

## A New Aulopid Species, *Aulopus formosanus* (Aulopiformes: Aulopodidae) from Taiwan \*

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(Accepted January 13, 1994)

**Sin-Che Lee and Wei-Chen Chao (1994)** A new aulopid species, *Aulopus formosanus* (Aulopiformes: Aulopodidae) from Taiwan. *Zoological Studies* 33(3): 211-216. The unidentifiable species of *Aulopus* sp.1 of Masuda et al. (1984) is described and named based on observations and electrophoretic comparisons of specimens collected from Kaohsiung, Taiwan. The new species differs from all other members of the genus by lower gill-raker counts; and, among males the second dorsal ray is an extended filament. The two morphological forms are confirmed as members of the same species.

**Key words:** Sexual dimorphism, Electrophoresis, Congeneric species.

**A**ulopodidae is one of twelve families within the Order Aulopiformes, it is distinguished by having two supramaxillae, an orbitosphenoid bone, and fulcral scales on the caudal region. Only one genus *Aulopus*, with 7 species, is found throughout the tropical and subtropical seas excluding the eastern Pacific (Nelson 1984).

In Taiwan, *Aulopus japonicus* has long been regarded as the only indigenous species within the genus and was first recorded, without description, by Liang in 1951. The subsequent records of this species by Chen (1954 1956 1969 1986) and Shen (1984a,b) are made accordingly. A second species of *A. damasi* was reported by Kao and Lin in 1986. During our recent examination of the specimens stored in National Taiwan University, we found that some specimens had been misidentified as *A. japonicus*. In addition, the species identified as *A. japonicus* by Shen (1984b) is identical to the *Aulopus* sp.1 described by Masuda and his colleagues in 1984. This raises an interest in pursuing a further clarification of the systematic status of the entire *Aulopus* species, since other species may have been included in the previous records by mistake.

After a close examination of 30 specimens (16 males and 14 females) collected from Kao-

hsiung, we found that none of them fit the typical *A. japonicus* description; both sexes have fewer gill-rakers and only the 16 males had a second dorsal ray extending into a filament. The above characteristics quite agree with those shown in pl.61-c of Masuda et al. (1984) as *Aulopus* sp.1.

Since the two morphological types of *Aulopus* are found together in Taiwan, to avoid possible confusion of the 30 specimens with respect to the presence or absence of a dorsal filament, we employed electrophoresis for enzymes and none enzymatic muscle proteins. Thus, the purpose of this paper is to describe a new species and biochemically confirm whether or not the two morphological types belong to one species.

### MATERIALS AND METHODS

A typical *Aulopus japonicus* specimen used here for comparison is preserved and was collected from Nanfanao, Taiwan in November, 1970 (ASIZP 054460; SL. 155.3 mm; male). The 30 specimens used in this study were collected from the coastal waters off Kaohsiung, Taiwan from a depth of 30 m. They were frozen immediately after capture and brought to the laboratory deep freezer ( $-75^{\circ}\text{C}$ )

\*This paper is contribution No. 389 of the Institute of Zoology, Academia Sinica, ROC.

as soon as possible. The skeletal muscle, eyes, and liver of each specimen were removed and were homogenized for electrophoresis. The following enzyme system (and loci scored) were analyzed by starch gel electrophoresis: aspartate aminotransferase (*AAT-A, B*), creatine kinase (*CK-A*), glucosephosphate isomerase (*GPI-A, B*), isocitrate dehydrogenase (*IDH-A*), lactate dehydrogenase (*LDH-A, B, C*), malate dehydrogenase (*MDH-A, B*), malic enzyme (*ME-1*), phosphoglucumutase (*PGM-A, B*), and general muscle proteins (*Gp-1, Gp-2, Gp-3*). The enzyme and buffer system employed are listed in Table 1. The electrophoresis procedure follows that of Tsoi et al. (1987). The TC buffer running time is 4-5 hours while that for the EBT buffer, about 12 hours.

The remaining body was fixed and preserved in 10% neutral formalin for further inspection of external characteristics including morphometrics. The body proportion measurements and meristic counts follow Lee (1980). Locus nomenclatures follow Shaklee et al. (1990).

## RESULTS

### *Aulopus formosanus* sp. n.

(Figs. 1-2; Tables 2-3).

*Aulopus* sp.1.: Masuda et al., 1984: 60.

*Aulopus japonicus* (non Gunther): Shen, 1984b: 15.

*Holotype*: ASIZP 056190, male, 169.4 mm SL, August 13, 1987, Kaohsiung.

*Paratypes*: ASIZP 056153, male, 138 mm SL, March 13, 1987, Kaohsiung; ASIZP 056142, female, 190.9 mm SL, April 1987, Kaohsiung. Other 30 unregistered paratypes (16 males and 14 females), 148.9-248.6 mm SL, April to August 1987, Kaohsiung.

*Diagnosis*: Meristic data and morphometric data based on holotype and 30 paratypes. D.14-16 (modally 16), A.8-10 (modally 9), P.11, branched caudal rays 17, L1.39-44 (modally 42), Ltra.5-6 (modally 5), vertebrae 40-43 (modally 42), GR (developed) 4-5 + 10-12 = 14-17. Body moderately elongated, depth 4.51-5.89 in standard length (or 22.2-17% of SL). Orbit larger than snout measured 31.0-37.5% of HL, maxilla with two well developed supramaxillae. Second dorsal ray longer, extending into a rather long filament in male only, measuring 32.4-51.9% of SL in contrast to 14.4-18.0% in female. Caudal region with fulcral scales. Pyloric caeca absent. Color when fresh, pinkish red with irregularly scattered black spots on back and two rows of violet red spots on lateral side. Dorsal fin with yellowish spots in male and reddish spots in female. Anal fin with a median yellowish stripe in male only.

*Description of holotype*: Counts and measure-

**Table 1.** Enzyme system tested and electrophoretic buffers employed, with a list of loci scored and allelic frequencies of two morphological *Aulopus* sp. types

Enzyme (abbr.)	E.C.No.	Buffer	Tissue exam.	Locus	Allele	Morph A male (n = 14)	Morph B female (n = 16)
Aspartate aminotransferase (AAT)	2.6.1.1	TC	liver	<i>AAT-1*</i>	100	1.00	1.00
				<i>AAT-2*</i>	100	1.00	1.00
Creatine kinase (CK)	2.7.3.2	EBT	muscle	<i>CK-A*</i>	100	1.00	1.00
Glucosephosphate isomerase (GPI)	5.3.1.9	EBT	muscle	<i>GPI-A<sub>2</sub>*</i>	100	1.00	1.00
				<i>GPI-B<sub>2</sub>*</i>	100	1.00	1.00
Isocitrate dehydrogenase (IDH)	1.1.1.42	TC	heart	<i>IDH-A*</i>	100	1.00	1.00
Lactate dehydrogenase (LDH)	1.1.1.27	TC	muscle	<i>LDH-A<sub>4</sub>*</i>	100	1.00	1.00
			heart	<i>LDH-B<sub>4</sub>*</i>	100	1.00	1.00
			eye	<i>LDH-C<sub>4</sub>*</i>	100	1.00	1.00
Malate dehydrogenase (MDH) (NADsuperanantant)	1.1.1.37	TC	muscle	<i>S-MDH-A*</i>	100	1.00	1.00
			eye	<i>S-MDH-B*</i>	100	1.00	1.00
Malic enzyme (ME)	1.1.1.40	TC	heart	<i>ME-1*</i>	100	1.00	1.00
Phosphoglucumutase (PGM)	2.7.5.1	EBT	muscle	<i>PGM-A<sub>2</sub>*</i>	100	1.00	1.00
				<i>PGM-B<sub>2</sub>*</i>	100	1.00	1.00
General proteins		EBT	muscle	<i>Gp-1*</i>	100	1.00	1.00
				<i>Gp-2*</i>	100	1.00	1.00
				<i>Gp-3*</i>	100	1.00	1.00



Fig. 1. *Aulopus formosanus* sp. n., holotype, ASIZP 056190, male, 169.4 mm SL, August 13, 1987, Kaohsiung.



Fig. 2. *Aulopus formosanus* sp. n., paratype, ASIZP 056142, female, 190.9 mm SL, April 1987, Kaohsiung.

Table 2. Counts and measurements of *Aulopus formosanus* sp. n.

	Holotype	Paratypes	
		Morph A Range (mean)	Morph B Range (mean)
Standard length (mm)	169.4	147.5-229.5	152.8-205.6
Sex	male	male	female
No. fish examined	1	16	14
In % standard length			
Head length	32.5%	30.7-33.2% (31.9%)	31.1-33.4% (32.4%)
Body depth	20.4%	17.0-22.2% (19.5%)	17.6-21.5% (19.5%)
Longest dorsal ray	36.3%	32.4-51.9% (39.6%)	14.4-18.0% (16.8%)
Pectoral fin	19.5%	19.2-22.5% (21.0%)	18.6-20.5% (20.0%)
In % head length			
Eye diameter	37.5%	31.0-36.6% (33.8%)	32.7-35.3% (33.9%)
Snout length	26.7%	24.2-27.3% (25.6%)	23.8-27.7% (25.2%)
Dorsal rays	16	15-16(mode 16)	14-16(mode 16)
Anal rays	10	9-10(mode 9)	8-9(mode 9)
Ventral rays	9	9	9
Pectoral rays	11	11	11
Branched caudal rays	17	17	17
Scales on lateral line	41	39-41	40-44
Scales from origin of dorsal fin to lateral line	5	5-6	5-6
Total gill rakers (lower limb)	15 (12)	14-17 (10-12)	14-16 (10-12)
Second dorsal rays filamentous	yes	yes	no
Coloration of spots on dorsal fin	yellow	yellow	red
A median yellowish stripe on anal fin	present	present	absent

**Table 3.** Comparisons of some critical characteristics among *Aulopus formosanus*, *A. japonicus*, *A. microps*, and *A. damasi*

	<i>A. formosanus</i> n = 30	<i>A. japonicus</i> <sup>1</sup> n = 11	<i>A. microps</i> <sup>1</sup> n = 33	<i>A. damasi</i> <sup>2</sup> n = 1
Dorsal rays	16	16-17	16-17	14
Anal rays	8-10(9)	9-10	10-11	8-9
Pectoral rays	11	11	11	13
Second dorsal ray prolonged in male	yes	no	no	no
Second dorsal ray prolonged in female	no	no	no	no
Pyloric caeca	0	9-11	0	not examined
Total gill rakers	14-17	17-25	21-23	20
Scales on lateral line	39-44	41-44	43-45	36
Vertebrae	40-43	42-43	41-43	not examined
Size of orbit larger or smaller than snout	larger	larger	smaller	smaller

<sup>1</sup>Based on Parin and Kotlyar 1989.

<sup>2</sup>Based on Kao and Lin 1986.

ments of the holotype and paratypes are shown in Table 2.

Body moderately elongated, slightly compressed laterally, greatest depth 20.4% SL. Orbit slightly larger than snout, 37.5% of HL, interorbital space concave, about half the width of orbit. Mouth terminal, very wide, maxilla reaches slightly beyond the posterior margin of pupil, with two well developed supramaxillary bones. Small conical tooth bands on jaws and palatines. The palatine tooth band is fused with those on the vomer and pterygoids. Body covered with ctenoid scales, except those on the caudal region which appear fulcral; forty one scales on lateral line and 5 between the origin of the dorsal and lateral line. Adipose fin present, base of dorsal fin long, 1.65 times as long as the distance between rear end of dorsal fin and origin of adipose fin, 16 rays, the anterior two rays simple, the second extending into a filament, measuring 36.3% of SL. The predorsal length is much greater than the distance between the posterior end of the dorsal fin and the anterior margin of the adipose fin. Anal base short, 10 rays. Pectoral fin in lower position, originating slightly before the dorsal fin, 11 rays. Ventral fin thoracic, with 9 rays, the anterior four slightly thickened. Caudal fin deeply forked with 17 branching rays. Number of gill-rakers on lower limb of first left arch 12 (total 15), longer. Gill-rakers on the second arch shorter while those on the third and fourth arches are bulb-like, consisting of spinule patches. Pyloric caeca absent.

Color when fresh pink with several irregularly scattered black spots on the back and two rows

of purplish red spots on the lateral side. Dorsal fin with yellowish spots in male and reddish spots in female. Anal fin transparent, with a yellowish median stripe in male, absent in female. Caudal fin yellowish with pink spots in both sexes.

*Etymology:* The name for this species is given because of its predominancy in Taiwan (Formosa).

Electrophoretic comparisons between two types of *Aulopus formosanus*:

In order to confirm the hypothesis that among our *Aulopus formosanus* specimens the 14 females have a shortened second dorsal ray and the 16 males a filamentous second dorsal ray, genetic implications were taken into account. As indicated in Table 1, the 17 loci with 17 alleles scored in both sexes are shown to be identical, giving evidence to support that they belong to same species. All the loci investigated are monomorphic among all individuals.

## DISCUSSION

The status of genera *Aulopus* and *Hime* were discussed previously by several authors: *Hime* was separated as a valid genus from *Aulopus* in 1924 by Starks based on its weaker or absence of ossification in the anterior interorbital region (orbitosphenoid), and a longer dorsal base. The most recent authors, Parin and Kotlyan (1989) agree with this classification. However, Mead (1966), Nelson (1984), and the present authors recognized *Hime* as a generic synonym for *Aulopus*. Regarding the *Aulopus* fauna in Taiwan, the two other types

frequently encountered in Taiwan along with the existing *Aulopus japonicus* and *A. damasi* is the subject specimen. We conclude from electrophoretic comparison that the subject specimens are *Aulopus formosanus*, and that the presence of a filamentous ray and a yellowish median stripe on the anal fin, are simply a sexual dimorphism. Still, in the case of two morphologically similar Hawaiian bone-fish *Albula* (Shaklee and Tamura 1981) and three Hawaiian lizard fish, *Saurida* (Waples 1982), revealed a high level of fixed allelic differences. This is applicable to the two *Aulopus* sp. morphs; no differences were found. Consequently, both forms belong to the same species.

Though *Aulopus japonicus* is the earliest recorded Taiwan species, it is much less common than the present new species, *A. formosanus*. Although not available as fresh material for electrophoretic comparison with *A. formosanus*, an old preserved specimen of *A. japonicus* proved readable for morphological inspection. The following characteristics seem to illustrate some differences between the two species: male *A. formosanus* has a filamentous second dorsal ray; whereas, male *A. japonicus* has no filaments. *A. formosanus* has fewer gill-rakers, 10-12 on the lower limb as opposed to that of 15 in *A. japonicus*. Pyloric caeca is absent in *A. formosanus* but present in *A. japonicus*. Moreover the anterior portion of the dorsal fin has a large reddish blotch in male *A. japonicus*. The present new species can also be separated from *A. filamentosus* of the Mediterranean Sea and the Atlantic Ocean, and *A. purpurissatus* of Australia. *A. filamentosus* classified by Gunther (1864:402) has both second and third dorsal ray filaments, and 11-12 anal rays. *A. purpurissatus* classified by Gunther (1864:403) has the second and third dorsal ray filaments too, and has more dorsal rays (19-22) and anal rays (12-14). This new species is more closely related to *A. japonicus* than *A. filamentosus* and *A. purpurissatus* based on some morphological characteristic. *A. formosanus* differs from *A. damasi* in that the latter species has fewer dorsal rays (14) and a smaller orbit (shorter than the snout). When compared with the recently published *Hime microps* Parin and Kotlyan (1989) (= *Aulops microps*), *A. formosanus* is the most closely-related. It shares the following characteristics: absence of pyloric caeca, similar fin rays counts, lateral line scales, and vertebrae. However, they are readily recognizable by lower gill-raker counts (14-17 vs. 21-23), the prolonged second dorsal ray in male, and larger orbit (31.9-37.5% vs. 22.5-24.3% of head length).

In the case of female *A. formosanus*, *A. japonicus*, *A. microps*, and *A. damasi*, though resembling one another in external appearance, they differ in gill-raker counts, orbit size, and the presence or absence of pyloric caeca (Table 3).

It is concluded that to date there are three aulopid species in Taiwan, namely *A. formosanus*, *A. japonicus*, and *A. damasi*. Their distinctive characteristics are summarized in the following key:

1. Dorsal rays 14; orbit shorter than snout ..... *A. damasi*  
Dorsal rays 16-17 (mostly 16); orbit equal or larger than snout ..... 2
2. Second dorsal ray of male prolonged into a filament; gill-rakers on lower limb of first arch 10-12; pyloric caeca absent ..... *A. formosanus*  
Second dorsal ray of male not prolonged; gill-rakers on lower limb of first arch 14 or more; pyloric caeca 9-13 ...  
..... *A. japonicus*

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## 台灣產新種仙女魚(*Aulopus formosanus*)之記述

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益田氏等1984年書中所記之未定名仙女魚 *Aulopus* sp.1，經本作者確定為一有效新種，並經命名為台灣仙女魚 (*Aulopus formosanus*)。該種魚類之有別於同屬之其他仙女魚在於雄性第二背鰭軟條呈顯著之絲狀延長，且鰾數亦較少。與具絲狀延長鰭條之雄魚同時採獲之不呈絲狀延長之雌魚，經同工異構酶及肌蛋白之電泳分析比較結果，證實二者同屬一種。

關鍵詞：性徵，電泳，屬內種間比較。

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