A new species of rainbowfish (Melanotaeniidae: Melanotaenia), from Batanta Island, western New Guinea

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Abstract
A new species of rainbowfish, Melanotaenia synergos, is described on the basis of 45 specimens, 24.1-63.3 mm SL, collected in 1998 at Batanta Island, western New Guinea (Papua Barat Province, Indonesia). It is closely allied to M. catherinae from the nearby island of Waigeo in the Raja Ampat Group. The two species share similar meristic and morphological features as well as general colour pattern similarities. However, they differ in modal counts for pectoral-fin rays and lateral scales. They also exhibit slight colour pattern differences related to the width of the dark midlateral stripe, which is generally narrower in M. synergos, covering one and a half scale rows for most of its length versus 2 to 3 scale rows for M. catherinae. Analysis of genetic relationships based on cytochrome b sequences indicates a close relationship between the two species. Of four species that were analysed (M. synergos, M. catherinae, M. batanta, and M. affinis) the mean Kimura 2-parameter genetic divergences between species varied from 1.3 to 17.1%. The new species differed from M. catherinae by between 2.4 and 2.7%.

Zusammenfassung

Résumé
Une nouvelle espèce de poisson arc-en-ciel, Melanotaenia synergos est décrit sur base de 45 spécimens, de 24,1 à 63,3 mm de LS, collectés en 1998 sur l’île Batanta, Nouvelle-Guinée occidentale (province de Papua Barat, Indonésie). Elle est très proche de M. catherinae, de l’île voisine de Waigeo, dans l’archipel de Raja Ampat. Les deux espèces ont en commun des données méristiques et morphologiques ainsi que des similitudes globales de coloration. Néanmoins, elles se distinguent par le nombre modal de rayons des pectorales et des écailles latérales. Elles montrent aussi de légères écarts de coloration, en rapport avec la largeur de la ligne médiane foncée qui est généralement plus étroite chez M. synergos, où elle couvre une rangée et demie d’écailles sur l’essentiel de la longueur, contre 2 à 3 rangées d’écailles pour M. catherinae. L’analyse de relations génétiques, basée sur des séquences de cytochrome b, révèle une parenté étroite entre les deux espèces. Sur quatre espèces analysées (M. synergos, M. catherinae, M. batanta et M. affinis) les écarts principaux des paramètres génétiques Kimura 2 entre ces espèces varient de 1,3 à 17,1%. La nouvelle espèce se distingue de M. catherinae par des valeurs de 2,4 à 2,7%.

Sommario
Una nuova specie di pesce arcobaleno, Melanotaenia synergos, è descritta sulla base di 45 esemplari di 24,1-63,3 mm SL raccolti nel 1998 all’isola di Batanta, Nuova Guinea occidentale (provincia di Papua Barat, Indonesia). È strettamente imparentata a M. catherinae della vicina isola di Waigeo del gruppo Raja Ampat. Le due specie hanno tratti morfologici e meristici quasi sovrapponibili e una colorazione generale molto simile. Tuttavia, esse differiscono nei valori modal di raggi della pinna pettorale e in quelli delle scaglie della linea laterale. M. synergos è generalmente più stretta in M. catherinae in grado di ricoprire una fila di scaglie e mezza per la mag-
A new species of rainbowfish (Melanotaeniidae: Melanotaenia), from Batanta Island, western New Guinea

INTRODUCTION

Rainbowfishes of the family Melanotaeniidae are common freshwater inhabitants of Australia and New Guinea. The group is believed to have evolved in relatively recent times from marine atherinoids (Allen 1980) and is closely related to the Pseudomugilidae (Saeed et al. 1989). Allen (1995) provided a popular account, including colour illustrations, and a summary of biological information for all known species. Seven genera are currently recognised: Cairnsichthys Allen, 1980, Chilatherina Regan, 1914, Glossoplepis Weber, 1907, Iriatherina Meinke, 1974, Melanotaenia Gill, 1862, Pelangia Allen, 1998, and Rhadinocentrus Regan, 1914. Allen (1996) summarised the 42 known species of Melanotaenia, which is by far the largest genus, but since then two additional species were described (Allen & Renyaan 1998) from New Guinea, another from Australia (McGuigan 2001), and M. solata Taylor, 1964 from northern Australia was elevated from subspecific to full species status (Allen et al. 2002). New Guinea is inhabited by 35 species of Melanotaenia, including the new species described in this paper. Nine species are found in Australia and two species are shared by the two regions. Rainbowfishes are exceptionally abundant throughout their distributional range. Clear, running streams and lakes are the preferred habitats, although they also occur in turbid waters, ponds, swamps, and isolated rocky pools in otherwise dry areas.

Fig. 1. Map of the Raja Ampat Islands. The approximate collections locations of Melanotaenia synergos on Batanta shown by stars.
streambeds. Most species form loose aggregations, which swim either in midwater or just below the surface. The main dietary items include insects which fall onto the surface and micro-crustaceans. Spawning occurs year round in most species, but reproductive activity often peaks at the onset of rainy periods.

The present paper describes a new species of Melanotaenia that was collected during a National Geographic-sponsored fish survey of the Raja Ampat Islands of far western New Guinea (Fig. 1) in 1998-1999. The two collection sites are located 27 km apart on the island of Batanta, which was first explored for freshwater fishes by Bleher (1992). We also include genetic comparisons with allied species including M. catherinae (De Beaufort, 1910) its closest relative from the nearby island of Waigeo, the sympatric M. batanta Allen & Renyaan 1996, and M. affinis (Weber, 1907), a widespread species from northern New Guinea.

MATERIALS AND METHODS

Counts and measurements that appear in parentheses refer to the range for paratypes if different from the holotype. Type specimens are deposited at Pusat Penelitian dan Pengembangan Oceanologi, Jakarta, Indonesia (NCIP), Natural Museum of Natural History (Naturalis), Leiden (RMNH), United States National Museum of Natural History, Washington, D.C. (USNM), and the Western Australian Museum, Perth (WAM).

The methods of counting and measuring are as follows: dorsal and anal rays - the last ray of the anal and second dorsal fins is divided at the base and counted as a single ray; lateral scales - number of scales in horizontal row from upper edge of pectoral-fin base to caudal-fin base, excluding the small scales posterior to the hypural junction; transverse scales - number of scales in vertical row between anal fin origin and base of first dorsal fin; predorsal scales - number of scales along midline of nape in front of first dorsal fin; cheek scales - total number of scales covering the suborbital and preoperculum; standard length (SL) - measured from the tip of the upper lip to the caudal-fin base; head length - measured from the tip of the upper lip to the upper rear edge of the gill opening; caudal peduncle depth is the least depth and caudal peduncle length is measured between two vertical lines, one passing through the base of the last anal ray and the other through the caudal-fin base.

DNA sequencing included the following populations: M. catherinae collected at two sites on Waigeo Island (Wei Sam and Kali Raja), one population of the new taxon from Batanta Island (Wei Bin Creek), and two additional species known to be closely related to M. catherinae (McGuigan et al., 2000), M. batanta and M. affinis, the latter being used as the outgroup. Three individuals of each population/species were sequenced except M. affinis for which only a single individual was sequenced.

Total DNA was obtained from approximately 0.25 cm³ of caudal fin or muscle via standard phenol/chloroform extraction or Quigen DNeasy easy tissue kit following the manufacturer’s protocol. The entire cyt b gene was amplified by standard polymerase chain reaction (PCR) techniques using primers Glu31 - 15938. When this failed to produce sufficient PCR product the gene was amplified in two halves using Glu31 - HD and rainL505 - 15938. Primer Glu31 (5' TGRCTTGAAAAACCCAC-CGTTGT 3') was modified from Schmidt & Gold (1993), and HD (5'GGGGTTTTGATCCT- GTTTTCGT 3') is from T. Schmidt as given in Dowling & Naylor (1997). Primers rain L505 (5'TCYGTAGATAATGCCACCT 3') and 15938 (5'CGGCCTCGCTTACAAGAC 3') were designed as part of this study. Final concentrations for PCR components per 25 ml reaction were as follows: 25 ng template DNA, 0.25 mM of each primer, 0.5 units of Taq DNA polymerase, 0.2 mM of each dNTP, 5 mM of reaction buffer and 2.5 mM MgCl₂. Amplification parameters were as follows: 95°C for 2 min followed by 35 cycles of 95°C for 30 s, 48°C for 30 s, and 72°C for 9 or 60 s, and 72°C for 7 min. PCR products were examined on a 1.5% agarose gel using cyberstain. The PCR products were purified using a Montage PCR 96 plate (Millipore, Billerica, Massachusetts, USA). Sequencing reactions and clean up were performed using a Parallab 350 (Parallabs, Worcester, Massachusetts, USA). Sequences were obtained with an Applied Biosystems (Foster City, California, USA) 3730 XL Automated Sequencer at the Brigham Young University DNA Sequencing Center.

DNA sequences were edited using Chromas Lite 2.0 (Technelysium, Tewantin, Queensland, Australia) and then imported and aligned by eye in BioEdit 7.0.5.2 (HALL 1999). Sequences were checked via amino acid coding in Mega 3.1 (Kumar et al. 2004) to test for unexpected frame shift errors or unexpected stop codons. Phylogenetic analyses were performed using both parsimony and likelihood approaches using PAUP* (Swofford 2003).
Maximum parsimony (MP) was conducted via a heuristic search with 1,000 random additions and TBR branch-swapping. Maximum likelihood (ML) models were estimated via AIC in Modeltest 3.7 (Posada & Crandall 1998). ML was performed under the TrN+I+G model of evolution: Lset Base=0.2556 0.2370 0.2114 Nst=6 Rmat=(1.0000 5.5094 1.0000 1.0000 6.8661) Rates=gamma Shape=0.7315 Pinvar=0.4516. Robustness of nodes was estimated with PAUP* by bootstrap with 1,000 replicates for MP using a heuristic search with 10 random additions of taxa and TBR branch-swapping, and 1000 replicates for ML via a heuristic search with 10 random additions of taxa and TBR branch-swapping. All tree lengths reported for MP include both informative and uninformative characters. Among species variation was calculated using Kimura 2-parameter divergences in MEGA 3.1.

**Melanotaenia synergos** n. sp.
(Figs 2-7; Tables I-II)

**Holotype.** NCIP 6330, male, 55.0 mm SL, Wei Bin Stream, 0°49.774’S 130°45.874’E, on north-eastern end of Pulau Batanta, Raja Ampat Islands, Papua Barat Province, Indonesia, 0-2 m depth, rotenone, G. R. Allen and S. Renyaan, 28 April 1998.

**Paratypes (collected with holotype unless stated otherwise):** NCIP 6331, 10 specimens, 24.5-45.5 mm SL; RMNH 3558, 8 specimens, 26.5-50.0 mm SL; USNM 391010, 8 specimens 24.1-50.5 mm SL; WAM P .31462-001: 15 specimens, 25.0-60.8 mm SL; WAM P . 31555-007, 3 specimens: 46.6-63.3 mm SL, Warey River, 0°50.815’S 130°31.139’E, on northwestern end of Pulau Batanta, 0-2.5 m depth, seine net, G. R. and M. Allen, 28 April 1999.

**Comparative material examined:** Melanotaenia cathariniae – WAM P . 31560-001, 9 specimens, 26.2-74.3 mm SL, Marur River, western Waigeo, G. R. Allen and S. Renyaan; WAM P . 31562-002, 8 specimens, 55.0-72.5 mm SL, Rumei River, eastern Waigeo, G. R. Allen and S. Renyaan, 5 May 1999; WAM P . 31466-001, 26 specimens, 33.0-57.0 mm SL, Wei Sam Creek, near entrance to Mayalabit Bay, eastern Waigeo, G. R. Allen and S. Renyaan, 1 May 1998.

### Table I.
Proportional measurements of selected type specimens of *M. synergos* expressed as percentage of the standard length.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Holotype NCIP 6330</th>
<th>Paratype WAM P.31555</th>
<th>Paratype WAM P.31462</th>
<th>Paratype RMNH 3558</th>
<th>Paratype USNM 391010</th>
<th>Paratype USNM 391010</th>
<th>Paratype RMNH 3558</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Male</td>
<td>Female</td>
<td>Female</td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td>Sex</td>
<td>Standard length (mm)</td>
<td>Body depth</td>
<td>Body width</td>
<td>Head length</td>
<td>Snout length</td>
<td>Eye diameter</td>
<td>Bony interorbital width</td>
</tr>
<tr>
<td>male</td>
<td>55.0</td>
<td>20.0</td>
<td>7.7</td>
<td>16.5</td>
<td>5.5</td>
<td>4.9</td>
<td>6.1</td>
</tr>
<tr>
<td>male</td>
<td>63.7</td>
<td>22.5</td>
<td>8.9</td>
<td>16.3</td>
<td>5.5</td>
<td>4.5</td>
<td>6.1</td>
</tr>
<tr>
<td>male</td>
<td>60.8</td>
<td>21.9</td>
<td>8.4</td>
<td>16.8</td>
<td>5.6</td>
<td>4.9</td>
<td>6.6</td>
</tr>
<tr>
<td>male</td>
<td>44.3</td>
<td>15.5</td>
<td>6.4</td>
<td>12.6</td>
<td>3.8</td>
<td>3.8</td>
<td>4.7</td>
</tr>
<tr>
<td>male</td>
<td>37.5</td>
<td>12.9</td>
<td>5.2</td>
<td>11.2</td>
<td>3.3</td>
<td>3.5</td>
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<td>5.0</td>
<td>10.8</td>
<td>3.3</td>
<td>3.1</td>
<td>4.7</td>
</tr>
<tr>
<td>female</td>
<td>32.5</td>
<td>10.4</td>
<td>4.5</td>
<td>9.6</td>
<td>3.0</td>
<td>3.4</td>
<td>3.4</td>
</tr>
</tbody>
</table>

A new species of rainbowfish (Melanotaeniidae: Melanotaenia), from Batanta Island, western New Guinea.
**Diagnosis:** A species of melanotaeniid rainbowfish distinguished by the following combination of characters: dorsal rays IV to VI, 1, 11 to 14; anal rays I, 19-22; pectoral rays 13 or 14; lateral scales 31-33 (usually 33); colour generally brownish on back (blue in life), pale tan or whitish below with blackish (bluish black in life) midlateral stripe from upper edge of preopercle to caudal-fin base, covering about one and a half scale rows for most of its length and more strongly contrasted in males.

**Description:** Dorsal rays IV-I, 12 (IV to VI-I, 11 to 14); anal rays I, 8 (I, 19 to 22); pectoral rays 14 (13 or 14); pelvic rays I, 5; branched caudal rays 16 (14 to 16); lateral scales 32 (31 or 33); transverse scales 10 (one paratype with 9); predorsal scales 17 (15 to 17); cheek scales 18 (13 to 18); gill rakers on first arch 2+14 = 16 (1 to 3 + 13 to 15 = 14 to 18).

Body depth 2.8 (2.6-3.1), head length 3.3 (3.3-3.9), both in SL; greatest width of body 2.6 (2.3-2.7) in greatest body depth; snout length 3.0 (3.0-3.4), eye diameter 3.4 (2.8-3.6), interorbital width 2.7 (2.5-3.2), depth of caudal peduncle 2.0 (1.9-2.3), length of caudal peduncle 2.2 (1.8-2.1), all in head length.

Jaws about equal, oblique, premaxilla with an abrupt bend between the anterior horizontal portion and lateral part; maxilla ends just anterior to front border of eye; lips thin; teeth conical with slightly curved tips, extending on to outer surface of lips; teeth of upper jaw in 4-5 irregular rows anteriorly, reduced to a single row posteriorly, where they are exposed when mouth is closed; teeth in lower jaw in about 6 irregular rows anteriorly, reduced to 1 or 2 rows posteriorly; narrow row containing several small, conical teeth on vomer and palatines.

Scales of body cycloid, relatively large, and arranged in regular horizontal rows; scale margins smooth or slightly crenulate; predorsal scales extending forward to rear portion of interorbital space; preopercle with 3 scale rows between its posterior angle and eye.

First dorsal fin origin about level with anal fin origin; longest spines (usually second to fourth) of first dorsal fin 2.1 (1.9-2.6) in head length, its depressed tip not reaching or barely reaching spine of second dorsal fin in females and reaching to about base of second soft ray in mature males; longest rays (generally anterior ones in females and posterior ones in males) of second dorsal fin 1.7 (1.5-2.3) in head length, the depressed posterior rays extending about one-half length of caudal peduncle or less in females and full length of caudal peduncle in mature males; longest (middle rays in females, last 2 or 3 rays in males) anal rays 1.9 (1.7-2.0) in head length; pelvic fin tips when depressed reaching to base of first or second soft anal fin ray; length of pelvic fins 1.8 (1.4-1.8), of pectoral fins 1.5 (1.4-1.5), of caudal fin 1.3 (1.0-1.3), all in head length; caudal fin moderately forked, caudal concavity 4.5 (3.4-5.1) in head length.

**Colour of holotype in life** (Fig. 2): bluish with silvery reflections on upper third of body, individual scales with narrow dark blue margins; lower half of body whitish, although individual scales with grey centres; a blue-black stripe extending from upper preopercle to caudal-fin base, covering about one and a half scale rows for most of its length and more strongly contrasted in males.

The largest male paratype (WAM P. 31555-007, 63.7 mm SL), shown in Fig. 5 has a more uniform midlateral stripe with a silvery-white "halo" immediately above posterior one-third. Like the holotype, the portion of the midlateral stripe on the caudal peduncle is generally darker than the remainder of the stripe. The largest female specimen (USNM 391010, 37.4 mm SL) is shown in Fig. 3. Its general colour is similar to that of males.

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**Table II.** Summary of dorsal, anal, pectoral fin-ray, and lateral-scale counts for *M*. synergos and *M*. catherinae.

<table>
<thead>
<tr>
<th></th>
<th><strong>First Dorsal Fin</strong></th>
<th><strong>Soft Dorsal Rays</strong></th>
<th><strong>Soft Anal Rays</strong></th>
<th><strong>Pectoral Rays</strong></th>
<th><strong>Lateral Scales</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M</em>. synergos</td>
<td>IV 11 VI 3</td>
<td>11 12 13 14</td>
<td>19 20 21 22</td>
<td>13 14</td>
<td>31 32 33</td>
</tr>
<tr>
<td><em>M</em>. catherinae</td>
<td>IV 3 11 VI 12</td>
<td>4 11 3 1</td>
<td>4 10 18</td>
<td>11 8</td>
<td>1 2 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 16 12</td>
</tr>
</tbody>
</table>

|                |                      |
|----------------|----------------------|-------------------|
|                |                      |                   |                   |                   | 1 2 13           |
|                |                      |                   |                   |                   | 4 16 12          |

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A new species of rainbowfish (Melanotaeniidae: Melanotaenia), from Batanta Island, western New Guinea.

Fig. 2. Aquarium photograph of Melanotaenia synergos, male holotype, 55.0 mm SL, Wei Bin Stream, Batanta, Raja Ampat Islands. Photo by G. R. Allen.

Fig. 3. Aquarium photograph of Melanotaenia synergos, female paratype (USNM 391010), 37.4 mm SL, Wei Bin Stream, Batanta, Raja Ampat Islands. Photo by G. R. Allen.

Fig. 4. Melanotaenia synergos, preserved male, holotype, 55.0 mm SL, Wei Bin Stream, Batanta, Raja Ampat Islands. Photo by G. R. Allen.
Fig. 5. Aquarium photograph of *Melanotaenia synergos*, male paratype (WAM P. 31555-007), 63.3 mm SL, Warey River, Batanta, Raja Ampat Islands. Photo by G. R. Allen.

Fig. 6. Aquarium photograph of *Melanotaenia synergos*, male, approx. 70.0 mm SL, collected and photographed 1992 at Warey River, Batanta, Raja Ampat Islands. Photo by H. Bleher.

Fig. 7. Aquarium photograph of *Melanotaenia synergos*, female, approx. 70.5 mm SL, Aquarium population (approx. F10) from Warey River, Batanta, Raja Ampat Islands. Photo by N. Khardina taken at Mr. Marcel Dielen's home, Belgium.
but the midlateral dark stripe is slightly narrower and less vivid. It also exhibits a yellowish white streak immediately below the midlateral dark stripe immediately behind the pectoral fin base and there is a diffuse bluish stripe immediately below across the belly region. The fins are generally clear.

The new species was also illustrated in colour by Bleher (1992) who collected the first live examples for the aquarium trade from the Warey River, western Batanta in 1992 (Fig. 6). The same stock still exists in the European aquarium hobby (Fig. 7).

**Colour of holotype in alcohol** (Fig. 4): upper third of body light brown, lower half tan to whitish; a diffuse blackish stripe, occupying about 2 scale rows extending from pectoral region to caudal-fin base; extending forward as relatively narrow stripe from upper pectoral-fin base to rear edge of eye; dorsal surface of head brown, cheek and opercle pale yellowish; fins translucent dusky grey, the dorsal fins slightly darker.

The paratypes are similar, but most have a narrower midlateral stripe that covers only a single scale row for most of its length, widening to about two scales on the caudal peduncle. Several of the smaller (<about 45 mm SL) male paratypes have a series of about 8 to 10 narrow grey bars on the body, just below and joining the midlateral stripe. The USNM M female is overall pale yellowish with just a hint of the brownish back and dark midlateral stripe.

**Sexual dimorphism**: Similar to most *Melanotaenia*, males are generally deeper bodied and have a more elongate, somewhat pointed shape posteriorly on the soft dorsal and anal fins. In addition, the depressed first dorsal fin of adult males overlaps the second dorsal fin in males, but falls short of this point or barely reaches it in females. The body depth (as percentage of the standard length) of 26 males, 28.9-63.7 mm SL, ranged from 31.3-38.0 with an average of 35.0; that of 13 females, 27.2-37.4 mm SL, was 29.5-33.4 with an average of 33.8. However, if the females are compared with similar-sized males (7 specimens, 28.9-37.5), there is no difference between sexes with the body depth of both males and females averaging 33.8 % of the SL. The smallest individual with detectable ova was 27.2 mm SL and the smallest male exhibiting

**Table III. Mean Kimura 2-parameter divergences between rainbowfish species for cytochrome b.**

<table>
<thead>
<tr>
<th></th>
<th><em>M. catherinae</em></th>
<th><em>M. catherinae</em></th>
<th><em>M. synergos</em></th>
<th><em>M. batanta</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Wet Sam Creek</em></td>
<td>0.006</td>
<td>0.024</td>
<td>0.124</td>
<td>0.155</td>
</tr>
<tr>
<td><em>Kali Raja</em></td>
<td>0.027</td>
<td>0.130</td>
<td>0.169</td>
<td>0.169</td>
</tr>
<tr>
<td><em>M. synergos</em></td>
<td>0.128</td>
<td>0.130</td>
<td>0.169</td>
<td></td>
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<tr>
<td><em>M. batanta</em></td>
<td>0.170</td>
<td>0.130</td>
<td>0.169</td>
<td></td>
</tr>
<tr>
<td><em>M. affinis</em></td>
<td>0.130</td>
<td>0.130</td>
<td>0.169</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 8.** Aquarium photograph of *Melanotaenia catherinae*, male (WAM P.31560-001), 74.3 mm SL, Marur River, western Waigeo, Raja Ampat Islands. Photo by G. R. Allen.
secondary sexual characteristics (elongate first dorsal fin and pointed shape posteriorly of anal and second dorsal fins) was 28.9 mm SL. Judging from the first author's experience with aquarium-raised Melanotaenia spp., sexual maturity is probably reached before the end of the first year.

**Comparisons:** Meristic, morphological, and genetic data (see DNA analysis section below) indicate that the new species is most closely allied to *M. catherinae* (Fig. 8) from the nearby island of Waigeo. Only a few modal differences were detected, the most prominent of these involving counts for pectoral-fin rays and lateral scales (Table II). *Melanotaenia synergos* had 58% of specimens with 13 pectoral-fin rays and the remainder with 14 rays. By comparison, only 12.5% of specimens of *M. catherinae* possessed 13 rays and 87.5% had 14 rays. Similarly, 84% of *M. synergos* specimens had 33 lateral scales with the remainder possessing 31 or 32 scales. In contrast, 62.5% of *M. catherinae* specimens had 31 or 32 scales with the remainder characterised by 33 scales.

The two species also share similar live colour patterns, basically bluish on the back and whitish below with a bluish black midlateral stripe. However, closer inspection reveals that the new species generally has a narrower stripe that is about one and a half scales wide over most of its length compared to the 2 to 3 scale width in *M. catherinae*. In addition, the midlateral stripe of the latter species tends to be slightly darker.

**DNA analysis:** A total of 15 individuals from 4 populations (Table III) were sequenced for 1,140 bp of cytb. Of 1,140 bp, 900 were constant, 96 variable characters were parsimony uninformative, and 144 characters were parsimony informative. A heuristic search via MP with all characters weighted equally recovered one most parsimonious

![Fig. 9. Maximum likelihood tree for rainbowfish species based on analysis of cytochrome b sequences (1,140 bp) sampled from 15 individual fish. Branch lengths were estimated using maximum likelihood assuming the TrN + I + G model of evolution. Bootstrap values were obtained from 1,000 replicates from Maximum Parsimony and Maximum Likelihood (M P / M L). The tree was rooted with *Melanotaenia affinis*.](image-url)
Within population variation was typically low, with one individual from both Wei Bin and Wei Sam populations being different by one base pair. No variation was found within the Kali Raja population of M. catherinae or within M. batanta (Fig. 10). Some variation exists within Waigeo Island with the two M. catherinae populations differing by 0.6% (Table III). Between species the mean Kimura 2-parameter genetic divergences varied between 1.3% and 17.1%, with the new species differing from M. catherinae by between 2.4% and 2.7% (Table III). These levels of genetic divergence, while not particularly large, are similar to those between many other rainbowfish species. Based on the first 601 bp of cytb most pairwise species comparisons within the "australis", "macullochi", and "nigrans" species groups (clades A-C respectively in McGuigan et al. 2000) differ by only 2% to 5% (15 species total; Unmack 2005). In northern New Guinea Glossolepis maculosus Allen, 1981 and G. ramuensis Allen, 1985 also differ by 2% (Unmack 2005) and many other closely related species from New Guinea are yet to be examined genetically, but will likely have similar divergences. Thus, the levels of divergence found between M. catherinae and M. synergos are well within the range for the family Melanotaeniidae.

**Zoogeography and habitat:** The new species is endemic to Batanta, which is in the Raja Ampat Islands, and lies 36 km from Sorong near the western extremity of New Guinea (Fig. 1). The Raja Ampat Group is spread over a huge area, roughly 48,000 km² and contains hundreds of variable sized islands. The four largest, which include Batanta, Waigeo, Salawati, and Misool, were formerly connected to the mainland of New Guinea and support extensive freshwater habitat. Salawati is separated from the mainland by a narrow, shallow channel that averages less than 3 km in width. Not surprisingly, it is inhabited by a melanotaenid species that also occurs on the mainland, M. fredericki (Fowler, 1939) (Fig. 10, upper). Misool Island lies about 70 km southwest of Salawati, being separated by shallow seas (less than about 80 m depth) that were exposed dry land as recently as the last Pleistocene sea lowering. It is inhabited by M. misoolensis Allen, 1982 (Fig. 10, lower) as well as the only non-mainland populations of freshwater catfish (Plotosidae: Neosilurus) and grunter (Terapontidae: Hephaestes).

Unlike Salawati and Misool, the islands of Batanta and Waigeo are separated from the mainland by deep water and support mainly oceanic insular freshwater fishes, particularly sicydiine gobiiids such as Sicyopterus, Sicyopus, and Stiphodon. According to the paleogeographic reconstruction
of the southwest Pacific by Hill & Hall (2003) the two islands have oceanic origins and drifted south and then westward along the northern edge of the New Guinea/Australia continental block to their present position. It is not entirely clear how melanotaeniids reached these islands as deep marine waters form an insurmountable barrier to this family. One possible explanation is that the islands collided with the northern New Guinea craton and were temporarily docked before breaking loose to continue their westerly drift. This theory is strengthened by the apparent relationship between the rainbowfishes of these islands and *M. affinis*, which is widely distributed along New Guinea’s northern coast. Moreover, the sicydine-dominated fauna of the islands is very similar to that of steep gradient coastal watersheds of the northern New Guinea mainland.

It appears that a single species, *M. catherinae* (De Beaufort, 1910) inhabits Waigeo, although much of this 125 km long island remains unexplored. Batanta Island lies about 35 km directly to the south across the Dampier Strait. The island is long (61 km) and slender (averaging less than 10 km in width) and mountainous with a maximum elevation of about 1,050 m. It is separated from Salawati by the Sagewin Strait, which averages only 5 km in width, but has impressive depths to 521 m. The southern, Salawati-facing slopes are steep and drained by numerous small, steep gradient creeks, but no rainbowfishes occur there. The opposite side of the island is also steep, but is dissected by a few gradual valleys. Melanotaeniids have been collected from three of these *M. synergos* from the Wei Bin (type locality) and Warey River, at the respective eastern and western ends of the island. And a second species of rainbowfish, *M. batanta* Allen & Renyaan, 1998 (Fig. 10, middle), that although is allied to *M. catherinae* and *M. synergos*, but genetically well-separated from them (Table III), is from the Warmon Stream at the northern-central Batanta Island region.

The following key differentiates the five species of *Melanotaenia* that inhabit the Raja Ampat Islands.

**Key to the species of *Melanotaenia* of the Raja Ampat Islands**

1a. Maximum width of midlateral dark stripe on side usually covering a single scale row and poorly defined ........................................... 2

1b. Maximum width of midlateral dark stripe on side usually covering two or more scale rows and well defined ........................................... 3

2a. Cheek scales 17-20; dorsal rays usually 13 (occasionally 12 or 14) (western Bird’s Head Peninsula and Salawati Island) .......................... .................................................. *M. fredericki*

2b. Cheek scales 11-13; dorsal rays usually 14 (occasionally 13 or 15-16) (Batanta Island) ... .................................................. *M. batanta*

3a. Midlateral dark stripe on side not continuous, interrupted in middle section; anal rays usually 22-25 (rarely 20-21) (Misool Island) .......................... .................................................. *M. misoolensis*

3b. Midlateral dark stripe on side continuous; anal rays usually 19-21 (rarely 22) ........................................... 4

4a. Midlateral dark stripe on side covering 1.5 scale rows over most of its length (Batanta Island) .......................... .................................................. *M. synergos n. sp.*

4b. Midlateral dark stripe on side wider, covering 3 scale rows over most of its length (Waigeo Island) .......................... .................................................. *M. catherinae***
The habitat (Fig. 11) of M. synergos consists of narrow (to about 15-20 m wide), clear rivers with gradual gradients flowing initially through second growth forest, but entering primary, nearly closed-canopy forest after about 1 km upstream from the sea. The type specimens were collected from deeper pools (to about 2-3 m) over limestone cobble/gravel bottoms with slow to moderate flow rates. Temperature and pH values of 25.5 °C and 8.7 respectively were recorded at the type locality.

Etymology: The new species is named synergos to honour Peggy Dulany on the twentieth anniversary of the Synergos Institute, which she founded in 1986 to create a more just and equitable global society in which all individuals, families and communities have a meaningful opportunity to improve the quality of their lives for themselves and future generations. It is treated as a noun in apposition.

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