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A Revised Taxonomic Account of Ricefish *Oryzias* (Beloniformes; Adrianichthyidae), in Thailand, Indonesia and Japan

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ABSTRACT.– A taxonomic account of *Oryzias minutillus, O. mekongensis, O. dancena,* and *O. javanicus* from Thailand, *O. celebensis* from Indonesia and *O. latipes* from Japan are redescribed. Six distinct species are recognized. Keys, descriptions and illustrations of the species are presented. Morphological differences between and within all six species are clarified. Twenty-two morphometric characters and ten meristic characters were examined, and 14 morphometric and nine meristic characters were found to differ amongst the six species. Anal-fin ray numbers of *O. cellebensis, O. javanicus, O. dancena, O. minutillus, O. latipes* and *O. mekongensis* were 22, 23, 24, 19, 18 and 15, respectively. These differences suggest that the six species may be reproductively isolated from each other.

KEY WORDS: *Oryzias*, Revision, Morphological difference, Cluster analysis

INTRODUCTION

Ricefish of the genus *Oryzias* belong to the family Adrianichthyidae and are widely distributed in South, East and Southeast Asia and southwards to Sulawesi and the Timor islands (Yamamoto, 1975; Labhart, 1978; Uwa and Parenti, 1988; Chen et al., 1989; Uwa, 1991a; Roberts, 1989, 1998). The genus *Oryzias* includes about 24 species in Asia (Kotellat 2001a, b; Nelson, 2006; Parenti, 2008). In Southeast and East Asia, four species are known from Thailand, Laos, Myanmar, and Vietnam, but eleven species are found from Indonesia and one species in Japan (Magtoon, 1986; Roberts, 1998; Kotellat 2001a, b; Parenti and Soeroto, 2004; Parenti, 2008).

Recently, there have been several studies published on various aspects of *Oryzias* biology, for instance on the comparative osteology (Iwamatsu and Hirata, 1980, Parenti, 2008), karyology (Uwa and Iwata, 1981; Uwa and Ojima, 1981; Uwa, 1986: Magtoon et al.,1992), isozyme variation (Sakaizumi et al., 1980, 1983; Takata et al., 1993); molecular phylogeny (Takehana et al., 2003, 2005), development (Iwamatsu 1994; Termvichakhron and Magtoon, 2008) and phylogenetic position (Rosen and Parenti, 1981; Parenti, 2008).

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In East Asia, the ricefish species, *O. latipes*, called medaka in Japan, has been used in many fields of biological research as an excellent experiment animal. Interestingly, the other *Oryzias* members are also potentially useful species and/or genetic characters for the production of new experimental fish models.

In Southeast Asia, the occurrence of *Oryzias* in Thailand was the first reported by Smith (1945), who described *O. minutillus* based on specimens collected from Central Thailand. Since then, *O. mekongensis* has been described as a new species from the Mekong basin in Northeastern Thailand (Uwa and Magtoon, 1986), *O. javanicus* (Bleeker) and *O. dancena* (Hamilton) were reported from Peninsular Thailand (Smith, 1945; Magtoon, 1986; Magtoon and Uwa, 1986), whilst *O. minutillus* and *O. mekongensis* were described from the middle Mekong basin in Laos (Roberts, 1998; Kotellat, 2001b). Two species, *O. javanicus* and *O. mekongensis*, were reported in the lower Mekong in Cambodia (Rainboth, 1996). In addition, *O. minutillus* was also found in Tone Tale Sap, Cambodia (Magtoon et al., in press). However, *O. celebensis* (Weber, 1894) was found in the south-western arm of Sulawesi (Parenti and Soeroto, 2004) and River Moto Talau area, East Timor (Weber and de Beaufort, 1912; Larson and Pidgeon, 2004).

Ricefish have traditionally been identified on the basis of morphometric and meristric characters, for instance body length and the number of paired and unpaired fin rays. The objectives of this study were, (1) to provide an identification key and description, (2) to provided characters for recognizing the included species, (3) to list synonyms for all valid forms and illustrations, (4) to provide cytogenetic data, and (5) to provide morphology for statistic analysis.

MATERIALS AND METHODS

The counts and measurements followed in this manuscript are those of Hubbs and

TABLE 1. List of morphometric and meristric characters used in this study and their abbreviation.

Characters	Abbreviation
A. Morphometric:	
1. Standard length	SL
2. Total length	TL
3. Snout length	SnL
4. Eye diameter	ED
5. Head length	HL
6. Preanal length	PAL
7. Preanal fin length	PAFL
8. Predorsal fin length	PDFL
9. Prepelvic fin length	PVL or PPelFL
10. Long of dorsal fin base	LDFB
11. Long of anal fin base	LAFB
12. Pectoral fin length	PL
13. Pelvic fin length	VL or PelL
14. Caudal peduncle depth	CPD
15. Caudal peduncle length	CPDL
16. Body depth at origin of dorsal fin	BD_2
17. Body depth at origin of anal fin	BD_1
18. Anal fin length at anal fin origin	AFL
19. Dorsal fin length	DFL
20. Prepectoral fin length	PPL
21. Dorsal fin origin to caudal fin base	DFO-CFB
22. Anal fin origin to caudal fin base	AFO-CFB
B. Meristic:	
1. Dorsal-fin ray	DFR
2. Anal-fin ray	AFR
3. Pectoral-fin ray	PFR
4. Pelvic-fin ray	VFR
5. Branchiostegal ray	BG
6. Caudal-fin ray	
6.1 Upper (dorsal) caudal fin ray	UCFR
6.2 Lower (ventral) caudal fin ray	LCFR
7. Vertebrae	
7.1 Abdominal (precaudal) vertebrae	AbVR
7.2 Caudal vertebrae	CVR

Lagler (1958), and Nakabo (2002), except for the following; body depth was measured at the first body depth, vertical distance from first dorsal fin origin to ventral surface, and the second body depth was the vertical distance from ventral fin origin to dorsal fin surface (Fig. 1 and Table 1). Proportions are expressed in percent standard length (SL) and head length (HL). Adults were measured with dial calipers to the nearest 0.1 mm. Methods for clearing and staining specimens were those described by Dingerkus and Uhler (1977). Fin rays were counted with a binocular microscope. The meristic characters recorded are dorsal-, anal-, pelvic-, pectoral- and principal caudal-fin rays, including all branched caudal fin rays plus one upper and one lower branched ray; the number of vertebrae (total = precaudal + caudal) and branchiostegal rays. Morphometric and meristic variation amongst the six species was tested by analysis of covariance (ANCOVA), whilst meristic variation was also tested by analysis of variance (ANOVA). Canonical discriminant analysis (CDA) was carried out using 22 morphometric characters.

Sample of specimens examined were deposited in the following institutes: United States National Museum of Natural History, Washington, D.C. (USNM); Central Thai National Reference Collection (CTNRC); Natonal Science Museum Tokyo (NSMT); Museum of Fisheries, Kasetsart University, Bangkok (KUMF), National Inland Fisheries Institute (NIFI), Ministry of Agriculture, Thailand, and the Laboratory, Department of Biology, Srinakharinwirot University, Bangkok (LBSWU).

Key to the species of *Oryzias* in Thailand, Indonesia and Japan

1a. Dorsal-fin rays 5 - 6; caudal vertebrae 15 - 17 (17) or 18; branchiostegals 4; anal-fin rays 18 - 19 (19), anal fin without bony contact organs; upper and lower lobes of caudal-fin rays without marginal stripes……..….***Oryzias minutillus***

1b. Dorsal-fin rays 5 - 6; anal-fin rays usually less than 22……**2**

2a. Abdominal vertebrae 10 - 12 (11), anal-fin rays without bony contact organs in both sexes; bright orange submarginal bands on the dorsal and ventral portions of caudal fin (when live)……...…… ……..……..…***Oryzias mekongensis***

2b. Abdominal vertebrae 11 - 12 (12), anal-fin ray with bony contact organs in males;yellowish submarginal bands on the dorsal and ventral portions of caudal fin (when live)……...……***Oryzias latipes***

3a. Dorsal-fin rays 8 - 10 (8); anal-fin rays without bony contact organs in males, yellow-orange submarginal bands on the dorsal and ventral portions of caudal fin (when live)….…....…..…***Oryzias cellebensis***

3b. Dorsal-fin rays 7 - 8 (7); anal-fin rays usually more than 22……..…**4**

4a. Anal-fin rays 21 - 25 (23), anal-fin rays with bony contact organs in males; yellow submarginals bands portions of caudal-fin rays; premaxillary and dentery without large teeth in both sexes….....***Oryzias javanicus***

4b. Anal-fin rays 22 - 25 (24), anal-fin rays without bony contact organs in males; distal margin of anal fin whitish in both sexes……..…….……***Oryzias dancena***

RESULTS

Sytematic Descriptions

Oryzias javanicus (Bleeker, 1854)

Aplocheilus javanicus.- Bleeker, 1854:323-324 [type locality: Perdana, Java, Indonesia.- Weber and de Beaufort, 1922:372-373 (Singapore and Java, Indonesia)].

Haplochilus javanicus.- Gunther, 1866: 311.

Panchax javanicus. - Fowler, 1938:71,254 [Malaya].

Oryzias javanicus.- Alfred, 1961 [Seleter and Serangoon, Java, Indonesia]. – Iwamatsu et al., 1982: 190.-Magtoon, 1986: 859-865.-Uwa, 1986: 867-875.- Uwa and Parenti, 1988:159.- Hamaguchi, 1996: 757-763. -Roberts, 1998: 223.

Oryzias melastigma.- Labhart, 1978:53 [list of synonym].

Material examined.– CAS 58033, 10: 13.4 - 21.9 mm SL, Nai Han, Phuket, 2 Feb. 1985, hand net collected by N. Tawinsunnuk, H. Uwa and W. Magtoon; KUMF 2997, 4, Saphan-Hin Phuket, 26 Aug. 1988, collected by W. Magtoon and H. Uwa; NIFI 3218, 2 specimens, Saphan-Hin, Phuket, 15 May 2005, collected by W. Magtoon and P. Pongsai; NIFI 3410, 15, Muang, Phuket, 1 April 2005, W. Magtoon and N. Magtoon; NIFI 3411, 8, Muang, Phuket, 26 Aug. 1988, collected by W. Magtoon and P. Pongsai; LBSWU 00301, 56: 22.2 - 30.9 mm SL., Saphan-Hin, Phuket, 1 April 2005, collected by W. Magtoon and P. Pongsai.

Diagnosis.– *Oryzias javanicus* differs from all other *Oryzias* species by having: (i) Yellow submarginal bands on the dorsal and ventral portions of the caudal fin, and anal-fin rays in males have bony contact organs. (ii) A relatively posterior anal-fin origin, opposite vertebrae 21 - 22. (iii) Enlarged teeth posteriorly on the premaxilla of both sexes. (iv) The anterior border of the ethmoid cartilage is straight. (v) A relatively large and very deep-bodied species, with the greatest depth from 3.9 to 5.3 times SL. (vi) Pectoral-fin rays 11 - 12 (11), 6 - 8 (7) dorsal-fin rays, 22 - 26 (23) anal-fin rays, five branchiostegal rays and usually 17 - 20 (19) caudal vertebrae.

Description.– Proportions used here are based on 56 individuals including the type, ranging in size from 22.2 to 30.9 mm SL. Counts, likewise, are from specimens seen (Table 2).

Body compressed laterally, body depth at origin of first dorsal fin 5.4 (4.5 - 6.3) in SL, body depth at origin of first anal fin 4.1 (3.5 - 4.7) in SL; caudal peduncle compressed, depth 2.1 (1.9 - 2.3) in HL; caudal peduncle length, 2.1 (2.0 - 2.2) in HL. Head length 3.9 (3.7 - 4.2) in SL; head less compressed than body, anterior part of head depressed, head short, 21.2 to 34.2 (27.3 ± 2.1) % of SL. Snout length 5.4 (4.3 - 6.5) in HL; snout short, 14.0 - 25.3 (19.6 ± 2.7) % of HL, snout shorter than eye diameter. Eye diameter 2.2 (2.1 - 2.2) in HL, the pupil situated in the anterior part of head; eye large, 35.2 - 61.9 (44.1 ± 4.7) % of HL. Mouth terminal, almost horizontal; lower jaw slightly projecting beyond upper jaw. Each jaw with two lows of caniniform teeth, with large teeth. Dorsal body profile relatively straight from head to dorsal-fin origin; ventral profile convex from head to anal-fin origin. First pleural rib on parapophysis of third vertebrae; lateral process of pelvic bone attachés to third pleural rib. Caudal skeleton with two pleural plates; ventral accessory bone and accessory cartilage or bone. Body covered with cycloid scales, 27 - 30 in a lateral series. Principal caudal-fin rays i,4/5,i.

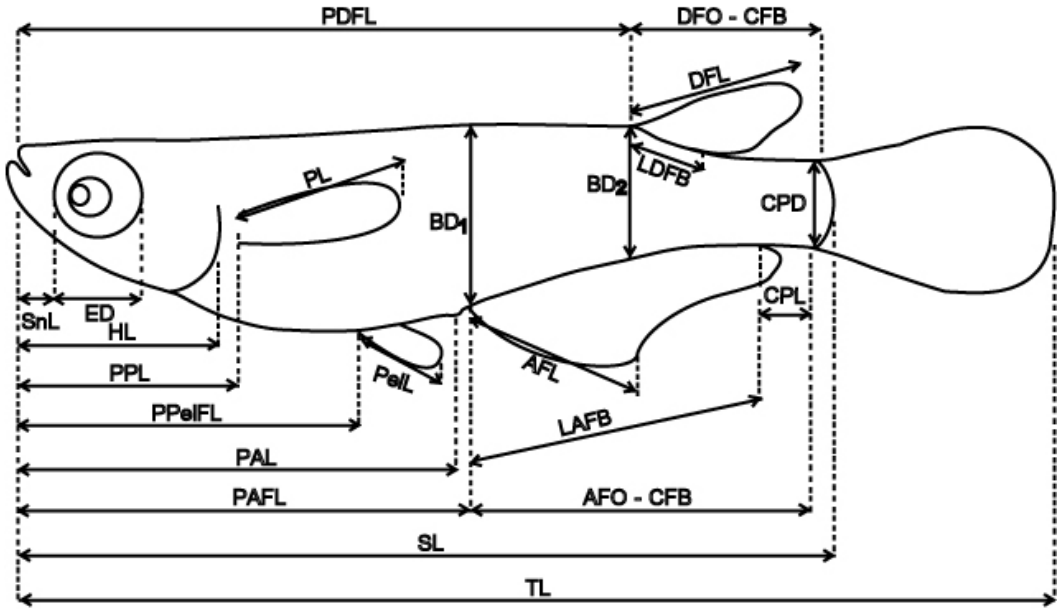

FIGURE 1. Outline drawing of a male *Oryzias minutillus* indicating points of measurements. The abbreviations are defined in Table 1.

Procurrent fin-rays, dorsal 4, ventral 5. Vertebrae 28 - 31 [10 - 11 (10) + 17 - 20 (19)]. Lateral line absent. Presence of numerous small papilla processes on the posterior region of anal fin in male fishes. Peritoneum dense black within, the outer surface next to body wall bright silvery.

Dorsal-fin rays 6 - 8 (7), 2nd - 6th rays bifurcated, 4th rays longest, a relative anterior dorsal-fin origin, opposite vertebrae 19 - 20; dorsal fin short, on the posterior half of body, dorsal fin length or height (longest rays) 1.5 (1.4 - 1.5) in HL, 6.1 (5.8 - 6.4) in SL, 7.0 (6.5 -7.4) in TL and 0.9 (0.8 -1.0) in depth of dorsum to belly in front of dorsal fin; dorsal fin length much longer than dorsal fin base, long of dorsal fin base 14.5 (12.2 - 16.7) in SL and 15.7 (12.2 -16.7) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.3 (1.2 -1.3) in SL, 1.5 (1.5 - 1.5) in TL.

Anal-fin rays 22 - 26 (23), 8th - 21st rays filamentous, prolonged in males; a relatively posterior anal-fin origin, opposite vertebrae 21 - 22; anal-fin rays with bony contact organ in males; anal fin length 1.2 (1.0 -1.4) in HL, 5.7 (5.4 - 6.0) in SL; anal fin base very long, its base 3.3 (2.8 - 4.1) in SL, 4.1 (3.4 - 4.7) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 1.3 (1.2 - 1.3) in SL, 1.5 (1.5 - 1.5) in TL.

Pectoral-fin rays 11 - 12 (11), 2nd - 5th rays bifurcated, pectoral fin inserted on the median line of body; pectoral fin 1.1 (1.0 - 1.2) in HL, 4.3 (3.7 - 5.0) in SL, 5.1 (4.4 - 5.8) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 3.8 (3.3 - 4.3) in SL, 4.5 (4.0 - 4.9) in TL.

Pelvic-fin rays 5 - 6 (6), pelvic fin small, pelvic origin halfway between tip of snout

TABLE 2. Counts and proportional measurements of *Oryzias* specimens, expressed as percentages of standard length.

Character	*Oryzias javanicus* n = 56	*Oryzias dancena* n = 57	*Oryzias celebensis* n = 30
Meristics counts			
Dorsal fin ray	6-8 (7)	7-8 (7)	8-9 (9)
Anal fin ray	18-26 (23)	22-25 (24)	20-23 (22)
Pectoral fin ray	11-12 (11)	10-12 (11)	10-11 (11)
Pelvic fin ray	5-6 (6)	6	6
Branchiostegal ray	5	5	5
Upper caudal fin ray number	4-5 (4)	4-5 (4)	4-5 (5)
Lower caudal fin ray number	5	5-6 (5)	4-5 (4)
Abdominal vertebrae	10-11 (10)	10-11 (11)	11-12 (11)
Caudal vertebrae	17-20 (19)	17-19 (19)	18-19 (19)
Morphometric character			
Standard length (mm)	22.2-30.8 (26.6±2.2)	21.6-35.6(28.4±4.4)	24.9-30.6 (27.5±1.4)
Percent of standard length			
Total length	101.2-127.7 (122.2±4.3)	115.8-145.1 (125.9±3.9)	118.5-130.8 (122.9±2.8)
Snout length/HL	13.9-25.3 (19.5±2.7)	15.7-32.6 (23.6±3.0)	12.0-33.1 (20.9±6.6)
Eye diameter/HL	35.2-61.9 (44.1±4.7)	38.8-75.1 (45.0±5.3)	33.2-51.7 (44.4±4.1)
Head length	21.2-34.2 (27.3±2.1)	15.1-33.3 (27.6±2.6)	22.1-27.2 (25.1±1.1)
Preanal length	46.3-61.1 (54.9±2.7)	42.3-65.5 (54.7±3.9)	51.4-59.2 (56.7±1.9)
Preanal fin length	48.2-63.0 (58.1±2.5)	52.5-69.9 (58.8±3.8)	42.3-78.5 (62.3±5.4)
Predorsal fin length	65.7-84.0 (80.6±2.6)	65.4-92.1 (80.4±3.2)	73.3-83.6 (80.0±2.4)
Prepelvic fin length	22.8-49.1 (43.8±3.6)	41.8-52.2 (46.0±2.3)	41.0-51.1 (45.4±2.7)
Length, Long of dorsal fin base	5.9-9.0 (7.4±0.6)	6.6-11.4 (9.9±1.5)	8.3-11.5 (9.9±0.8)
Length, Long of anal fin base	21.9-36.7 (31.2±2.9)	29.7-39.2 (34.1±1.9)	20.0-34.0 (29.4±2.6)
Pectoral fin height	19.4-32.9 (26.0±3.3)	20.7-31.8 (27.2±2.1)	23.1-32.8 (26.8±2.5)
Pelvic fin height	9.2-15.5 (12.3±1.3)	11.5-32.2 (15.6±2.9)	9.1-18.1 (13.7±2.3)
Caudal peduncle depth	10.1-18.5 (12.2±1.3)	10.7-15.9 (13.1±1.2)	9.1-18.2 (11.5±1.8)
Caudal peduncle length	8.9-14.1 (11.8±1.0)	7.5-14.5 (10.3±1.8)	10.0-15.7 (11.7±1.2)
Body depth at anterior anal fin	18.0-29.5 (25.5±2.6)	16.7-35.5 (28.6±3.5)	18.3-25.0 (21.4±2.0)
Body depth at anterior dorsal fin	11.7-23.3 (18.9±2.0)	11.6-42.4 (21.1,±3.9)	10.7-18.9 (15.8,±1.8)
Anal fin height	13.2-27.1 (20.4±3.9)	12.9-36.0 (24.8±7.1)	15.1-31.4 (22.5±5.4)
Dorsal fin height	12.6-24.0 (17.4±2.3)	14.7-26.6 (21.1±3.2)	14.6-34.1 (21.3±5.7)
Prepectoral fin length	22.1-35.1 (28.6±2.7)	21.0-34.2 (29.7±2.9)	21.3-34.1 (25.4±3.0)
Dorsal fin origin to caudal fin base	11.4-19.1 (14.7±2.5)	22.5-36.0 (29.5±3.0)	14.3-26.9 (17.7±2.7)
Anal fin origin to caudal fin base	28.5-40.60 (35.6±2.9)	31.5-45.2(36.9±2.6)	24.9-33.1 (29.7±1.8)

and posterior angle of anal base, pelvic fin 2.3 (2.1 - 2.5) in HL, 9.0 (7.6 - 10.3) in SL, 10.5 (7.3 - 11.3) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.9 (2.2 - 3.6) in SL, 3.3 (2.7 - 4.0) in TL.

Caudal fin truncated, caudal fin length 2.1 (2.0 - 2.2) in HL, 8.5 (7.5 - 9.4) in SL, 10.0 (9.9 - 10.8) in TL, caudal fin length shorter

TABLE 2. Cont.

Oryzias latipes n = 23	*Oryzias minutillus* n = 26	*Oryzias mekongensis* n = 32
5-7 (6)	5-6 (6)	5-6 (6)
16-20 (18)	17-21 (19)	15-17 (15)
7-11 (10)	7-9 (7)	7-8 (7)
5-7 (6)	4-5 (5)	5-7 (6)
5	4	4-5 (4)
4	3	4
5	4	5
12	9-10 (10)	11-13
17-18	16-19 (17)	15-18
17.0-28.8 (22.6±3.4)	8.7-12.9 (10.2±0.9)	12.6-20.4 (16.1±1.6)
116.3-13.3 (123.5±2.6)	122.7-131.9 (127.6±2.3)	120.9-133.3 (126.5±2.9)
17.9-29.6 (23.5±3.1)	18.9-31.2 (25.3±3.2)	16.4-26.2 (21.3±2.6)
32.2-42.7 (38.2±2.7)	33.6-46.8 (39.7±2.9)	36.3-47.0 (41.5±2.7)
23.1-27.6 (25.6±1.0)	20.1-25.2 (23.2±1.4)	20.9-25.9 (23.6±1.2)
48.7-58.0 (54.1±2.4)	38.7-50.8 (47.4±2.4)	48.2-55.8 (52.4±1.9)
52.8-61.8 (57.9±1.9)	46.5-54.0 (50.8±1.9)	53.4-60.1 (55.9±1.9)
69.4-80.7 (77.2±2.5)	76.6-84.6 (79.8±2.1)	74.1-80.5 (77.0±1.5)
40.6-49.5 (46.0±2.0)	36.2-45.2 (40.6±2.0)	39.2-46.9 (41.9±1.9)
5.3-9.3 (7.0±0.9)	6.1-8.0 (6.9±0.5)	5.1-7.5 (6.4±0.6)
23.1-29.5 (25.7±1.5)	28.4-34.9 (31.6±1.6)	18.9-29.5 (25.1±2.3)
16.2-23.8 (20.3±1.5)	17.5-24.0 (20.4±1.5)	16.6-22.7 (19.6±1.5)
8.8-13.0 (11.3±1.1)	6.4-19.3 (9.6±2.5)	9.1-15.8 (11.9±1.5)
8.7-11.0 (10.1±0.6)	8.3-10.6 (9.1±0.6)	8.1-11.4 (9.7±0.9)
9.6-18.4 (14.0±1.8)	12.3-19.5 (14.9±1.8)	13.5-20.8 (17.5±1.6)
17.8-22 (20.0±1.4)	16.2-20.9 (18.6±0.9)	17.4-23.6 (19.8±1.4)
13.4-17.1 (15.1±1.2)	9.3-12.9 (11.7±0.8)	11.6-16.3 (13.6±1.0)
12.0-20.9 (15.5±2.4)	14.5-21.3 (17.4±2.0)	15.7-22.3 (18.5±2.0)
13.6-21.2 (16.8±2.2)	13.2-22.2 (16.8±2.8)	11.721.4 (17.9±2.3)
27.2-31.2 (29.6±0.9)	17.8-30.9 (27.8±2.7)	25.1-30.6 (27.2±1.3)
20.1-25.0 (22.6±1.2)	17.1-22.4 (19.6±1.5)	21.6-26.0 (23.5±1.2)
36.8-41.8 (39.2±1.3)	42.4-50.6 (45.5±1.9)	37.1-48.3 (42.8±2.5)

than head length; caudal peduncle moderately slender; caudal peduncle depth 2.1 (1.9 - 2.2) in HL, 8.4 (7.1 - 9.7) in SL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 5.4 (4.5 - 6.3) in SL, body depth at

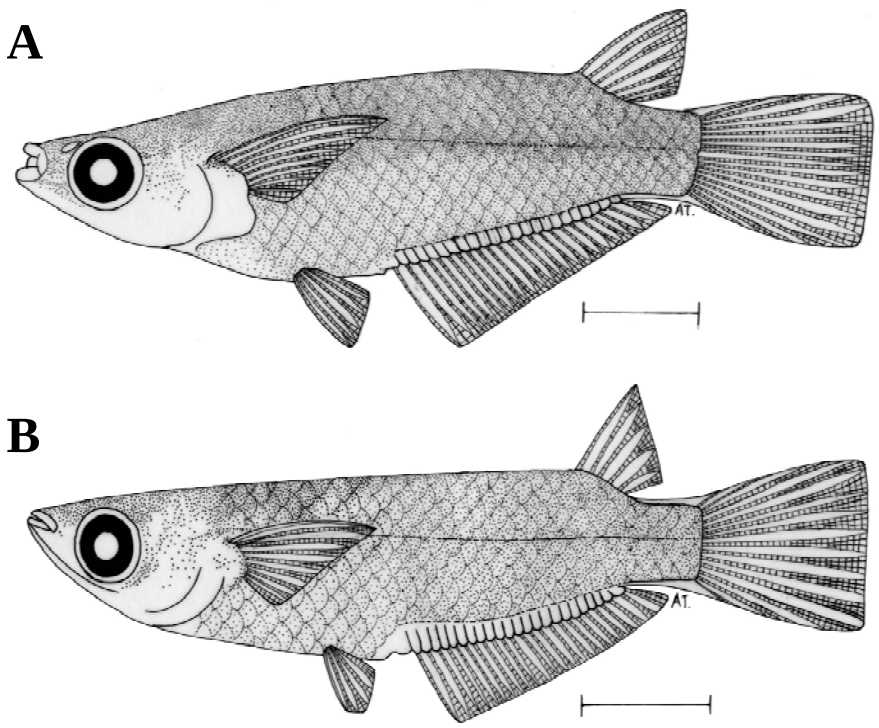

FIGURE 2. Illustration of *Oryzias javanicus* (Bleeker) based on material specimens of NIFI 3218; A, adult male and B, adult female, from Phuket province, Peninsular Thailand. Bar indicate 5 mm.

the origin of the first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 4.1 (4.7 - 3.5) in SL.

Cytogenetic data.– *Oryzias javanicus* from Ranong, Phuket and Krabi province, Peninsular Thailand, have 2n = 48 chromosomes. The karyotype consistes of one subtelocentric and 23 acrocentric chromosome pairs. Chromosome arm number is 48. Genome size is reported as 1.7 pg DNA per nucleaus. *O. javanicus* belongs to the monoarmed chromosome constitution and NORs are located on the secondary constrictions of acrocentric pairs (Uwa, 1986, 1991b; Magtoon, 1986).

Color of fresh specimens.– Body translucent, belly more or less silver. Head and body dark greyish brown in males, light brown in females. Anal fin with black edge, caudal fin with yellowish submarginal bands on the dorsal and ventral lobes and along the distal edge, and the color being more intense in males. Both sexes with silvery operculum.

Color of preserved specimens. – Body pale grey to blackish, brownish dorsally and pale ventrally. Melanophores forming a blackish line along anal fin base and on mid-lateral line. Blackish spots on dorsal part of head, body and caudal peduncle. Dorsal and anal fin interradial membranes with scattered melanophores. The color is more intense in males.

Sexual dimorphism.– In addition to the different body color patters mentioned above, the anal fin has a convex distal margin with bony contact organs in males, whereas the distal margin of the anal fin is straight or

slightly concave in females. Anal fin rays are longer and thicker in males. Melanophores on caudal and pelvic fins and on body side are denser in males during the breeding season. Genital papilla short, a conical tube in males, bilobes in females. Interneural spines and wings of basipterygium more developed in males.

Distribution.– *Oryzias javanicus* is widely distributed in Peninsular Thailand, Malaysia and Singapore, Western Borneo and Indonesia. In Thailand, the species has been found in mangrove swamps of the Andaman Sea in southern Thailand. It does not occur in the Chao Phraya basin or any of the small basins draining into the Gulf of Thailand. In addition, this species coexists with *O. dancena* in the mangrove area in the Andaman Sea of Ranong province, southern Thailand (Fig. 8)

Comparisons.– *Oryzias javanicus* is similar to *O. dancena* in general body appearance, especially in having the same number of dorsal-fin, branchiosteagal and pelvic-fin rays. However, the former is distinguished from the latter in (i) often, but not always, having a lower number of precaudal vertebrae [10 - 11 (10) vs.10 - 11(11)], (ii) a more slender body depth at the origin of dorsal fin [11.7 - 23.3 (mean 18.9) % of SL vs. 11.6 - 42.4 (21.1) % of SL], (iii) a longer snout length [14.0 - 25.3 (19.5) % of HL vs.15.7 - 32.6 (23.6) % of HL], (iv) a smaller orbit diameter [35.2 - 61.9 (44.1) % of HL vs. 38.8 - 75.1 (45.0) % of HL], (v) a more slender body depth at the origin of first anal fin, [18.0 - 29.5 (25.5) % of SL vs. 16.7 - 35.5 (28.6) % of SL], and (vi) the appearance of a bony processes or contact organ on the anal-fin rays in males (the absence of bony contact organ on anal-fin rays in males of *O. dancena*).

Remarks.– Bleeker (1854), who originally described this species as *Aplocheilus javanicus* from Java and Singapore, reported seven dorsal-fin rays, 21 - 23 anal-fin rays, 1 - 10 pectoral-fin rays, six pelvic-fin rays, a rounded caudal fin, and two fine dark lines, one in the middle of the body and the other above the anal fin base. Gunther (1866) reported this species, as *Haplochilus javanicus,* from Java, but with seven dorsal-fins, 25 anal-fin rays, 30 scales in a longitudinal series, the head length one-fifth and body height one-fourth of TL; eye diameter more than one-third of HL; and body greenish in living, with a narrow violet streak from head to caudal fin. Specimens described by Weber and Beaufort (1922) as *Aplocheilus javanicus* showed nearly the same characters as those described by Bleeker (1854). Iwamatsu et al. (1982), reported that *Oryzias javanicus* were found from Pontianak, western Borneo.

According to Uwa (1986), *O. javanicus* from Singapore have 6 - 7 dorsal-fin rays and 21 - 23 anal-fin rays. In Thailand, the species has been found in mangrove swamps in the Peninsula region. Here Magtoon and Uwa 1988 described *O. javanicus* from twenty-two specimens from Phuket with 6 - 7 (7) dorsal-fin rays, 23 - 24 (23) anal-fin rays, 28 - 31 (30) longitudinal scales, 9 - 10 (10) transverse scales, a truncate tip to the caudal fin, and male fish had a horny process at the posterior of the anal-fin rays. However, in some contrast, Uwa and Parenti (1988) also described *O. javanicus* from Phuket, Thailand, with seven dorsal-fin rays, 22 - 25 (23) anal-fin rays, head length 24.8 % SL, preanal length 50.7 % SL, predorsal fin length 83.6 % SL and preanal fin length 53.6 % SL. In addition, Roberts (1998) reported this species from Banten, west Java, as having 6 – 7 dorsal-fin rays, 21 – 25 anal-fin rays (21 - 25 in specimens from Java, 21 - 22 in specimens from Singapore), 11 pectoral-fin rays, 5/6 caudal-fin rays and 28 -

29vertebrae. The Thai specimens reexamined in the present study from Phuket, Southern part of Thailand, had 6 - 8 (7) dorsal-fin rays, 22 - 26 (23) anal-fin rays, 11-12 (11) pectoral-fin rays, 5 branchiostegal rays, i,4/5,i principal caudal-fin rays, and 28 - 31 vertebrae. These specimens had a much smaller SL than the type material described by Roberts (1998), SL being 21.6 - 35.6 (28.4) mm SL against 30 mm SL described in Roberts (1998).

***Oryzias dancena* (Hamilton, 1822)**

Cyprinus dancena Hamilton, 1822: 342, 393 (Calcutta).
Aplocheilus mcclellandi Bleeker, 1854:323.
Aplocheilus MacClellandi Bleeker, 1860:491.
Panchex argenteus Day, 1867: 706 (type localities "near Madras").
Haplochilus melastigma.-Day 1877 (Calcutta, India and Burma).
Haplochilus melastigma.-Duncker, 1912: 249, 257-258 (Sri Lanka).
Panchex melastigma.- Munro, 1955:85 (Sri Lanka).
Oryzias melastigma.- Smith, 1938: 165-166. –Rosen, 1964:227.- Uwa,1986: 867-875.- Uwa and Parenti, 1988;159.- Hamaguchi, 1966:757-763.-Magtoon and Uwa, H. 1988: 206
Oryzias dancena.- Roberts, 1998: 214-217 (India, Bangladesh and Myanmar).

Material examined.– NIFI 3236, 4: 20.3 - 30.1 mm SL, mangrove area of Ranong province, Thailand, 6 Dec. 2007, dip net collected by W. Magtoon and T. Deesin; NIFI 3404, 7, Bang Ban, Ranong province, Thailand, 10 Apr. 2004, collected by W. Magtoon and T. Deesin; LBSWU 0005, 53: 21.6 - 35.6 mm SL, ponds in Phuket, Thailand, 15 May, 2004, collected by W. Magtoon and P. Pongsai. NIFI 3407, 9, Muang, Ranong Province, Thailand, 15 May, 2004, collected by W. Magtoon and T. Deesin.

Diagnosis.– *Oryzias dancena* is distinguished from all other Thai species of *Oryzias* by the white distal margin of the anal fin in both sexes. Females have large teeth only on the premaxillary, whilst males have large teeth on both premaxillary and dentary. Anterior border of ethmoid cartilage irregular. A relatively large and very deep-bodied species with a greatest depth range of 4.3 to 5.7 times the SL. Anal-fin rays 22 - 25 (23) without bony contact organs in males, a relatively posterior anal-fin origin, opposite vertebrae 22 - 23; five branchiostegal rays and usually 19 caudal vertebrae.

Description.– Counts and proportions are from 57 specimens, ranging from 21.6 - 35.6 mm SL (Table 2).

Body compressed laterally, elongate, body depth at origin of first dorsal fin 5.7 (3.7 - 7.7) in SL, body depth at origin of first anal fin 4.3 (3.3 - 5.4) in SL; caudal peduncle compressed, depth 2.0 (2.0 - 2.0) in HL, caudal peduncle length 2.4 (2.3 - 2.6) in HL. Head not very compressed, with depressed anterior part, head length 4.0 (3.5 - 4.5) in SL. Interorbital space broad. Snout length 4.1 (3.9 - 4.3) in HL; snout short 15.8 - 32.6 (23.6 ± 3.0) % of HL, snout shorter than diameter of eye. Eye diameter 2.0 (1.8 - 2.3) in HL, the pupil situated in the anterior part of head. Eyes large 38.8 - 75.1 (45.0 ± 5.3) % of HL. Mouth terminal, almost horizontal; upper jaw short, not protractile; lower jaw slightly projecting beyond upper jaw. Caniniform teeth in jaws; large teeth on premaxillary and dentery in males, only on dentary in females. Dorsal body profile relatively straight from head to dorsal-fin origin; ventral body profile convex from head to anal-fin ray origin. First pleural rib

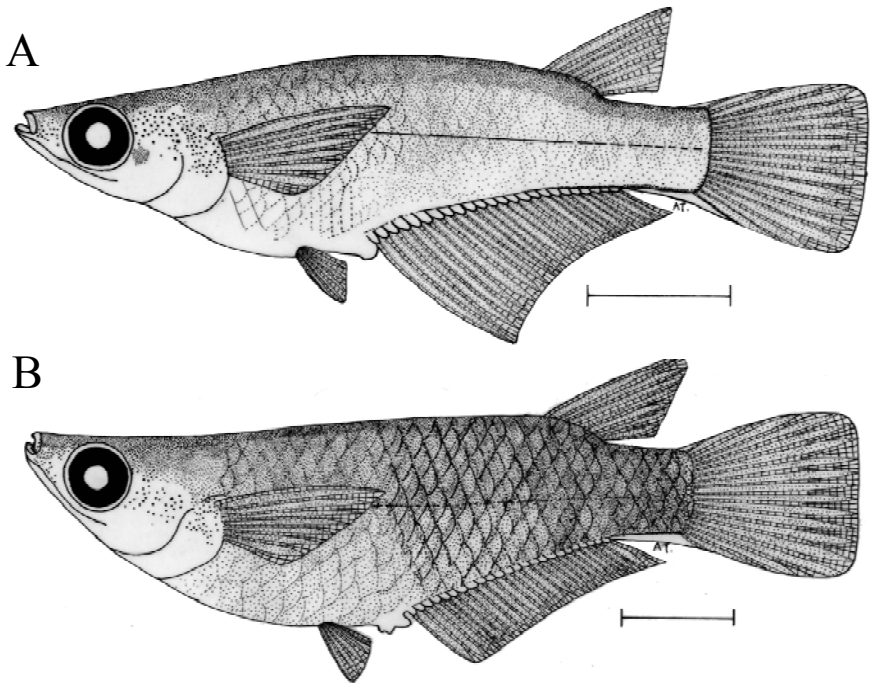

FIGURE 3. Illustration of *Oryzias dancena* (Hamilton), based on material specimens, NIFI 3236; A, adult male and B, adult female, from Ranong province, Peninsular Thailand. Bar indicate 5 mm.

on parapophysis of third vertebrae; lateral process of pelvic bone attaches to third pleural rib. Caudal skeleton with two pleural bones; one ventral accessory bone and second accessory cartilage. Basihyal bone relatively short and triangular, basihyal cartilage elongate and rectangular. Body covered with cycloid scales. Scales in lengthwise series 27 - 28, in transverse series 10. Principal caudal-fin rays i,4-5/5,i. Procurrent fin-rays, dorsal 4, ventral 5. Branchiostegal rays 5, Vertebrae 28 - 30 [10 - 11 (11) + 17 - 19 (17)]. Lateral line absent.

Dorsal-fin rays 7 - 8 (7), 2nd and subsequent rays bifurcated, 5th rays longest, a relative anterior dorsal-fin origin, opposite anal fin 19 - 20; dorsal fin short, on the posterior half of body, dorsal fin length or height (longest rays) 1.3 (1.2 - 1.4) in HL, 5.3 (4.1 - 6.5) in SL, 6.6 (5.3 - 8.0) in TL and 1.0 (0.9 - 1.2) in depth of dorsum to belly in front of dorsal fin; dorsal fin length much longer than dorsal fin base, long of dorsal fin base 11.9 (8.8 - 15.0) in SL and 14.9 (11.3 - 18.5) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.3 (1.2 - 1.3) in SL, 1.6 (1.6 - 1.6) in TL.

Anal-fin rays 20 - 25 (24), 7th - 22nd rays filamentous, prolonged in males; a relatively posterior anal-fin origin, opposite vertebrae 22 - 23; anal-fin rays without bony contact organs in males; anal fin length 1.1 (0.9 - 1.4) in HL, 4.6 (3.0 - 6.2) in SL; anal fin base very long, its base 3.0 (2.8 - 3.2) in SL, 3.8 (3.6 - 3.9) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 1.3 (1.2 - 1.3) in SL, 1.6 (1.6 - 1.6) in TL.

Pectoral-fin rays 11 - 12 (11), 2nd - 9th rays bifurcated, pectoral fin inserted on the median line of body; pectoral fin 1.0 (0.9 - 1.0) in HL, 3.8 (3.5 - 4.1) in SL, 4.3 (3.5 - 5.0) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 3.3 (3.0 - 3.7) in SL, 4.2 (3.8 - 4.5) in TL.

Pelvic-fin rays 5 - 6 (6), pelvic fin small, pelvic origin halfway between tip of snout and posterior angle of anal base, pelvic fin 1.3 (1.0 - 1.7) in HL, 5.6 (3.4 - 7.8) in SL, 6.9 (4.3 - 9.6) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.2 (2.1 - 2.3) in SL, 2.8 (2.7 - 2.9) in TL.

Caudal fin truncated, caudal fin length 2.4 (2.3 - 2.6) in HL, 9.6 (9.0 - 10.2) in SL, 12.0 (11.5 - 12.5) in TL, caudal fin length shorter than head length; caudal peduncle moderately slender; caudal peduncle depth 2.0 (2.0 - 2.0) in HL, 7.9 (6.9 - 8.9) in SL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 5.7 (3.7 - 7.7) in SL, body depth at origin of first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 4.3 (3.3 - 5.4) in SL.

Cytogenetic data.– *Oryzias dancena* from Thailand has 2n = 48 chromosomes. The karotype consistes of 24 acrocentric chromosome pairs and a chromosome arm number of 48. Genome size is reported as 1.8 pg DNA per nucleus. In the monoarmed group, *O. dancena* from South India and Thailand (NF = 48) has a karyotype closely related to *O. javanicus* from Phuket, Thailand, and Singapore (NF = 48); all chromosomes are monoarmed type and NORs are located on the secondary constrictions of an acrocentric pair (Uwa, 1986, 1991b; Magtoon, 1986, 1993).

Color of fresh specimens.– Head and body greyish brown in males, light brown in females. Dorsal margin of dorsal fin outlined with white. Anal fin with a white distal margin and thin, bright blue distal sub-margin, the blue being more intense in males. Pelvic fin with a narrow margin.

Color of preserved specimens.– Body brownish dorsally, pale ventrally. A blackish line running along mid-dorsal line from head to caudal fin base, and a faint back line along the anal fin base. Dorsal and anal fin interradial membranes with scattered melanophores. Peritoneal membrane black.

Sexual dimorphism.– In addition to the differences in the teeth and coloration mentioned above, males have distal margins of dorsal and anal fin convex, with filamentous fin rays, whereas females have a straight or slightly concave distal margin of anal fin. The fins are higher in males than in females. Males have some anal-fin rays extended as white-tipped filaments. Genital papilla of the male is short and slightly conical, the female's is bilobed. Interneural spines and wings of basipterygium are more developed in males than females.

Distribution.– This species is distributed in India, Sri Lanka, Myanmar and Thailand. In Thailand, *Oryzias dancena* is usually found near the mangrove area in the brackish habitats, but may live in freshwater paddy fields in Ranong province, Southern part of Peninsular Thailand (Fig. 8).

Comparisons.– *Oryzias dancena* is similar to *O. javanicus* in having somewhat the same number of pectoral-fin rays and principal caudal-fin rays. However, the former is distinguished from the latter in having a greater body depth origin of the dorsal fin [11.6 - 42.4 (21.1) % SL vs. 11.7 - 23.3 (18.9) % of SL], a greater caudal depth [10.7 - 15.9 (13.1) % SL vs. 10.1 - 18.5 (12.2) % of SL], a longer snout length [15.8 -

32.6 (23.6) % SL vs.13.9 - 25.3 (19.5) % of SL] and a longer anal fin base [29.7 - 39.2 (34.1) % SL vs.21.9 - 36.7 (31.2) % of SL].

Remarks.– Day (1877), who reported this species from India as *Haphochilus melastigma*, described it as having 6 - 7 dorsal-fin rays, 22 anal-fin rays, six pelvic-fin rays, 23 scales of lateral series, 13 transverse scale rows and a round caudal fin. In contrast, Jordan and Synder (1906) described *Oryzias melastigma* from India with 6 - 7 dorsal-fin rays, 18 - 25 anal-fin rays, 10 pelvic-fin rays, 27 - 31 scales in longitudinal series and 9 - 11 transverse scale rows. Whereas, *O. melastigma* from Thailand has 7 - 8 (7) dorsal-fin rays, 22 - 25 (24) anal-fin rays, and the tip of the caudal fin truncated (Magtoon and Uwa, 1988). This species is reidentified by Roberts (1998), who described a specimen of *Oryzias dancena* that does not have a black spot at the dorsal fin base, and with 6 - 7 dorsal-fin rays, 20 - 24 anal-fin rays, 10 – 11 (10) pectoral-fin rays, six pelvic-fin rays, 5/6 or 6/6 principal caudal-fin rays (specimens from Chindambaram) and 28 - 29 vertebrae (10 – 11 + 17 – 18). The Thai specimens reexamined in this study from Ranong province, Thailand, had seven dorsal-fin rays, 22 - 25 (23) anal-fin rays, i,4/5,i principal caudal-fin rays, 10 - 11 (11) precaudal vertebrae, and 17 - 19 (19) caudal vertebrae. However, specimens of *O. dancena* from Thailand are much longer than the type material described by Roberts (1998), those specimens from Yangon (Rangoon) having a SL of 21.6 - 35.6 (28.4) mm compared to 11.0 - 25.0 mm SL in Roberts (1998).

Oryzias minutillus Smith, 1945

Oryzias minutillus Smith, 1945: 424-425, fig. 95. [type locality "small canal in Bangkok" Thailand]. - Rosen, 1964: 227.- Scheel, 1969: 5-7, fig. 1. –Magtoon and Uwa, 1985;157-160.- Magtoon, 1986: 859-865.- Uwa, 1986: 867-875.- Uwa and Magtoon, 1986: 475-477.- Ashida & Uwa, 1987: 1003.- Uwa et al., 1988; 332-340.- Uwa & Parenti, 1988: 159.- Chen et al., 1989:239-246.- Chen et al., 1990 :227-228. - Magtoon et al., 1992: 489-497.-Takata et al., 1993:757-763.- Magtoon et al., 1993:137-147. - Hamaguchi, 1996:757-763.- Seegers, 1997: 15,21.- Roberts, 1998:219. - Kottelat, 2001b: 143, fig. 406. Ngamniyom et al., 2007:17-21.

Material examined.– CAS 58022, 19: 8.0 - 12.7 mm SL, Bangkhen (Bangkok suburb), 16 Jan. 1983, dip net collected by W. Magtoon (4: 8.5 - 13.9 mm SL cleared and stained); CAS 58023, 5: 8.1 - 10.3 mm SL, Chieng Mai, 25 Apr. 1984, collected by W. Magtoon and H. Uwa (2: (9.6 - 9.7 mm SL cleared and stained); CAS 60741, 9: 12.5 - 15.5 mm SL, Thungsong, Nakhon Sithammarat province, 10 Dec. 1984, collected by W. Magtoon and H. Uwa; CAS 58025, 9: 10.0 - 13.9 mm SL, Teachers college, Phuket Island, 2 Feb. 1985, collected by N. Tawinsunnuk, H. Uwa, and W. Magtoon; KUMF 2995, 6, Bangkhen, Bangkok, Thailand, 25 Aug. 1988, W. Magtoon and H. Uwa; NIFI 3506, 2: 10.1 - 15.6 mm SL, Chiang Yuen, Maha Sarakham province, 14 Aug. 2008, collected by W. Magtoon and W. Kramsi; NIFI 3502, 4: 9.5 - 13.4 mm Sl., Khlong Luang, Pathum Thani province, 21 Feb. 2006, collected by W. Magtoon and P. Phaichumphon; NIFI 3504, 4: 10.2 - 12.2 mm SL., Thung Yai, Nakhon Si Thammarat province, 16 Mar. 2006, collected by W. Magtoon and P. Phaichumphon; LBSWU 0027; 26: 8.7 - 12.9 mm SL., Ban Tad, Udon Thani province, 21

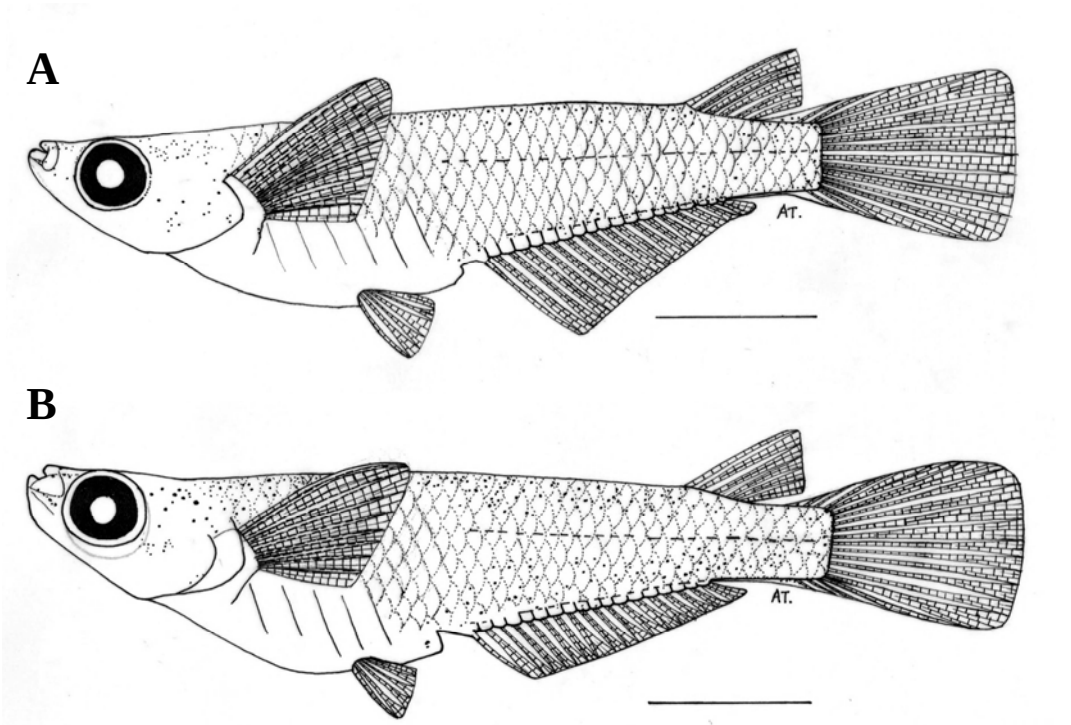

FIGURE 4. Illustration of *Oryzias minutillus* Smith, 1945, based on material specimens, NIFI 3215; A, adult male and B, adult female, from Ban Tad, Udon Thani province, the Mekong region. Bar indicate 3 mm.

Apr. 2006, collected by W. Magtoon and T. Deesin.

Diagnosis.– *Oryzias minutillus* is distinguishable from congeners in the combination of the following characters: pelvic-fin rays 4 - 5 (5); anal-fin rays 17 - 21 (19), last ray unbranched, a relatively anterior anal-fin origin, opposite vertebrae 18 - 22 (20); branchiostegal rays 4; caudal vertebrae 17, or much less frequently, 18; principal caudal-fin rays i,3/4,i; no large teeth on premaxillary and dentary; body small, not exceeding 14.5 mm SL in adults. Largest known specimens 14.5 mm SL. Melanophore pigment on vent or genital area.

Description.– Counts and proportions are from 26 specimens, ranging from 8.7 - 12.9 mm SL (Table 2).

Body compressed laterally slender, body depth at origin of first dorsal fin 8.5 (7.78 - 9.9) in SL; body depth at origin of first anal fin 5.4 (5.0 - 5.8) in SL. Head length 4.3 (4.1 - 4.4) in SL; head less compressed than body, anterior part of head depressed. Snout length 4.3 (4.1 - 4.4) in HL, snout shorter than eye diameter; snout length, 18.9 - 31.3 (25.3 ± 3.2) % of HL. Eye large, diameter 2.6 in HL. Mouth terminal, almost horizontal; lower jaw slightly projecting. Each jaw with two rows of minute teeth, with large teeth. Vomer smooth. Dorsal body profile relatively straight from head to dorsal fin-origin; ventral body profile slightly convex from head to anal fin-origin. Body covered with cycloid scales. Lateral line absent. First pleural rib on parapophysis of second vertebrae; lateral process of pelvic bone line

with third or fourth pleural rib. Peritoneum dense black within, the outer surface next to body wall bright silver. Caudal skeleton with two epural bones; one ventral accessory bone and second cartilage. Anteriormost dorsal and ventral procurrent rays hooked at base. Basihyal bone triangular, basihyal cartilage extremely elongate and rectangular. Body covered with cycloid scales. Scales longitudinal series 26 - 29 (28); and transverse series 9 - 10. Principal caudal-fin i,3/4,i; procurrent fin-rays, dorsal 3 - 4(3), ventral 3 - 4 (4). Branchiostegal rays 4 - 5 (4). Vertebrae 25 - 29 [9 – 10 (10) + 16 – 19 (17)]. Both sexes have melanic pigment on vent or genital area.

Dorsal-fin rays 5 - 6 (6), 2nd - 4th rays long, a relative anterior dorsal-fin origin, opposite anal-fin rays 14 - 20 (17), and vertebrae 18 - 22 (20); dorsal fin short, on the posterior half of body, dorsal fin length or height (longest rays) 1.4 (1.3 - 1.7) in HL, 6.3 (5.8 - 6.9) in SL, 7.9 (7.4 - 8.7) in TL and 1.0 (0.7 - 1.3) in depth of dorsum to belly in front of dorsal fin; dorsal fin length much longer than dorsal fin base, length of dorsal fin base 14.9 (13.9 - 15.8) in SL and 19.0 (17.7 - 20.2) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.3 (1.3 - 1.3) in SL, 1.6 (1.6 - 1.6) in TL.

Anal-fin rays 17 - 21 (19), the 2nd - 8th rays long in males; a relatively posterior anal-fin origin, opposite vertebrae 9 - 11; anal-fin rays without contact organ in males; anal fin length 1.4 (1.3 - 1.5) in HL, 6.0 (5.9 - 6.1) in SL; anal fin base very long, its base 3.2 (3.1 - 3.3) in SL, 4.1 (4.0 - 4.2) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 2.0 (2.0 - 2.1) in SL, 2.6 (2.5 - 2.7) in TL.

Pectoral-fin rays 7 - 9 (7), pectoral fin inserted on the median line of body; pectoral fin 1.2 (1.1 - 1.2) in HL, 5.0 (4.9 - 5.1) in SL, 6.4 (6.6 - 6.3) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 4.5 (3.7 - 5.1) in SL, 5.6 (4.7 - 6.5) in TL.

Pelvic-fin rays 5 - 6 (6), pelvic fin small, pelvic origin halfway between tip of snout and posterior angle of anal base, pelvic fin 2.4 (1.6 - 3.3) in HL, 10.2 (7.0 - 13.4) in SL, 13.0 (8.9 - 17.1) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.6 (2.5 - 2.6) in SL, 2.9 (2.5 - 3.3) in TL.

Caudal fin rounded, caudal fin length 1.7 (1.5 - 2.0) in HL, 7.3 (6.5 - 8.1) in SL, 9.1 (8.3 - 10.4) in TL, caudal fin length shorter than head length; caudal peduncle moderately slender; caudal peduncle depth 2.6 (2.5 - 2.7) in HL, 11.3 (11.3 - 11.4) in SL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 8.5 (7.8 - 9.9) in SL, body depth at origin of first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 5.4 (5.0 - 5.8) in SL.

Cytogenetic data.– *Oryzias minutillus* from the Mae Num Mun Basin in the Mekong and Peninsular regions has 2n = 42, with 24 acroncentric chromosomes pairs. The arm number is 42. The chromosomal polymorphism in *O. minutillus* was first reported in specimens from Bangkok (2n = 34; NF = 44), central and Chiang Mai (2n = 30; NF = 44), and from the Chao Phraya region in Thailand. *O. minutillus* belongs to the monoarmed chromosomes type, genome size is 1.5 pg of DNA per nucleus (Magtoon and Uwa, 1985; Uwa, 1986; Magtoon et al., 1992).

Color of fresh specimens.– Body translucent, colorless or slightly yellowish. Black pigment spreading over head, trunk

and fins. No difference in coloration between sexes. Both sexes with tendency to melanoproctism, i.e. melanophores on genital area. Both sexes with a silvery operculum.

Color of preserved specimens.– Body brownish dorsally, pale ventrally. Melanophore forming a thin black stripe running along mid-lateral line from head to caudal fin base, and a line along anal fin base. Clusters of black speck around genital papilla. Dorsal fin membrane pale, rays dark brown. Anal and pelvic fin pale. Pectoral fin dark brown, pale distally. Peritoneal membrane blackish.

Sexual dimorphism.– Anterior rays in dorsal and anal fin rays are greatly elongated in males. Distal margin of anal fin is convex in males, straight to slightly concave in females. Pelvic fin rays elongate in females, not extending to anal fin origin. Genital papilla bilobed in females, and a short and conical tube in males. Melanophores on body side, caudal and pelvic fins are more densely scattered in males during the breeding season.

Distribution.– This species occurred widely in freshwaters in Thailand, including all of the five ichthyogeographic regions of the country. Outside of Thailand, the fish has been reported from Yunnan in China (Fig. 8).

Comparisons.– *Oryzias minutillus* is similar to *O. mekongensis* in having somewhat the same number of branchiostegal rays and dorsal-, pectoral-and pelvic-fin rays. However, the former is distinguished from the latter in having a longer snout length [18.9 - 31.3 (25.3) % of HL vs. 16.4 – 26.2 (21.3) % of SL], a shorter head length [20.1 - 25.2 (23.2) % of SL vs. 20.9 – 25.9 (23.6) % of SL],; a shorter body depth origin of the anal fin [16.2 -20.9 (18.6) % of SL, vs. 17.4 – 23. 6 (19.8) % of SL], and larger anal-fin rays than the latter [17 - 21 (19) rays vs. 15 - 17 (14) rays].

Remarks.– Smith (1945) described this species from Bangkok as *Oryzias minutillus* with six dorsal-fin rays, 19 anal-fin rays, 27 - 28 scales in longitudinal series and depth of body 3.5 in SL. Scheel (1969) described *O. minutillus* from Bangkok with 6 - 7 dorsal-fin rays and 17 - 21 anal-fin rays. Magtoon (1986) described *O. minutillus*, from Bangkok, Chaiang Mai, Chon Buri, Thung Song and Phuket, Thailand, as having 5 – 7 (6) dorsal-fin rays, 17 - 21 (19), 26 - 29 (28) scales in longitudinal series and 9 - 10 (10) scales in transverse series.

Uwa and Parenti (1988) described *O. minutillus* from Bangkhen, Thailand, with six dorsal-fin rays, 19 anal-fin rays,a head length 24.4 % of SL, a preanal length 50.6 % of SL, a predorsal fin length 82.2 % of SL, and a preanal fin length 55.4 % of SL. However, Uwa et al., (1988) described *O. minutillus* from Yunan, Southwestern China, with a 16.8 ± 1.4 mm. SL having 5 - 6 (6) dorsal-fin rays, 18 - 21(19) anal-fin rays, a head length 23.5 ± 1.1 % of SL, a predorsal fin length 80.2 ± 1.0 % of SL, and a preanal fin length 54.8 ± 1.8 % of SL.

A recent survey of small ricefish of all regions by several authors have mentioned the family Adrianichthyidae. Magtoon (1993) described *O. minutillus* from five regions of Thailand, the Chao Phraya, Mekong, Salween, Chachoengsao and Peninsular regions, which have a much more slender body than the type material described by Smith (1945), body depth being 3.9 - 3.5 (4.4) mm SL against 3.5 mm SL in Smith (1945). Roberts (1998) also described *O. minutillus* from Chao Phraya, Mekong and Peninsular regions, Thailand with 5 - 7 (6) dorsal-fin rays, 17 - 21 anal-fin rays, 7 - 8 pectoral-fin rays, five pelvic-fin rays and 24 - 28 vertebrae.

Oryzias mekongensis Uwa and Magtoon, 1986

Oryzias mekongensis, Uwa and Magtoon, 1986: 474 [type locality pond at Yang Talat, Kalasin Prov., Thailand].- Iwamatsu, 1986:99-109.-Uwa, 1986: 867-875.- Uwa & Parenti, 1988: 159.- Hamaguchi, 1996:757-763.- Rainboth, 1996:172.- Roberts, 1998: 220-221.- Kottelat, 2001b:143, fig.405.

Material examined.– USNM 268540; adult male 13 mm SL; a pond at Yang Talat, Kalasin Province, Thailand, 19 Apr. 1984, dip net collected by W. Magtoon and H. Uwa; NSMT P23233-23238, 6 males and P 23239-23244, 6 females; CTNRC 42.2612-2620, two males and seven females; a pond at Kantharalak, ($14^0$14′ 65″ N, 104^0 65′ E) Srisaket Province, Thailand, 15 Mar. 1984; collected by S. Chunchai and W. Magtoon: NIFI 3209; two specimens, Muang ($28^0$17′ N, 102^0 49′ E) Udon province, Thailand, 6 Dec. 2007, collected by W. Magtoon and T. Deesin; LBSWU 00017, 55 specimens, 21.6 - 35.6 mm SL., Nong Kung Sri (16^0 45′ N, 103^0 25′ E), Kalasin province, Thailand, 1 Nov. 2006, collected by W. Magtoon and S. Deesin.

Diagnosis.– *Oryzias mekongensis* is distinguishable from other members of the genus occurring in Thailand by the combination of the following characters: a low anal-fin rays 14 - 17 (14), the last rays branched, a relatively anterior anal-fin origin, opposite vertebrae 10 - 12 (10); six dorsal-fin rays, the 3rd - 6th rays branched, a relatively anterior dorsal-fin origin opposite vertebrae 18 - 20 (19); principal caudal-fin rays i,4/5,i; bright orange sumarginal bands on the dorsal and ventral portions of caudal fin. Largest known specimens 12.4 mm SL.

Description.– Counts and measurement proportions are from 32 specimens including the material specimens, ranging from 12.6 to 20.4 mm SL (Table 2).

Body compressed, elongate, body depth at origin of first dorsal fin 7.3 (7.1 - 7.6) in SL; body depth at origin of first anal fin 5.2 (4.9 - 5.4) in SL; caudal peduncle compressed, depth 2.5 (2.3 - 2.7) in HL. Head length 4.3 (4.1 - 4.5) in SL, head less compressed than body, anterior part of head depressed, head short, 20.9 - 25.9 (23.6 ± 1.2) in % SL. Interorbital space broad. Snout length 5.0 (4.3 - 5.7) in HL; snout short 16.4 to 26.2 (21.3 ± 2.6) % of HL, snout shorter than eye diameter. Eye diameter 2.3 (2.4 - 2.3) in HL, the pupil situated in anterior part of head; eye large, 36.3 - 47.0 (41.5 ± 2.7) % of HL. Mouth terminal, almost horizontal. Premaxillary and dentary with large teeth in both sexes. Dorsal body profile relatively straight from head to dorsal fin-origin; ventral body profile slightly convex from head to anal fin-origin. First pleural rib on parapophysis of third vertebrae; lateral process of pelvic bone line with fourth or fifth pleural rib. Caudal skeleton with two epural bones; one ventral accessory bone and a secondary cartilage or bone. Basihyal bone relatively short and triangular, basihyal cartilage elongate and rectangular. Body covered with cycloid scales in longitudinal series 29 - 32 (30), and in transverse series 9 - 10. Principal caudal-fin i,4/5,i. Procurrent fin-rays, dorsal 3 – 5 (4) and ventral 3 – 5 (5). Branchiostegal rays 4 - 5 (4). Vertebrae 26 - 31 [11 - 13 + 15 - 18]. Lateral line absent.

Dorsal-fin rays 6 - 7 (6), 2nd- 4th rays long, 3rd- 6th rays branched, a relative anterior dorsal-fin origin, opposite vertebrae 18 - 20 (19); dorsal fin short, on the posterior half of body, dorsal fin length or height (longest rays) 1.4 (1.3 - 1.4) in HL, 5.8 (5.8 -5.8) in

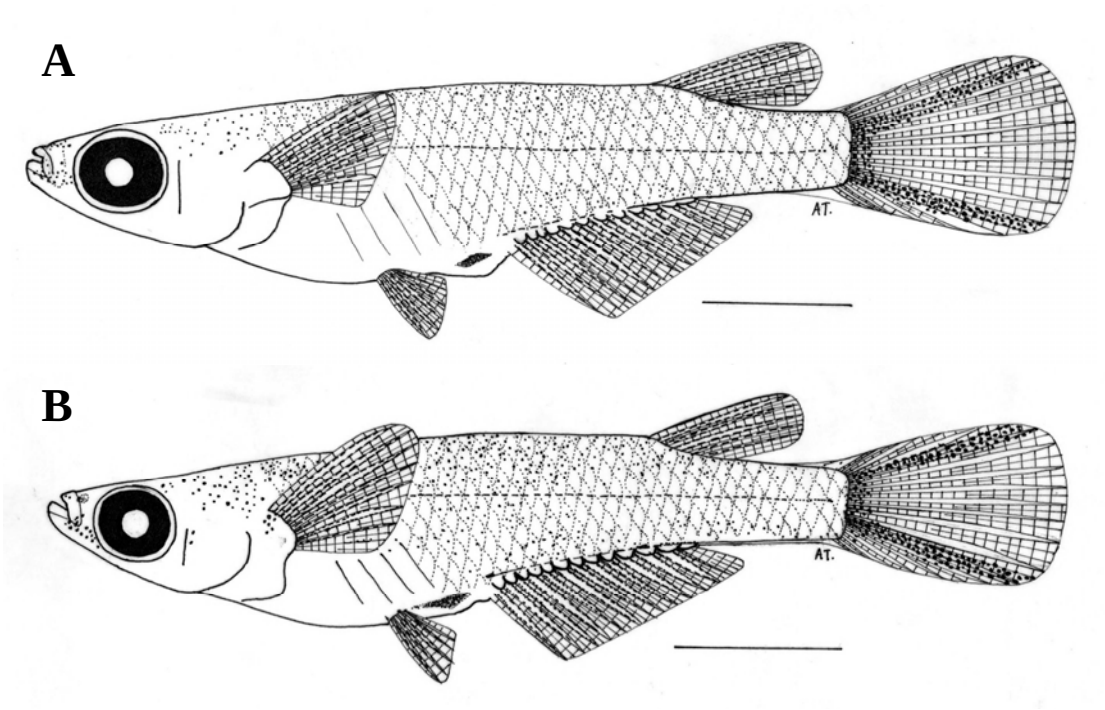

FIGURE 5. Illustration of *Oryzias mekongensis* Uwa and Magtoon, 1986, based on material specimens, NIFI 3209; A, adult male and B, adult female, from Udon Thani, province, Peninsular region. Bar indicate 3 mm.

SL, 7.3 (7.2 - 7.5) in TL and 1.3 (1.2-1.3) in depth of dorsum to belly in front of dorsal fin; dorsal fin length much longer than dorsal fin base, length of dorsal fin base 15.9 (15.0 - 16.8) in SL and 20.8 (18.6 - 23.1) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.3 (1.3-1.3) in SL, 1.6 (1.6 - 1.7) in TL.

Anal-fin rays 15 - 17 (15), last ray branched, anal fin rays without bony contact organ in both sexes; a relatively posterior anal-fin origin, opposite vertebrae 10 - 12 (11); anal fin length 1.3 (1.3 - 1.3) in HL, 5.9 (5.7 - 6.0) in SL; anal fin base very long, its base 3.4 (3.8 - 4.0) in SL, 4.9 (4.7-5.2) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 1.7 (1.7 - 1.9) in SL, 2.2 (2.1 - 2.4) in TL.

Pectoral-fin rays 7 - 8 (7), pectoral fin inserted on the median line of body; a back spot at the base of pectoral fin; pectoral fin 1.2 (1.2 - 1.2) in HL, 5.2 (5.1 - 5.3) in SL, 6.5 (6.5 - 6.5) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 3.6 (3.5 - 3.8) in SL, 4.6 (4.5 - 4.7) in TL.

Pelvic-fin rays 5 - 6 (6), pelvic fin small, pelvic origin halfway between tip of snout and posterior angle of anal base, pelvic fin 2.0 (1.6 - 2.4) in HL, 8.5 (7.4 - 9.6) in SL, 10.7 (9.2 - 12.3) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.4 (2.3 - 3.5) in SL, 3.0 (2.8 - 3.1) in TL.

Caudal fin truncated, caudal fin length 1.6 (1.2 - 1.4) in HL, 5.5 (5.3 - 5.7) in SL, 6.9 (6.6 - 7.2) in TL, caudal fin length shorter

than head length; caudal peduncle moderately slender; caudal peduncle depth 2.6 (2.3 - 2.8) in HL, 10.6 (10.4 - 10.9) in SL, 12.2 (10.4 - 13.9) in TL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 7.3 (7.1 - 7.6) in SL, body depth at origin of first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 5.2 (4.9 - 5.4) in SL, 6.5 (6.3 - 6.7) in TL.

Cytogenetic data.– *Oryzias mekongensis* from Kalasin province in the Mekong region has 2n = 48 chromosomes. The karyotype consistes of one metacentric, four submetacentric, 12 subtelocentric and seven acrocentric pairs. Chromosome arm number is 58, with a genome size of 1.5 picograms of DNA per nucleus. In the biarmed chromosome group, NORs are located at the centrometric regions of the acrocentric pair (Uwa and Magtoon, 1986).

Color of fresh specimens.– Body brownish, translucent in both sexes. Males manifesting bright orange lines along upper and lower edges of caudal fin; no prominent marginal lines in females and both sexes with a silvery operculum.

Color of preserved specimens.– Ground color pale yellow, upper part of head blackish. A black line along anal fin base. A cluster of black specks at pectoral fin base.

Sexual dimorphism.– The genital papilla of the male forms a short tube. The female genital papilla forms a bilobed structure. Bright orange submarginal bands on the dorsal and ventral portions of caudal fin in males, without contact organs on the anal-fin rays in males.

Distribution.– *Oryzias mekongensis* are widely distributed in the northeast Thailand. The geographic distribution of this species is limited to the Mekong basin in northeast Thailand and Laos (Fig. 8).

Comparisons.– *Oryzias mekongensis* is distinguished from *O. minutillus* in having fewer anal-fin rays [15 - 17 (15) rays vs. 17 - 21 (19) rays], more precaudal vertebrae [11 - 12 (12) rays vs. 9 - 10 (10) rays], and more principal caudal-fin rays (i,4/5,i rays vs. i,3/4,i rays). However, *O. mekongensis* is similar to *O. minutillus* in having the same number of branchiostegal rays and dorsal-, pectoral- and pelvic-fin rays,, but the former is distinguished from the latter in having an extremely shorter snout length [16. 4 – 26.2 (21.3) % of HL vs. 18.9 -31.2 (25.3) % of HL], a greater caudal peduncle depth [8.1 - 11. 5 (9.7) % of SL vs. 8.3 - 10.6 (9.1) % of SL], a shorter predorsal length [74.1 - 80.5(77.0) % of SL vs. 76.6 – 84.6 (79.8) % of SL], bright orange submarginal bands on the dorsal and ventral portions of caudal fin in life without bright orange submarginal bands on the dorsal and ventral portions of caudal fin in *O. minutillus*.

Remarks.– Uwa and Magtoon (1986) originally described these specimens as *Oryzias mekongensis*, based on the holotype and paratype specimens from Thailand (USNM 268540; CTNRC42.2621). These type specimens had the smallest number of anal-fin rays, 14 - 16 (14), the last ray being branched, and bright orange submarginal bands on the dorsal and ventral portions of caudal fin in males. In addition, the diploid chromosome of *O. mekongensis* revealed 2n = 48 chromosomes. The karyotype was as above.

According to Roberts (1998), who described specimens of *O. mekongensis* from the Num Theum watershed, Laos, they had dorsal-fin rays 5 - 6; anal-fin rays 13 - 16 (usually 14), pelvic-fin rays 6/6; principal caudal-fin rays 4-5, 5/6, 4-5, and vertebrae 27 - 29. However, Kottelat (2001) described specimens of *O. mekongensis* from Laos that had 13 - 16 anal-fin rays and 14 mm SL.

The Mekong specimens examined in the present study from Udon Thani, Thailand had six6 dorsal-fin rays, 15 - 17 (15) anal-fin rays, 11 - 12 (12) precaudal vertebrae, 15 - 17 (16) caudal vertebrae and four branchiostegal rays. Unlike, *O. minutillus,* there are no black specks around the uriogenital papilla. The anterior rays of the anal and dorsal rays are extremely elongated, a feature that is seen in *O. curvinotus, O. latipes, O. celebensis* and *O. luzonensis.*

Oryzias latipes (Temminck and Schlegel, 1846)

Poecilia latipes Temminck & Schlegel, 1846:224.

Haplocheilus lattices.- Gunther, 1866:311.

Oryzias latipes- Jordan & Synder, 1906: 289-290.- Oshima, 1926:1-25.-Smith,1938: 166.-Arai, 1973: 173.- Egami & Yamamoto, 1975: 276-365.- Sakaizumi et al., 1980.- Sakaizumi, 1980.- Sakaizumi, 1983.- Uwa, 1986:867-875.-Parenti, 1987.-Uwa & Parenti 1988: 159.- Chen et al., 1980: 171-172.- Fujita, 1992: 107-109.- Roberts, 1989: 221.- Naruse et al., 2000.- Matsuda et al., 2003: 159-161.- Takehana et al., 2005: 417-428.

Oryzias latipes latipes, Chen et al., 1989: 239-246.- Uwa, 1991a: 361-367.

Material examined.– CAS 92746, 4: 20.8 - 22.7 mm SL, rice paddy field at Caudien near Hanoi, April 1995, collected by Hung, Hoa and W. Magtoon; NIFI 3424, 2 : 16.0 - 28.7 mm SL, paddy field at Gifu prefecture, Japan, 5 Mar. 2007, collected by K. Ikeya. LBSWU 00014, 23: 17.0 - 28.8 mm SL., Gifu prefecture, Japan, 5 Mar. 2007, collected by K. Ikeya.

Diagnosis.– *Oryzias latipes* differs from all other *Oryzias* species in having the 31 scales in a lateral row; 16 - 20 (20) anal fin rays, a relatively anterior anal-fin origin, posterior vertebrae 19 - 20 (20) and bony contact organs at the posterior of the anal fin in males.

Description.– Counts and proportions are from 28 specimens, ranging from 17.0 to 28.8 mm SL (Table 2).

Body compressed elongate, body depth at origin of first dorsal fin 6.9 (6.4 - 7.5) in SL, body depth at origin of first anal fin 5.2 (4.8 - 5.6) in SL; caudal peduncle compressed, depth 2.6 (2.6 - 2.7) in HL; caudal peduncle length 1.8 (1.7 - 1.8) in HL. Head length 4.0 (4.0 - 4.0) in SL, head less compressed than body, anterior part of head depressed; head short, 23.1 to 27.6 (25.6 ± 1.0) % of SL. Interorbital space broad. Snout length 4.0 (3.7 - 4.3) in HL, snout short 18.0 to 29.6 (23.5 ± 3.1) % of HL, snout shorter than eye diameter. Eye diameter 2.5 (2.4 - 2.6) in HL, the pupil situated in the anterior part of head; eye large, 32.2 to 42.7 (38.2 ± 2.7) % of HL. Mouth terminal, lower jaw slightly projecting; each jaw with two rows of minute teeth, without large teeth. Vomer smooth. Dorsal and ventral body profile straight from head to dorsal- and anal-fin origin. First pleural rib on parapophysis of fourth vertebrae; lateral process of pelvic bone attaches to fourth than fifth pleural rib. Caudal skeleton with two epural bones: one accessory bone and one accessory cartilage. Basihyal bone short and triangular, basihyal cartilage elongate and rectangular. Principal caudal-fin rays i,4/5,i. Procurrent fin-rays, five dorsal and six ventral. Branchiostegal rays 5 - 6. Vertebrae 29 - 30 [12 + 17 - 18]. Body covered with cycloid scales; 28 - 31 (31) in a lateral series. Lateral line absent.

Dorsal-fin rays 5 - 7 (6), 2^{nd} - 6^{th} rays bifurcated, 4^{th} rays longest, a relative anterior dorsal-fin origin, opposite anal-fin rays 13 - 14; dorsal fin short, on the posterior half of body, dorsal fin length or height (longest

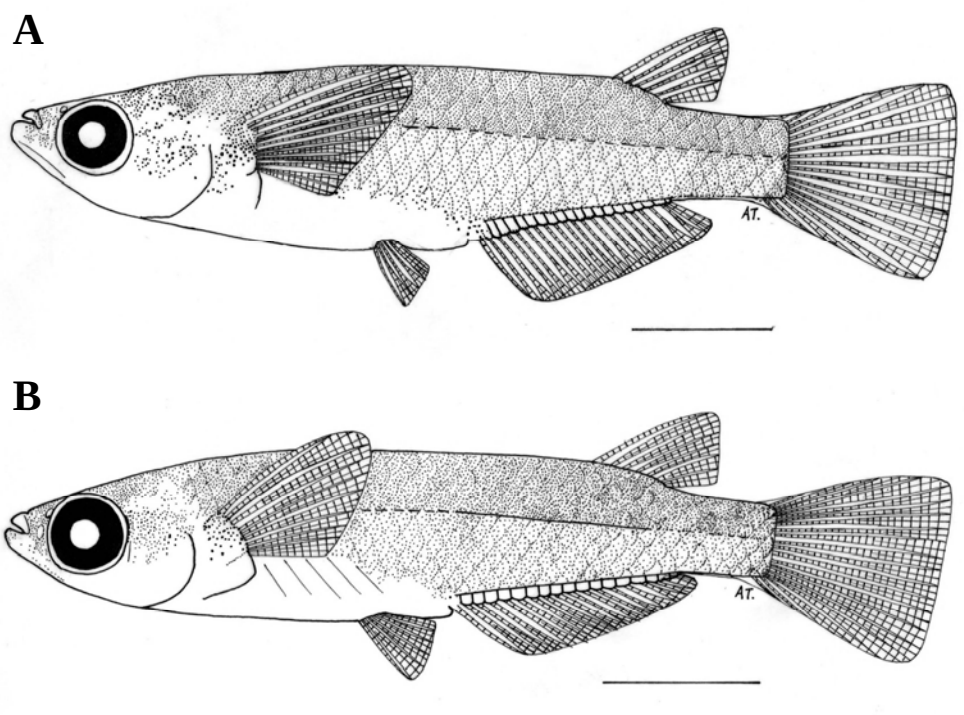

FIGURE 6. Illustration of *Oryzias latipes* (Temminck & Schlegel 1846), NIFI 3424, A, adult male and B, adult female, from Gifu Prefecture, Japan. Bar indicate 5 mm.

rays) 1.4 (1.3 - 1.6) in HL, 6.0 (5.4 - 6.5) in SL, 7.3 (6.6 - 8.1) in TL and 1.2 (1.1 - 1.2) in depth of dorsum to belly in front of dorsal fin; dorsal fin length much longer than dorsal fin base, long of dorsal fin base 13.6 (12.2 - 15.0) in SL and 16.7 (14.8 - 18.7) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.3 (1.3 - 1.3) in SL, 1.6 (1.6 - 1.6) in TL.

Anal-fin rays 16 - 20 (18), a relatively posterior anal-fin origin, opposite vertebrae 22 - 23; anal-fin rays out contact organ in males; anal fin length 1.5 (1.2 - 1.8) in HL, 6.1 (4.8 - 7.4) in SL; anal fin base very long, its base 3.4 (3.9 - 4.1) in SL, 4.8 (4.7 - 5.0) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 1.7 (1.7 - 1.8) in SL, 2.1 (2.1 - 2.2) in TL.

Pectoral-fin rays 7 - 11 (10), 2^{nd} - 8^{th} rays bifurcated, pectoral fin inserted on the median line of body; pectoral fin 0.9 (0.5 - 1.3) in HL, 5.0 (4.9 - 5.1) in SL, 4.6 (3.4 - 5.9) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 2.2 (2.1 - 2.2) in SL, 2.4 (2.1 - 2.7) in TL.

Pelvic-fin rays 5 - 7(6), 2^{nd} - 5^{th} rays bifurcated, pelvic fin small, pelvic origin halfway between tip of snout and posterior angle of anal base, pelvic fin 2.0 (2.0 - 2.1) in HL, 8.3 (8.0 - 8.5) in SL, 10.0 (9.6 - 10.4) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.2 (2.1 - 2.2) in SL, 2.6 (2.6 - 2.7) in TL.

Caudal fin truncated, caudal fin length 1.8 (1.8 - 1.8) in HL, 7.2 (7.0 - 7.5) in SL, 8.9

(8.5 - 9.3) in TL, caudal fin length shorter than head length; caudal peduncle moderately slender; caudal peduncle depth 2.6 (2.6 - 2.7) in HL, 10.6 (10.6 - 10.7) in SL,13.1 (12.9 - 13.2) in TL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 6.9 (6.4 - 7.5) in SL, body depth at origin of first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 5.2 (4.8 - 5.6) in SL.

Cytogenetic data.– *Oryzias latipes* from southern Japan (Matsuyama) and Korea has 2n = 48 chromosomes. The karyotype consists of two metacentric, eight submetacentric, one subtelocentric and 13 acrocentric pairs. Chromosomes arm number is 68, whereas the chromosomes arm number is 70 from the northern Japan (Aomoi). Genome size of *Oryzias latipes* is 1.7 picograms of DNA per nucleus. In the biarmed chromosome group, *Oryzias latipes* showed karyotypic polymorphism between southern and northern populations, and they contained one pair of " large" metacentric chromosome. NORs were located on a subnetacentric pairs (Uwa, 1986).

Color of fresh specimens.– Body translucent and the top of head dark, check, subopercle, and lower half of opercula silver. The body in upper half is grayish-black, whilst the portion below the lateral line series are pale grey brawn. Melanophore is present on interracial membrane of caudal fin. Anal fin has a darkened interracial membrane. Yellowish submarginal bands portions on the dorsal and ventral of caudal fin. Both sexes with a silvery operculum.

Color of preserved specimens.– Body pale grey above, brownish dorsally and pale ventrally. Melanophores form blackish lines above the anal fin base and middle line, along the anal-fin base. Blackish spots on dorsal part of head, body and caudal peduncle. Dorsal and anal fin interradial membrane with scattered melanophores. Peritoneum black. The colors are more intense in males.

Sexual dimorphism.– In addition to the difference in teeth and coloration mentioned above, the distal margins of the dorsal and anal fins in males are convex with filamentous fin rays, whereas females have a straight or slightly concave distal margin of anal fin. Pelvic-fin rays of female specimens elongate, nearly meeting anal-fin origin. Posterior anal-fin rays medial pectoral-fin rays with bony contact organs in males. The genital papilla are a short, slightly conical, tube in males and a bilobed structure in females. Morphometric characters of male fish differs from female fish in having: longer dorsal fin length (18.3 ± 1.9 % of SL vs. 16.0 ± 1.9 % of SL), longer anal fin length (16.0 ± 2.7 % of SL vs. 15.9 ± 3.7 % of SL) and shorter pelvic fin length (19.5 ± 1.9 % of SL vs. 21.1 ± 1.2 % of SL).

Distribution.– *Oryzias latipes* are widely distributed in freshwater to brackish water in Japan, Korea, China, Vietnam and Laos (Fig. 8).

Comparisons.– *Oryzias latipes* is similar to *O. luzonensis* in having the mode number of dorsal fin rays, pelvic-fin rays and pectoral-fin rays, but the former can be distinguished from the latter in having a smaller snout length [18.9 - 29.6 (23.5)% of SL vs. 21.0 - 34.7 (26.2) % of SL], a more slender body depth at anal fin origin [13.4 - 17.1 (15.1) % of SL vs. 19.3 - 25.4 (22.0) % of SL], a shorter caudal peduncle length [9.6 - 18.4 (14.0) vs. 11.8 - 17.8 (14.1)% of SL] and in having in sexual dimorphism with bony contact organs at the posterior of the anal fin in males. *Oryzias latipes* from Japan is similar to *O. latipes sinensis* from Yunan, China (Holotype No. 8610002) in having the mode number of dorsal-, pectoral- and

pelvic-fin rays but, the former is distinguished from latter in having a longer head length [23.1 - 27.6 (25.6) % of SL vs. 24.7 % of SL].

Remarks.– This species was originally described from Nagasaki, Japan (type specimens LMNH:2713) as *Poecillia latipes* by Temmingk and Schlegel (1846), who reported six dorsal-fin rays, 20 anal-fin rays, seven ventral-fin rays and 14 pectoral-fin rays. Bleeker (1860) also reported this species as *Aplocheilus latipes* from Nagasaki, Japan (LMNH: 6978) with nearly the same characters as those described by Temmingk and Schlegel (1846). Specimens described by Jordan and Synder (1906) as *Oryzias latipes*, from Shantung, Japan, had the following description: 20 - 29 mm SL, six dorsal-fin rays, 16 - 20 anal-fin rays, five branchiostegals and scale of lateral series 29 - 32. Oshima (1919) described this species, as *O. latipes* from Shori, Japan, with six dorsal-fin rays, 18 anal-fin rays, nine pectoral-fin rays, five ventral-fin rays, five branchiostegals and 31 scales in a lateral series, the tip of the caudal fin rounded, body covered with cycloid scales, eye large, anterior and superior, and lateral line absent.

Jordan and Tanaka (1927) reported this species, from Amami-Oshima and Okinawa, with the description of six dorsal-fin rays, anal-fin rays 17 or 18, and scales in lateral series 30. However, Uwa and Parenti (1988) reported this species from Kanasawa, Japan and Beijing, China, with 5 - 7 (6) dorsal-fin rays, 16 - 18 (18) anal-fin rays, five branchiostegals, 25.3 - 26.0 mm SL, a head length 26.0 % of SL, and a preanal length 59.1 - 64.7 % of SL.

Roberts (1998) described *O. latipes* from the Nam Theum watershed, Laos with 18 - 20 anal-fin rays, 9 - 10 pectoral-fin rays, and 30 vertebrae [11 + 19 - 20]. However, the Japanese specimens examined in the present study from Gifu prefecture, Japan had 5 - 6 (6) dorsal-fin rays, 16 - 20 (18) anal-fin rays, 9 - 11 (9) pectoral-fin rays, 5 - 6 (5) pelvic-fin rays, five branchiostegals and 29 - 30 vertebrae [12 + 17 - 18 (18)], body covered with cycloid scales, and a truncate tip of the caudal fin.

Oryzias celebensis (Weber, 1894)

Haplochielus celebensis Weber, 1894, p. 426 [type locality: Indonesia: Sulawesi, Makassar].

Aplochielus celebensis, Weber & de Beaufort, 1912.

Oryzias celebensis.- Rosen, 1964: 227.-Uwa et al., 1981: 95-99.- Hamaguchi, 1983:553-561.- Iwamatsu et al., 1984b:653-663.- Sakaizumi, 1985: 521-522.- Uwa, 1986: 867-875.-Whitten et al., 1987:295.-Uwa and Parenti, 1988:159.-Kotellat, 1990: 735-736, fig. 9.-Hamaguchi, 1996: 757-763.-Seegers, 1997: 15,19.- Albert et al., 1999: 650.-Parenti, 2000: 2150.

Material examined.– NIFI 3237, 2: 21.0 - 30.1 mm SL, Indonesia, 2006, collected by H. Uwa and W. Magtoon; NIFI 3398, 23: 25.0 - 30.7 mm SL, Indonesia, April 1991 by H. Uwa and W. Magtoon.

Diagnosis.– This species is distinguishable from congeners by the combination of the following characters: dark brown to black vertical bars on base on the side of body; pelvic fins much smaller, almost always with six rays, tips usually extending only to the anterior margin of genital area; anal-fin rays 20 - 23 (22), without bony contact organs, a relatively posterior anal-fin origin, opposite vertebrae 22 - 23; five branchiostegal rays; caudal vertebrae 18 or, much less frequently, 19; caudal peduncle length 8.7 in SL. Predorsal fin length 1.2 in SL.

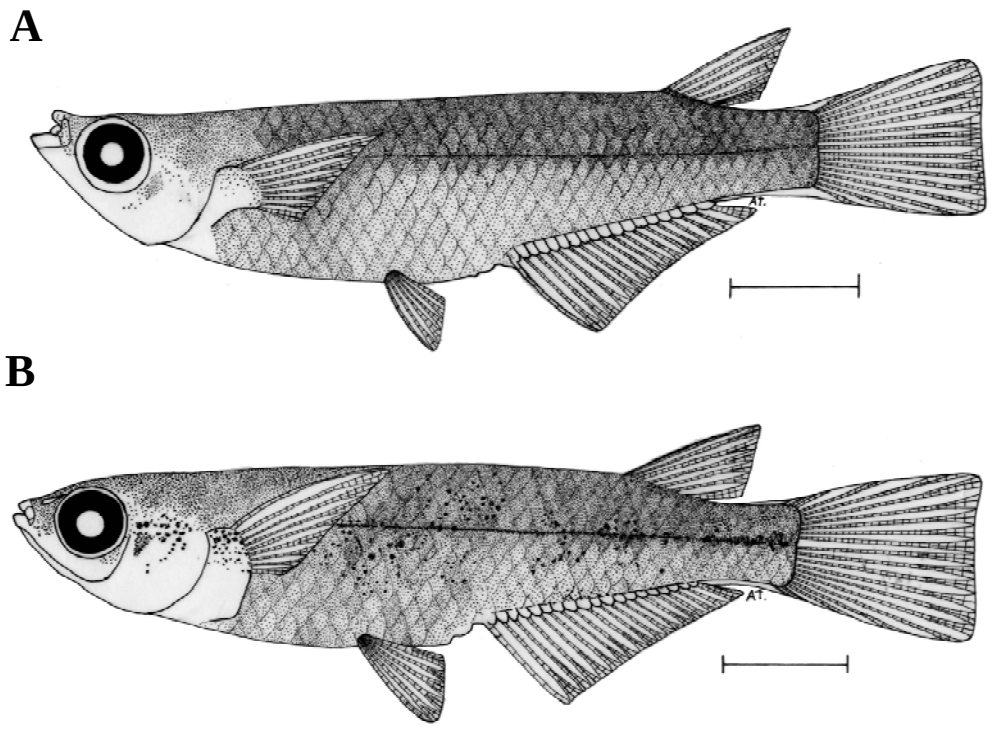

FIGURE 7. Illustration of *Oryzias celebensis* (Weber, 1894), base on material specimens, NIFI 3237: A, adult male and B, adult female, from Sulawesi, Indonesia. Bar indicate 5 mm.

Description.– Counts and proportions are from 30 specimens, ranging from 25.0 to 30.7 mm SL (Table 2).

Body compressed, elongate, body depth at origin of first dorsal fin 7.1 (5.6 - 8.6) in SL, body depth at origin of first anal fin 4.7 (4.4 - 5.2) in SL; caudal peduncle compressed, depth 2.0 (1.6 - 2.4) in HL. Head length 4.0 (4.0 - 4.0) in SL, head less compressed than body, anterior part of head depressed; snout length 5.4 (3.2 - 7.6) in HL; head length 4.0 (4.0 - 4.0) in SL; snout shorter than eye diameter. Eye diameter 2.3 (2.2 - 2.4) in HL, pupil situated in the anterior part of head. Mouth terminal, almost horizontal. Premaxillary and dentary with large teeth in both sexes. Vomer smooth. Dorsal body profile relatively straight head to dorsal-fin origin; ventral body profile somewhat convex from head to anal-fin origin. First pleural rib on parapophysis of third vertebrae; lateral process of pelvic bone line with third or fourth pleural rib. Caudal skeleton with two epural bones: one or two ventral accessory bones. Body covered with cycloid scales in longitudinal series 29 - 33. Principal caudal-fin rays i,4/5,i. Procurrent fin-rays, dorsal 4, ventral 5 - 6 (5). Branchiostegal rays 5 - 6 (5). Vertebrae 29 - 31 [11 – 12 (11) + 18 - 19]. Lateral line scales absent.

Dorsal-fin rays 8 - 9 (8), 2^{nd} - 4^{th} rays long; a relative anterior dorsal-fin origin, opposite vertebrae 21 - 22 (22), and opposite anal-fin rays 15 - 16, dorsal fin with short, on the posterior half of body, dorsal fin length or height (longest rays) 1.2 (0.7 - 1.6) in HL, 4.8 (3.1 -6.5) in SL, 5.9 (3.8 - 7.9) in TL and 1.5 (1.3 - 1.8) in depth of dorsum to belly in front

of dorsal fin; dorsal fin length much longer than dorsal fin base, long of dorsal fin base 10.2 (9.2 - 11.2) in SL, 12.8 (14.1 - 14.4) in TL; dorsal fin length much shorter than predorsal length. Predorsal length 1.2 (1.2 - 1.3) in SL, 1.5 (1.5 - 1.5) in TL.

Anal-fin rays 20 - 23 (22), 5^{th} - 12^{nd} rays filamentous, prolonged in males; a relatively anterior anal-fin origin, opposite vertebrae 11 – 12 (12); anal-fin rays without contact organ in males; anal fin length 1.2 (0.9 - 1.5) in HL, 4.7 (3.4 - 6.0) in SL; anal fin base very long, its base 3.9 (3.2 - 4.6) in SL, 4.7 (3.9 - 5.6) in TL; anal fin base much longer than anal fin length; anal fin length shorter than preanal length, preanal length 1.7 (1.5 - 1.9) in SL, 1.9 (1.5 - 2.4) in TL.

Pectoral-fin rays 10 - 11 (11), pectoral fin inserted on the median line of body; pectoral fin 0.9 (0.9 - 1.0) in HL, 3.7 (3.5 - 4.0) in SL, 4.6 (4.3 - 4.9) in TL; pectoral fin much shorter than head length; pectoral fin length shorter than prepectoral length; prepectoral length 3.8 (3.2 - 4.4) in SL, 4.7 (3.9 - 5.7) in TL.

Pelvic-fin rays 5 - 6 (6), pelvic fin small, pelvic origin halfway between tip of snout and posterior angle of anal base, pelvic fin 2.1 (1.6 - 2.6) in HL, 8.3 (6.2 - 10.4) in SL, 10.2 (7.7 - 12.7) in TL; pelvic fin length shorter than head length; pelvic fin length shorter than prepelvic length; prepelvic length 2.2 (2.1 - 2.4) in SL, 2.3 (2.6 - 2.9) in TL.

Caudal fin truncated, caudal fin length 2.0 (1.7 - 2.2) in HL, 5.5 (5.3 - 5.7) in SL, 9.7 (8.3 - 10.1) in TL, caudal fin length shorter than head length; caudal peduncle moderately slender; caudal peduncle depth 2.0 (1.6 - 2.4) in HL, 8.0 (6.4 - 9.6) in SL, caudal peduncle depth much longer than caudal fin length.

Body deep, body depth at origin of first dorsal fin 7.1 (5.6 - 8.6) in SL, body depth at origin of first dorsal fin much shorter than body depth at origin of first anal fin; body depth at origin of first anal fin 4.5 (4.2 - 5.2) in SL.

Cytogenetic data.– *Oryzias celebensis* has 36 diploid chromosomes, with eight metacentric, four submetacentrics and 24 or 26 acrocentric chromosome pairs. Chromosome arm number is 48. In the fused chromosome group, *O. celebensis* from Sulawesi has four pairs of "large" biarmed chromosomes and NORs are located on a submetacentric pair (Uwa, 1986, 1991a).

Color of fresh specimens.– Head and body are pale yellow dorsally and laterally. Dorsal fin membrane transparent; anal fin pale yellow basally. Yellow–orange submarginal bands portions on the dorsal and ventral of caudal fin; pelvic fin membrane pale yellow. Both sexes with a silvery opercula region.

Color of preserved specimens.– Body pale grey to blackish. Melanophores forming a thin black stripe running along middle line from head to caudal fin base, a line along anal base and caudal has one or two rows of black spots basally. Diffuse dark brown bar extends dorsally and ventrally to middle line.

Sexual dimorphism.– In addition to the different body color pattern, the male anal fin has a convex distal margin without bony contact organs on the posterior region, whereas the distal margin is slightly concave in females. Anal fin rays are longer and thicker in males. Male manifesting has more bright yellow lines along the upper and lower edges of the caudal fin than females. Tubular urogenital papilla are more developed in males and bilobed in females. Morphometric characters of male fish differ from females in having: longer dorsal fin length (24.1 ± 4.8 % SL vs. 16.1 ± 1.1 % SL), longer anal fin length (26.1 ± 3.7 % SL vs. 17.2 ±1.7 %SL), and shorter pelvic fin length (12.6 ± 2.0 % SL vs. 15.4 ± 1.6 % SL).

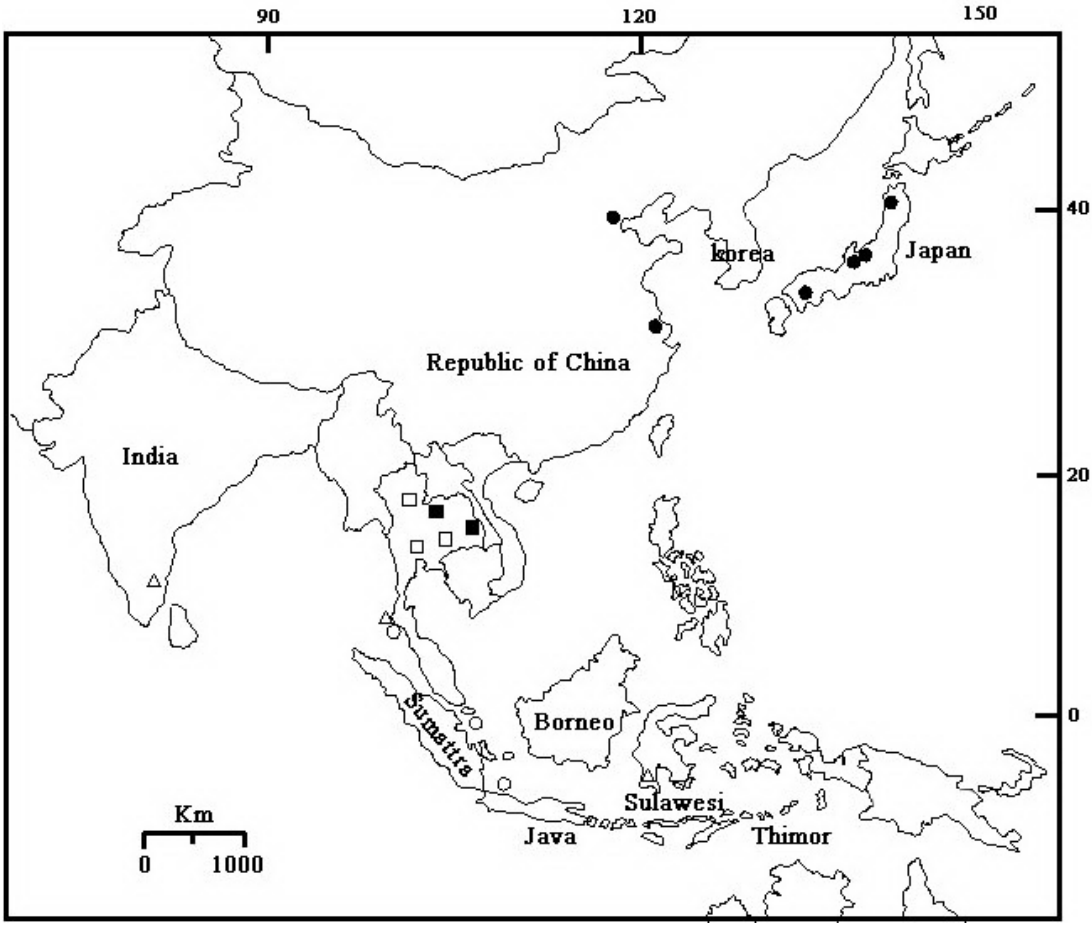

FIGURE 8. Geographical distribution of the *Oryzias* species: *O. dancena* (★), *O. javanicus* (◆), *O. mekongensis* (■), *O. minutillus* (□), *O. celebensis* (▲) and *O. latipes* (●).

Distribution.– *Oryzias celebensis* are widely distributed in Sulawesi, Indonesia and East Timor (Fig. 8).

Comparisons.– *Oryzias celebensis* is similar to *O. nigrimas* in having a somewhat similar number of dorsal- and pelvic-fin rays and branchiostegal rays. However, *O. celebensis* is distinguished from *O. nigrimas* in having a longer head length [22.1 - 27.2 (25.1) % SL vs. 21.0 - 25.3 (22.8) % SL], a smaller snout length [12.0 - 33.1 (20.9) % SL vs. 20.6 - 39.7 (26.3) % SL], and a greater body depth at origin of anal fin [18.3 - 25.0 (21.4) % SL vs. 20.0 - 22.2 (20.8) % SL]. Both *O. celebensis* and *O. nigrimas* are also distributed in Indonesian waters and the anterior rays in both dorsal- and anal-fin rays are greatly elongate in males, but differ from *O. nigrimas* in having a small number of pectoral-fin rays counts [6 - 9 (8) vs. 10 - 11(11)].

Remarks.– Weber and Beaufort (1922) originally reported this species as *Aplocheilus celebensis*, and described it as having 7 - 9 (9) dorsal-fin rays, 17 - 19 anal-fin rays, 30 - 32 scales in longitudinal series and 14 scales in transverse series. However, Uwa and Parenti (1988) described *Oryzias*

celebensis from Ujung Pandang with 8 - 10 (9), 19 - 22 (21) anal-fin rays, head length (22.5 % SL), preanal length (55.2 % SL), and predorsal fin length (59.2 % SL).

The Indonesian specimens examined of this present study had a much slender total length than the type material described by Weber and Beaufort (1922), total length being 30.5 - 37.9 (33.9) mm TL against 38 mm TL in Weber and Beaufort (1922). Moreover, these specimens had a smaller preanal length than the material specimens described by Uwa and Parenti (1988), preanal length being 51.4 - 59.2 (56.7 ± 1.9) % SL against 55.2 ± 1.7 % SL (Uwa and Parenti, 1988).

DISCUSSION

Interspecific variation were found in the number of anal-, pectoral-, principal caudal- and pelvic-fin rays, and the number of vertebrae ($P<0.001$, Table 1). Other meristric counts showed little or no variation, such as branchiostegal rays. These meristic characters of the six species examined here coincided with the reported species differentiation as defined by morphological data (Uwa and Parenti, 1988; Magtoon, 1993).

The morphometric characters of the six species suggested by Uwa and Parenti (1988) are roughly in correspondance to the morphometrics found in this study. Significant differences in elevations amongst morphometrics were shown in 14 morphometric characters. For example, the eye diameter was longer [38.8 - 75.1 (45.1 ± 5.3) % HL] in *O. dancena* than in *O. cellebensis* [33.2 - 51.7 (44.4 ± 4.1) % HL], in *O. javanicus* [35.2 - 61.9 (44.1 ± 4.7) % HL], in *O. mekongensis* [36.3 - 47.0 (41.5 ± 2.7) in % HL], in *O. minutillus* [33.6 - 46.8 (39.7 ± 2.9) % HL] and *O. latipes* [32.2 - 42.7 (38.2 ± 2.7) % HL]. The CDA of these morphometric characters revealed that 61.5% of the total variation was expressed in the first five principal components, with canonical correlation and eigenvalues of .977 and 21.23, respectively (Table 3). With the first canonical discriminant, *O. minutillus* and *O. mekongensis* overlapped moderately, and *O. mekongensis* and *O. latipes* were not clearly distinguished, whereas *O. minutillus* and *O. latipes* were completely separated. For the second canonical discriminant, *O. dancena* and *O. javanicus* overlapped moderately but both species were clearly distinguished from *O. celebensis* (Fig. 9). The greatest contributions to the variance along the first and second axis was made by eye diameter (positive) and caudal fin base (negative), respectively. The clear results of CDA in this study suggested that morphometric analyses are in fact more appropriate for discriminating between the different morphologies of *Oryzias*.

A cluster analysis based on 22 morphometric proportions, expressed as percentages of SL was performed. Dissimilarity was calculated from standardized squared Euclidean distances, and an average based method was adopted in constructing the clusters. Based on morphometric characters, the six species constituted two clusters, each corresponding to the large- and small-sized groups, comprised of *O. minutillus*, *O. mekongensis* and *O. latipes,* and *O. javanicus*, *O. dancena* and *O. celebensis,* for the small- and large–sized groups, respectively, with a great dissimilarity between the two clusters (Fig. 10).

Cytogenetics data can karyotypically divide ricefish into three groups, firstly the monoarmed chromosome type [*O. dancena* and *O. javanicus* with (2n = 48; NF = 48)],

TABLE 3. Standardized canonical (CDA) coefficients based on 22 morphometric characters amongst *O. minutillus, O. mekongensis, O. latipes, O. dancena, O. javanicus* and *O. celebensis.*

Characters	Function				
	1	2	3	4	5
Standard length	.451	.013	.245	.649	.095
Total length	.453	.073	.180	.684	.098
Snout length/HL	.391	.056	.026	.547	-.142
Eye diameter/HL	.560	.106	.093	.632	.245
Head length	.477	.115	.215	.643	-.090
Preanal length	.472	-.001	.221	.625	.037
Preanal fin length	.469	-.057	.246	.678	.153
Predorsal fin length	.472	.052	.171	.666	.066
Prepelvic fin length	.412	.006	.201	.726	-.057
Long of dorsal fin base	.339	-.068	-.161	.755	.083
Long of anal fin base	.459	.158	-.054	.616	-.112
Pectoral fin height	.418	.042	.079	.561	.096
Pelvic fin height	.285	.038	-.065	.638	.317
Caudal peduncle depth	.350	.116	.068	.606	.047
Body depth at anterior anal fin	.266	.166	.124	.649	-.002
Body depth at anterior dorsal fin	.481	.227	-.106	.548	.137
Anal fin height	.184	.044	-.049	.374	.083
Dorsal fin height	.182	-.004	-.119	.447	.048
Prepectoral fin length	.343	.152	.197	.614	-.178
Dorsal fin origin to caudal fin base	.344	.371	.056	.706	.161
Anal fin origin to caudal fin base	.265	.193	.216	.615	.068
Eigenvalues	21.233	5.832	2.992	1.256	.204
% of variance	65.10	20.30	9.70	4.00	0.90
% of cumulative	65.10	85.40	95.10	99.10	100

secondly the biarmed chromosome type [*O. latipes* (2n = 48; NF = 64) and *O. mekongensis* (2n = 48; NF= 58)], and thirdly the fused chromosome type [*O. cellebensis* (2n = 36; NF = 48) (Uwa et al.,1983; Uwa, 1986). This classification also coincides well with that indicated by electrophoretic studies of allozymes and muscle proteins, and with mitochondrial DNA (Sakatzumi, 1985; Takehana et al., 2005).Note that the mono- and bi-armed grouping concurs with the two related clades derived from the morphometric analysis in this study (Fig. 10), it is just the two fused chromosome type members that are split in this dendrogram, each as an outlier to the mono- and bi-armed chromosome groups but unrelated to each other.

Morphological differences were also found in both morphometric and meristic characters amongst the six geographic populations of *O. minutillus, O. mekongensis*, *O. latipes*, *O. javanicus*, *O. dancena* and *O. celebensis.* The CDA for morphometric characters showed that the two populations divided into two groups: small- and large-sized groups. These morphological differences agreed closely with the cytogenetic differences already discussed and with the cladogram of morphology based relationships amongst the members of the genus *Oryzias* (Parenti, 2008).

It is interesting that, amongst the 24 known species of *Oryzias*, *O. minutillus*, *O. mekongensis,* and *O. latipes* have small-sized bodies, and that the three species show comparatively narrow geographic ranges, *O.*

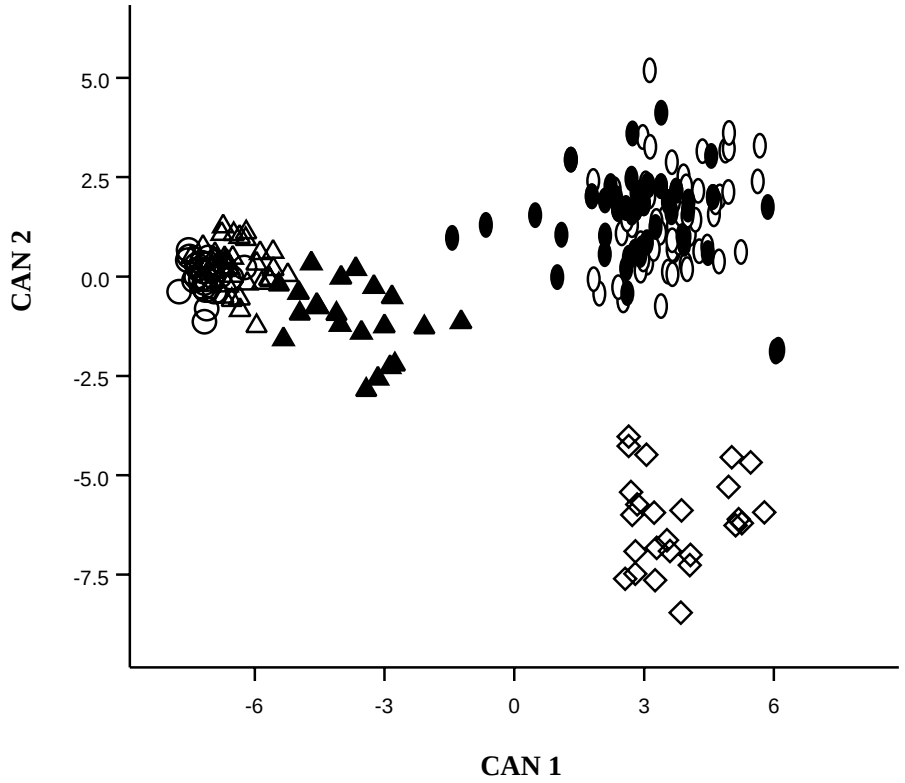

FIGURE 9. Plots of canonical discriminent scores on the first and second canonical (CAN) axes (B) among six species, *O. minutillus* (open circles), *O. mekongensis* (open triangles), *O. latipes* (closed triangles), *O. dancena* (open ellipses), *O. javanicus* (closed ellipses) and *O. celebensis* (open squares).

minutillus occurring in Thailand and parts of adjacent areas, *O. mekongensis* is confined in the Mekong basin in northeast Thailand and Laos, and *O. latipes* occurring in China, Korea and Japan. In contrast, *O. dancena*, *O. javanicus* and *O. celebensis* belong to the large-sized group and have much wider distributions, *O. dancena* spreading over coastal areas from the Peninsula region of Thailand to India and Sri Lanka. *O. javanicus* occurring inform Thailand through Malaysia Indonesia and Borneo, and *O. celebensis* occurring from Sulawesi island, Indonesia to east Timor It is also noteworthy that *O. dancena* and *O. javanicus* are morphologically similar to those reported from neighboring countries such as from Myanmar (Day, 1871; Yamamoto, 1975; Labhart, 1978) and from Indonesia, Singapore and Malaysia (Bleeker, 1854; Gunther, 1866; Beaufort, 1951; Alfred, 1966).

The present study disclosed many significant differences in both morphometric and meristic characters amongst the six species. These differences might caused by environmental modification. However, meristic characters of species within the genus *Oryzias* tend not to vary directly in response to environmental factors and so, along with the morphological differences observed in these six species reported here,

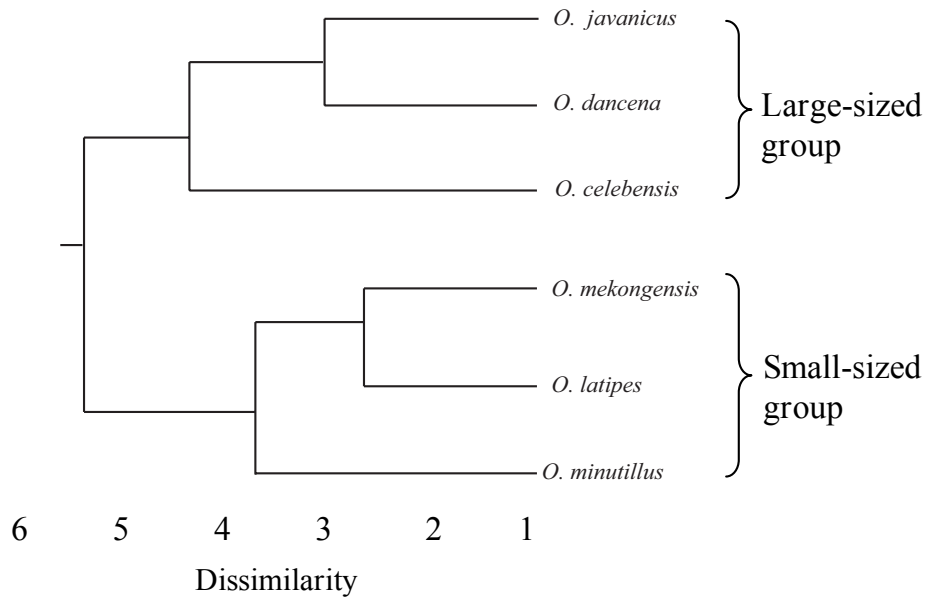

FIGURE 10. Dendrogram of six species of *Oryzias* derived by group average method base on 22 morphometric characters.

this would suggest that they represent distinct species. To confirm the proposed distinct species nature for these six species, however, requires more detailed ecological studies and assessment of the levels of intraspecific variation.

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