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A Taxonomic Survey of Freshwater Dinoflagellates of Nagano Prefecture, Japan

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Twenty eight species of freshwater dinoflagellates were collected from various lakes, water reservoirs and ponds of Nagano Prefecture, Japan, and morphology of these dinoflagelattes was studied by means of light and scanning electron microscopy. Special effort was made to discover and investigate as many unarmored species as possible, since the freshwater unarmored dinoflagellates are poorly known in Japan. Of 28 species, 13 species were confirmed to be newly recorded taxa to Japanese dinoflagellate flora and short descriptions were given for these species with photomicrographs and/or line drawing. Other species were also recorded either by photomicrographs or line drawings. Of the species examined, 12 species were found to belong to the genus *Gymnodinium*, 10 species belong to *Peridinium* and two species belong to *Katodinium* and four species belong to the genera *Amphidinium, Gyrodinium, Woloszynskia* and *Ceratium*.

Key Index Words: Armored dinoflagellates—Dinophyceae—Freshwater dinoflagellates—Unarmored dinoflagellates—Taxonomy

There have been several taxonomic or floristic studies on freshwater dinoflagellates in Japan (e.g. Akiyama 1956; Hada 1943; Imamura and Fukuyo 1990; Toriumi 1964; Tsumura 1977). It must be pointed out, however, little extensive taxonomic works have been made on freshwater unarmored (naked) dinoflagellates in Japan and our knowledge on this group, therefore, is still limited. For example, recently published "An Illustrated Guide to Freshwater Zooplankton in Japan" (Mizuno and Takahashi 1991) includes only 12 species of unarmored dinoflagellates (discribed as protozoa), three species of *Amphidinium* and nine species of *Gymnodinium*, and the number is relatively low when compared with the number of species (43 spp. as members of Gymnodiniaceae) included in Süsswasser Flora von Mittel Europe (Popovský and Pfiester 1990). The difference between species numbers recorded for Japan and for Europe seems simply reflecting lack of extensive taxonomic survey of freshwater unarmored dinoflagellates in Japan.

We have undertaken a taxonomic survey of freshwater dinoflagellates, including both armored and unarmored species, of Nagano Prefecture, Japan. Although we have studied both armored and unarmored species, special effort was made to discover as many unarmored species as possible. In this paper, we present the list of 28 species of freshwater dinoflagellates, of which 18 species are unarmored species, collected from various lakes, water reservoirs and small ponds of Nagano Prefecture, Japan. Photomicrographs and/or line drawings for each species are also presented.

Materials and Methods

Collecting localities are listed in Table 1 and Fig. 45. The number is assigned to each locality (Table 1 and Fig. 45) and these numbers are used for distribution records. Collections were made during April 1992 and De-

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Table 1. Sampling localities and distribution of freshwater dinoflagellates in Nagano Prefecture. Number in parenthesis represents altitude of each locality.

Site no.	Locality (altitude)	Dinoflagellates
1	Lake Nojiri (650 m), Shinano Town	Ghel, Kmaz, Ppen, Pumb, Cera
2	Kagami-ike Pond (1200 m), Togakushi Village	Amph, Pvol, Pwil
3	Kotoriga-ike Pond (1220 m), Togakushi Vil.	Pumb, Pvol, Pwil
4	Lake Reizenj (860 m), Mure Vil.	Pber, Pumb
5	Small water reservoir (700 m), Mure Vil.	Gaer, Gtho, Pber, Pumb
6	Small water reservoir (700 m), Mure Vil.	Gaer, Gwaw
7	Nekomata-ike Pond (910 m), Nagano City	Gacc, Gaer, Gube, Pelp, Pvol. Cera
8	Kitago-oike Pond (930 m), Nagano City	Pelp
9	Yanagisawa-ike Pond (1040 m), Nagano C.	Pwil
10	Kami-ichinokura-ike Pond (1040 m), Nagano C.	Gube, Plom, Pumb, Pvol, Cear
11	Shimo-ichinokura-ike Pond (1020 m), Nagano C.	Pwil
12	Wakatuski-oike Pond (520 m), Nagano C.	Gacc, Gyro, Pber, Pelp, Ppal, Cera
13	Kanetsukido-ike Pond (480 m), Nagano C.	Gsp 2, Gyro, Pber, Pbip, Plom, Ppal, Ppen, Pumb, Pvol
14	Jinguji-ike Pond (360 m), Nagano C.	Gsp. 2, Pber
15	yamanokami-ike Pond (450 m), Nagano C.	Pumb
16	Tokuma-ike Pond (400 m), Nagano C.	Cera
17	Sansai-ike Pond (350 m), Nagano C.	Pber
18	Harano-ike Pond (360 m), Nagano C.	Cera
19	Kanne-ike Pond (360 m), Nagano C.	Pber
20	Tatumi-ike Pond (370 m), Nagano C.	Gacc, Gaus, Pber, Pvol, Cera
21	Chidoriga-ike Pond (400 m), Nagano C.	Pumb
22	Pond in Shinshu Univ. (400 m), Nagano C.	Gube
23	Kohanami-ike Pond (800 m), Ohoka Vil.	Cera
24	Ohanami-ike Pond (880 m), Ohoka Vil.	Gaer, Gube
25	Ashinuma-ike Pond (870 m), Ohoka Vil.	Gaer, Glac, Gsp. 2, Wolo, Pber, Pumb
26	Ashinuma (870 m), Ohoka Vil.	Gaer, Glac, Gube, Gsp. 2, Pber, Pumb
27	Shirakaba-ike (1170 m), Ohoka Vil.	Gsp. 1, Pumb
28	Hijiri-ike Pond (1170 m), Ohoka Vil.	Pelp, Pumb
29	Lake nakatuna (1230 m), Ohoka Vil.	Cera
30	Onuma (1120 m), Ohoka Vil.	Gaer, Gube, Pgat, Ppen, Pumb, Pvol, Cera
31	Lake Hijiri (950 m), Ohoka Vil.	Gaer, Gube, Pgat, Pumb, Cera
32	Chikuma Kogen-oike Pond (840 m), Ohoka Vil.	Gaer, Gube, Pumb, Pvol, Cera
33	Lake Aoki (820 m), Ohomachi City	Glim, Cera
34	Lake Nakatuna (820 m), Ohomachi C.	Gsp. 1, Pbip, Pumb, Cera
35	Lake Kizaki (760 m), Ohomachi C.	Pbip, Pelp
36	Tamizo-ike Pond (750 m), Matumoto C.	Pber
37	Okada-ike Pond (700 m), Matumoto C.	Gsp. 2, Kwol
38	Siokura-ike Pond (700 m), Matumoto C.	Pber
39	Moat of Matumoto Casle (579 m), Matumoto C.	Gsp. 1
40	Kosibu Water reservoir (600 m), Nakagawa vil.	Gacc, Gube, Pbip, Pelp
41	matukawa Water reservoir (700 m), Matukawa T.	Pbip
42	Kosaka Wate reservoir (800 m), Saku City	Gaer
43	Tokoji-ike Pond (530 m), Ueda C.	Pelp
44	Tearai-ike Pond (530 m), Ueda C.	Gacc
45	Shin-ike Pond (480 m), Ueda C.	Pumb
46	Shitakui-ike Pond (530 m), Ueda C.	Pelp
47	Suga-ike Pond (1260 m), Yamanouchi Town	Ppen
48	Naga-ike Pond (1570 m), Yamanouchi T.	Gfus, Pumb
49	Hasu-ike Pond (1500 m), Yamanouchi T.	Gfus, Pumb
50	Shijuhachi-ike Pond (1880 m), Yamanouchi T.	Wolo, Pumb

Abbreviations used in Table 1.Amph: *Amphidinium elenkinii*, Gacc: *Gymnodinium accuminatum*, Gaer: *G. aeruginosum*, Gaus: *G. austriacum*, Gfus: G. fuscum, Ghel: *G. helveticum*, Glac: *G. lacstre*, Glim: *G. limitatum*, Gtho: *G. thomasi*, Gube: *G. uberimum*, Gwaw: *G. wawricae*, Gsp. 1: *Gymnodinium* sp. 1, Gsp. 2: *Gymnodinium* sp. 2, Gyro: *Gyrodinium hyalinum*, Kmaz: *Katodinium mazuricum*, Kwol: *k. woloszynskae*, Wolo: *Woloszynskia neglecta*, Pber: *Peridinium berolinense*, Pbip: *P. bipes*, Pelp: *P. elpatiewsky*, Pgat: *P. gatunense*, Plom: *P. lomnickii*, Ppal: *P. palatinum*, Ppen: *P. penardiforme*, Pumb: *P. umbonatum*, Pvol: *P. volzii*, Pwil: *P. willei*, Cera: *Ceratium hirundinella*

cember 1992. Samples were collected with a plankton net and examined live using compound microscope. Alternatively, 250 ml of water was collected and centrifuged in order to concentrate cells and they were examined live. For observing unarmored species, it is essential to examine live materials, for these dinoflagellates are sensitive to fixatives and quickly loose their original shape.

For scanning electron microscopy, cells were picked up individually by capillary pipette and rinsed in distilled water several times and naturally dried on cover slip. The cover slip was, then, mounted on a specimen holder and coated with gold. Observations were made using a JEOL T-20 scanning electron microscope.

Results

The freshwater dinoflagellates found in our survey are listed below. For the species which have been found in Japan for the first time (new record), short descriptions are given. For all the species, either photomicrographs and/or line drawings are presented. Distribution of each dinoflagellate is also given in the text (only the numbers are cited) as well as in Table 1. Only the main references are given for each species.

Dinophyceae Fritsch
Gymnodiniales Lemmermann
Gymnodiniaceae Lankester

***Amphidinium elenkinii* Skvorcov** 1925. (Figs. 2, 19)

Huber-Pestalozzi p. 104 Fig. 78 (1968), Popovský and Pfiester p. 90 Fig. 63 (1990), Schiller p. 288 Fig. 278 (1933)

Cell seems somewhat pentagonal with rounded corners in ventral view. Antapical portion of the cell is notched by distal end of the sulcus. Hypocone is twice as long as epicone. Cingulum is wide and deeply excavated, encircling the cell without displacement. Sulcus is also wide and reaches antapex. Neither chloroplast or eyespot is present. A spherical pale yellowish colored globules of about 4 μm in diameter was sometimes observed in the epicone.

Dimensions: 12.0 × 12.0 μm

Distribution: 3 (new to Japan)

***Gymnodinium accuminatum* Christen** 1954. (Figs. 6, 23)

Popovský and Pfiester p. 100 Fig. 75 (1990)

Cell is almost spheroidal, although sometimes width is greater than length. Cingulum is well excavated and slightly left-handed. Sulcus is narrow, invading into halfway of epicone and not reaching antapex. Chloroplasts are many, yellowish brown, rod-shaped and radially arranged. Eyespot is present. Nucleus is located in hypocone.

Dimensions: 23.5–27.5 × 25.0 μm

Distribution: 7, 12, 20, 40, 44 (new to Japan)

Our specimen is in good agreement with that of Christen's original description, except shape of the epicone. The epicone is moderately rounded in the former, while the epicone is pointed in the latter species. However, based on the overall similarity, such as cell size, shape and arrangement of the chloroplast and presence of the eyespot, we identified our species as *G. accuminatum*.

***Gymnodinium aeruginosum* Stein** 1883. (Figs. 11, 18)

Huber-Pestalozzi p. 127 Fig. 99 (1968), Kofoid and Swezy p. 183 Fig. X, 25 (1921), Popovský and Pfiester p. 100 Fig. 776 (1990), Schiller p. 327 Fig. 330 (1933)

Dimensions: 28.5–38.5 × 18.0–31.0 μm

Distribution: 5, 6, 7, 24, 25, 26, 30, 31, 32, 42

***Gymnodinium austriacum* Schiller** 1933. (Figs. 5, 22)

Huber-Pestalozzi p. 142 Fig. 124 (1968), Popovský and Pfiester p. 100 Fig. 76 (1990), Schiller p. 336 Fig. 340 (1933)

Cell is ellipsoidal, slightly dorsoventrally flattened. Epicone is hemi-spheroidal, while hypocone is trapezoidal. Cingulum is wide, about 1/8 of cell length and is displaced about 1/2 of its own width. Sulcus is narrower than cingulum, invading into epicone and reaching antapex. Nether chloroplast or eyespot is present. Nucleus is ovoidal and is located in epicone. Yellowish food vacuole is sometimes observed in hypocone.

Dimensions: 20.0-25.0×17.0-20.0 μm
Distribution: 20 (new to Japan)

***Gymnodinium fuscum* (Ehrenberg) Stein** 1878. (Fig. 12)

Huber-Pestalozzi p. 117 Fig. 87 (1968), Ling, Croome and Tyler p. 113 Figs. 2, 84 (1989), Kofoid and Swezy p. 210 Fig. X, 19 (1921), Popovský and Pfiester p. 105 Figs. 83, 84 (1990), Prescott p. 426 Pl. 89 Fig. 23 (1962), Schiller p. 359 (1933)

Dimensions: 42.5-43.8×30.0-35.0 μm
Distribution: 48, 49.

***Gymnodinium helveticum* Penard** 1891. (Figs. 13, 29)

Huber-Pestalozzi p. 139 Fig. 121 (1968), Kofoid and Swezy p. 219 Fig. Y, 11 (1921), Popovský and Pfiester p. 107 Figs. 85, 86 (1990), Schiller p. 368 Fig. 374 (1933)

Cell is relatively large and wedge-shaped. Epicone is dome-shaped with a knob-like protrusion at apex, while hypocone is conical with a pointed antapex. The hypocone is larger than the epicone. Cingulum is broad, well excavated and with little displacement. Sulcus is narrow and not reaching the antapex. Many rod-shaped refractive bodies are scattered throughout cytoplasm. Neither chloroplasts or eyespot is present. Nucleus is located in the epicone.

Dimensions: 47.5-55.0×25.0-30.0 μm
Distribution: 1. (new to Japan)

This relatively large dinoflagellate possesses characteristic cell shape and, therefore, unmistakable. The dinoflagellate was found in the samples collected at depth of 15 m from the surface of the Lake Nojiri.

***Gymnodinium lacustre* Schiller** 1933. (Figs. 4, 21)

Huber-pestalozzi p. 137 Fig. 118 (1968), Popovský and Pfiester p. 110 Fig. 89 (1990), Schiller p. 374 Fig. 383 (1933)

Cell is ovoidal in ventral view and slightly dorsoventrally flattened. The epicone is hemi-spheroidal, while hypocone is hemi-spheroidal with a flattened antapex. The hypocone is larger than the epicone. Cingulum is well excavated with little displacement. Sulcus is narrow, extending up to 4/5 of the epicone and reaching the antapex. Chloroplasts are many, yellowish brown, discoidal and peripherally arranged. Eyespot is elongated and is located at the sulcus. Nucleus is situated in the middle of the cell.

Dimentions: 13.5×11.0 μm
Distribution: 25, 26 (new to Japan)

***Gymnodinium limitatum* Skuja** 1933. (Figs. 1, 18)

Javornicky p. 58, Fig. 12 (1965)

Cell is ovoidal and dorsoventrally compressed. Hypocone is larger than epicone. Cingulum is deeply excavated, slightly left-handed. Sulcus is narrow, reaching antapex and invades into epicone, as well. Chloroplasts are 10-20 in number, yellowish brown, elliptical, about 5 μm in length and arranged radially. Nucleus is ovoidal and occupies most part of the epicone. No stigma is present. many small rod-shaped granules are arranged radially along the peripheral region of the cell.

Dimensions: 25.0-35.0×18.0-25.0 μm
Distribution; 33 (new to Japan)

***Gymnodinium thomasi* Christen** 1959. (Figs. 3, 20)

Popovský and Pfiester p. 114 Fig. 95 (1990)

Cell is egg-shaped, slightly compressed dorsoventrally. Both epicone and hypocone are hemi-spheroidal and almost equal in length. Cingulum is wide and slightly left-handed. Sulcus is narrower than the cingulum, not invades into the epicone and does not reach antapex. Chloroplasts are 10-20 in number, clubshaped, yellowish brown and they are mostly located in the hypocone and arranged like a bunch of bananas or almost radially. Most part of the epicone is occupied by a spherical nucleus. No eyespot is present.

Dimensions: 11.0-15.0×7.0-13.0 μm
Distribution: 5 (new to Japan)

***Gymnodinium uberrimum* (Allman) Kofoid et Swezy** 1921. (Figs. 9, 26)

Huber-Pestalozzi p. 124 Fig. 97 (1968), Kofoid and Swezy p. 264 Fig. X, 9 (1921), Popovský and Pfiester p. 116 Fig. 97 (1990), Schiller p. 422 Fig. 444 (1933)

Dimensions: 40.0-72.5×40.0-65 μm
Distribution: 7, 10, 22, 24, 26, 30, 31, 32, 40

***Gymnodinium wawrikae* Schiller** 1955.

(Figs. 7, 24)

Popovský and Pfiester p. 118 Fig. 99 (1990)

Cell is ovoidal or spherical in ventral view and dorsoventrally compressed. Epicone is dome-shaped, while hypocone is hemispheroidal with notched antapex. The hypocone is slightly shorter than the epicone. Cingulum is broad and slightly left-handed. Sulcus is as broad as the cingulum, reaching antapex and not invade into the epicone. Chloroplasts are many, yellowish brown, large, discoidal and peripherally arranged. Eyespot is large and conspicuous. Nucleus is located in the middle of the cell.

Dimensions: 25.0 × 22.5 μm

Distribution: 6 (new to Japan)

***Gymnodinium* sp. 1** (Figs. 10, 27)

Cell is almost rounded in ventral view and more or less dorsoventrally compressed. Epicone is hemispherical, while hypocone is conical with pointed antapical end. Sometimes right side of the hypocone is moderately concaved. The epicone is slightly longer than the hypocone. Cingulum is deep, left-handed and descends its own width. Sulcus is narrower than the cingulum and does not invade into the epicone and reaches antapex. Chloroplasts are many, rod-shaped and radially arranged. Eyespot is asymmetrical in shape and slightly curves toward ventral side. Nucleus is ovoidal and is located in upper part of the hypcone.

Dimensions: 37.0–40.0 × 30.0–35.0 μm

Distribution: 27, 34, 39

Of described species of freshwater gymnodinioids, *Gymnodinium caudatum* Prescott seems to be the closest relative of this species. Both species share the characteristics such as cell shape, shape, number and arrangement of the chloroplasts and presence of the eyespot. However, *G. caudatum* is 3 times as big as our species. Furthermore, the eyespot of *G. caudatum* is small and obscure (Prescott, 1944), while that of our species is large and distinctive. Therefore, we concluded that these two species are not conspecific. It may be a new species, but requires more detailed study.

***Gymnodinium* sp. 2** (Figs. 8, 25)

Cell is almost spherical and slightly dorsoventrally compressed. Antapical end of the cell is more or less pointed. Epicone and hypocone are almost equal in length. Cingulum is wide, slightly left-handed and displaces 1/2 to 1/1 of its own width. Sulcus is narrow and does not invade into the epicone. No chloroplasts or eyespot are present. Nucleus is slightly curved ovoidal and located in the hypocone. Spherical globules are scattered throughout cytoplasm.

Dimensions: 25.0–33.0 × 22.0–26.0 μm

Localities: 13, 14, 25, 26, 37

The present species resembles *Gymnodinium hiemale* (Schiller) Popovský in overall morphology. It is, however, different from our species in having smaller size, viz. 10–15 × 9–12 μm (Popovský and Pfiester 1991) and possession of flattened or rounded antapica end. This species might belong to a new species. More detailed study is, however, needed before final taxonomic conclusion is drawn.

***Gyrodinium hyalinum* (Schilling) Kofoid et Swezy** 1921. (Figs. 16, 32)

Huber-Pestalozzi p. 147 Fig. 131 (1968), Kofoid and Swezy p. 311 Fig. CC, 15 (1921), Popovský and Pfiester p. 135 Fig. 128 (1990), Schiller p. 473 Fig. 503 (1933)

Cell is ovoidal or ellipsoidal, slightly dorsoventrally compressed and asymmetrical in ventral view. Epicone is dome-shaped, while hypocone is elongated dome-shaped and is notched by distal end of sulcus. Cingulum is broad, well excavated and greatly displaced. Sulcus is positioned on the right side of the cell and reaches antapex. No chloroplast is present. Eyespot is conspicuous and is located at where the sulcus and the cingulum meet. Semi-hyaline bodies of various sizes are present in the cytoplasm. Nucleus is usually located in the upper part of the hypocone.

Dimensions: 25.0–32.5 × 20.0–25.0 μm

Distribution: 12, 13 (new to Japan)

Members of the genus *Gyrodinium* are mostly marine and only a few species have been known from freshwater habitats. Our species is in good agreement with *G. hyalinum* in

having no chloroplast, possession of the eyespot, overall morphology and cell size.

cf. *Katodinium mazuricum* Javornicky 1965. (Figs. 15, 31)

Popovský and Pfiester p. 128 Fig. 113 (1990)

Cell is mushroom-shaped, slightly depressed dorsoventrally. Epicone is hemispherical or conical, while hypocone is hemispherical with a slightly pointed apices. The epicone is two times as long as the hypocone. Both cingulum and sulcus are not conspicuous and only the upper edge of the cingulum is recognizable. A single chloroplast is plate-like, yellowish brown and peripherally arranged. It is divided into two lobes, one extends into the epicone, while the other into the hypocone. Nucleus is slightly curved ellipsoidal and located in left side of the epicone. Sometimes reddish colored plate-like structure was observed in somewhere in the cytoplasm. No eyespot was observed.

Dimensions: 12.0 × 10.0 μm

Distribution: 1 (new to Japan)

Our specimens well agree with the description of *K. mazuricum* (Javornicky, 1965), including cell size, overall morphology, position of nucleus and shape of chloroplast. The only discrepancy exists is presence of the eyespot in the latter species. The other possibly related species is *Gymnodinium triceratium* Skuja (1939). It is, however, different from our species in possession of one to five oval-shaped chloroplasts and position of nucleus. Although the eyespot does not exist in our specimens, we tentatively identified it as *K. mazuricum* based on overall similarities.

***Katodinium woloszynskae* (Schiller) Loeblich III** 1965. (Figs. 14, 30)

Popovský and Pfiester p. 133 Fig. 122 (1990)

Cell is ovoidal in ventral view and dorsiventrally compressed. Epicone is almost triangular in side view, while hypocone is hemispheroidal. Cingulum is deep and broad, slightly left-handed and displaced 1/2 to 1/1 of its own width. Sulcus is narrow, extending up to 2/3 of the epicone and reaching antapex. No chloroplast is present. Eyespot is conspicuous and located at the sulcus. Nucleus is situated in the center of the cell. Many hyaline globules of various sizes are scattered in the cytoplasm. Sometimes, colored bodies (bright yellowish brown or red) are present.

Dimensions: 17.5-22.5 × 15.0-17.5 μm

Distribution: 37 (new to Japan)

Family Lophodiniaceae Osorio-Tafall

***Woloszynskia neglecta* (Schilling) Thompson** 1950. (Figs. 17a, b, 33)

Popovský and Pfiester p. 141 Fig. 134 (1990)

Cell is ovoidal or spheroidal. Cingulum is broad and slightly left-handed. Right end of the cingulum is slightly narrower than that of left end. Sulcus is shallow and inconspicuous and seems to reach antapex. Upper edge of the cingulum and the left edge of the sulcus seem to be thickened. Cell is covered with many, small, thin, hexagonal plates. Chloroplasts are many, small, yellowish brown, discoidal and peripherally arranged. Eyespot is conspicuous and located at the sulcus. Nucleus is located in the lower part of the epicone.

Dimensions: 27.5-31.0 × 22.5-26 μm

Distribution; 25, 50 (new to Japan)

Order Peridiniales Haeckel

Family Peridiniaceae Ehrenberg

***Peridinium berolinense* Lemmermann** 1900. (Fig. 34)

Huber-Pestalozzi p. 245 Fig. 268 (1968), Popovský and Pfiester p. 199 Fig. 217 (1990), Schiller p. 111 Fig. 107 (1937)

Dimensions: 27.0-30.0 × 22.0-26.0 μm

Distribution: 4, 5, 12, 13, 14, 17, 19, 20, 25, 26, 36, 38

***Peridinium bipes* Stein** 1883. (Fig. 35)

Bourelly p. 62 Pl. 8, Figs. 6-11 (1985), Huber-Pestalozzi p. 208 Fig. 201 (1968), Popovský and Pfiester p. 172 Figs. 30, 179 (1990), Schiller p. 158 Fig. 156 (1937)

Dimensions: 50.0-58.0 × 45.0-54.0 μm

Distribution: 13, 34, 35, 40, 41

***Peridinium elpatiewsky* (Ostenfeld) Lemmermann** 1910. (Fig. 36)

Bourelly p. 68 Pl. 11, Figs. 1-6 (1985), Huber-Pestalozii p. 237 Fig. 256 (1968), Popovský and Pfiester p. 190 Fig. 205 (1990), Schiller p. 115 Fig. 133 (1937)
Dimensions: 27.0-34.0 × 22.0-26.0 μm
Distribution: 7, 8, 12, 28, 35, 40, 43, 46

***Peridinium gatunense* Nygaard** 1925. (Fig. 37)

Bourelly p. 60 Pl. 7, Figs. 6-11 (1985), Huber-Pestalozzi p. 202 Fig. 188 (1968), Popovský and Pfiester p. 168 (1990), Schiller p. 155 Fig. 155 (1937)
Dimensions: 36.0-40.0 k35.0 40.0 μm
Distribution: 30, 31

***Peridinium lomnickii* Woloszynska** 1916. (Fig. 38)

Bourelly p. 64 pl. 9, Figs. 7-10 (1985), Huber-Pestalozii p. 215 Fig. 211 (1968), Popovský and Pfiester p. 176 Fig. 186 (1990)

Cell is ovoidal or almost spherical, not dorsoventrally flattened. Cell width is slightly broader than cell length. Cingulum is not displaced, wide, about 1/8 of cell length and shallow. Sulcus does not reach antapex. Thecal plate formula: pp, x, 4', 3a, 7″, 6c, 4s, 5‴, 2″″. Thecal plates are thin. Surface of thecal plates is covered with many, small wart-like projections. Chloroplasts are many, yellowish brown, ellipsoidal and are scattered throughout cytoplasm.
Dimensions: 27.0-45.0 × 26.0-40.0 μm
Distribution: 10, 13 (New to Japan)

***Peridinium palatinum* Lauterborn** 1896. (Fig. 39)

Bourelly p. 62 Pl. 8, Figs. 1-5 (1985), Huber-Pestalozii p. 205 Fig. 196 (1968), Popovský and Pfiester p. 170 Fig. 176 (1990)
Dimensions: 41.0-43.0 × 35.0-40.0 μm
Distribution: 12, 13

***Peridinium penardiforme* Lindemann** 1918. (Fig. 40)

Huber-Pestalozii p. 247 (1968), Popovský and Pfiester p. 197 Fig. 214 (1990), Schiller p. 113 Fig. 110 (1937)
Dimensions: 27.0-29.0 × 25.0-28.0 μm
Distribution: 1, 13, 30, 47

***Peridinium umbonatum* Stein** 1883. (Fig. 41)

Huber-Pestalozii p. 220 Fig. 218 (1968), Ling, Croome and Tyler p. 117 Figs. 55-62, 95-97 (1989), Popovský and Pfiester p. 183 Fig. 220 (1990)

This species has the widest distribution among the dinoflagellates studied in this survey. We treated *Peridiniium inconspicuum* Lemm. as synonym of this species, following Popovský and Pfiester (1990).
Dimensions: 27.0-33.0 × 24.0-30.0 μm
Distribution: 1, 3, 4, 5, 10, 13, 15, 21, 25, 26, 27, 28, 30, 31, 32, 34, 45, 48, 49, 50

***Peridinium volzii* Lemmermann** 1905. (Fig. 42)

Huber-Pestalozii p. 195 Fig. 177 (1968), Ling, Croome and Tyler p. 117 Figs. 38-41, 98-100 (1989), Schiller p. 147 Fig. 149 (1937)
Distribution: 2, 3, 7, 10, 13, 20, 30, 32

***Peridinium willei* Huitfeld-Kaas** 1990. (Fig. 43)

Huber-Pestalozii p. 193 Fig. 176 (1968), Ling, Croome and Tyler p. 117 Figs. 43-46, 91-94 (1989), Popovský and Pfiester p. 165 Fig. 170 (1990), Schiller p. 146 Fig. 148 (1937)
Dimensions: 45.0-50.0 × 45.0-50.0 μm
Distribution: 2, 3, 9, 11

Family Ceartiaceae Lindemann

***Ceratium hirundinella* (O. F. Müller) Schrank** 1841. (Fig. 44)

Bourelly p. 86 Pl. 18, Figs. 1-10, Huber-Pestalozii p. 260 Fig. 277 (1968), Popovský and Pfiester p. 207 Fig. 226 (1990), Both three-horned and two-horned types have been found. Cysts have also been found in several localities.
Dimensions: 148.0-250.0 × 35.5-49.0 μm
Distribution: 1, 7, 10, 13, 16, 18, 20, 23, 29, 30, 32, 33, 34

Samples were collected from some 80 ponds and lakes and 50 of them contained dinoflagellates (Table 1 and Fig. 45) and we were able to find 13 species of dinoflagellates which are new record to the Japanese dinoflagellate flora. We have to point out, however, that we know little about seasonal variations of species composition of freshwater dinoflagellates

in our region. The result of our survey suggests that there are still many dinoflagellates to be discovered and to be recorded. It is certain that more extensive research, both geographically and seasonally, will expand our basic knowledge concerning freshwater dinoflagellates in Japan.

Acknowledgement

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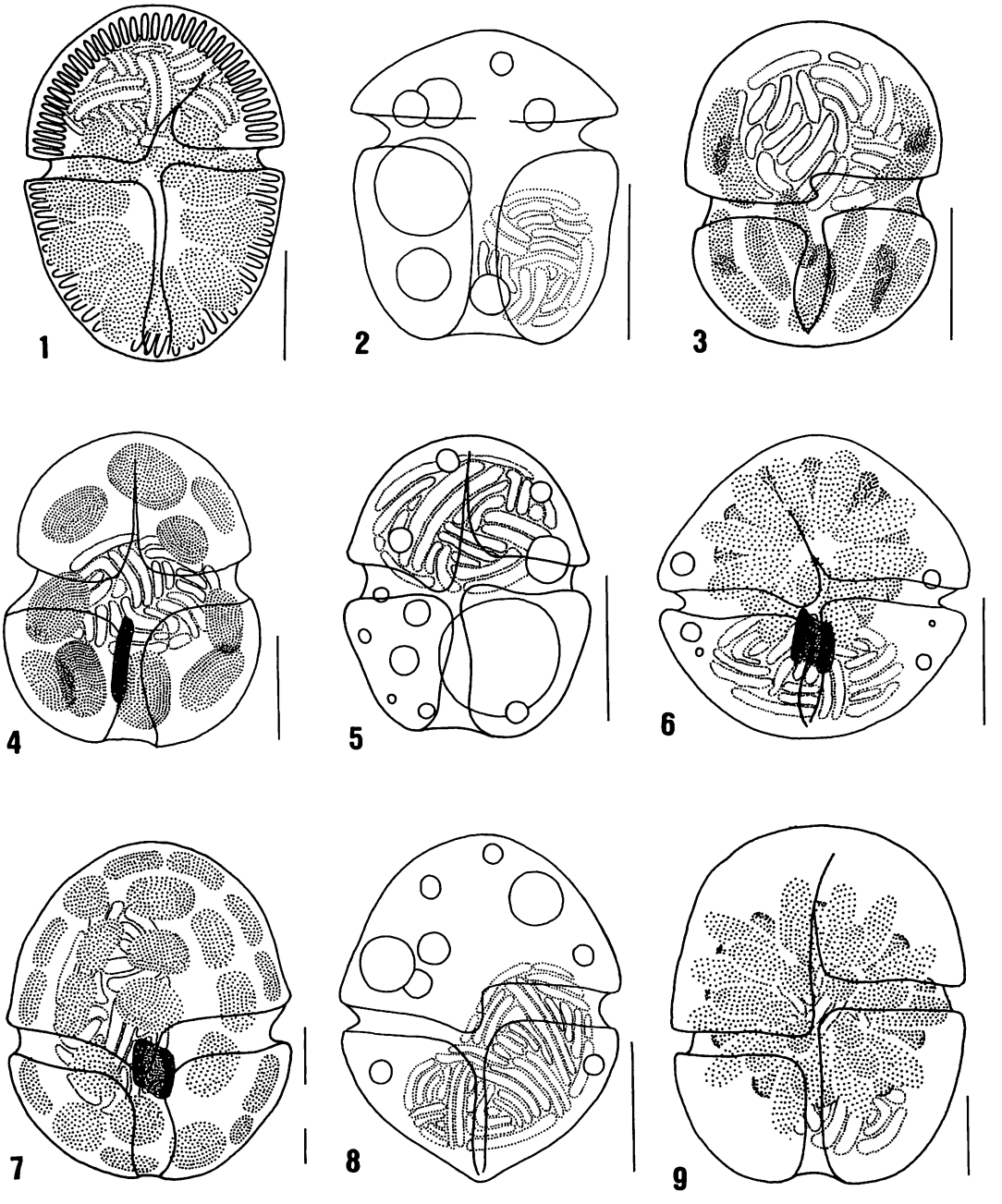
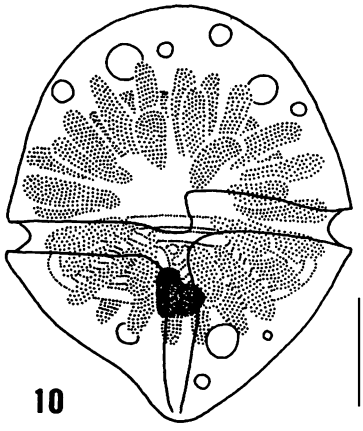


Figs. 1–9. Freshwater unarmored dinoflagellates of Nagano Pref. Fig. 1. *Gymnodinium limitatum*, Fig. 2. *Amphidinium elenkinii* Fig. 3. *G. thomasii*, Fig. 4. *G. lacustre*, Fig. 5. *G. austriacum*, Fig. 6. *G. accuminatum*, Fig. 7. *G. wawrikae*, Fig. 8. *Gymnodinium* sp. 2, Fig. 9. *G. uberrimum*. All scale bars=10 μm.

Figs. 10–17. Freshwater unarmored dinoflagellates of Nagano Pref. Fig. 10. *Gymnodinium* sp. 1, Fig. 11. *G. aeruginosum*, Fig. 12. *G. fuscum*, Fig. 13. *G. helveticum*, Fig. 14. *Katodinium woloszynskae*, Fig. 15. cf. *K. mazuricum*, Fig. 16. *Gyrodinium hyalinum*, Fig. 17a, b. *Woloszynskia neglecta* Fig. 17a. ventral view, Fig. 17b. empty hypotheca showing many small thin hexagonal plates. All scale bars=10 μm.



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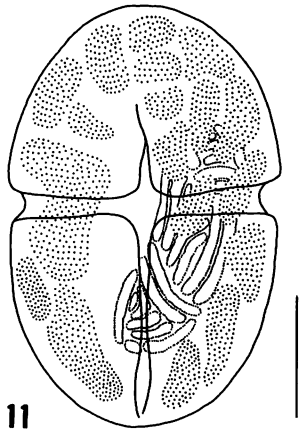

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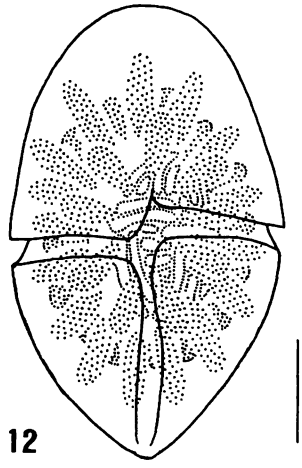

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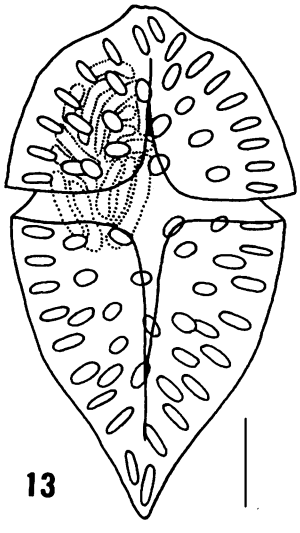

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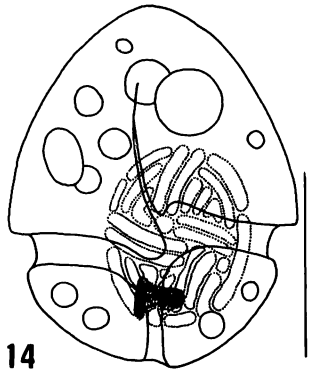

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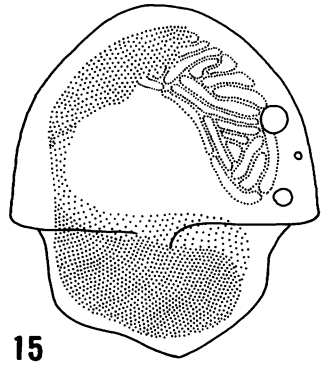

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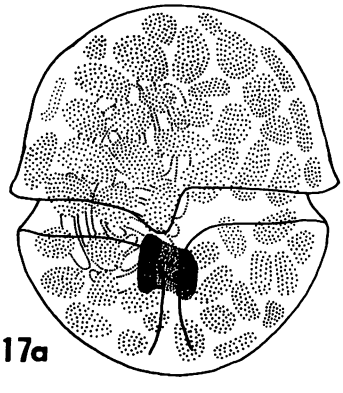

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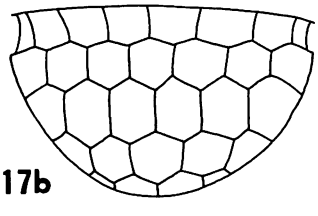

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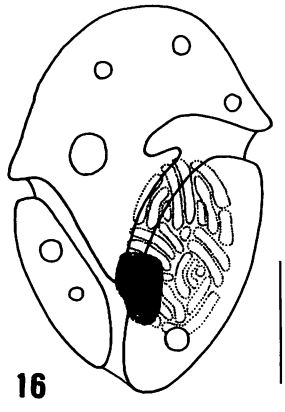

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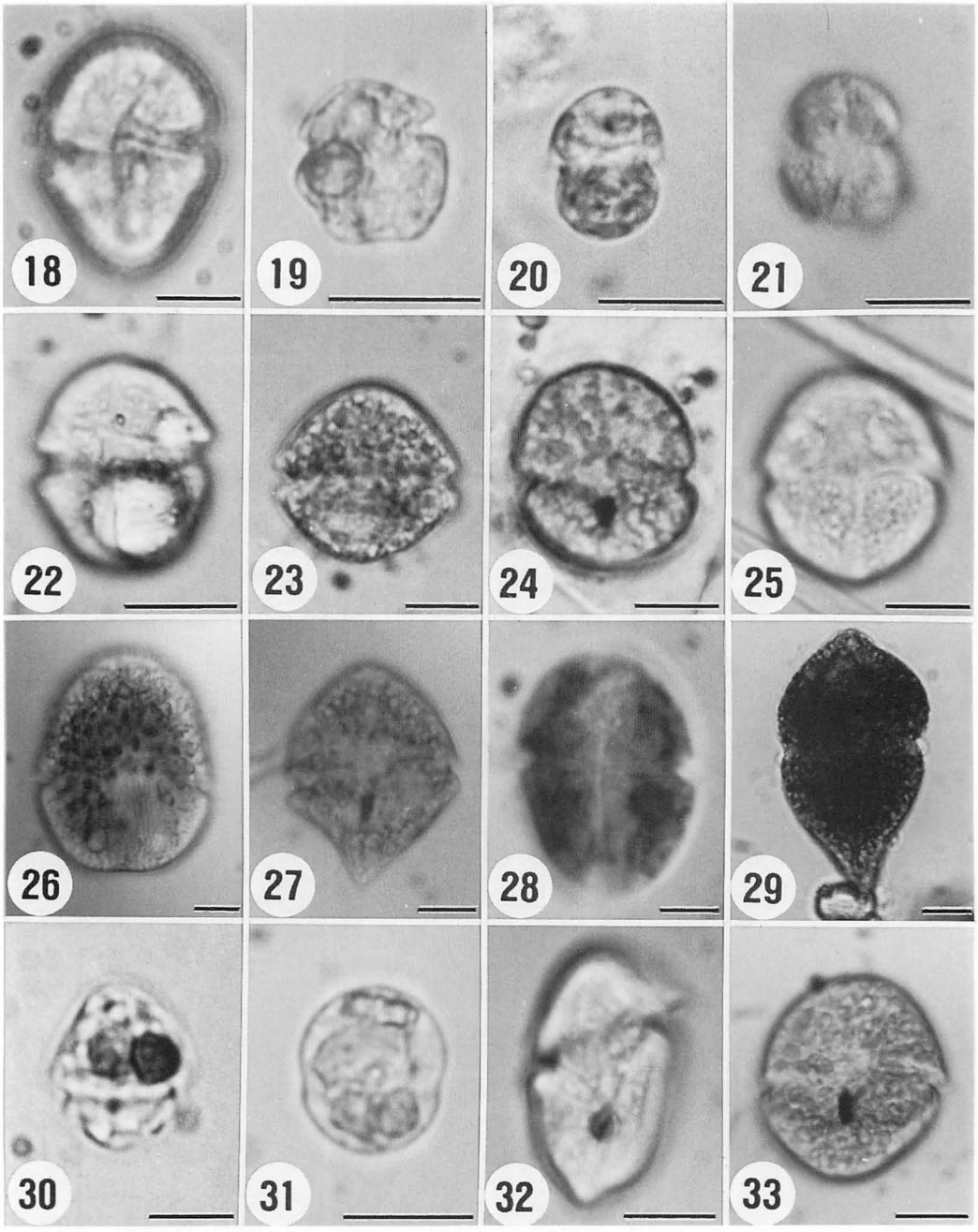
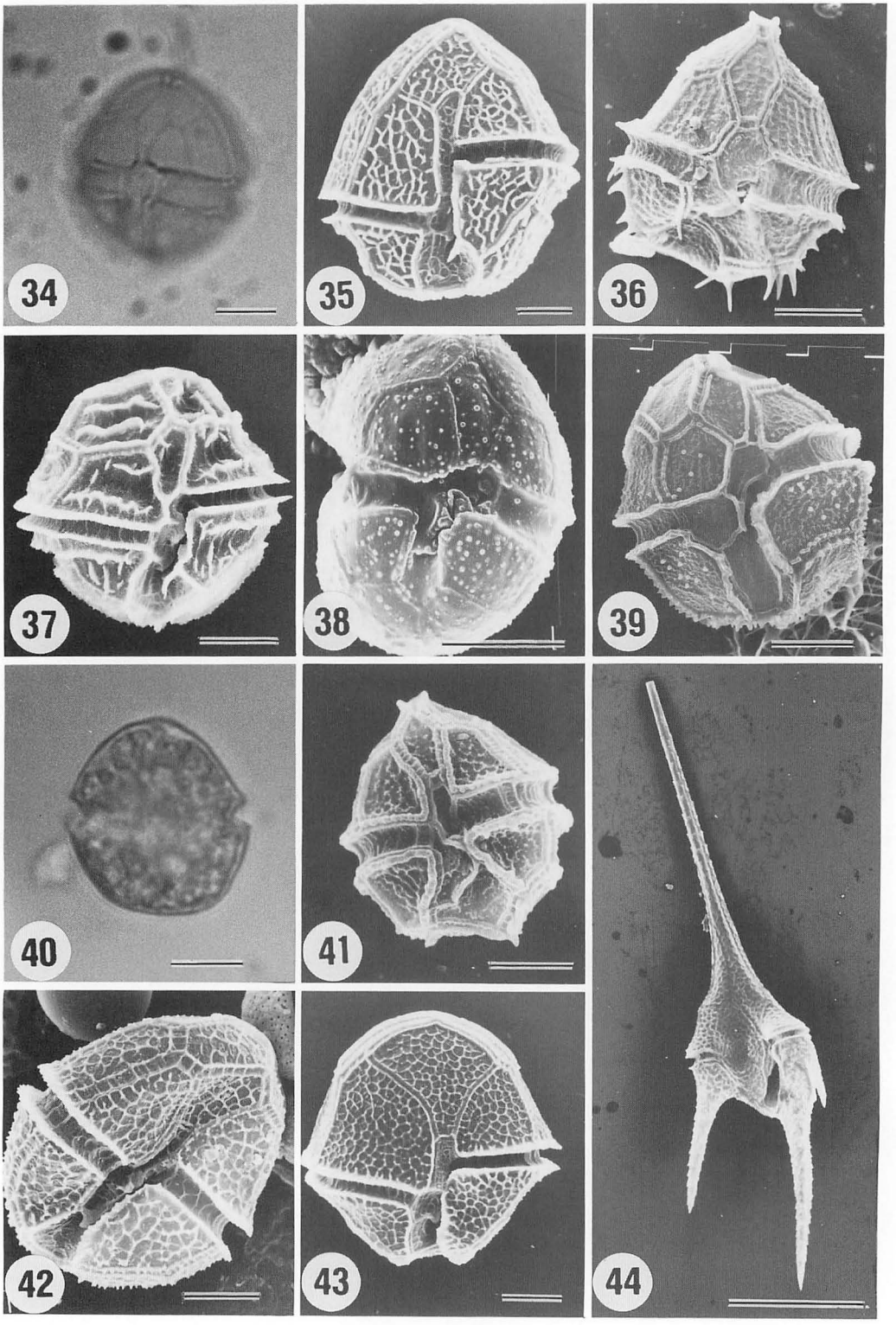


Figs. 18–33. Freshwater unarmored dinoflagellates of Nagano Pref. Fig. 18. *Gymnodinium limitatum*, Fig. 19. *Amphidinium elenkinii*, Fig. 20. *G. thomasii*, Fig. 21. *G. lacustre* Fig. 22. *G. austriacum* Fig. 23. *G. accuminatum* Fig. 24. *G. wawrikae* Fig. 25. *Gymnodinium* sp. 2, Fig. 26. *G. uberrimum*, Fig. 27. *Gymnodinium* sp. 1, Fig. 28. *G. aeruginosum*, Fig. 29. *G. helveticum*, Fig. 30. *Katodinium woloszynskae*, Fig. 31. cf. *K. mazuricum*, Fig. 32. *Gyrodinium hyalinum*, Fig. 33. *Woloszynskia neglecta*. All scale bars=10 μm.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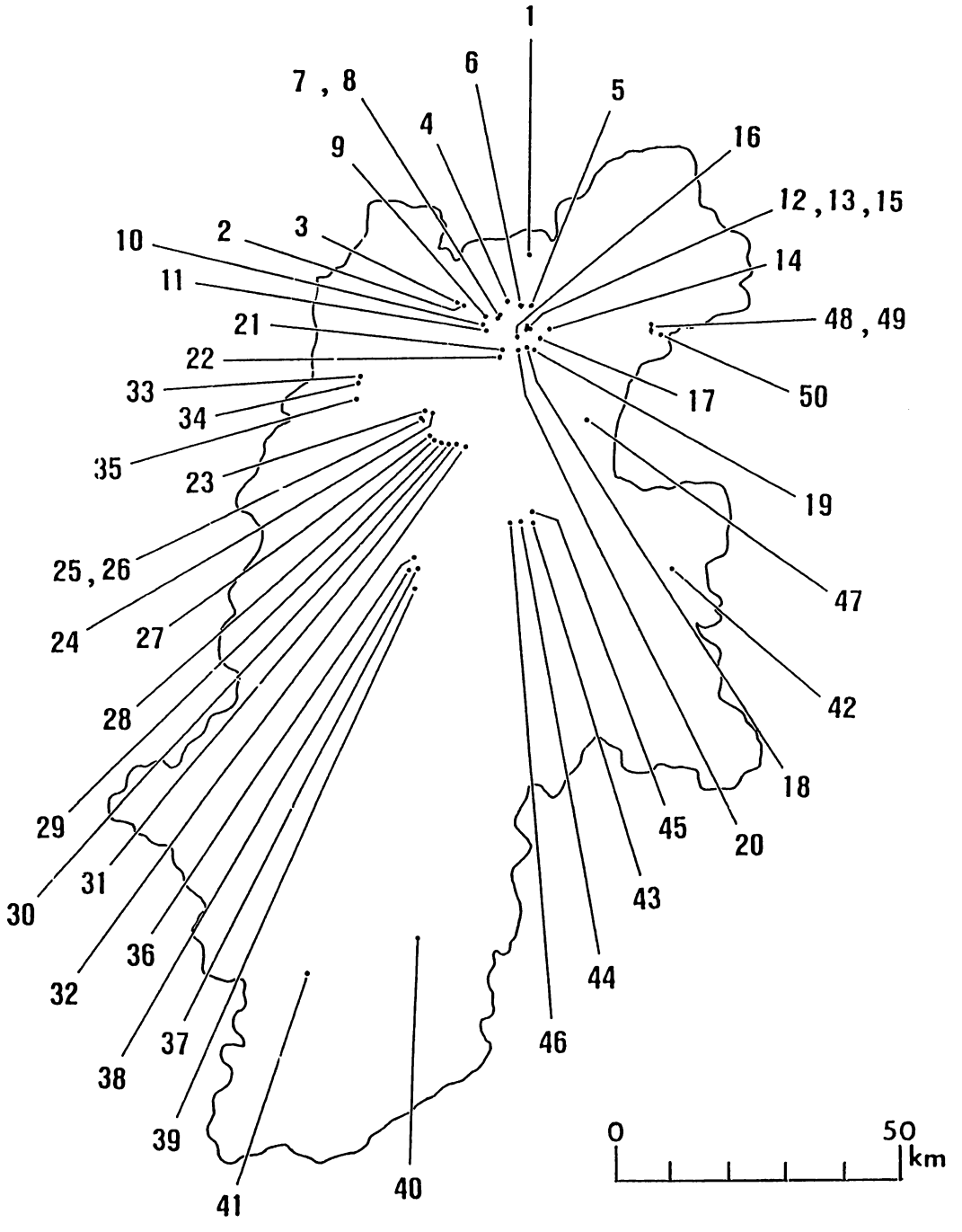

Fig. 45: Sampling localities in Nagano Prefecture. The numbers correspond to those of Table 1.

Figs. 34–44. Freshwater armored dinoflagellates of Nagano Pref. Fig. 34. *Peridinium berolinense*, Fig. 35. *P. bipes*, Fig. 36. *P. elpatiewsky*, Fig. 37. *P. gatunense*, Fig. 38. *P. lomnickii*, Fig. 39. *P. palatinum*, Fig. 40. *P. penardiforme*, Fig. 41. *P. umbonatum*, Fig. 42. *P. volzii*, Fig. 43. *P. willei*, Fig. 44. *Ceratium hirundinella* Fig. 34–43: Scale bars=10 μm, Fig. 44: Scale bar=50 μm.

先崎　智・堀口健雄*：長野県産淡水渦鞭毛藻類の分類学的研究

長野県内の湖，ダム，池などから28種類の渦鞭毛藻類を採集し，その形態を光学顕微鏡ならびに走査型電子顕微鏡を用いて調査した。特に，わが国においてその知見が少ない無殻の渦鞭毛藻類に関してはなるべく多くの種類を調べるように努力した。28種類のうち13種類が本邦新産種であることが明らかとなった。これらについては写真および線画ならびに簡単な記載文を添えて記録した。その他の種類に関しては写真または線画を掲載して種の記録とした。今回，研究した種類のうち12種類が *Gymnodinium* 属に，10種類が *Peridinium* 属に，2種類が *Katodinium* 属に，残りの4種類がそれぞれ *Amphidinium* 属，*Gyrodinium* 属，*Woloszynskia* 属，*Ceratium* 属に所属するものであることが明らかとなった。（380 長野市西長野6－ロ　信州大学教育学部，*060 札幌市北区北10条西8丁目　北海道大学理学研究科生物科学専攻）

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