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# Chromosomes of Japanese Gobioid Fishes (III)[1)]

By

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In the previous reports we described the karyotypes of 14 species of gobioid fishes, i.e., 5 species of sleepers and 9 species of gobies (ARAI and SAWADA, 1974; ARAI *et al.*, 1974). In this report, karyotypes of thirteen species of Japanese gobioid fishes are added.

Method of chromosome preparation is the same as was given in ARAI and KATSUYAMA (1973).

Classification of chromosomes is adopted from LEVAN *et al.* (1964). Metacentrics and submetacentrics are described as two-arm chromosomes, and subtelocentrics and acrocentrics as one-arm chromosomes.

All the specimens used for the examination are deposited in the fish collection of the Department of Zoology, National Science Museum, Tokyo.

## ***Rhinogobius brunneus*** (TEMMINCK et SCHLEGEL) "Yoshinobori"

(Plate 1, figs. 1–6)

This species is the commonest fresh water goby in Japan. The classification of this species has been very ambiguous, although ITÔ and MIZUNO (1972) divided this species into three types, i.e., "Ôhan" type (=*R. nagoyae* JORDAN et SEALE, 1906), "Kokushoku-Ôgata" type (=*R. fluviatilis* TANAKA, 1925), and "Kokushoku" type.

Three specimens of the "Ôhan" type (Type A), 55.5 to 62.5 mm in total length, were collected at Minato River, Chiba Prefecture. Two males, 85.5 and 90.5 mm in total length, and two females, 74.5 and 80.0 mm in total length, of the "Kokushoku-Ôgata" type (Type B) were caught at the upper stream of Ô-kawa River, Itô City, coexisting with "Amago", a fluviatile form of *Oncorhynchus rhodurus*. The other type (Type C) of four males, 32.8 to 41.0 mm in total length, and a female of 35.0 mm in total length from the moat of the Imperial Palace resembles the "Ôhan" type, but differs from the latter by the absence of dark spots on the pectoral fin base (Table 1).

1) This investigation was supported in part by a grant-in-aid for the senior author from the Itô Foundation for the Advancement of Ichthyology.

Table 1. Characters of thirteen species of material fishes.

| Species | No. of fish | S.L. (mm) | $D_1$ | $D_2$ | A | VN |
|---|---|---|---|---|---|---|
| *Rhinogobius brunneus** | | | | | | |
| Type A | 3 | 45.5– 52.0 | VI | I, 7–8 | I, 8 | 10+16 |
| Type B | 4 | 62.0– 76.0 | VI | I, 8 | I, 8 | 10+15–16 |
| Type C | 5 | 27.5– 34.5 | VI | I, 8–9 | I, 7–8 | 10+16 |
| *Chasmichthys dolichognathus* | 2 | 45.0– 46.5 | VI | I, 10 | I, 8–9 | 14+18 |
| *C. gulosus* | 7 | 65.5–110.5 | VI | I, 10–11 | I, 8–10 | 14+19 |
| *Pterogobius elapoides* | 4 | 70.5– 79.0 | VIII | I, 20–21 | I, 19–20 | 14+20 |
| *P. zonoleucus* | 3 | 58.5– 68.5 | VIII | I, 20–21 | I, 19–20 | 15+19–20 |
| *Acanthogobius flavimanus* | 4 | 58.5–115.0 | VIII | I, 13 | I, 11 | 13+20–21 |
| *Synechogobius hasta* | 4 | 56.5– 69.0 | VIII–IX | I, 19–20 | I, 16 | 16–17+26 |
| *Chaenogobius isaza* | 6 | 58.0– 66.0 | VI | I, 10 | I, 10 | 15+18–19 |
| *C. annularis*** | 2 | 103.0–106.0 | VI | I, 11 | I, 11 | 15+18 |
| *Bathygobius fuscus* | 4 | 51.5– 66.5 | VI | I, 9 | I, 8 | 10+17 |
| *Odontamblyopus rubicundus* | 4 | 174.5–200.5 | VI | I, 42–44 | I, 40–42 | 10+24 |
| *Boleophthalmus pectinirostris* | 4 | 115.5–126.5 | V | I, 24–26 | I, 24–25 | 10+16–17 |
| *Periophthalmus cantonensis* | 2 | 55.5– 59.5 | XII | I, 11 | I, 11 | 10+16 |

* As for Types A, B and C, see text.

** From Lake Biwa.

As shown in Table 2, the diploid chromosome number is 44 in all of the three types, the karyotypes of which do not differ from one another. Each karyotype comprises 22 pairs of subtelocentric-acrocentric chromosomes. The chromosomes are roughly comparable in appearance, and show a continuous gradation in size. There was no noticeable difference between male and female karyotypes. This result agrees well with those of ARAI and KOBAYASI (1973) and NISHIKAWA *et al.* (1974).

### ***Chasmichthys dolichognathus*** (HILGENDORF) "Ago-haze"

(Plate 2, figs. 1 and 3)

Two specimens, 53.5 and 54.5 mm in total length, were caught at Arasaki, Miura Peninsula, Kanagawa Prefecture (Table 1).

The diploid chromosome number is 44 (Table 2). The karyotype of this species comprises 22 pairs of subtelocentric-acrocentric chromosomes. In size, one-arm chromosomes show a gradation from largest to smallest, hence cannot be easily divided into size groups. The arm number is 44. The karyotype of this species agrees with that of *Rhinogobius brunneus* in the diploid chromosome number, but differs in the number of subtelocentrics.

### ***Chasmichthys gulosus*** (SAUVAGE) "Dorome"

(Plate 2, figs. 2 and 4)

Five specimens, 79.5 to 96.5 mm in total length, were collected at Kariyagasaki,

Table 2. Frequency distributions of diploid chromosome counts in thirteen species of gobioid fishes.

| Species | 2n | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | |
| *Rhinogobius brunneus* | | | | | | | | | | | | | | |
| Type A | | | | | | 3 | 15 | | 1 | | | | | 19 |
| Type B | | | | | 1 | 1 | 11 | 3 | | | | | | 16 |
| Type C | | | | | | 2 | 9 | 3 | | | | | | 14 |
| *Chasmichthys dolichognathus* | | | | | 5 | 8 | 33 | 4 | 1 | | | | | 51 |
| *C. gulosus* | | | | 1 | 2 | 9 | 39 | 2 | | 1 | | | | 54 |
| *Pterogobius elapoides* | | | 2 | 1 | 2 | 6 | 22 | 4 | | | | | | 37 |
| *P. zonoleucus* | | | 1 | 1 | 1 | 5 | 31 | 4 | | | | | | 43 |
| *Acanthogobius flavimanus* | | 1 | | 1 | 7 | 1 | 40 | 3 | 1 | | | | | 53 |
| *Synechogobius hasta* | | | | 1 | 3 | 2 | 33 | 4 | | 1 | | | | 44 |
| *Chaenogobius isaza* | 1 | | | 3 | 2 | 12 | 31 | 4 | | | | | | 53 |
| *C. annularis* | | 2 | | | 3 | 8 | 22 | | | | | | | 35 |
| *Bathygobius fuscus* | | | | | | 1 | 1 | 2 | 9 | 10 | 33 | 4 | | 60 |
| *Odontamblyopus rubicundus* | | 1 | | | | 2 | 2 | 8 | 18 | 3 | | | | 34 |
| *Boleophthalmus pectinirostris* | | | | | 1 | | 6 | 13 | 38 | 2 | | | | 60 |
| *Periophthalmus cantonensis* | | | | | | 1 | | | 5 | | | | | 6 |

Miura Peninsula, a specimen of 98.0 mm in total length from Arasaki, Miura Peninsula, Kanagawa Prefecture, and a specimen of 126.5 mm in total length from Amatsukominato, Awa, Chiba Prefecture (Table 1).

As shown in Table 2, the diploid chromosome number is 44. The karyotype comprises 22 pairs of subtelocentric-acrocentric chromosomes. The arm number is 44. This result agrees with that of NISHIKAWA *et al.* (1974). The karyotype of *C. gulosus* is similar to that of *C. dolichognathus*.

### ***Pterogobius elapoides*** (GÜNTHER) "Kinubari"

(Plate 3, figs. 1 and 3)

Three specimens, 82.0 to 86.5 mm in total length, were obtained at Kariyagasaki, Miura Peninsula, Kanagawa Prefecture, and a specimen of 94.5 mm in total length at Niemon Island, Awa, Chiba Prefecture (Table 1).

The diploid chromosome number is 44 (Table 2). The karyotype comprises 7 pairs of submetacentric, and 15 pairs of subtelocentric chromosomes. The arm number is 58. The karyotype of this species differs from those of *Rhinogobius* and *Chasmichthys* in the large arm number.

### ***Pterogobius zonoleucus*** JORDAN et SNYDER "Chagara"

(Plate 3, figs. 2 and 4)

Three specimens, 70.5 to 76.5 mm in total length, were caught at Arasaki, Miura Peninsula, Kanagawa Prefecture (Table 1).

As shown in Table 2, the diploid chromosome number is 44. The karyotype comprises 7 paris of submetacentric, and 15 pairs of subtelocentric-acrocentric chromosomes. The arm number is 58. The karyotype of *P. zonoleucus* is similar to that of *P. elapoides*, although there seems to be difference in the morphology of one-arm chromosomes between the two species.

***Acanthogobius flavimanus*** (TEMMINCK et SCHLEGEL) "Ma-haze"

(Plate 4, figs. 1 and 3)

Two males, 78.5 and 83.0 mm in total length, were collected in a small stream near Hanamizu River, Ôiso, Kanagawa Prefecture, and two specimens, 118.0 and 140.0 mm in total length, from Kariyagasaki, Miura Peninsula, Kanagawa Prefecture (Table 1).

The diploid chromosome number is 44 (Table 2). The karyotype comprises 18 pairs of subtelocentric, and 4 pairs of acrocentric chromosomes. The arm number is 44. This result agrees with those of ARAI and KOBAYASI (1973) and NISHIKAWA *et al.* (1974).

***Synechogobius hasta*** (TEMMINCK et SCHLEGEL) "Hazekuchi"

(Plate 4, figs. 2 and 4)

Four specimens, 67.0 to 81.5 mm in total length, were caught at the mouth of Honmyô River, Isahaya City, Nagasaki Prefecture (Table 1).

As shown in Table 2, the diploid chromosome number is 44. The karyotype comprises a pair of metacentric, and 21 pairs of subtelocentric-acrocentric chromosomes. The arm number is 46. The karyotype of this species agrees with that of *A. flavimanus* in the diploid chromosome number, but differs in the arm number.

***Chaenogobius isaza*** TANAKA "Isaza"

(Plate 5, figs. 1 and 3)

This species is endemic to Lake Biwa, Shiga Prefecture. It lives usually below 30 meters in water depth, and comes up to the shore of the lake in breeding season. Such a behavior is very characteristic among the genus *Chaenogobius*.

Six specimens, 69.0 to 78.0 mm in total length, were collected at Onoe, Lake Biwa (Table 1).

The diploid chromosome number is 44 (Table 2). As centromeric position on chromosomes of this species changes serially, it is very difficult to separate submetacentrics from subtelocentrics. However, we report on the karyotype of this species as follows. The karyotype comprises 6 pairs of submetacentric, and 16 pairs of subtelocentric chromosomes. The arm number is 56. Although NOGUSA (1957) reported that the diploid and haploid chromosome numbers of this species are 46 and 23 respectively on the basis of classical gonad section method, the present study clearly

indicates that this species has 44 chromosomes in the diploid number.

### *Chaenogobius annularis* GILL "Ukigori"

(Plate 5, figs. 2 and 4)

The karyotype of this species was reported in the previous papers on the basis of material from Lake Kasumiga-ura and Hayakawa River in Odawara City (ARAI *et al.*, 1974) and Nagata River, Shimonoseki (NISHIKAWA *et al.*, 1974). However, it has been considered by some ichthyologists that specimens from Lake Biwa have some characteristics peculiar to Lake Biwa, though it has not been recognized as an independent species. Accordingly, we examined the karyotype of this species.

Two specimens, 120.5 and 122.5 mm in total length, from Onoe, Lake Biwa, were used as material (Table 1).

As shown in Table 2, the diploid chromosome number is 44. In this species, centromeric position on chromosomes changes serially, and it is very difficult to draw a border-line between submetacentric and subtelocentric chromosomes. However, it seems doubtless that the number of two-arm chromosomes of the material is more numerous than that in *C. isaza*, and we describe the karyotype of *C. annularis* from Lake Biwa as follows. The karyotype comprises 9 pairs of submetacentric, and 13 pairs of subtelocentric chromosomes. The arm number is 62. As regards the karyotypes, *C. annularis* from Lake Biwa is more similar to *C. isaza* than to *C. annularis* from Lake Kasumiga-ura, Hayakawa River and Nagata River.

### *Bathygobius fuscus* (RÜPPELL) "Kumo-haze"

(Plate 6, figs. 1 and 3)

Two specimens, 61.5 and 64.5 mm in total length, were collected from Kariyagasaki, Miura Peninsula, a specimen of 78.0 mm in total length from Arasaki, Miura Peninsula, Kanagawa Prefecture, and a specimen of 79.5 mm in total length from Amatsu-kominato, Awa, Chiba Prefecture (Table 1).

The diploid chromosome number is 48 (Table 2). The karyotype comprises 24 pairs of acrocentric chromosomes. The chromosomes are comparable in appearance and show a gradation in size which makes it impossible to arrange them in size groups. The arm number is 48. In gobioid fishes, many species have 44 chromosomes in the diploid number, and karyotypes of species with 48 chromosomes have been reported in *Bostrichthys sinensis* and *Pomatoschistus minutus* (ARAI *et al.*, 1974; WEBB, 1974).

### *Odontamblyopus rubicundus* (HAMILTON-BUCHANAN) "Warasubo"

(Plate 6, figs. 2 and 4)

Taxonomic status of this species has not been fixed in the world. This species has been classified in Taenioididae by MATSUBARA (1955), in Gobiidae by TAKAGI (1963), and in Gobioididae by GREENWOOD *et al.* (1966).

Four specimens, 207.0 to 236.0 mm in total length, were caught at the mouth of Honmyô River, Isahaya City, Nagasaki Prefecture (Table 1).

As shown in Table 2, the diploid chromosome number is 46. The karyotype comprises 2 pairs of metacentric, 8 pairs of submetacentric, and 13 pairs of subtelocentric-acrocentric chromosomes. The arm number is 66.

### *Boleophthalmus pectinirostris* (LINNAEUS) "Mutsugorô"

(Plate 7, figs. 1 and 3)

The systematic position of this species has not been fixed either. It was included in Gobiidae by MATSUBARA (1955) and GREENWOOD *et al.* (1966), but in Periophthalmidae by SMITH (1949).

Four specimens, 142.0 to 153.0 mm in total length, were collected at the mouth of Honmyô River, Isahaya City, Nagasaki Prefecture (Table 1).

The diploid chromosome number is 46 (Table 2). The karyotype comprises 23 pairs of subtelocentric-acrocentric chromosomes. The arm number is 46. This result agrees well with that of NISHIKAWA *et al.* (1974). The karyotype of this species is similar to that of *B. boddaerti* (see SUBRAHMANYAM, 1969).

### *Periophthalmus cantonensis* (OSBECK) "Tobi-haze"

(Plate 7, figs. 2 and 4)

This species has been classified in Periophthalmidae by SMITH (1949), and in Gobiidae by MATSUBARA (1955) and GREENWOOD *et al.* (1966).

Two specimens, 73.0 and 79.0 mm in total length, were caught at Gyôtoku, the mouth of Edogawa River, Chiba Prefecture (Table 1).

As shown in Table 2, the diploid chromosome number is 46. The karyotype comprises 9 pairs of metacentric, 6 pairs of submetacentric, and 8 pairs of subtelocentric-acrocentric chromosomes. The arm number is 76, which is the most numerous among gobioid fishes with 46 chromosomes. The karyotype of this species agrees with that of *Boleophthalmus pectinirostris* in the diploid chromosome number, but differs in the arm number.

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## Explanation of Plates 1–7

### Plate 1

Figs. 1–3. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of *Rhinogobius brunneus*. —— 1. Type A (from Minato River), 2n=44. ×1,560. —— 2. Type B (from Ô-kawa River), 2n=44. ×1,560. —— 3. Type C (from moat of the Imperial Palace), 2n=44. ×1,560.

Figs. 4–6. Karyotypes of *Rhinogobius brunneus*. —— 4. Type A, from Fig. 1, NF=44. ×1,470. —— 5. Type B, from Fig. 2, NF=44. ×1,470. —— 6. Type C, from Fig. 3, NF=44. ×1,470.

**Plate 2**

Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of *Chasmichthys*. —— 1. *C. dolichognathus*, 2n=44. ×2,360. —— 2. *C. gulosus*, 2n=44. ×1,850.

Figs. 3–4. Karyotypes of *Chasmichthys*. —— 3. *C. dolichognathus*, from Fig. 1, NF=44. ×2,360. —— 4. *C. gulosus*, from Fig. 2, NF=44. ×1,850.

**Plate 3**

Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of *Pterogobius*. —— 1. *P. elapoides*, 2n=44. ×1,840. —— 2. *P. zonoleucus*, 2n=44. ×2,150.

Figs. 3–4. Karyotypes of *Pterogobius*. —— 3. *P. elapoides*, from Fig. 1, NF=58. ×1,850.—— 4. *P. zonoleucus*, from Fig. 2, NF=58. ×2,150.

**Plate 4**

Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of gobies. —— 1. *Acanthogobius flavimanus*, 2n=44. ×2,130.—— 2. *Synechogobius hasta*, 2n=44. ×2,500.

Figs. 3–4. Karyotypes of gobies. —— 3. *Acanthogobius flavimanus*, from Fig. 1, NF=44. ×2,130. —— 4. *Synechogobius hasta*, from Fig. 2, NF=46. ×2,500.

**Plate 5**

Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of *Chaenogobius*. —— 1. *C. isaza*, 2n=44. ×2,480.—— 2. *C. annularis* (from Lake Biwa), 2n=44. ×2,180.

Figs. 3–4. Karyotypes of *Chaenogobius*. —— 3. *C. isaza*, from Fig. 1, NF=56. ×2,480. —— 4. *C. annularis*, from Fig. 2, NF=62. ×2,180.

**Plate 6**

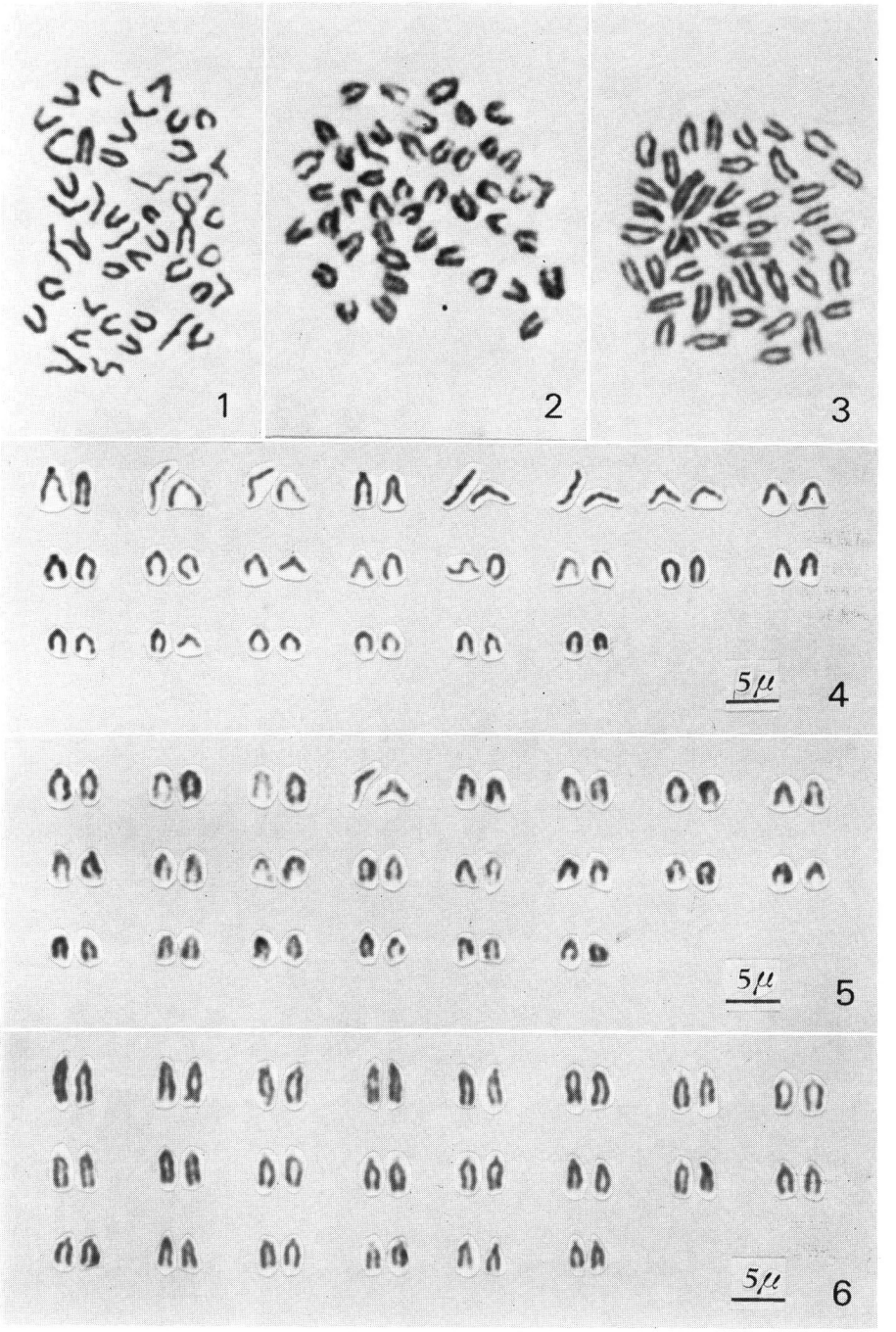
Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of gobioid fishes. —— 1. *Bathygobius fuscus*, 2n=48. ×1,870. —— 2. *Odontamblyopus rubicundus*, 2n=46. ×1,930.

Figs. 3–4. Karyotypes of gobioid fishes. —— 3. *Bathygobius fuscus*, from Fig. 1, NF=48. ×1,870. —— 4. *Odontamblyopus rubicundus*, from Fig. 2, NF=66. ×1,930.

**Plate 7**

Figs. 1–2. Photomicrographs of mitotic metaphase chromosomes from gill epithelial cells of gobioid fishes. —— 1. *Boleophthalmus pectinirostris*, 2n=46. ×2,300. —— 2. *Periophthalmus cantonensis*, 2n=46. ×1,780.

Figs. 3–4. Karyotypes of gobioid fishes. —— 3. *Boleophthalmus pectinirostris*, from Fig. 1, NF=46. ×2,300. —— 4. *Periophthalmus cantonensis*, from Fig. 2, NF=76. ×1,780.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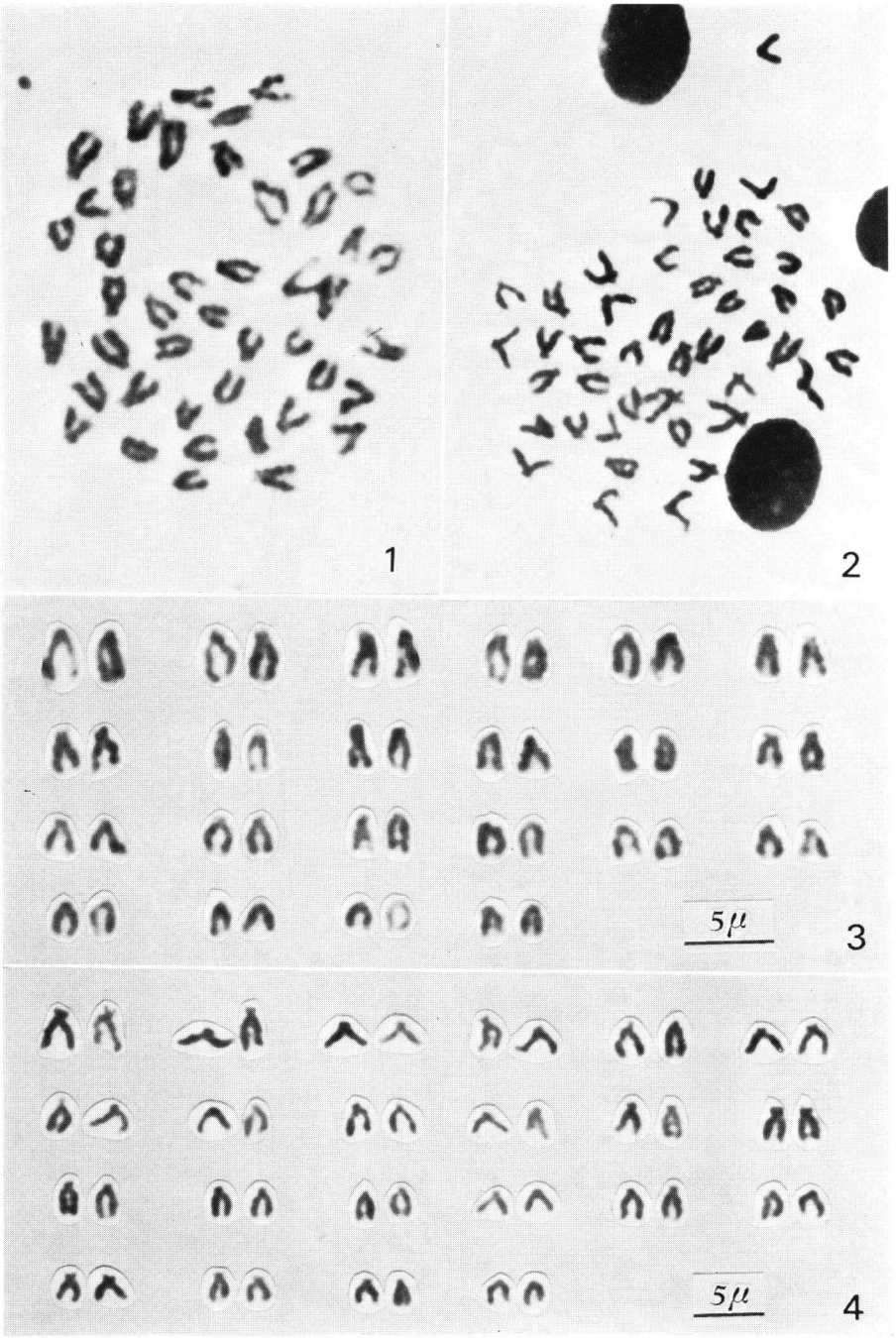
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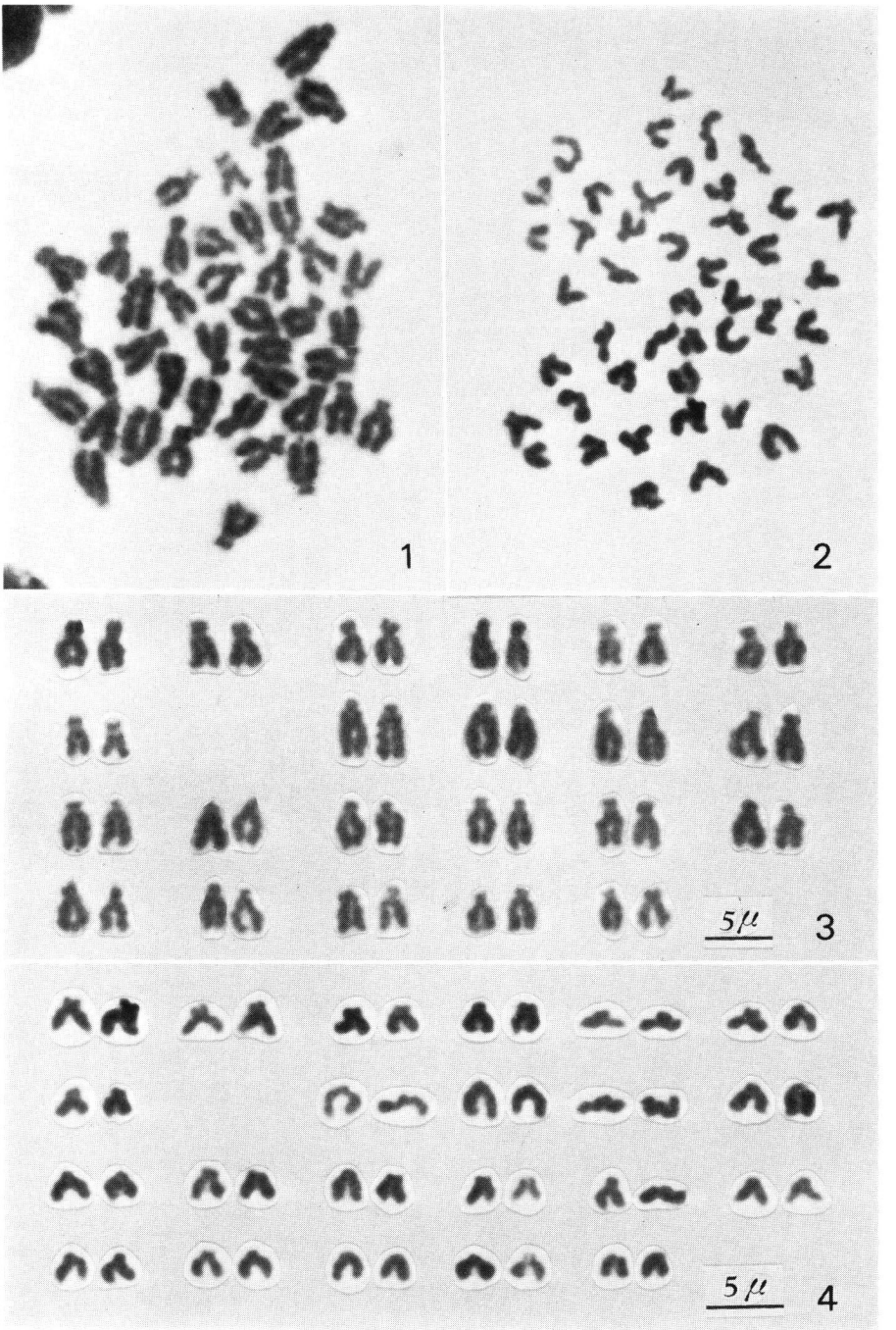
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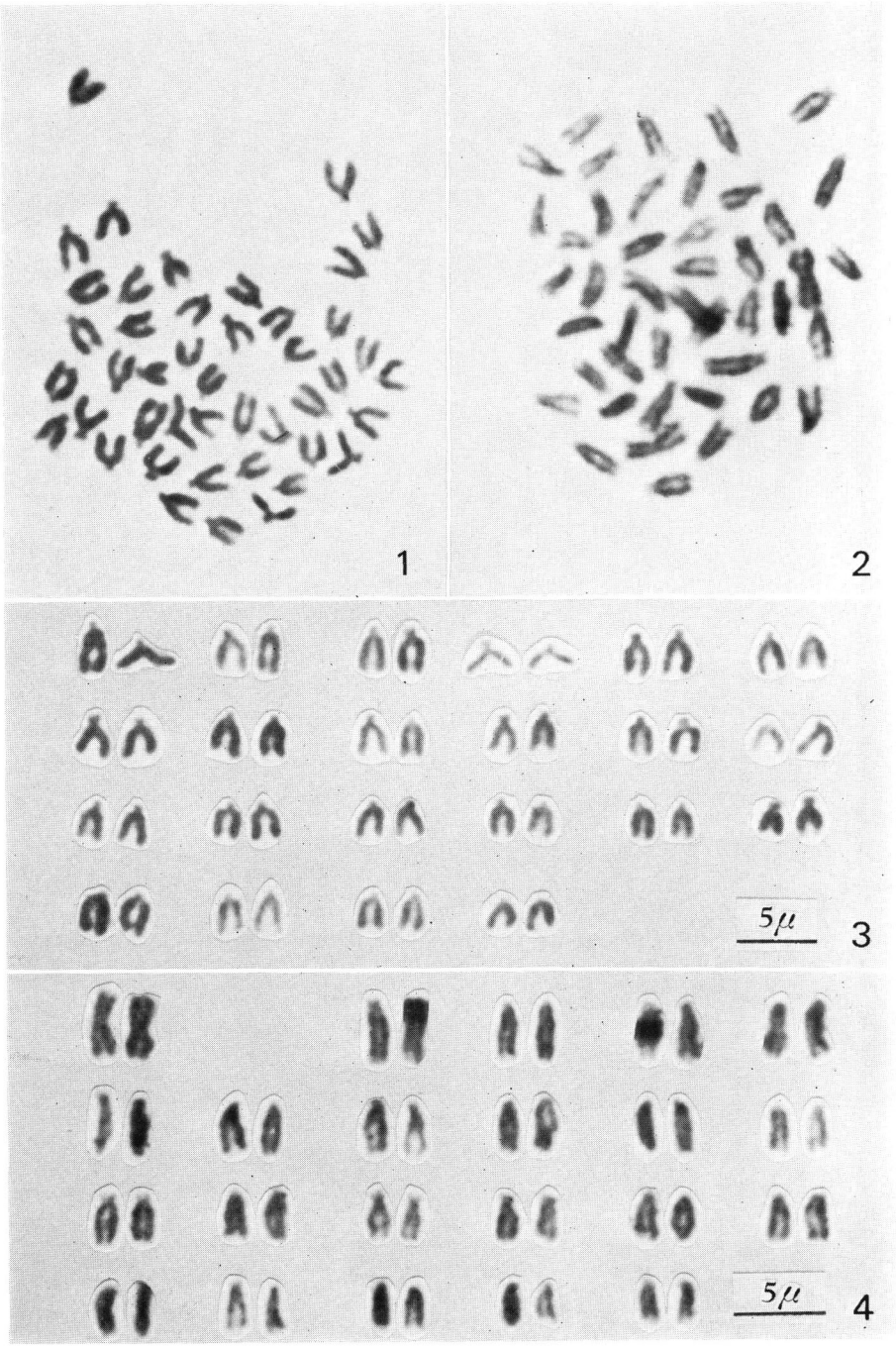
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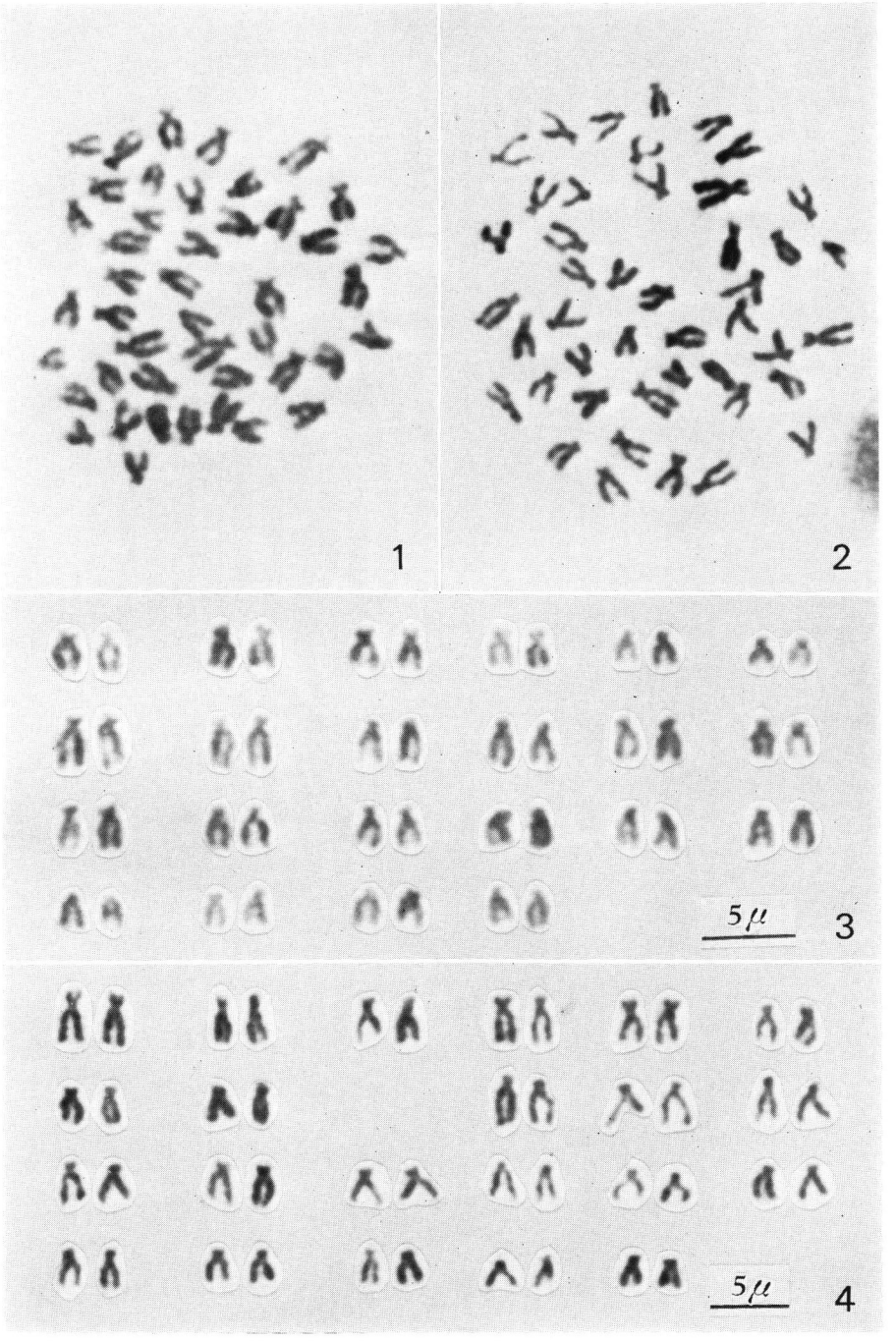
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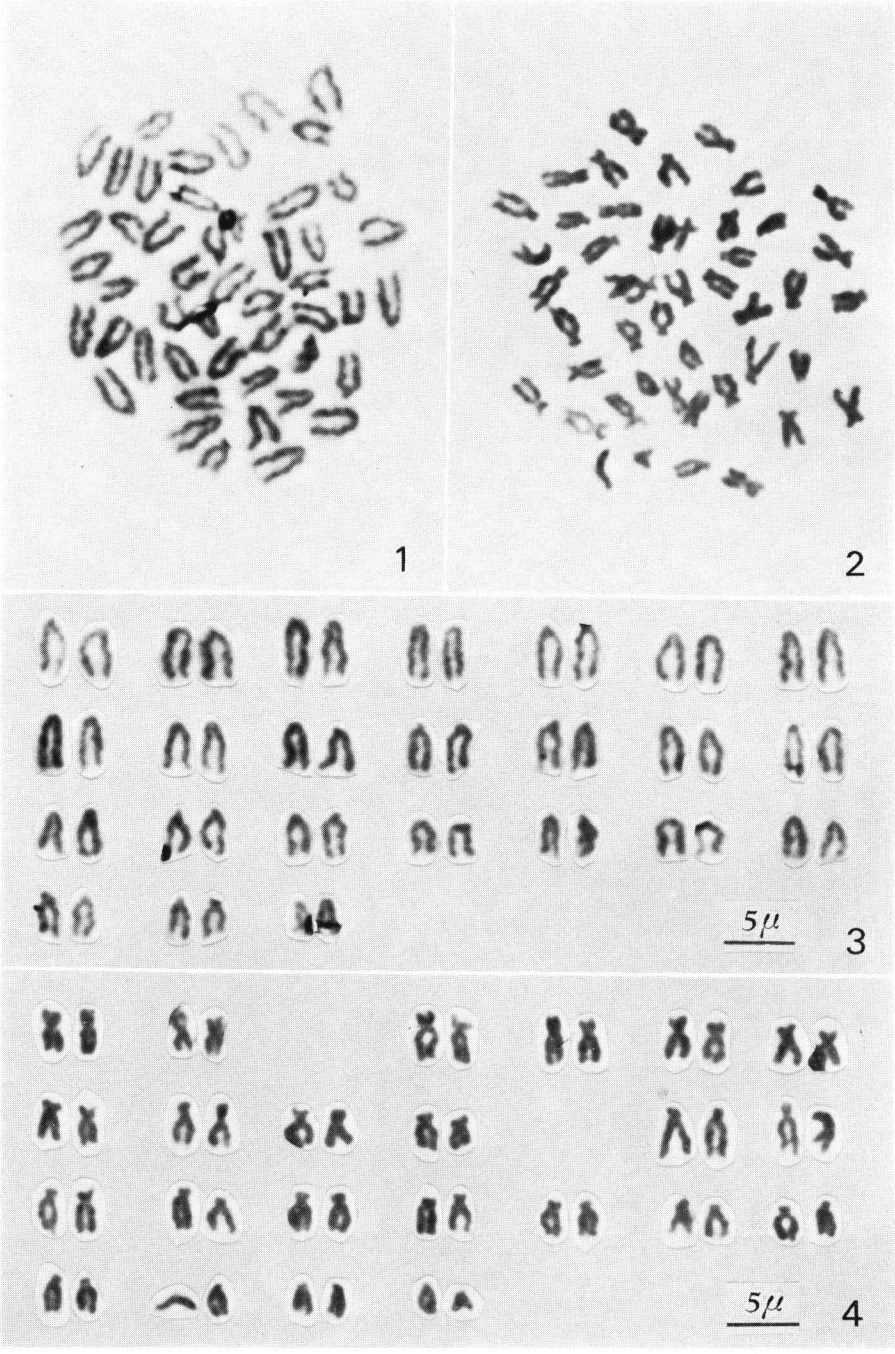
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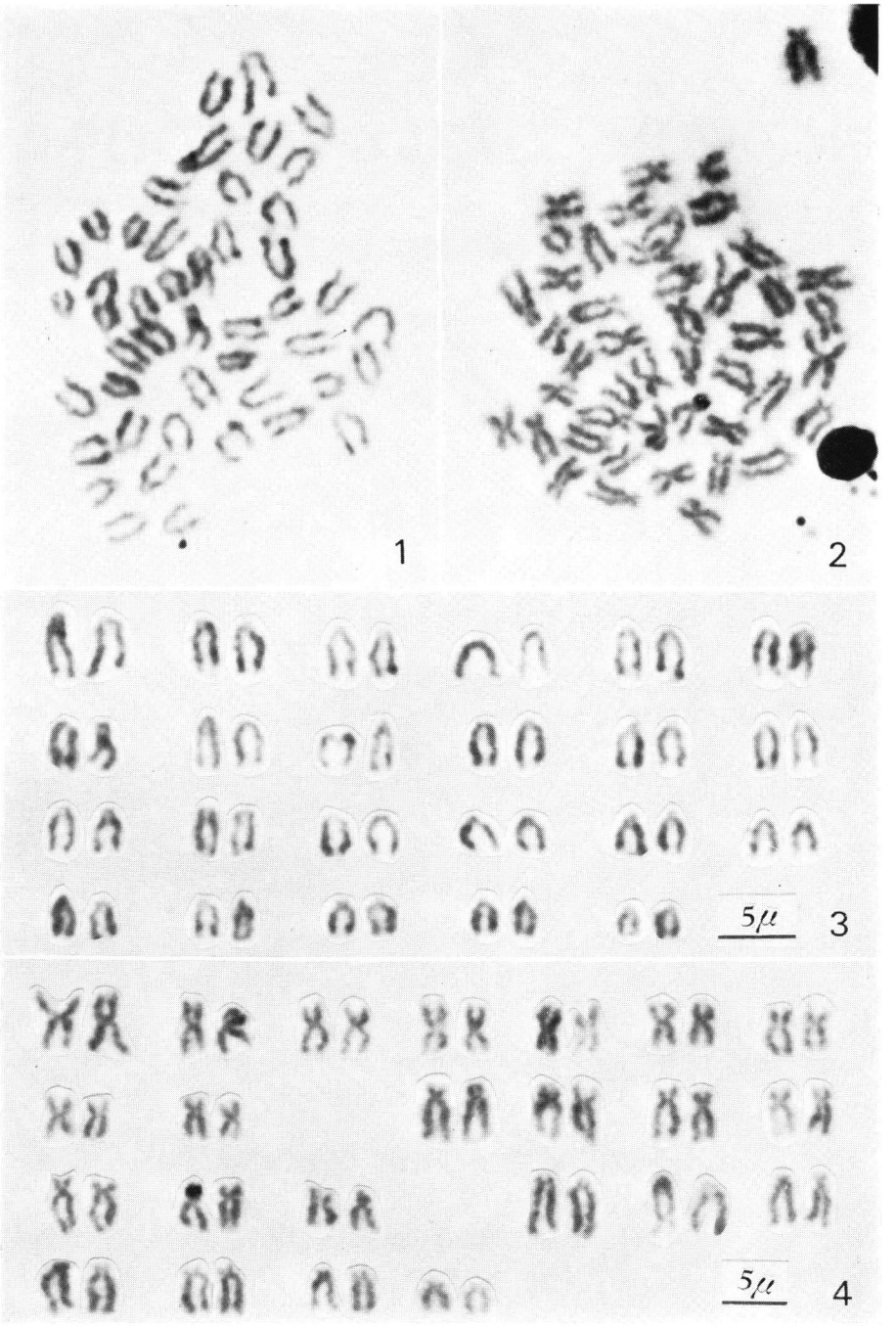
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