL No. 2438-b (ZIHU No. 3455). Loc.: Off the Wagoto Peninsula, St. 2 (49 m in depth). Aug. 1, 2008. A narrow black arrow surrounded by a white outline: mouth; a black, bold-and-curved arrow: genital pore. Scale (black): 1 mm.

Fig. C: Enlarged head of the specimen of Fig. B. Central view. Notice the adhesive organ located at the mid-central portion of the ventral side of the head. This organ seems to be a slit in this whole-mounted specimen. Scale (white): 0.1 mm.

Figs D and E: Preserved cocoons. KSL No. 2439. Loc.: Off the Wagoto Peninsula, St. 2 (49 m in depth). Aug. 1, 2008. Scale (black): 1 mm.

Plate II. A sketch map of the Japanese Islands showing locations of 10 lakes (6 caldera, 1 dammed and 3 tectonic lakes) where lake-dwelling populations of freshwater planarians were recorded (1916-2008).

Plate III.

Fig. Top-left. Lake Mashû-ko chart. 1, *Mesostoma?* sp. was collected (210 m in depth); 2, *Gyratrix?* sp. was collected (150 m in depth). After Kawakatsu, Murayama, Nishino & Ohtaka (1999: 89, fig. 9).

Fig. Top-right. Lake Usoriyama-ko chart. 1, Ôzukushi-sawa Stream; 2, Kozukushi-sawa Stream; 3, Ichi-no-watari Stream; 4, the outlet of the Shôzu-gawa River. After Teshirogi, Sasaki & Kawakatsu (1981: 87, fig. 3).

Fig. Bottom. Map of Lake Usoriyama-ko and its vicinity, showing the distribution of 3 freshwater planarian species. Solid ellipses: *Bdellocephala brunnea* Ijima et Kaburaki, 1916 from bottom of the Lake. ✕: Bottom stations where planarians were not collected. Solid triangles: *Dugesia japonica* Ichikawa et Kawakatsu, 1964: Solid circles: *Phagocata vivida* (Ijima et Kaburaki, 1916). After Teshirogi, Sasaki & Kawakatsu (1981: 88, fig. 4; slightly modified).

Plate IV.

Fig. Top. Lake Towada-ko chart, with the distribution data of lake-dwelling populations of *Polycelis sapporo* (Ijima et Kaburaki, 1916)(open circles). Distribution of 3 planarian species inhabiting epigeal water around the Lake is also shown. Solid triangles: *Dugesia japonica* Ichikawa et Kawakatsu, 1964; solid circles: *Phagocata vivida* (Ijima et Kaburaki, 1916); solid squares: *Seidlia auriculata* (Ijima et Kaburaki, 1916). After Kawakatsu, Teshirogi & Tokui (1976: 478, fig. 1; slightly modified). See also Kawakatsu (1978: II, 7, fig. 12).

Fig. Bottom-left. Lake Tazawa-ko chart (after Shiraishi, 1972; modified).

Fig. Bottom-right. Lake Numazawa-ko chart (after Shiraishi, 1972; modified).

Plate V.

Fig. Top-left. Lake Motosu-ko chart (after Shiraishi, 1972; modified).

Fig. Top-right. Lake Aoki-ko chart (after Shiraishi, 1972; modified).

Fig. Bottom-left. Lake Kizaki-ko chart (after Shiraishi, 1972; modified).

Fig. Bottom-right. Lake Biwa-ko chart, with the distribution data of lake-dwelling populations of *Phagocata kawakatsui* Okugawa, 1956 (open square with center dot), *Bdellocephala annandalei* Ijima et Kaburaki, 1916 (solid circle) and *Dendrocoelopsis?* sp. (solid square). After Kawakatsu, Oki, Tamura, Takai, Yamamoto, Nishino, Timoshkin, Kuznedelov & Sluys (1996: 8, fig. 7). See also Oki, Tamura, Nishino, Takai, Kuznedelov, Timoshkin & Kawakatsu (1998: 316, fig. 1). For early versions of this distribution map, see Kawakatsu (1978, II: 6, fig. 9); Kawakatsu & Nishino (1993: 100, pl. III).