Systematics and Distribution of the *Diplophos taenia* Species Complex (Gonostomatidae), with a Description of a New Species

Takakazu Ozawa, Kouhei Oda[1] and Toshihide Ida[2]

Faculty of Fisheries, Kagoshima University, 4–50–20 Shimo-arata, Kagoshima 890, Japan
[1] Present address: A-203, 7–20 Manatsu-cho, Naze 894, Japan
[2] Present address: KK Sugiyo, 1–4–7 Taihou-machi, Atsuta-ku, Nagoya 456, Japan

Abstract For the systematic study of the gonostomatid fishes of the *Diplophos taenia* species complex, a total of 698 specimens was obtained from the three oceans. Four valid species were recognized: *D. taenia* Günther, *D. proximus* Parr, *D. orientalis* Matsubara, and *D. australis* sp. nov. The diagnostic characters are 90–100 total vertebrae (TV) (37–41 abdominal (AV)+52–60 caudal vertebrae (CV)) and 103–115 IC photophores (IC) for *D. taenia*, 85–90 TV (36–39 AV+48–52 CV) and 98–104 IC for *D. proximus*, 83–86 TV (33–35 AV+49–52 CV) and 92–100 IC for *D. orientalis*, and 84–91 TV (33–37 AV+50–54 CV) and 99–105 IC for *D. australis*. In addition to the above, *D. proximus* has larger orbital diameter (the proportion to head length 21–28%) than the other three species (15–23%) beyond 70 mm in standard length. Due to wide distribution, *D. taenia* shows meristic variations: the numbers of TV, IC and anal fin rays (A) are smaller at lower latitudes and larger at higher ones in all oceans, and the number of A is smaller in the Atlantic (56–71) than in the other oceans (59–72) of the same latitude. Because of these variations, identification to species level is possible only area by area. The distribution of each of the four species is also distinct: *D. taenia* is a cosmopolitan between about 40° N and 30° S exclusive of the eastern tropical Pacific; *D. proximus* is endemic to the eastern tropical Pacific; *D. orientalis* is limited to the North Pacific transitional zone between about 30° and 40° N; and *D. australis* in a transitional zone of the Southern Ocean south of 20° S.

In the gonostomatid genus *Diplophos* Günther, 1873, Grey (1960) included five species: *D. taenia* Günther, 1873, *D. pacificus* Günther, 1889, *D. maderensis* (Johnson, 1890), *D. proximus* Parr, 1931, and *D. orientalis* Matsubara, 1940. Later, two new species, *D. greyae* Johnson, 1970 and *D. rebainsi* Krefft et Parin, 1972, were reported. Among the seven nominal species, *D. taenia, D. pacificus, D. proximus*, and *D. orientalis* are easily separable by the presence of grouped last two AC photophores (see Fig. 2) from the other three members which have the separated last two AC (see Grey, 1964; Johnson, 1970; Krefft and Parin, 1972), but there is some doubt on their validity. For example, they have been grouped into a *D. taenia* complex (Grey, 1960) or variously synonymized under the first species *D. taenia* (Johnson, 1970; Johnson and Barnett, 1972, 1975). Mukhacheva (1978) who reviewed the world wide distribution of *Diplophos* species followed Johnson (1970) on the status of *D. taenia* complex. Recently, Ozawa and Oda (1986) recognized two species, *D. taenia* and *D. orientalis*, in the study on larvae from the western North Pacific. Therefore, it can be said that the species composition of *D. taenia* complex is still obscure.

For the taxonomic study, the present authors obtained many *Diplophos* specimens from the world. In this paper, *D. taenia* species complex is classified into four valid species one of which is a new species, and their distributions are presented.

Materials and methods

A total of 698 specimens of the *D. taenia* species complex was obtained for the study from the following institutions or collections by vessels, covering all the three oceans (Fig. 1): Scripps Institution of Oceanography (SIO), University of California at San Diego, La Jolla; Bernice Pauahi Bishop Museum (BPBM), Honolulu; National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C.; Muséum National d'Histoire Naturelle (MNHN), Paris; Institute für Seefischerei (ISH), Zoologisch Museum, Universität Hamburg, Hamburg; South African Museum (SAM), Capetown; Natural History Museum of Los Angeles County

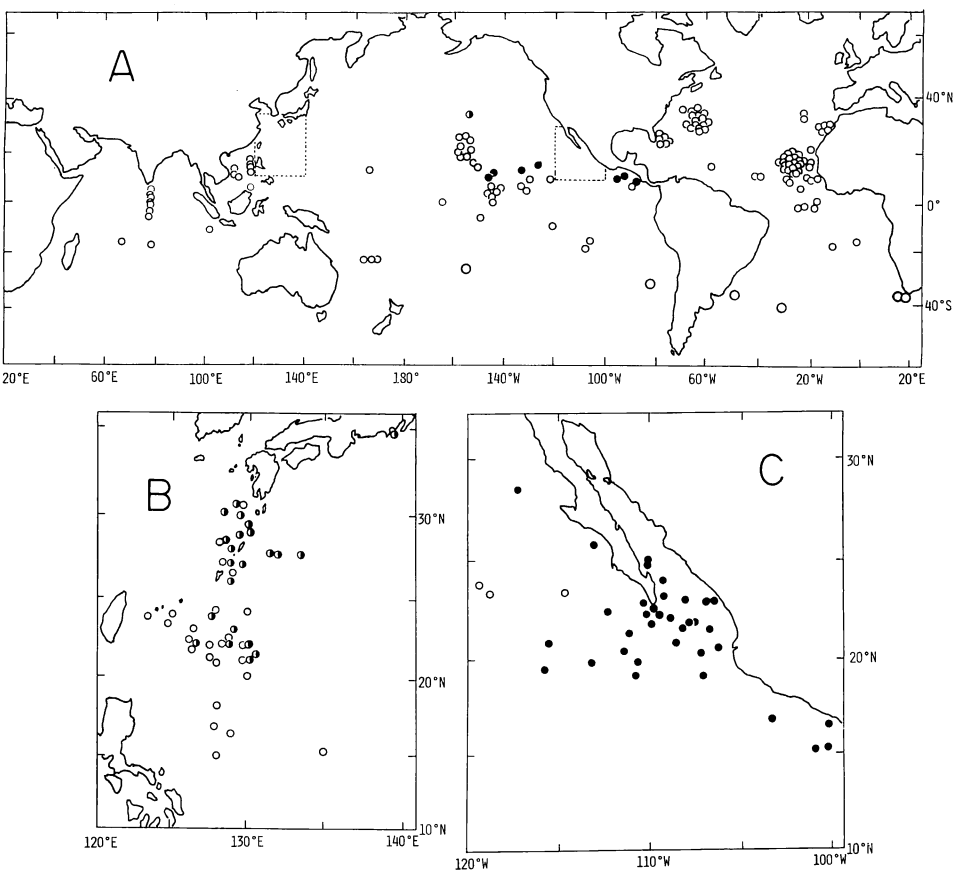

Fig. 1. Collection localities of study materials of the *Diplophos taenia* species complex (A). For the areas enclosed by broken lines, see B and C. Small white circles represent *D. taenia*, black ones *D. proximus*, half black ones *D. orientalis*, and large white ones *D. australis* sp. nov.

(LACM), Los Angeles; Museum of Comparative Zoology (MCZ), Harvard University, Cambridge; Institute of Oceanographic Sciences (IOS), Wormley, U.K.; Ocean Research Institute (ORI), University of Tokyo, Tokyo; R.V. Hakuho Maru, ORI; R.V. Shunyo Maru, Fishery Agency of Japan; and T.V. Kagoshima Maru and Keiten Maru, Kagoshima University. Specimens by vessels are deposited at the Laboratory of Fisheries Resources, Faculty of Fisheries, Kagoshima University.

Study materials are presented below according to species recognized. To avoid long expression due to many specimens, sampling dates are omitted for catalogued specimens and sampling localities are grouped into the following seven oceans: North and South Atlantic; eastern North and South, and western North and South Pacific; and Indian.

Diplophos taenia (468 specimens in total). Eastern North Pacific (100 specimens): SIO 54-95, 1 (95.2 mm SL), 60-219, 1 (62.3), 60-239, 1 (50.7), 60-247, 1 (93.0), 60-249, 1 (86.5), 60-252, 2 (34.1, 38.5), 60-247, 1 (57.9), 61-342, 2 (42.2, 48.0), 63-817, 2 (86.7, 91.9), 63-851, 1 (69.5), 63-957, 1 (105.8), 68-534, 1 (35.9), 71-298, 1 (52.2), 72-9, 1 (59.4), 73-75, 1 (65.7), 75-517, 2 (53.1, 97.3), 75-519, 1 (69.5), 75-520, 1 (138.8), 75-521, 1 (156.5), 75-522, 4 (41.0–55.8), 75-523, 2 (47.9, 71.6); BPBM 24443, 16 (57.6–77.9), 24475, 11 (51.2–117.8), 24562, 5 (112.2–132.1), 25052, 32 (53.0–77.2), 25692, 1 (145.2); USNM 112109, 5 (33.2–37.7); Hakuho Maru, uncatalogued, Sep. 1969, 1 (38.3). Western North Pacific (190 specimens): SIO 56-127, 1 (38.1), 61-576, 3 (34.2–40.3), 61-650, 1 (32.6), 61-741, 1 (36.1), 70-344, 1 (127.3), 70-346, 2 (46.5, 65.3), 70-347, 1 (32.7); Shunyo Maru, uncatalogued, Feb. 1962, 2 (53.8, 77.5), Apr.–May 1962, 2 (41.2, 43.5), June 1962, 12 (34.1–55.8); Hakuho Maru, uncatalogued, Feb.–Mar. 1973, 114 (40.5–107.0), Nov.–Dec. 1973, 21 (37.8–87.3), Jan.–Feb. 1975, 28 (36.5–69.4); Kagoshima Maru,

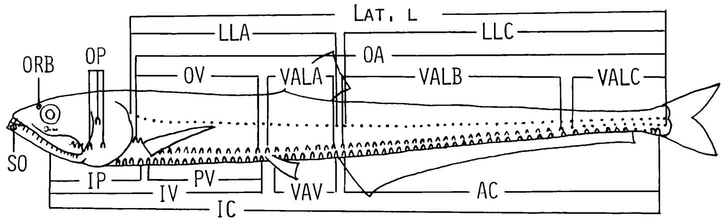

Fig. 2. Arrangement and terminology of photophores in *Diplophos* (see the text for explanation).

uncatalogued, Nov. 1980, 1 (35.5). Eastern South Pacific (7 specimens): SIO 69-334, 1 (148.0), 69-348, 2 (33.0, 44.2); BPBM 26029, 2 (62.8, 68.0), 26895, 2 (46.8, 54.2). Western South Pacific (12 specimens): MNHN 1116, 1 (129.7), 1117, 1 (129.8), 1118, 4 (113.3–154.6), 1119, 2 (126.0, 144.9), 1120, 2 (128.2, 160.3), 1121, 1 (132.9), 1122, 1 (117.0). Indian (29 specimens): SIO 69-24, 1 (36.0); Kagoshima Maru, uncatalogued, Dec. 1963-Jan. 1964, 19 (35.0–49.9), June 1977, 9 (31.2–62.9). North Atlantic (117 specimens): MCZ 42313, 2 (124.5, 132.5), 52536, 3 (84.8–141.8), 52537, 1 (92.3), 52538, 1 (72.9), 52545, 1 (54.1), 52567, 1 (53.8), 52569, 1 (131.5), 59162, 2 (56.8, 94.2), 59166, 1 (80.2), 59167, 1 (76.0), 59168, 1 (89.4), 59169, 2 (65.7, 93.7), 59170, 1 (119.5), 59171, 1 (116.1), 59172, 1 (100.3), 59174, 3 (40.1–66.5), 59175, 3 (56.1–80.1), 59176, 1 (132.2), 59177, 1 (144.5), 59178, 2 (124.1, 133.5), 59180, 1 (114.8), 59181, 1 (77.0), 59182, 1 (100.9), 59183, 3 (59.3–74.9), 59184, 1 (63.0), 59185, 1 (107.6), 59186, 1 (65.8), 59187, 1 (50.3), 59188, 1 (67.6), 59189, 1 (48.3), 59190, 2 (72.1, 91.2), 59191, 2 (54.7, 89.0); IOS 4724, 1 (53.5), 5799#2, 1 (70.1), 5817#2D, 1 (30.3), 5824, 1 (150.4), 6662#11, 4 (65.2–84.9), 6662#14, 3 (44.1–68.2), 6666#7, 9 (38.0–76.0), 7080#1, 8 (32.6–45.0), 7089#2, 1 (35.0), 7089#3, 1 (34.0), 7089#11, 2 (34.5, 40.1), 7089#12, 1 (56.2), 7089#13, 3 (29.3–33.5), 7089#21, 22, 23, 3 (32.0–49.8), 7089#22, 1 (30.7), 7089#26, 27, 3 (45.2–58.0), 7089#27, 4 (34.0–75.9), 7089#28, 3 (58.5–61.0), 7089#32, 1 (40.1), 7132, 1 (56.0), 8556#1, 2 (90, 93.0); USNM 248757, 1 (115.0), 248758, 1 (110.2), 248759, 1 (124.0), 248760, 2 (116.3, 118.1), 248761, 1 (139.2), 248762, 4 (109.1–136.9), 248763, 1 (148.0), 248764, 4 (113.2–130.8), 248765, 2 (93.2, 101.8). South Atlantic (13 specimens): SIO 63-552, 1 (52.4); MCZ 59163, 1 (73.8), 59179, 1 (134.1); ISH 2197/71, 10 (80.3–121.2).

Diplophos proximus (133 specimens in total from the eastern North Pacific): LACM 30033, 6 (84.0–105.9), 30035, 12 (56.0–100.9), 30041, 3 (93.5–96.4); SIO 52-88, 1 (95.3), 54-88, 1 (87.0), 54-89, 4 (39.0–98.0), 54-92, 2 (79.1, 85.0), 54-93, 1 (98.1), 55-213, 1 (87.5), 60-212, 1 (59.6), 60-216, 1 (101.8), 60-243, 1 (45.0), 63-76, 1 (77.0), 63-355, 1 (47.5), 63-616, 1 (83.9), 63-819, 1 (81.1), 63-824, 1 (62.4), 63-851, 1 (77.0), 63-853, 1 (38.4), 63-864, 15 (35.0–95.0), 63-920, 1 (99.4), 63-933, 1 (82.1), 63-959, 2 (90.8, 112.8), 63-968, 5 (84.8–104.2), 63-972, 1 (61.7), 63-976, 2 (75.0, 77.2), 63-979, 2 (57.3, 105.8), 63-980, 2 (93.9, 98.1), 64-161, 3 (43.0–97.3), 65-234, 1 (66.0), 65-236, 1 (78.1), 65-241, 5 (85.3–100.4), 65-243, 8 (53.1–96.4), 65-253, 2 (88.1, 91.0), 66-78, 1 (78.6), 67-286, 5 (79.2–96.5), 68-50, 23 (37.0–108.7), 68-54, 2 (68.3, 97.2), 68-580, 1 (68.9), 68-65, 1 (66.5), 69-448, 1 (103.0), 69-457, 1 (85.7); BPBM 24428, 6 (53.0–62.9).

Diplophos orientalis (89 specimens in total). Western North Pacific (85 specimens): Hakuho Maru, uncatalogued, Feb.–Mar. 1973, 8 (65.0–72.4), Nov.–Dec. 1973, 54 (23.8–54.1), Jan.–Feb. 1975, 1 (40.8); Shunyo Maru, Dec. 1961, 8 (not measured); Keiten Maru, uncatalogued, Nov. 1971, 4 (28.8–44.6); Kagoshima Maru, uncatalogued, Nov. 1979, 1 (26.0), Nov. 1980, 8 (24.6–29.0); IRO, uncatalogued, May 1970, 1 (260.0). Eastern North Pacific (4 specimens): Hakuho Maru, uncatalogued, Sep. 1969, 4 (29.5–38.4).

Diplophos australis sp. nov. (8 specimens in total from the Pacific and Atlantic south of 20°S): SIO 75-631, 1 (41.2), 69-321, 1 (37.5); ISH 754/71, 3 (138.2–183.0); MCZ 59164, 1 (64.6), 59165, 1 (61.5); SAM 24495, 1 (132.1). More detailed information on the specimens will be presented in the description of the new species.

Measurement of body parts follows Uyeno (1984). Fin rays, vertebrae inclusive of the first preural, and photophores were counted on all of the specimens. Counts of vertebrae were made from radiographs. Terminology of photophores (Fig. 2) follows mainly Grey (1964) and in part Johnson (1970) except use of LLA and LLC: ORB, at anterodorsal corner of eye between eye and nasal area; OP, on operculum; SO, a pair at the symphysis of lower jaw; BR, on branchiostegal membranes; IP, ventral series from isthmus to pectoral insertion; PV, ventral series from the last IP to pelvic insertion; IV, summation of IP+PV; VAV, ventral series from the last PV to anal origin; AC, ventral series posterior to the anal origin; IC, summation of all ventral series; OV, lateral series from opercular margin to above pelvic insertion; VALA, lateral series from the last OV to above anal origin; OAA, summation of OV+VALA; VALB, lateral series from the last VALA to the last large photophore of the series; VALC, small photophores following VALB to caudal fin: OAB, summation of OAA+VALB; OA, summation of OAB+VALC; LLA, series along lateral line from opercular margin to above anal origin; LLC, series along lateral line from the last LLA to caudal fin; Lat. l., summation of LLA+LLC. Most of the counts of the three main photophore series (AC, OA and Lat. l.) were usually uncertain due to loss or indistinctness at their caudal part, and were estimated with the observation of some intact specimens; they showed that AC photophores behind anal fin base except the last two had the same interval with those before anal fin base, OA photophores were paired with AC ones, and Lat. l. photophores were paired with myomeres.

In addition to the above, numbers of gill rakers and olfactory lamellae, form and number of head and accessory body photophores, arrangement of jaw teeth, and body surface pigmentation were examined on limited individuals.

In addition to those for photophores shown in Fig. 2, the following terminologies are abbreviated in the description: total (TL), standard (SL) and head (HL) length; number of total (TV), abdominal (AV) and caudal (CV) vertebrae; and number of anal (A), dorsal (D), pectoral (P_1), and pelvic (P_2) fin rays.

Short account of the past descriptions on the *Diplophos taenia* species complex

One of the reasons for the uncertainty of the *D. taenia* complex seems to have stemmed from the poor original descriptions. Along with some later descriptions, they are summarized below and in Table 1 for understanding of the present status of the *D. taenia* complex.

Diplophos taenia Günther: This species was originally described on the basis of a small specimen, 38 mm SL, from the Atlantic (Günther, 1873). The description was quite simple and incomplete (Table 1), being confined to two body proportions, three fin ray counts (D 8, A ca. 43, and P_2 8), position and shape of fins, and presence of two photophore rows. With two somewhat larger specimens (41 and 85 mm TL) from the Atlantic, Lütken (1892) counted the number of photophores, in which a few were un-

Table 1. Characters of the type specimens of the *Diplophos taenia* species complex. Because of the poor original description, two earliest descriptions on *D. taenia* are added. [1] Tail behind the end of anal fin lost; [2] Parr's (1931) counts from Günther's (1889) fig. B of pl. IV; [3] separated at the end of anal fin base; [4] probably only large photophores OAB (=OA-VALC) were counted.

Species	*taenia*			*pacificus*	*proximus*	*orientalis*
Author	Günther 1873	Lütken 1892	Brauer 1906	Günther 1889	Parr 1931	Matsubara 1940
Locality	30°S, 24°W; 22° N, 30°W (Atlantic)	10°N, 25°W; 10°S, 12°W; 20°N, 50W (Atlantic)	5°N, 13°W (Atlantic)	5°24′N, 147°02′W (Mid-Pacific)	20°07′N 108°40′W (Eastern Pacific)	Suruga Bay, Japan (Western Pacific)
Length (mm)	38 SL	41–85 TL	59 SL	37 SL	82+[1] SL	179.8 SL
Anal rays	ca. 43	ca. 43–60	61	53	58	63
Photophores						
IP	—	18–21	17	—	16	15
PV	—	26–28	27	23(?)[2]	25	25
VAV	—	16, 17	16	11(?)[2]	13	15
AC	—	43–47+2	43+2	51(?)+2[2]	41+2	39+4[3]
IC	—	ca. 110	105	—	95	98
OA	—	ca. 68–72[4]	70[4]	—	ca. 77, 78	87
Lat. l.	—	ca. 90	91	—	ca. 80	86
Body proportions, %						
Orbit/HL	—	16.7	20.0	12.5–14.3	21.2	22.6
Head/BL	16.7	14.1–15.8	17.0	20	16.5	16.8
Body depth/BL	6.4	7.3–8.1	10.0	10	10.5	12.3

certain (Table 1). Brauer (1906) reported two specimens from the Indian and Atlantic, the Atlantic one (59 mm SL) having nearly the same photophore numbers with those of Lütken (Table 1). The descriptions by Lütken (1892) and Brauer (1906) partly supplemented the inadequate original one by Günther (1873).

Diplophos pacificus Günther: This species was described on a small specimen (37 mm SL) from the central Pacific, 5°54′N, 147°02′W (Günther, 1889). It shows characteristically more developed photophores than *D. taenia* though they are of almost the same size (see Table 1). However, Günther (1889) did not count the photophores which were later counted by Parr (1931) from Günther's (1889) figure, and the description was limited to the body form and fin ray counts (Table 1). Because of the counts from a figure, the number of photophores, useful taxonomic character usually, was uncertain and inadequate.

Diplophos proximus Parr: The original description of this species is fairly satisfactory. The holotype was collected from the eastern Pacific and had characteristically fewer photophore counts than *D. taenia* (Table 1). However, the tail behind the end of anal fin was lost, rendering the photophore counts of the main series questionable.

Diplophos orientalis Matsubara: This species was described most precisely and completely based on a large specimen (179.8 mm SL) from the western North Pacific, and characterized by the large proportional eye size, high anal fin ray count, etc., compared with the previous species (Matsubara, 1940) (Table 1).

Among later descriptions on this species complex, those of Grey (1960) and Johnson and Barnett (1972) seem most precise and comprehensive. Grey (1960) compared the Atlantic and Pacific specimens inclusive of the holotypes, and considered the Pacific specimens as belonging to a distinct species or subspecies, and further that *D. orientalis* should probably be retained as a distinct species. However, she could not determine the number of species contained in the complex. Johnson and Barnett (1972) examined the meristics of many specimens from all the three oceans inclusive of or around the collection localities of the holotypes, and on obtaining longitudinal meristic variation synonymized *D. pacificus*, *D. proximus* and *D. orientalis* with *D. taenia*.

From the above account, it can be said that most of the original descriptions on the *D. taenia* species complex were incomplete especially in that they were based on only one small or broken specimen each. Vertebral counts, which were found in this study to be the most reliable distinct character of *D. taenia* species complex, were rarely made (Grey, 1960, 1964) or referred to as concordant with other meristics (Johnson and Barnett, 1972).

Examination of the characters useful for identification

Because of the expected difficulty of identification, the morphology of the *D. taenia* complex was examined as precisely as possible to isolate useful taxonomic characters of the species involved. The results are as follows.

Vertebrae. Vertebral counts were rarely made or regarded as unimportant for classification in the past studies (for example, Johnson and Barnett, 1972). However, it is proved in this study that TV and its combination (AV and CV) have a wide variation and are the most important systematic characters for *D. taenia* complex. This is analyzed in the next section.

Main photophores. SO, ORB and OP photophore counts are definitely 1, 1 and 3 in number, respectively, in all specimens. The following ones have a narrow range of numbers and have no significance in identification: IP (14–19), VAV (13–16) and VALA (13–17). The counts of other photophore rows show a wide range of variation and are useful for determining species characters, though there is partial or broad overlap among species depending on rows examined. These are analyzed in the next section.

Accessory photophores. Many small photophores develop in head and body (for precise arrangement, see the description of the new species). Most of them are indistinct or lost. The clearest and most easily counted photophores such as those along lateral side of dentary, below eye, behind SO photophore, below pectoral fin increase in number with growth and are identical among species.

Fin rays. Variations of the numbers of D (10–12), P_1 (8–10) and P_2 (8–9) are narrow among species. On the other hand, the number of A varies widely and is one of the important taxonomic characters. This is used in the analysis of the next section.

Body proportions. Except orbital diameter, there are no significant differences in body proportions

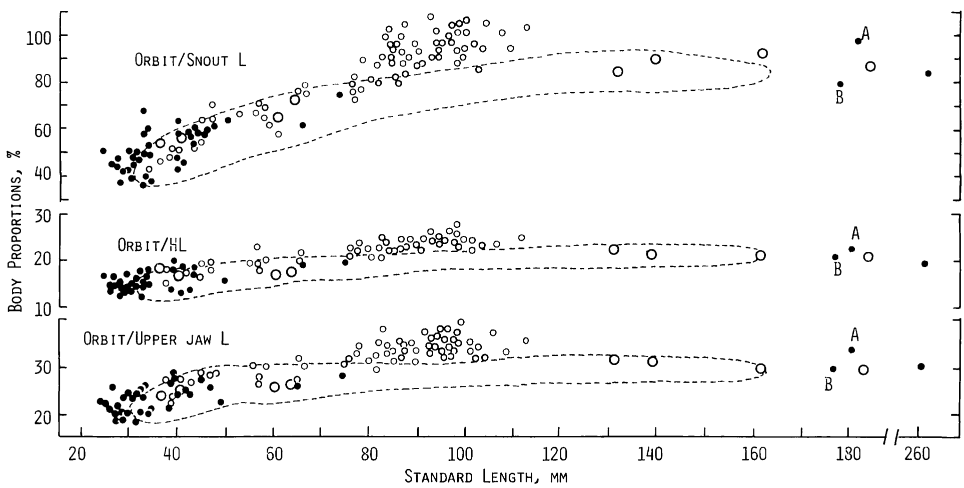

Fig. 3. Proportions of orbital diameter to three body parts in *Diplophos*. A is calculated from the values of Matsubara (1940), and B from those of Abe (1958). Small white circles indicate *D. proximus*, black ones *D. orientalis*, and large white ones *D. australis* sp. nov. The values of *D. taenia* are enclosed by broken lines because of many specimens.

among the species recognized in this study. The relative sizes of orbital diameter increase with growth: they are identical among all of the species in less than about 70 mm SL, and thereafter become apparently larger in *D. proximus* than in the other species (Fig. 3). Therefore, orbital size is one of the diagnostic characters of *D. proximus* specimens larger than about 70 mm SL. Among the three proportions in Fig. 3, those to snout length become larger in the other three species beyond the upper limit of SL in *D. proximus*, and finally overlap broadly with that of *D. proximus*. On the other hand, proportions to head and upper jaw lengths remain constant beyond 70 mm SL in all species: those to head length 21–28%, to upper jaw 29–39% for *D. proximus*, and 15–23% and 25–33% respectively for the others.

Color. There is no difference in coloration among species: body is uniformly dark brown, and head is also basically dark brown with variation by parts such as yellow cheek and black operculum.

Upper jaw teeth. There seems some difference in arrangement of upper jaw teeth: in *D. taenia*, teeth are nearly uniform in size; in *D. orientalis*, large and small teeth are arranged alternately; and in *D. proximus* and *D. australis* sp. nov., they are almost arranged as a set of a large tooth with a few small teeth. However, this difference is not decisive since tooth arrangements are usually uncertain due to loss

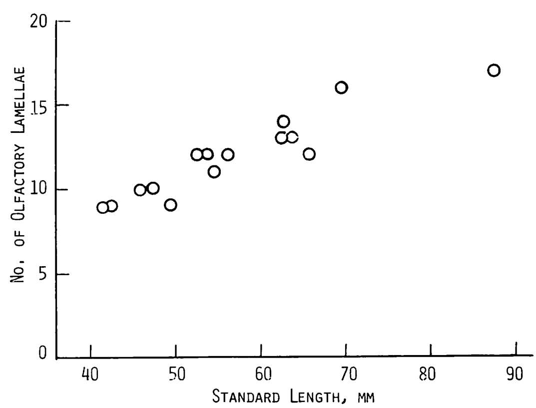

Fig. 4. Increase of the number of olfactory lamellae with growth in *Diplophos taenia*.

or damage.

Gill rakers. The number of gill rakers on the first arch is definitely 9+3=12 in the majority of specimens.

Olfactory lamellae. Olfactory lamellae in nasal rosette increase in number with growth (Fig. 4), and overlap broadly among species.

Identification to species

Key characters of the *D. taenia* species complex were determined by those stated above to be useful

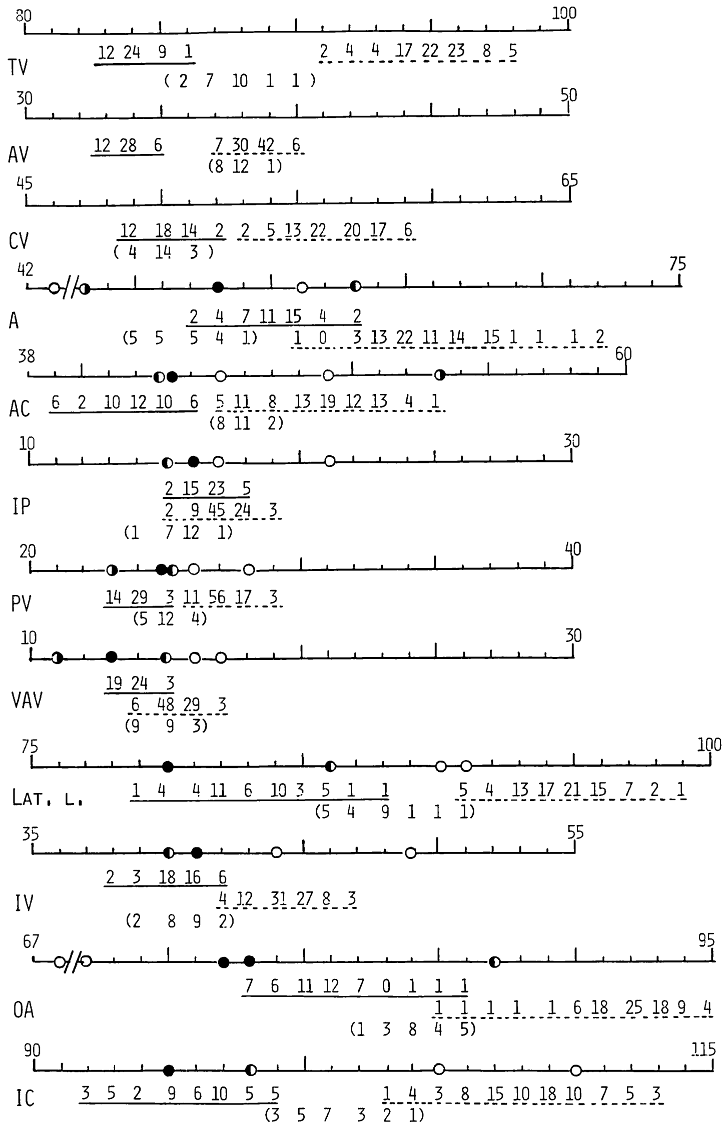

Fig. 5. Meristic characters of the holotypes and the present selected samples (see the text) of *Diplophos*. White circles indicate, instead of the holotype, the two earliest descriptions of *D. taenia* (see Table 1), black ones the holotype of *D. proximus*, right half black ones that of *D. pacificus*, and left half black ones that of *D. orientalis*. The numbers represent those of the present individuals having the characters above them, and are divided into *D. taenia* with broken underlines, *D. orientalis* with solid ones, and *D. proximus* with parentheses.

for classification with selected specimens. The collections were obtained from two areas: the western North Pacific where the occurrence of two distinct species had been reported in the study on larvae (Ozawa and Oda, 1986), and the eastern North Pacific where the holotype of *D. proximus* was collected. The latter area is one of the major distributional regions for oceanic organisms (Briggs, 1974; McGowan, 1974). The western North Pacific collection was composed of 133 specimens obtained mainly from the area shown in Fig. 1B during the cruises by Shunyo Maru, Hakuho Maru, Kagoshima Maru and Keiten Maru. The eastern North Pacific collection was composed of 21 specimens (LACM

30033 (6), 30035 (12) and 30041 (3)) from the area shown in Fig. 1C.

Significant differences were observed in the counts of vertebrae, anal fin rays and photophores (Fig. 5). Especially the first of these clearly shows the existence of three species: two in the western North Pacific which can be distinguished from each other by TV, AV and CV; and one in the eastern North Pacific which can be separated from the others by the combination of AV and CV. The other characters in Fig. 5 show a broad overlap among three species but two characters (Lat. l. and IC) are distinctly different between two species of the western North Pacific.

There is no doubt about the occurrence of three species. Species names were decided by comparison with the holotypes. Unfortunately the vertebrae had never been counted on any holotype (Table 1), and the original descriptions were incomplete as stated before; however, some of the characters in Fig. 5 were useful for determination of species name as follows. The specimens with the highest TV (more than 91) can be determined to be *D. taenia* because most of their characters except OA (see the explanation of Table 1) cover those of the two earliest descriptions of *D. taenia*, especially AC, PV, IV and IC showing unique correspondence between them. The specimens with the least TV (less than 86) can be assigned to *D. orientalis* by the unique coincidence of A (when *D. taenia* is excluded), AC and IC between them: AC and IC of the holotype of *D. proximus* are undoubtedly underestimated due to loss of caudal end (see Table 1). All other characters in Fig. 5 cover those of the holotype except that OA of the holotype is only one more than the range of the present specimens.

The last sample from the eastern North Pacific with intermediate TV (86–90) has relatively fewer unique characters than the previous ones (Fig. 5). Considering the poor description, especially underestimation of AC, Lat. l., OA and IC photophores due to loss of caudal end, of the holotype of *D. proximus*, the last sample can be attributed to *D. proximus* by the correspondence of other characters, especially A, when the identified samples are eliminated.

Specimens referable to *D. pacificus* were not recognized.

From the above comparison, it can be concluded that *D. orientalis* and *D. proximus* are valid and *D. pacificus* may be invalid. Moreover, three valid species are apparently distinguishable from each other by the combination of some characters such as TV and AV (Fig. 5). However, the differences among all characters in Fig. 5 are very small, suggesting that even clear-cut characters such as AV could possibly become wide and overlapping if the sample size were to be increased. In fact, the specimens for the study amounted to 698 compared with 154 used in Fig. 5. Possible ranges of the values in Fig. 5 were computed statistically, the confidence limits for the means being set at $P=0.999$ because the number of specimens examined amounted to about 700.

The results are shown in Table 2 (lines r1): fractions were omitted at lower ends and raised at upper ones to satisfy possible ranges. As supposed, all of the characters overlap broadly among three species, and therefore a dichotomic classification seems impossible. A few other methods for classification basically using the characters in Fig. 5 were examined. The one that proved to be effective enabled all of the specimens to be attributed to one of the three species, and finally permitted the construction of a dichotomic key for the polytypic North Pacific specimens. This is presented below, and the other methods which proved impossible to use for classification will be mentioned in the Discussion.

Ranges peculiar to each species were established for the characters by use of the possible ranges (lines r1 of Table 2). Peculiar ranges for a species are those never overlapping with the possible ranges of other species. For example, in case of TV the peculiar ranges are 81–83 for *D. orientalis* (the possible range 81–87), 88 and 89 for *D. proximus* (84–91), and 92–100 for *D. taenia* (90–100). It is considered that specimens with peculiar ranges can be classified to a particular species with a probability of 0.999. The peculiar ranges are shown only for TV, AV, CV and A in Table 2 (lines r2) because they worked well for classification, and therefore those for other characters had no actual significance.

Of 698 specimens available, 690 were used for this method, the others belonging to a new species and being treated independently. The classification was started with r2 of TV. Specimens which could not be identified were then put under the selection of AV, CV and A. The specimens having any of the peculiar values were further examined on whether all of their characters were coincident with the possible ranges of the characters of species considered. When coincident, specimens were finally assigned to one of the three species. With this procedure, 667 of 690 specimens or 97% of the total were classified to one of the three species.

The ranges of characters for the specimens identified above are summarized in Table 2 (lines r3). They were obtained from many specimens, i.e. 460 for *D. taenia*, 126 for *D. proximus* and 81 for *D. orientalis*. Therefore, it seems that values outside these ranges do not occur in nature for any species. Seeing these ranges called real ones below, an important point appears: the real ranges of AV are 33–35 for *D. orientalis*, 36–39 for *D. proximus* and 37–41

Table 2. Meristic characters of three species of the *Diplophos taenia* species complex. [1] Possible ranges estimated statistically (P = 0.999) with values in Fig. 5; [2] peculiar ranges not overlapping with r1 of other species; [3] real ranges occupied by specimens identified with r2; [4] number of sepcimens for r3; [5] ranges possessed by specimens unidentified with r3 (see the text for identification of these specimens); [6] number of specimens for r4; [7] only one specimen.

		taenia			*proximus*	*orientalis*
		Pacific	Indian	Atlantic		
TV	r1[1]		90–100		84–91	81–87
	r2[2]		92–100		88, 89	81–83
	r3[3]	90–99	91–96	90–100	85–90	83–86
	n3[4]	203	24	123	126	64
	r4[5]	91	—	90–91	85–87	84–86
	n4[6]	1	—	7	7	8
AV	r1		34–43		35–40	31–36
	r2		41–43		—	31–33
	r3	37–40	37–39	37–41	36–39	33–35
	r4	38	—	37–39	36	33–35
CV	r1		52–61		48–52	47–53
	r2		54–61		—	47
	r3	53–59	53–58	53–60	48–52	49–52
	r4	53	—	52–54	49–50	49–51
A	r1		60–73		52–61	55–65
	r2		66–73		52–54	—
	r3	60–72	62–67	59–71	54–62	55–63
	r4	59	—	56–61	56–59	57–61
PV	r1		25–30		22–28	22–26
	r3	25–29	25–29	25–29	24–26	23–25
	r4	26	—	25–27	24–25	24–25
AC	r1		42–55		43–48	37–47
	r3	45–53	46–50	45–53	43–48(50)[7]	39–45
	r4	47	—	45–46	44–45	43–44
IC	r1		101–116		96–106	89–103
	r3	104–115	103–112	104–115	98–104	92–100
	r4	106	—	104–107	98–101	97–100
IV	r1		40–48		38–44	37–44
	r3	42–47	42–46	42–48	39–43	38–42
	r4	43	—	42–44	39–41	40–42
OA	r1		86–98		80–89	75–86
	r3	85–97	86–93	87–96	81–87	78–86
	r4	88	—	87–88	82–84	80–83
Lat. l.	r1		89–100		83–92	76–90
	r3	90–99	91–99	90–99	84–91	79–88
	r4	91	—	90–92	85–89	83–86

Table 3. List and characters of specimens unidentified with the peculiar ranges (see Table 2). See the text for identification of these specimens. [t] Values peculiar to *Diplophos taenia*, but not to *D. proximus* when limited to these species; [p] values peculiar to *D. proximus*, but not to *D. taenia* when limited to these species. O, *D. orientalis*; P, *D. proximus*; T, *D. taenia*.

Specimen No.	Locality (Lat.; Long.)	SL (mm)	Orbit/ HL (%)	AV	CV	TV	A	PV	IV	AC	IC	OA	Lat. l.	Species classifiable	Species identified
A1	27°01.9′N; 129°41.8′ E	70.7	19.3	35	49	84	61	25	42	43	99	81	83	O or P	O
A2	28°25.1′N; 128°32.3′ E	65.0	18.4	35	50	85	57	25	41	44	99	82	84	”	”
A3	23°53.5′N; 127°34.0′ E	65.2	19.1	35	49	84	60	24	42	43	99	80	84	”	”
A4	27°37′ N; 133°46′ E	—	—	35	50	85	60	24	40	44	99	82	84	”	”
A5	” ”	—	—	35	51	86	59	24	41	44	100	83	86	”	”
A6	” ”	—	—	35	50	85	61	24	40	43	97	80	84	”	”
A7	21°04.8′N; 130°05.0′ E	—	—	35	49	84	60	24	40	43	97	81	84	”	”
A8	21°01.3′N; 130°02.9′ E	—	—	35	49	84	58	24	41	43	99	81	84	”	”
B1	20°15′ N; 107°14′ W	83.5	24.6	36	49	85	57	24	40	45	100	84	85	P or O	P
B2	” ”	65.0	20.8	36	50	86	57	25	41	44	100	83	85	”	”
B3	23°26′ N; 114°55′ W	105.8	24.1	38	53[t]	91	59[p]	26	43	47	106	88	91	P or T	T
B4	22°43′ N; 109°58′ W	108.7	23.8	36	51	87	56	25	42	44	101	84	89	P or O	P
B5	22°20′ N; 110°03′ W	85.3	24.3	36	49	85	59	24	39	44	98	82	85	”	”
B6	21°46.3′N; 107°59.5′W	96.4	22.2	36	49	85	56	24	41	44	100	82	85	”	”
B7	22° N; 110° W	—	—	36	50	86	57	24	40	45	100	83	86	”	”
B8	” ”	79.2	22.5	36	50	86	58	—	—	45	—	—	86	”	”
C1	2°27′ S; 19°00′ W	113.7	21.9	37	54[t]	92	58[p]	25	42	46	104	87	90	T or P	T
C2	” ”	110.1	20.5	39	52	91	60	27	44	45	105	87	91	”	”
C3	0°27′ N; 17°28′ W	94.2	20.5	38	52	90	56[p]	27	44	46	105	87	90	”	”
C4	” ”	56.8	17.8	37	54[t]	91	57[p]	26	44	46	107[t]	88	91	”	”
C5	10°57.2′N; 19°56.0′W	65.2	21.4	38	53[t]	91	57[p]	27	43	46	105	88	90	”	”
C6	” ”	44.8	16.2	39	52	91	—	27	44	45	105	87	90	”	”
C7	0°17′ S; 22°22.7′W	ca. 90	—	—	—	—	61	27	44	46	106	88	92	”	”

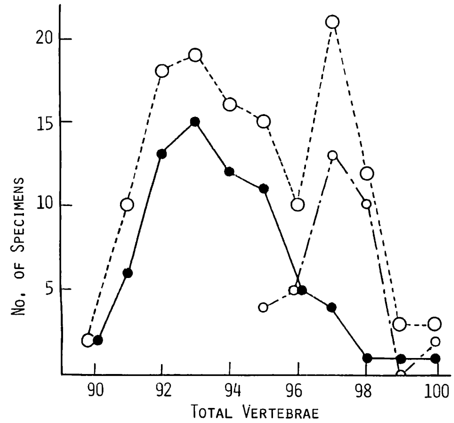

Fig. 6. Composition of *Diplophos taenia* Atlantic specimens by total vertebrae. Black circles represent specimens from off the western Sahara (0°–30°N; 10°–30°W), small white ones from off the east coast of USA (20°–40°N; 60°–80° W), and large white ones from the all Atlantic.

for *D. taenia*; those of CV are 49–52 for *D. orientalis*, 48–52 for *D. proximus* and 53–60 for *D. taenia*. With these characters, dichotomic key can be written as follows.

1 a. AV≦35 .... *D. orientalis*
1 b. AV>35 2
2 a. CV≦52 .... *D. proximus*
2 b. CV>52 .... *D. taenia*

This key was applied to the 23 specimens which were left in the classification with peculiar ranges. They are divided into three groups (A, B and C in Table 3): members of A are from the western North Pacific off southern Japan and are either *D. orientalis* or *D. proximus* because they have values of all characters intermediate between the peculiar ranges of these two species; members of group B are from the eastern North Pacific off California Peninsula and are either *D. proximus, D. orientalis*, or *D. taenia* for the same reason; and members of C are from the equatorial Atlantic and either *D. proximus* or *D. taenia*.

With the key above, all members of group A were classified to *D. orientalis*; all their characters fall within the real ranges of this species. Similarly, members of group B except specimen B3 were ascribed to *D. proximus*. Specimen B3 seems to be *D. taenia* with 53 CV, but has 59 A which is outside the real range of this species and inside that of *D. proximus*. Since the other characters in Table 3 are all within the real ranges of *D. taenia*, especially TV, IC and OA being outside those of *D. proximus*, it was considered to be *D. taenia*. However, it should be noted that its proportion of orbital diameter to HL (24%) is slightly outside the range of this species and inside that of *D. proximus* (see Fig. 3).

The last group C from the equatorial Atlantic was

Table 4. Parameters (a and b) and correlation coefficients (r) of linear relation (y=a+bx) between TV (x) and other meristic characters (y) of the eastern (E), western (W) and all (T) Atlantic *Diplophos taenia* specimens (see Fig. 6). The ranges of meristics are given on the line of meristics for E and W. * Insignificant at P=0.05.

	T	E	W
AV		37–41	39–41
a	14.775	12.975	11.304
b	0.255	0.275	0.290
r	0.736	0.704	0.586
A		56–69	62–71
a	−33.901	−30.936	−31.565
b	1.208	0.995	1.007
r	0.819	0.777	0.590
IV		42–47	44–48
a	13.177	23.243	35.476
b	0.333	0.225	0.108*
r	0.633	0.440	0.133*
IC		104–115	109–115
a	4.037	11.146	31.478
b	1.115	1.038	0.837
r	0.922	0.893	0.716
OA		87–95	91–96
a	1.398	2.747	8.043
b	0.948	0.933	0.880
r	0.954	0.934	0.878
CV		52–60	55–59
a	−14.769	−12.968	−11.304
b	0.744	0.724	0.709
r	0.953	0.933	0.870
PV		25–29	27–29
a	8.363	11.849	13.945
b	0.199	0.162	0.142*
r	0.629	0.490	0.298*
AC		45–53	48–52
a	−14.855	−18.431	−6.956
b	0.670	0.708	0.588
r	0.893	0.880	0.718
Lat. l.		90–99	94–99
a	−0.213	2.935	−6.782
b	0.996	0.962	1.062
r	0.979	0.972	0.936

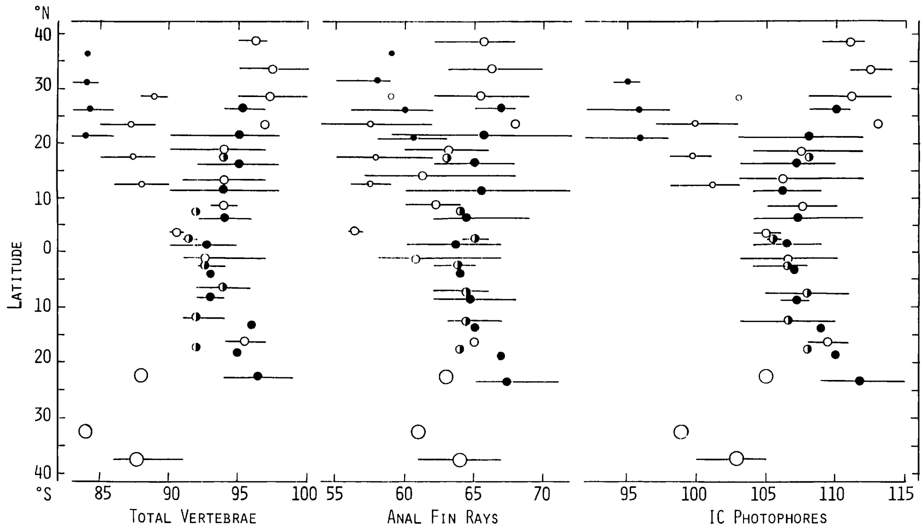

Fig. 7. Latitudinal variation of 3 meristic characters by 5 degrees in *Diplophos*. Circles and lines represent the means and the ranges of meristics, respectively. Small black circles indicate *D. orientalis*, small white ones *D. proximus*, medium ones *D. taenia*, and large white ones *D. australis* sp. nov. *D. taenia* is separated into 3 oceans: The Atlantic by white circles, the Pacific by black ones, and the Indian by half black ones.

divided into two species using the aforementioned key (Table 3): specimens with 52 CV were referred to *D. proximus* and those with 53 or 54 to *D. taenia*. Moreover, the latters have the anal fin ray counts peculiar to *D. proximus* when confined to these two species (see the line r1 of A in Table 2). These specimens may indicate the existence of another species, when it is considered that two of them, C5 and C6, were collected from the Mauritanian upwelling region where some endemic mesopelagic fishes are known to inhabit (Backus et al., 1977). The characters of the Atlantic specimens are reported below.

As seen from Fig. 1, the majority of Atlantic specimens were collected from two regions: one off the east coast of the USA (20°–40° N; 60°–80° W) and the other off the western Sahara (0°–30° N; 10°–30° W). Of 113 specimens in total whose vertebrae were able to be counted, the former comprised 31 (27%) and the latter 61 (54%). Apart from the possibility of the existence of undescribed species, the characters of the Atlantic specimens may be dependent on this collection bias. First of all, total vertebrae were compared between the western and eastern groups. They were significantly different between the groups, the western having higher TV and the eastern lower ones (Fig. 6). The questionable specimens in Table 3 are included in the lower TV group. Between the two groups, other characters were compared statistically by the linear correlation against TV.

The statistics for the groups and the total are shown in Table 4. Except PV and IV of the western group, all other characters are significantly correlated with TV, indicating their dependence on TV. Moreover, the slopes are not different at all for all characters between three groups, and the adjusted means are different in six of 27 combinations, especially AV, CV and A having the same correlation between three groups. Significantly ($P=0.05$) different adjusted means are obtained for the following combinations: IV (T vs W, and E vs W), IC (T vs W), Lat. l. (T vs E), and OA (T vs E).

The above comparison suggests that the meristic characters analyzed are consecutive and dependent on TV through the two groups, and therefore the low CV and A of group C in Table 3 seem indicative of the occurrence of specimens with low TV, but not of undescribed species. This is further supported by another point of view.

The fact that the eastern Atlantic group has lower TV and the western one higher TV recalls a well known phenomenon, Jordan's rule, of latitudinal meristic variation (Lindsey, 1988). This variation was examined on TV, A and IC of specimens grouped by five latitudes for all species, *D. taenia* being separated into three oceans (Fig. 7). Three species, i.e. *D. orientalis, D. proximus* and *D. australis* sp. nov. do not exhibit any significant variation of meristics along latitude because of their limited distribution. On the other hand, *D. taenia* shows a clear cline along its wide latitudinal distribution, the meristics being fewer in low latitudes and becoming progressively higher towards high latitudes. The clines of TV and IC are the same among three oceans, but that of A is different between the Atlantic and the other two oceans: the values of A in the Atlantic are apparently fewer, especially in low latitudes than those in the Pacific and Indian. It is considered about group C in Table 3 that the low TV (52) is derived from the latitudinal cline, and the low A (56–58) from both the property to have fewer A and the cline in the Atlantic *D. taenia*.

From the above consideration on the dependence on TV and the cline of meristics, it can be concluded that among the *D. taenia* species complex *D. taenia* alone is distributed in the Atlantic with the exception of a newly described species (see below).

Eight specimens collected from south of 20°S (Fig. 1) showed a peculiarity of the characters which are summarized in Table 5. Most of their characters are clearly different from those of *D. taenia*. Although the clearly differentiated characters TV and AV overlap partially between these specimens and *D. taenia*, due to wide latitudinal variation in *D. taenia*, TV and IC are distinctly different between them when confined to the specimens collected from south of 20° S: TV 84–91 and IC 99–105 for these specimens, and 94–99 and 109–115, respectively for *D. taenia* (Fig. 7).

TV (84–91), OA (80–87) and Lat. l. (84–90) of these specimens are similar to those (85–90, 81–87 and 84–91) of *D. proximus*, but AV (33–37) to that (33–35) of *D. orientalis*. Moreover, their A (61–67) is different from those (54–63) of both species. Thus, these specimens can not be identified with any of the known species and thus represent an undescribed species, though all of their characters overlap in part with those of the known species (Table 5).

Summarizing the above examination, it is concluded that *Diplophos taenia* complex comprises four valid species, i.e. *D. taenia* (Fig. 8), *D. proximus* (Fig. 9), *D. orientalis* (Fig. 10) and a new one which is described below as *D. australis* (Fig. 11), and *D. pacificus* seems synonymous with either *D. taenia* or *D. proximus* because no specimens possessing the characters of holotype (Table 1) were recognized and the holotype was collected from around the boundary of distribution of these two valid species (Fig. 13).

Identification to species is impossible all together due to slight overlap of all characters (Table 5), but possible area by area as follows.

Key to species of *Diplophos taenia* species complex

I. Pacific Ocean north of 20°S.
- 1a. AV≦35 .... *D. orientalis*
- 1b. AV>35 2
- 2a. CV≦52 .... *D. proximus*
- 2b. CV>52 .... *D. taenia*

II. Atlantic and Indian Oceans north of 20°S.
- *D. taenia* only

III. Pacific, Atlantic and possibly Indian Oceans south of 20°S.
- 1a. TV≦91; IC≦105 .... *D. australis* sp. nov.
- 1b. TV≧94; IC≧109 .... *D. taenia*

Table 5. Meristic characters of the *Diplophos taenia* species complex. * See Table 2.

	D. taenia			*D. proximus*	*D. orientalis*	*D. australis* sp. nov.
	Pacific	Indian	Atlantic			
TV	90–99	91–96	90–100	85–90	83–86	84–91
AV	37–40	37–39	37–41	36–39	33–35	33–37
CV	53–59	53–58	52–60	48–52	49–52	50–54
A	59–72	62–67	56–71	54–62	55–63	61–67
PV	25–29	25–29	25–29	24–26	23–25	23–26
AC	45–53	46–50	45–53	43–48(50)*	39–45	43–47
IC	104–115	103–112	104–115	98–104	92–100	99–105
IV	42–47	42–46	42–48	39–43	38–42	41–44
OA	85–97	86–93	87–96	81–87	78–86	80–87
Lat. l.	90–99	91–96	90–99	84–91	79–88	84–90

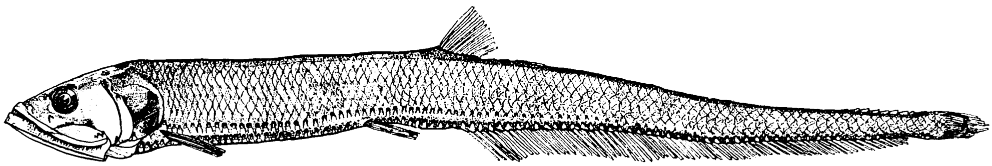

Fig. 8. *Diplophos taenia*, BPBM 24443, SL 59.3 mm.

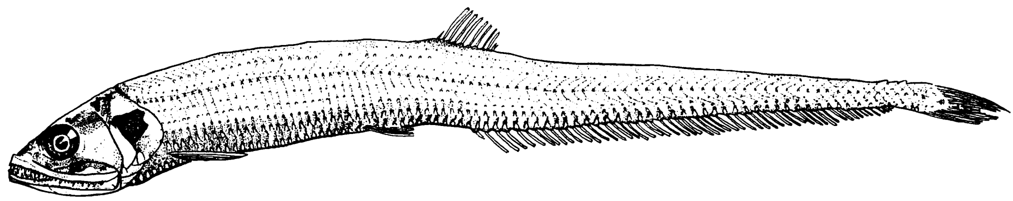

Fig. 9. *Diplophos proximus*, SIO 68-50, SL 86.3 mm.

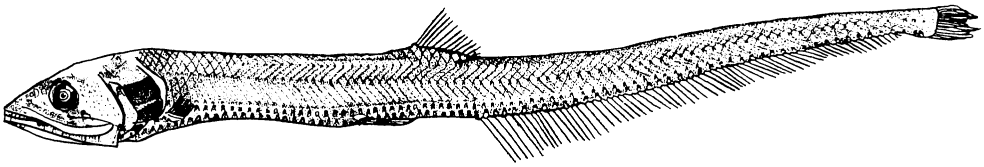

Fig. 10. *Diplophos orientalis*, not catalogued, SL 45.0 mm.

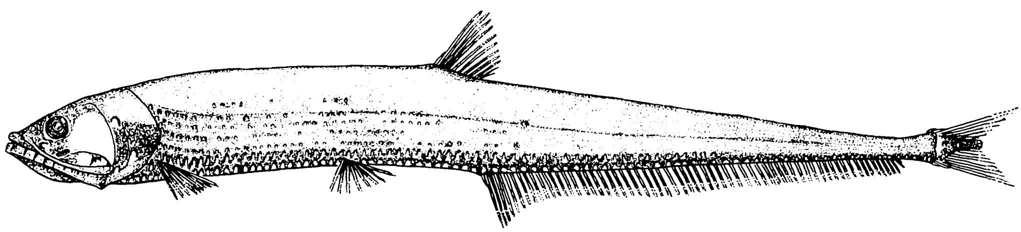

Fig. 11. Holotype of *Diplophos australis* sp. nov., ISH 754/71, SL 183.0 mm.

Diplophos australis sp. nov.
(Fig. 11)

Holotype. ISH (Institut für Seefischerei der Bundesforchungsanstalt für Fischerei, Hamburg) 754/71, 183.0 mm SL; sex undetermined; FRS "Walther Herwig" Station 371–I/71; 40°00′ S, 30°40′ W; depth 99–102 m; 3 Oct. 1971; gear, CMBT 1600.

Paratypes. Two specimens taken with the holotype: ISH 3453/71, 138.2 and 160.2 mm SL.

Five additional specimens (non-types; 37.5–132.1 mm SL). SIO 75-631, 41.2 mm SL (24°56′ S, 155°19′ W; 31 July 1972); SIO 69-321, 37.5 mm SL (30°46′ S, 81°32′ W; 4 Mar. 1969); SAM 24495, 132.1 mm SL (off Cape Point; 5 Mar. 1965); MCZ 59164, 64.6 mm SL (36°03′ S, 17°10′ E; 30 Apr. 1971); MCZ 59165, 61.5 mm SL (35°02′ S, 48°46′ W; 4 Apr. 1971).

Description. In the present description, counts are based on the holotype, two paratypes and five non-types, the measurements on the holotype and two paratypes, and the notes on the holotype. Values other than those of holotype are given by ranges in parentheses. The measurements are expressed as percentages of standard length.

Branchiostegal rays 14 (14–15); gill rakers on 1st arch 3+1+8 (3+1+8); Dorsal 11 (10–12), Anal 64 (61–67), Pectoral 9 (9), Pelvic 8(8), Caudal 10+9 = 19 (10 + 9=19); Vertebrae inclusive the first preural 35+54=89 (33–37+50–54=84–91); IP 18 (16–19), PV 25 (23–26), IV 43 (41–44), VAV 1+14 (1+13–15), AC 45+2 (41–45+2), IC 105 (99–104), OV 24 (23–26), VALA 15 (14–15), VALB 25 (23–26), VALC 22 (19–21), OAA 39 (37–40), OAB 64 (61–66), OA 86 (80–87), BR 12 (11–13), Lat. l. 42 + 47 = 89 (40–43 + 43–47 = 84–90); body depth 11.8 (11.0–12.1); body width 4.2 (3.8–4.3); caudal depth (least) 2.7 (2.9); head 1. 16.0 (16.3–16.9); snout 1. 3.7 (3.7–3.8); interorbital width 3.9 (3.7–4.2); upper jaw 11.4 (11.3–12.2); premaxillary 4.9 (4.7–5.0); toothed maxillary 5.8 (5.9–6.1); dorsal base 5.0 (5.6); anal base 44.3 (43.1–45.1); predorsal 46.7 (46.9–47.9); preanal 52.5 (53.2–53.6); prepelvic 37.6 (38.9–39.4); eye diameter 3.1 (3.1–3.3); head depth 11.1 (11.0–11.6); postorbital head length 8.7 (8.3–9.2); lower jaw 11.5 (11.3–11.9); pectoral base to pelvic base 20.4 (21.8–22.4); pelvic base to anal origin 14.4 (13.7); caudal peduncle length 4.6 (4.0–4.3).

Body elongate and compressed; its dorsal and ventral profiles almost straight in front of dorsal fin, gradually tapering to caudal peduncle. Scales cycloid and deciduous, being almost lost in all of type specimens. Head scaleless. Anus immediately in advance of anal origin. All fin rays short, transparent and fragile, their tips usually broken; caudal fin dotted with many minute chromatophores. Anal origin under the last dorsal ray. Dorsal origin a little before midpoint of body. Pelvics abdominal, inserted well in advance of dorsal origin. Pectorals ventrolateral, inserted just below posterior margin of operculum. The skin over caudal fin base forming a short black tube, its length (from base of caudal fin to tip of tube) 4.2% of SL. Adipose fin absent.

Dorsal surface of head with moderate downward profile. Head depth a little smaller than body depth, head width about equal to body width. Eyes circular and small. Interorbital area flat, its width narrow. Nostrils close together at anterodorsal corner of eye. Snout pointed and longer than orbit. Mouth large and oblique: premaxillary straight, maxillary smoothly convex, reaching preoperculum; premaxillary much shorter than toothed part of maxillary.

All teeth canine-like and straight or slightly recurved. Premaxillary teeth changing posteriorly their direction from slightly anteriad to slightly posteriad, unequal in size (large, L, medium, M equal to half or 2/3 of L, and small, S equal to or less than 1/3 of L) and uniserial with backward arrangement of 1S, 1L, 2S, 1L, 3S, 1L, 5S, 2M and 4S. Maxillary teeth directed slightly anteriorly, unequal in size (M and S) and uniserial with backward arrangement of 1S, 1M, 2S, 1M, 1S, 1M, 2S, 1M, 5S, 1M, 2S, 1M, and about 24S. Dentary teeth biserial to the origin of dentary photophore row and uniserial thereafter: biserial portion consisting of five large inner teeth curving slightly backward and six small outer teeth curving inward; uniserial row with large teeth becoming smaller in size posteriorly and separated by several small teeth. Head of vomer with one tooth on each side. Palatines with a single row of about 18 teeth decreasing in size posteriad. Three small teeth on the anterior tip of tongue.

Four gill arches present with well-developed slit behind the fourth. Lathlike gill rakers on the first three gill arches, only small teeth on the fourth. Pseudobranchiae small with about 16 short filaments each.

Head photophores: Supraorbital photophore at anterodorsal corner of eye between eye and nasal area, small, embedded in skin (this description is based on the paratypes because this photophore was indistinguishable in the holotype). Anterior infraorbital (lachrymal) series with a large photophore directed posterodorsally at anteroventral corner of eye followed by six small photophores in horizontal linear series. One medium-sized photophore above anterior supramaxillary. Three photophores in ascending linear series under posterior supramaxillary, the rearer photophores the larger. One large photophore beneath dorsal end of preoperculum. Three (left side) and five (right) faint photophores in vertical series beneath mid-preoperculum anterior to opercular border. One large photophore at lower part of preoperculum posterior to the end of upper jaw. Five medium-sized photophores in a little ascending linear series along dorsal margin of suboperculum. One large photophore at the anteroventral corner of operculum. Two photophores just inside the first two large teeth of premaxillary. A row of one large (directed anteriad) and about 15 small photophores (directed ventrad) on lateral surface of dentary, embedded in a common black membrane, extending from about 1/4 to 3/4 of lower jaw length behind symphysis. One large photophore (SO) with very large silvery reflecting area on inner surface of lower jaw, preceded by two (left side) and three (right) small photophores and followed by about ten small photophores embedded in a common black membrane and in a posteriorly directed series ending at level of tip of isthmus. Br photophores followed by one to few small photophores between the last three branchiostegal rays.

Main photophores: Photophores elongate vertically except the last 8th to 3rd AC, the last five VALB and the all VALC which are round. Last two AC photophores distinctly larger than preceding AC and grouped together.

Accessory body photophores: Due to skin being

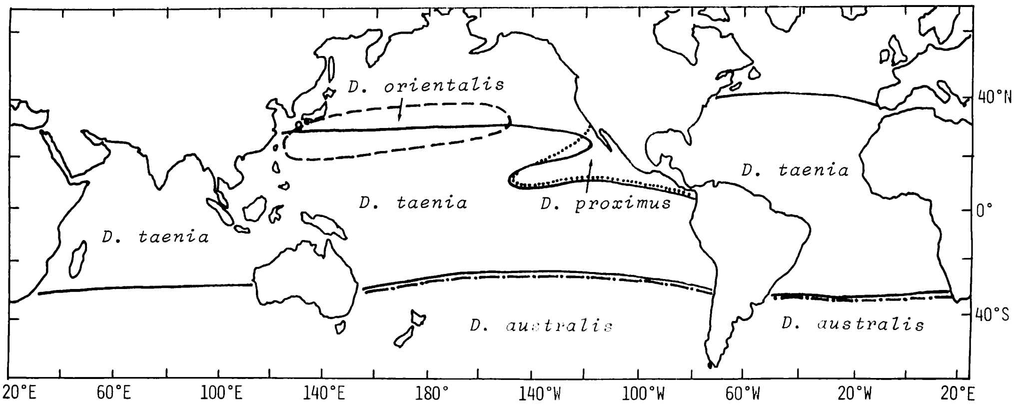

Fig. 12. Distribution of the *Diplophos taenia* species complex.

rubbed off nearly completely on all of the types, the precise arrangement of accessory photophores was not clear and their numbers were deduced in a manner stated in Materials and methods. Maximum nine principal rows of small photophores on body paralleling IC and OA. Four and three rows on dorsolateral side of trunk and tail, respectively, the uppermost one along middorsal line except dorsal base with one row on its either side (due to loss of skin, where and which row ends were uncertain). Photophores along lateral line slightly larger in size than other accessory photophores. Four, three and one rows on the ventrolateral side of trunk, anterior and posterior half of tail, respectively: the uppermost one complete throughout body; 2nd uppermost one ending above anus; 2nd lowest one curving slightly upwards above anus and ending above the last 6th VALB; lowest one locating along posteroventral corner of each OA photophores and ending below the last 5th VALB. Five photophores ventral to pectoral fin, the first similar in size and shape to the main row photophores and the others changing in size and shape posteriorly to those of accessory photophores. Five small photophores on triangular skin tube of caudal fin: along midlateral line, one at base and midpoint of tube, and two at tip of tube; two on lower half of tube base.

Color: Color in alcohol uniformly dark brown except dull yellow cheek, and black operculum and skin tube of caudal fin.

Distribution

The areas covering the collection localities of each species (Fig. 12) are separated each other, though partly overlapped, and correspond excellently to the distributional patterns of oceanic organisms (McGowan, 1974; Backus et al., 1977).

According to the terminology of McGowan (1974), *D. taenia* is a cosmopolitan, being distributed circumtropically between about 40°N and 30°S except the eastern tropical Pacific; *D. proximus* is definitely a member of the eastern tropical Pacific fauna; *D. orientalis* is a North Pacific transitional zone species between about 30° and 40°N and therefore may be distributed in the eastern North Pacific off California like a notosudid fish *Scopelosaurus harryi* (Bertelsen et al., 1976); and *D. australis* seems a transitional zone species of the Southern Ocean south of 20°S, and probably occurs in the Indian Ocean because the majority of endemic organisms there have circumglobal ranges (Briggs, 1974: p. 330).

Table 6. Ratios of meristic characters in the *Diplophos taenia* species complex.

Species	CV/AV	A/AV	CV/(CV-AV)
D. taenia	1.384–1.521	1.550–1.769	2.950–3.666
D. orientalis	1.400–1.515	1.647–1.941	2.941–3.500
D. proximus	1.230–1.405	1.435–1.594	3.466–5.333
D. australis	1.444–1.606	1.743–1.853	2.650–3.250

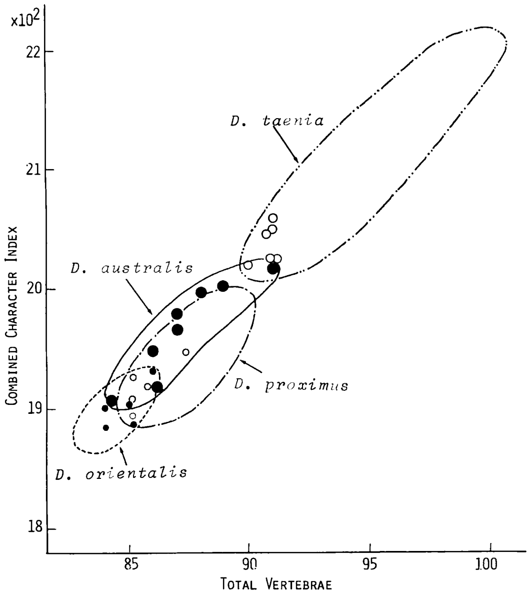

Fig. 13. Combined character index plotted against total vertebrae for *Diplophos*. The ranges of indices are enclosed by lines for each species because of many specimens except all indices for *D. australis* and those of specimens listed in Table 3 for other species. Large black circles represent *D. australis*, small black ones *D. orientalis*, small white ones *D. proximus*, and medium white ones *D. taenia*.

Discussion

In this study, the numbers of vertebrae, anal fin rays, and photophores were regarded as the useful taxonomic characters of *D. taenia* species complex. However, the classification produced by them was not simple, being possible only area by area. And further, care must be taken that there is a possibility of statistical error of $P=0.001$ because in the process of identification, statistically ($P=0.999$) determined values of characters were included. Other methods with the useful characters were investigated below.

Johnson (1982) succeeded in identification of specimens having an intermediate character of two evermannellid species *Coccorella atlantica* and *C. atrata* by the combined character index calculated with five morphometric characters for each specimens. This index is a sum of differences from mean values for proportion of character to standard length (for exact procedure, see Johnson, 1982). In this study, the index was calculated with 19 meristic characters adding seven photophore rows (BR, OV, VALA, OAA, OAB, OA-OAA, and LLA) to those in Fig. 2, because the morphometric characters were significantly different only in the orbit proportions of *D. proximus* among *D. taenia* complex.

The indices are linearly dependent on TV across the species involved, and are not isolated species by species, those of *D. orientalis* being the least, of *D. taenia* the highest, and of *D. proximus* and *D. australis* intermediate (Fig. 13). Most of the indices of unidentified specimens in Table 3 are located around the limits, i.e. overlapped portions of the species concerned, indicating the invalidity of the method for the present species complex.

Although the meristic characters are as a whole dependent on TV in all of the species, the exception was found in *D. proximus* which has higher AV and less A against intermediate TV compared with the other species (Table 5). This means the ratios calculated with these opposite characters may be different among species. Three ratios are shown in Table 6. As supposed, *D. proximus* has the least CV/AV and A/AV, and the highest CV/(CV-AV), and can be separated from *D. orientalis* and *D. australis* with these ratios. In the other cases, however, all of the ratios overlap among species, indicating the invalidity of this method for classification of *D. taenia* species complex.

From the above discussion, it is concluded that the key in the text is best at present, though with a possibility of statistical error ($P=0.001$).

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ヨコエソ科 *Diplophos taenia* 複合種群の分類と分布，および1新種 *D. australis* の記載

小沢貴和・織田康平・井田俊秀

三大洋から得られたヨコエソ科 *Diplophos taenia* 複合種群 698 個体を用いて分類学的研究を行った．同群にはネッタイユメハダカ *D. taenia* Günther, *D. proximus* Parr, ユメハダカ *D. orientalis* Matsubara, および1新種 *D. australis* の4有効種が認められ，それらは以下の特徴的形質を有する．ネッタイユメハダカ：総脊椎骨 (TV) 90–100, 腹椎骨 (AV) 37–41, 尾椎骨 (CV) 52–60, および IC 発光器 (IC) 103–115; *D. proximus*: TV 85–90, AV 36–39, CV 48–52, および IC 98–104; ユメハダカ：TV 83–86, AV 33–35, CV 49–52, および IC 92–100; *D.australis*: TV 84–91, AV 33–37, CV 50–54, および IC 99–105. 以上の形質に加えて，*D. proximus* は他3種と比べより大きな眼径を体長 70 mm 以上で有する（眼径／頭長比は同種で 21 – 28%, 他3種で 15 – 23%). 幅広く分布するネッタイユメハダカの TV, IC および臀鰭条数は三大洋において低緯度で少なくて高緯度で多く，また大西洋での臀鰭条数は同緯度の他の2大洋の値よりも少ない．これらの変異のため，種の同定は海域毎にのみ可能である．4種の分布域は明瞭に異なり，ネッタイユメハダカは東部熱帯太平洋を除く北緯 40°–南緯 30° の普遍種，*D.proximus* は東部熱帯太平洋固有種，ユメハダカは北緯 30°–40° の北太平洋移行帯種，そして *D. australis* は南緯 20° 以南の南大洋移行帯種である．

(890 鹿児島市下荒田 4-50-20 鹿児島大学水産学部；織田，現住所：894 名瀬市真名津町 7-20 A203 号；井田，現住所：456 名古屋市熱田区大宝町 1-4-7 KK スギヨ)