Managing Editor:
Heiko Bleher
Via G. Falcone 11,
27010 Miradolo Terme (PV), Italy
Tel.: +39-0382-754707
Fax: +39-0382-754129
E-mail: heiko@aquapress-bleher.it
www.aqua-aquapress.com

Scientific Editor:
Friedhelm Krupp
Curator of Fishes
Senckenberg Research Institute
and Natural History Museum
Senckenberganlage 25
60325 Frankfurt am Main, Germany
Tel: +49-69-7542.1255
Fax: +49-69-7542.1253
E-mail: fkrupp@senckenberg.de

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Two new species of Trimma (Gobiidae) from the central, western, and south Pacific

Richard Winterbottom

Department of Ichthyology & Herpetology, Royal Ontario Museum, 100 Queen’s Park Toronto, Ontario M5S 2C6; and Department of Zoology, University of Toronto, Toronto, Ontario M5S 3G5.

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Keywords
Ichthyology, systematics, Gobiidae, Trimma, new species, Pacific Ocean

Abstract
Two new species of the genus Trimma are described. Trimma milta n. sp. is characterized by the presence of scales in the predorsal midline, an unbranched fifth pelvic fin ray which is about half the length of the fourth ray, a lack of elongate spines in the first dorsal fin, a red-brown or yellowish coloration, usually with the scale pockets clearly outlined with melanophores and chromatophores, and, at least in adults, two to three scales on the upper portion of the opercle. Trimma woutsi is distinguished by a white saddle along the dorsal margin of the pectoral base, large irregular spots on the head and body, an elongate dorsal spine, no predorsal scales, and a fifth pelvic fin ray which branches dichotomously 2-3 times.

Zusammenfassung

Résumé
Deux espèces nouvelles du genre Trimma sont décrites. Triba milta n. sp. est caractérisée par la présence d'écaillles sur la ligne médiane prédorsale, un cinquième rayon pelvien non ramifié faisant à peu près la moitié du quatrième rayon, l’absence de rayons épineux allongés à la première nageoire dorsale, une coloration brun-rouge ou jaunâtres avec les poches écaillueuses généralement soulignées par les mélanophores et les chromatophores de façon nette et, au moins chez les adultes, la présence de deux ou trois écailles sur la partie supérieure de l’opercule. Trimma woutsi se distingue par une tache blanche en forme de selle à la partie dorsale de la base de la pectorale, de grandes taches irrégulières sur la tête et le corps, une épine dorsale allongée, pas d’écailles prédorsales, et un cinquième rayon pelvien ramifié, ses branches divisées deux ou trois fois.

Sommarion
Vengono descritte due nuove specie del genere Trimma. Trimma milta n. sp. è caratterizzata dalla presenza di scaglie sulla linea predorsale mediale, un quinto raggio pelvico non ramificato lungo circa la metà del quarto, l’assenza di raggi spinosi allungati nella prima pinna dorsale, una colorazione rosso-bruna o giallastra, generalmente accompagnata da scaglie marginate di melanofori e cromatofori, e, almeno negli adulti, due o tre scaglie sulla parte superiore dell’opercolo. Trimma woutsi si distingue per una macchia bianca a cavallo del margine dorsale della base della pinna pettorale, grandi macchie irregolari sul capo e sul corpo, un raggio spinoso dorsale allungato, assenza di scaglie predorsali e un quinto raggio pelvico che si ramifica 2-3 volte.

Introduction
Trimma contains some 80 species of small (<30 mm SL), often colourful, gobids, primarily associated with Indo-Pacific coral reefs. A total of 36 names has been proposed for members of this genus. Of these, two are junior synonyms (T. capostrata (Goren 1981) = T. striatus (Herre 1945), and T. caudomaculata Yoshino and Araga in Masuda, Araga and Yoshino 1975 = T. tevegae Cohen and Davis 1969). A third name is a junior subjective homonym (Gobius townsendii Boulenger 1897 is preoccupied by Gobius townsendii Eigenmann and Eigenmann, 1889), and has been renamed as T. winterbottomi by Randall and Downing (in Randall et al., 1994). Further studies have revealed that T. necopinnus (Whitley 1959), considered a junior synonym of T. macrophthalma by Winterbottom (1984).
on the basis of personal communication from Hoese, is a valid species, and the same appears to be true of T. flammneum (Smith, 1959), which was also considered a junior synonym of T. macrophthalma in the work cited above. Thus, 33 of the described species of Trimma are currently recognized as valid. Finally, as hinted in Winterbottom (1984: 699), T. eviotops has been removed from Trimma and placed in Trimmatom (Winterbottom, 1989), and is thus not included in the above total.

The purpose of this paper is to provide names for two new species of the genus. Descriptions are confined to meristic values and colour patterns. Little modification of the diagnosis of Trimma from that given by Winterbottom (1984) is necessary. The genus may be distinguished from other gobid genera by its small size (<30 mm SL), lack of cephalic sensory canal pores, much reduced cephalic sensory papillae pattern, wide gill opening extending to below the vertical limb of the preopercle or, more usually, anterior to this, lack of spicules on the outer gill rakers of the first gill arch, less than 12 dorsal and anal fin rays, and a fifth pelvic fin ray that is equal to or more than half the length of the fourth pelvic fin ray.

Methods

Methods are standard (Hubbs and Lagler, 1964) except for the following: the last fin ray of the second dorsal and anal fin, although split through its base, articulates with the elements of a single pterygiophore and is counted as a single element; lateral scale counts are made along the midlateral row from the scale abutting the inner base ('armpit') of the pectoral fin to the scale reaching or covering the posterior margin of the hypural plate; transverse scale counts begin at the (usually small) scale adjacent to the anal spine and are made forwards and upwards to the last scale adjacent to the dorsal fin bases (counted as 1/2 where that scale is half the height of the previous scales in the series) for the anterior transverse scale count and backwards and upwards for the posterior transverse scale count; lower gill raker counts include any developed rakers on the first hypobranchial as well as all those on the ceratobranchial (including the raker in the ‘angle’ between epi- and ceratobranchials, which arises from the latter bone). Pectoral and pelvic fin ray branching is described from cleared and stained material. Pelvic fin ray branching is called sequential where the outer branch is shorter than the more medial branch and dichotomous where the two branches are of equal length.

Meristic values for the holotype are shown in bold where relevant.

Institutional abbreviations for repositories of the material examined follow Leviton et al. (1985).

Trimma milta n. sp.
(Figs. 1-4)

Material examined

All type series specimens collected off Moorea, Society Islands, unless otherwise stated.


Paratypes: AMS I. 39772-001, 32 (7.8-19.4 mm SL), N.E. tip of pass out of Cook Bay (17º28'41.6"S, 149º49'22.3"W), vertical coral rock wall of gulley and adjacent sand/rubble bottom, 6-14 m, R. Winterbottom and R. Mooi, 15 Dec. 1989; BPBM 8617, 5(14.2-18.3 mm SL), Papetoa Bay, Point Papeere, outer edge of inshore reef, 12-15 m, J. E. Randall, 14 Sept 1967; BPBM 9410, 2 (19.8-21.4 mm SL), Tahiti, Papara, Teavaraa Pass, S.E. side in 12-15 m, J. E. Randall and C. Walters; CAS 59921, 11 (9.7-14.7 mm SL), Tahiti, Papeari District, Hotumatau Pass (17º45'07"S, 149º20'27"W), coral wall with sand bottom, 8-11 m, Bingham et al., 8 Jul. 1957; MNHN 1991-0093-0102, 10 (9.9-19.2 mm SL), data as for ROM 59752; ROM 59748, 6 (12.8-15.6 mm SL), S.E. end of Cook Bay.

Fig. 1. Trimma milta n. sp., freshly collected specimen selected to represent the predominant coloration. Moorea, Society Islands (ROM 59751, 22.1 mm SL paratype). Photo by R. Winterbottom
500 m S. of Teva Aquarium (17º31’S, 149º49’W), patch reef with rubble, sand, and silt on a 200 slope, 14-20 m, R. Winterbottom, W. Holleman, R. Mooi, and R. Steger, 4 Dec. 1989; ROM 59749, 17 (9.7-17.6 mm SL), lagoon slope just E. of Cook Bay (17º29’00’S, 149º48’48”W), coral rock with sand and rubble bottom, 12-18 m, R. Winterbottom, R. Mooi, and W. Holleman, 8 Dec. 1989; ROM 59751, 48 (11.1-23.6 mm SL), collected with the holotype; ROM 59752, 47 (7.9-19.8 mm SL), halfway down W. side of Oponohe Bay off green beacon (17º30’24”S, 149º51’24”W), vertical coral rock wall and adjacent soft sand/mud slope, 9-21 m, R. Winterbottom, R. Mooi, and W. Holleman, 11 Dec. 1989; ROM 59753, 1 (19.6 mm SL), outer reef 300 m W. of pass out of Cook Bay (17º28’37”S, 149º49’45”W), broad gully (15 m wide) with coral, rock, and coarse sand, with gently sloping sides, 30% live coral (Acropora, Porites), 21-26 m, R. Winterbottom, W. Holleman, and R. Mooi, 13 Dec. 1989; ROM 59754, 39 (7.5-18.8 mm SL), N.W. tip of Cook Bay off green channel marker (17º29’15.8”S, 149º49’28”W), vertical coral rock wall with sandy-floored caves and sloping ledges 6-15 m, R. Winterbottom, R. Mooi, and R. Steger, 17 Dec. 1989; ROM 59816, 34 (7.4-19.5 mm SL), W. side of pass off Maharepa at about middle of pass (17º29’24”S, 149º48’00”W), steep slope and 3 m wall with coral, rubble, sand and silt, 12-18 m, R. Winterbottom and R. Mooi, 5 Dec. 1989; ROM 1307CS, 10 (10.2-17.9 mm SL), cleared and stained specimens, data as for ROM 59752; USNM 315086, 10 (9.3-19.4 mm SL), data as for ROM 59752.


Diagnosis:
A species of Trimma with a concave bony interorbital less than half the pupil diameter in width, the scale pockets usually strongly outlined with chromatophores (if not, chromatophores fairly evenly distributed over head and body), 6-8 scales in the midline of the predorsal region and 2-3 cycloid scales on the upper margin of the opercle (may be absent in juveniles), fifth pelvic fin ray unbranched and about half the length of the fourth, no trough or groove posterior dorsal to the eye, epaxial musculature reaching anteromedially to a point in line with the posterior margin of the pupil in adults, and no greatly elongated spines in the first dorsal fin (longest spine reaching to, or slightly beyond, origin of second dorsal fin when fin is depressed).

Description
The description is based primarily on the holotype, and 19 other specimens (90, 10 R) from ROM 59751.

Dorsal fins VI + 1 9, second and third spines longest but not elongate, reaching to about the origin of the second dorsal fin when depressed, first ray of second dorsal usually branched; anal fin I 8, first ray usually unbranched; pectoral fin 17-18 (x = 17.3), at least the upper 3 and lower 4 unbranched, although all rays may be unbranched in small specimens (about 11 mm SL); pelvic fin I 5, first four rays with a single segmental branching pattern, fifth ray unbranched, and about half the length of the longer of the two branches of the fourth ray, no frenal, basal membrane one tenth the length of the fifth pelvic fin ray.

Lateral scales 22-23-24 (x = 23.1, 22 once); predorsal scales 6-7-8 (x = 7.1); posterior transverse scales 7; posterior transverse scales 6 1/2; nape, opercle, pectoral fin base, breast, and midline of belly with cycloid scales, ctenoid scales posterior to a line between the upper opercular margin and the origin of the first dorsal fin; opercle with a single horizontal row of two to three scales across upper margin; pectoral base margined by four scales.

Teeth of the outer row of the upper jaw, and of outer and inner rows of the lower jaw, consist of enlarged, curved, spaced canines, with several irregular rows of small conical teeth behind the outer rows. Tongue broadly rounded, about half pupil diameter in width. Gill opening extending ventrally to below midpoint of pupil; outer gill rakers of first gill arch 3-4 + 12-14-15 (x = 3.2 + 13.7). Anterior nasal opening a short tube, posterior nasal opening pore-like with a raised rim, nasal sac slightly raised, with nasal apparatus confined to the anterior half of the snout. A shallow interorbital trough; none posterior dorsal to the eye; bony interorbital width equal to about half pupil diameter; epaxialis musculature reaching anteriorly to above posterior margin of pupil.

Colour pattern, freshly collected (based on 35 mm colour slides of 4, 19.2-22.1 mm SL, and 4 R, 14.7-19.2 mm SL): overall color brownish red with centres of scales a lighter orange-red, mingled with melanophores, especially on head and anterior body. First dorsal fin with a row of yellow spots just distal to the base of the fin, one spot on each spine, or spots tending to coalesce to form a yellow stripe, rest of fin membrane sprinkled with melanophores. Second dorsal fin with a similar row of yellow spots on each fin ray (not forming a stripe); some individuals with an additional but more diffuse row of yellow spots centred on the fin rays in the region of the first branch;
rest of fin sprinkled with melanophores. Caudal fin membrane with melanophores, and with 0-3 vertical rows of light yellow spots. Anal fin with melanophores, sometimes a diffuse light yellow band or a few yellow spots just distal to the fin base. Pectoral and pelvic fins hyaline. Iris red with dark patches. Two very diffuse lighter bars under eye, a third along the vertical limb of the preopercle. The scale pockets on the body are usually outlined with melanophores and chromatophores. One specimen (R, 19.2 mm SL) more yellowish than the others, with the three light cheek bars better defined.

**Preserved coloration:** (ethyl alcohol) scale margins and pockets and the head with dark brown chromatophores and melanophores, centres of scales and yellow spots/stripe pale. The degree of chromatophore/
melanophore intensity decreases posteriorly along the body, where some specimens are pale straw-coloured. Two to four narrow transverse bands of melanophores across dorsal rim of orbit usually present.

**Distribution**

*Trimma milta* has been found off western Australia, Great Barrier Reef, Timor Sea, Papua New Guinea, Solomon Is., Indonesia, Philippines, Taiwan, Marshall Is., Caroline Is., Hermits Is., Fiji, Hawaii, and Society Is. The specimens have been collected at depths of 9-26 m off coral rock walls and reefs, and in areas with a sand/rubble bottom.

**Etymology**

From the Greek *miltos*, meaning red earth, in allusion to the predominant ground colour of the new species and the colour of the topsoil of the islands in the type locality. To be treated as a noun in apposition. *Trimma milta* has been referred to informally as *Trimma RW 34*.

**Affinities**

This species belongs to a complex of species possessing a bony interorbital width equal to or less than half pupil diameter, a scaled predorsal region, and scale pockets on the body usually outlined with chromatophores and/or melanophores. *Trimma milta* is the only species in the complex which possesses opercular scales and an unbranched fifth pelvic fin ray. It can be further distinguished from two as yet undescribed species. *Trimma RW SP 69* (western Pacific) has opercular scales, a branched fifth pelvic fin ray, an elongated second spine of the first dorsal fin, and more lower gill rakers on the outer surface of the first gill arch (15-16 vs. 13-14). *Trimma RW SP 51* (western Pacific) may occasionally have a few opercular scales, and a fifth pelvic fin ray 70-90% the length of the fourth pelvic ray and with a single, dichotomous branch.

*Trimma unisquamis* (Gosline, 1959) and *Trimmatom nanus* Winterbottom and Emery (1981) - new record - are the only other described species of this clade currently known from the Society Islands.

**Discussion**

Specimens of *T. milta* from the Great Barrier Reef have a slightly higher average pectoral-fin ray count ($\bar{x} = 17.8, n = 9$), lateral scale count ($\bar{x} = 23.9, n = 8$) and number of outer gill rakers ($\bar{x} = 3.8 + 14.4, n = 8$), whereas those from Western Australia were more similar in these values to the type specimens but differed in that two (of seven) specimens had eight (instead of nine) rays in the second dorsal fin. The fresh coloration of Australian specimens has yet to be recorded. A freshly collected, photographed specimen from Palau (BPBM 31456, 15.1 mm SL), a live specimen photographed and then collected at the same locality (ROM 70731, 14.2 mm SL), and some specimens from Hawaii (personal communication, R. Holcom via J. E. Randall), are bright yellow with a yellow stripe in each of the dorsal fins.

Other Hawaiian specimens are reddish brown anteriorly grading to yellow posteriorly (Randall, personal communication), whereas most individuals exhibit the reddish-brown colour found in the majority of the type specimens. One (of three) Hawaiian specimens had D VI + I 10, A I 9. In addition, specimens from Micronesia and the Hermits Islands do not seem to reach as large a size as those from elsewhere (maximum recorded SL was 18.2 mm vs. a maximum of nearly 24 mm SL from 7 other localities). Finally, none of the Micronesian /New Guinea specimens examined had the short transverse bars across the top of the eye that are present in most (but not all) specimens from other areas. Further studies may reveal additional and systematically significant differences.

**Trimma woutsi** n. sp.

(Figs. 5-8)

**Material Examined**

A total of 10 lots, 16 specimens; all specimens from the Marquesas Islands.

![Fig. 5. *Trimma woutsi* n. sp., freshly collected specimen, Marquesas Islands, Hiva Oa, (ROM 72562, 0, 23.6 mm SL holotype). Photo by J. E. Randall.](image-url)
Holotype: ROM 72562 (ex-BPBM 12112), 23.6 mm SL, Hiva Oa, N.W. side of Tepuhiaatuua Point, 1.5-9.1 m, J. E. Randall and D. Cannoy, 26 April 1971.

Paratypes: AMS I. 217690-020, 2 (9.9 - 16.2 mm SL), Anaho Bay, B. Goldman, 1976; AMS I 22015-008, 2 (13.2 - 14.1 mm SL), Nuku Hiva, Anaho Bay, B. Goldman, Aug. 1976; BPBM 11001, 1 (16.8 mm SL), Ua Huka, 0.4 miles N. E. of Motu Takatai, N. side of bay, 4.6 - 9.1 m, J. E. Randall, J. Haywood and R. McNair, May 7, 1971; BPBM 11827, 1 (14.7 mm SL), Fatu Hiva, off point on N. side of Hanauu Bay, J. E. Randall, D. Cannoy and R. McNair, Apr. 21, 1971; BPBM 12112, 4 (18.1 - 21.0 mm SL), Hiva Oa, N.W. side of Tepuhiaatuua Point, 1.5 - 9.1 m, J. E. Randall and D. Cannoy, Apr. 26, 1971; BPBM 12156, 1 (18.1 mm SL), Ua Pou, Hakahetau, S. side of bay, 10.7 m, J. E. Randall, Apr. 28, 1971; BPBM 12762, 1 (22.0 mm SL), Nuku Hiva, W. side of Sentinelle de l’Ouest, 30.5 m., J. E. Randall, D. Cannoy and D. Bryant, May 16, 1971; ROM 72563 (ex-BPBM 12112), 2 (20.8-21.0 mm SL), data as for holotype; ROM 1740CS (ex BPBM 12112), 1 (20.8 mm SL), data as for holotype.

Diagnosis
A species of Trimma with large irregular orange to brown spots on the head and body, and a bright white saddle along the dorsal margin of the pectoral base in life. No predorsal scales, second dorsal spine elongate, bony interorbital width 1/4 pupil diameter. A slight to moderate interorbital trench, no postorbital trench, a fifth pelvic fin ray which branches two to three times dichotomously and measures 70% of the length of the fourth ray.

Description
The description is based on the holotype and 15 paratypes.

Dorsal fins VI I 9-10 (\(\bar{x} = 9.2\)), all fin rays branched, second spine elongate reaching posteriorly to at least the base of the second fin ray or as far as the seventh fin ray of the second dorsal fin when depressed; anal fin I 9; pectoral fin 17-18-19, reaching posteriorly to a vertical line through the anal spine, uppermost two to four rays and lowermost one to five rays unbranched, with 10-13-15 branched rays in between; pelvic fin I 5, no frenum, basal membrane 20-75% the length of the fifth ray (often torn and difficult to determine), first four rays with 3-4 sequential branches (often with additional dichotomous branching in large specimens), fifth ray branched 2-3 times dichotomously, and 60-75% of the fourth, fourth ray reaching posteriorly to the base of the anal spine.

Lateral scales 24-26 (\(\bar{x} = 25.3\), n=16), anterior transverse scales 8-9-10, posterior transverse scales 7-8-9; no scales on head, cheek or opercle. Three to seven rows of cycloid scales on the pectoral base,

Figs. 6, 7. Trimma woutsi n. sp. live specimens, Marquesas Islands, south coast Nuku-Hiva, cave in 3-5 m. Specimens not collected. Photos by Philippe Bacchet.
scales on breast and belly cycloid. Body scales extending anteriorly as far as the posterior margin of the opercle. Ventral extent of gill opening varies from in line with posterior margin of pupil to mid pupil.

Teeth in both jaws consist of an outer row of curved, spaced, enlarged canines, with an inner row of numerous small conical teeth. Tongue usually rounded but occasionally truncate. Gill rakers on first arch 1-3 (1 once) + 11-12 = 13-15 ($\bar{x} = 2.6 + 11.8$). Anterior nasal opening a short narrow tube, posterior nasal opening a short wide tube. Bony interorbital 1/4 - 1/3 pupil width with a slight to moderate interorbital trench, no postorbital trench.

**Colour pattern in life** (based on colour photos of live specimens): head and body with large irregular, randomly spaced, orange to brown spots on a very translucent colourless to orange background. Spots are more clearly defined on the anterior half of the body and more distinct when background colour is lighter. A series of alternating dark and light internal blotches are visible along the vertebral column. Scale pockets outlined with brown chromatophores on specimens with heavier pigmentation. Dorsal fins orange with a yellow to orange stripe just above the base. Pectoral, caudal, dorsal, and anal fin rays orange.

**Preserved coloration:** (ethyl alcohol) background colour of head and body pale straw-yellow sprinkled heavily with brown chromatophores giving a very dusky effect. Scale pockets outlined with brown chromatophores, large, irregular, randomly spaced, light spots on nape, cheek, and pectoral base. A greater concentration of chromatophores present along the dorsal margin of the pectoral base where the white saddle is seen in living specimens. Chromatophores also present in the membranes of the dorsal and anal fins, paired fins are hyaline. Specimens preserved in isopropyl alcohol are lighter in colour but the pattern of light spots on the nape, cheek and pectoral base is still visible.

All fins of specimens preserved in isopropyl alcohol are hyaline.

**Distribution**

*Trimma woutsi* has to date been found only at the Marquesas Islands in the southeast Pacific. Specimens were collected between 1.5 and 30.5 m.

**Etymology**

Named for Wouter Holleman, friend, colleague, and indispensable field collaborator on many field trips, including Moorea in the Society Islands. Pronounced “votes-i”.

*Trimma woutsi* has been informally referred to as *Trimma* RW sp. 48 (in lit.)

**Affinities**

The meristic characteristics of *Trimma woutsi* n. sp., *T. flammeum*, and *T. macrophthalmalma* are very similar and all three species also share the pattern of spots on the head and body. However, the intensity and shape of the spots can be used to separate these species. When alive, *Trimma woutsi* has a bright white saddle along the dorsal margin of the pectoral base, which is not seen in the other two species. The spots on the head of *Trimma woutsi* are irregular in shape and spaced randomly so they often run together. The spots on *Trimma flammeum* and *T. macrophthalmalma* are very round, spaced well apart, and do not overlap. When preserved, this difference in the pattern of spots is still clear. In addition, *T. macrophthalmalma* has two very distinct round dark spots centred in light spots on the pectoral base, which neither *T. woutsi* nor *T. flammeum* possess. Unfortunately all three species when preserved have a small concentration of chromatophores along the dorsal edge of the pectoral base, so the white saddle seen on living specimens of *T. woutsi* cannot be used as an identifying character in preserved material.

**Acknowledgements**

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**Fig. 8. Trimma woutsi** n. sp., live specimen, Marquesas Islands, south coast of Nuku-Hiva, cave in 3-5 m. Specimen not collected. Photo by Philippe Bacchet.
Holcom) for making their slides and specimens available, and to Philippe Bacchet of Papeete, Tahiti, for permission to use his underwater photographs of T. woutsi. I am grateful to the collections managers and curators who have furnished specimens of Trimma for my studies. Special thanks to Margaret Zur (ROM) for her careful data gathering, summation, and initial draft of the manuscript. Field work was facilitated in part through grants from the ROM Foundation and a National Science and Research Council of Canada Grant OGP 0007619 to the author. This is Contribution # 240 from the Centre for Biodiversity and Conservation Biology of the Royal Ontario Museum.

References


Keywords
Cryptocentrus pavoninoides, shrimp gobies, sexual dichromatism, western Pacific

Abstract
Cryptocentrus pavoninoides (Bleeker, 1849), a little known gobioid species, is redescribed in detail from the holotype and eleven additional specimens collected from the Gulf of Thailand, Singapore, and southwestern Thailand (Andaman Sea). The species is characterized by two to five ovoid black spots between the first to sixth spines at the mid-height of the first dorsal fin, distinctive black pelvic fins, and blue spots on head. It exhibits sexual dichromatism in which the males have a brownish body background with three vague darker bars and scattered blue spots; while the females possess a yellow body background with 8-10 distinct brown bars and without blue spots along sides of the body. Sexual dichromatism in several other species of shrimp gobies is documented.

Zusammenfassung

Résumé
Cryptocentrus pavoninoides (Bleeker, 1849), une espèce de gobioïdes peu connue, est décrite à nouveau en détails d’après le holotype et onze spécimens supplémentaires récoltés dans le golfe de Thaïlande, à Singapour et au sud-ouest de la côte de Thaïlande (Mer d’Andaman). L’espèce est caractérisée par la possession de deux à quatre taches ovoïdes entre le premier et le sixième rayon épineux à mi-hauteur de la première nageoire dorsale, des nageoires pelviennes noires et des taches bleues sur la tête. Elle exhibe un dichromatisme sexuel en ce sens que les mâles ont le corps de couleur brunâtre avec trois barres foncées peu nettes et des taches bleues disséminées, tandis que les femelles ont le corps jaune avec 8-10 barres brunes bien tranchées, sans taches bleues sur les flancs. Le chromatisme sexuel de plusieurs autres espèces de gobies-crevettes est décrit.

Introduction
Gobius pavoninoides was described by Bleeker (1849) on the basis of a single specimen from Sumanap, “Madurae orientalis” (Indonesia). The species was illustrated in colour, as Cryptocentrus pavoninoides, in Bleeker’s Atlas, first published in 1983 (105 years after Bleeker’s death). Recent collection by the senior author of several specimens of a Cryptocentrus from the vicinity of Phuket, Thailand, similar in many respects to Bleeker’s species, prompted us to re-examine Bleeker’s holotype (RMNH 4473). Specifically, our specimens differed from Bleeker’s (1983)
illustration in having two or four dark ovoid spots on the
first dorsal fin at about half way along the length of the
spines (as opposed to five such spots situated just
below the distal margin of the fin) and in a longer pelvic
fin (reaching posteriorly from the origin of the pelvic fin
to between the anterior margin of the anus and the ure-
genital papilla vs. three quarters of the distance to the
anus). We therefore borrowed the holotype of Gobius
pavoninoides in order to make comparisons between it
and our specimens.

Cryptocentrus pavoninoides was reported for the first
time in Thai waters by Wongratana (1975). The speci-
men on which his report is based is not in good condi-
tion (body scales largely absent, and most fin mem-
branes torn), and had been preserved for about two
years in formalin before examination. Perhaps because
of this, that author was either misled or failed to diag-
nose the colour pattern correctly (particularly the mark-
ings on the body and dorsal fin - and especially his
report of three spots in the first dorsal fin - we find four
in his specimen), and this made it difficult to link it to
what we observed in our fresh specimens. Despite this,
we agree with his identification based on our observa-
tions on his specimen.

Methods
Methods for measurements and counts generally
follow Hubbs and Lagler (1947), except as follows: body
depth was measured vertically from origin of pelvic fin
spine; lengths of dorsal fin spines were measured
from their posterior bases to their posteriormost tips
when adpressed against dorsum; lateral scale counts
were taken along the midline of the sides of the body,
from the upper end of the pectoral fin base to the end
of the hypurals; anterior and posterior transverse scale
counts begin at the scale adjacent to the anal spine,
and are counted anterodorsally and pos- terodorsally,
respectively, to the last scale in the series (for speci-
mens with varying scale counts on either side of the
body, the lower values were recorded).

The examination of head pores, papillae, and the
number and disposition of scales was greatly facilit-
ted by using cyanine blue as described by Saruwatari et al. (1997).

Institutional abbreviations are as follows: Reference
Collection of Phuket Marine Biological Center, Thai-
lant (PMBC); Rijksmuseum van Natuurlijke Historie,
Leiden (RMNH); Royal Ontario Museum, Toronto
(ROM) and Zoological Reference Collection, National
University of Singapore (ZRC).

Cryptocentrus pavoninoides
(Bleeker, 1849)
(Figs. 1-6)

Gobius pavoninoides Bleeker, 1849: 33 (Sumanap,
Madurae orientalis).

Cryptocentrus pavoninoides Bleeker, 1983, pl. 437,
# 2; Koumans, 1941: 240; 1953: 83; Wongratana,

Material examined
Gobius pavoninoides holotype: RMNH 4473,105.1
mm SL R (137 mm TL), Sumanap, “Madurae orientalis”
(eastern end of Madura Island, Indonesia; about
7°01'S, 113°51'E).

PMBC 5645 (formerly Ph. 2906), 72.0 mm 0 (caudal
peduncle damaged by attachment of specimen label),
Bangkok Fish Market (probably from the eastern part
All the following specimens from the vicinity of
Phuket, Thailand, assigned to PMBC and ROM, were
collected with single-barb spear by U. Satapoomin.
PMBC 16120, 43.5 mm R, Cape Phanwa (7°47'43"N,
98°24'45"E), Phuket, 6 m, 8 March 2000. PMBC
16121, 75.4 mm 0, Cape Phanwa, 9 m, 10 January
2001. PMBC 16122, 73.8 mm R, same data as pre-
ceding. PMBC 16123, 68.2 mm R, Cape Phanwa, 8 m,
15 February 2001. PMBC 16124, 34.0 mm (sex unde-
termined), same data as preceding. PMBC 16125,

Fig. 1. Cryptocentrus pavoninoides, 75.4 mm SL 0, PMBC 16121, Phuket, Thailand. Photo by U. Satapoomin.
64.5 mm, sex not determined, Tangkhen Bay (7°48′47″N, 98°24′32″E), southeastern Phuket, 7 m, 15 February 2001. ROM 72475, 63.7 mm ♂, taken with PMBC 16122. PMBC 16163, 87.0 mm ♀, Cape Phanwa (7°47′55″N, 98°24′35″E), 9 m, 16 July 2001. ROM 72476, 65.4 mm ♂, Cape Phanwa, 8 m, 20 November 2000. ZRC 19660, 84.6 mm ♂, Sg. Punggol, Singapore, A. Rahman, 26 October, 1967.

Diagnosis
Cryptocentrus pavoninoides is most easily recognized by the presence of two to four (perhaps occasionally five) ovoid black spots between first to third, fifth (or sixth if five spots) spines at the mid-height of the first dorsal fin, and predominantly black pelvic fins. The head possesses a variable number of blue spots about one-third pupil diameter in width, and similar spots may occur on the body, most obviously in adult males. Adult females possess 8-10 distinct brown body bars on a yellow background. All scales are cycloid, and there are about 20-25 irregular scale rows across the predorsal midline. The pectoral fin has 17-18 rays (usually 18), all except the first branched.

Description
(values for holotype in bold where appropriate)
Dorsal fin VI + I, 11, third and fourth spines longest, tips of spines reaching to the base of second to fourth ray of the second dorsal fin when depressed, length of the longest spine in body depth 1.1-1.6 times (1.2, \( \bar{x} = 1.2 \)), all rays branched; anal fin I, 10, all rays branched; pectoral 17-18 (\( \bar{x} = 17.7 \)), only uppermost ray unbranched (all others branched), longest ray reaching posteriorly to a point just above the anterior margin of the anus; pelvic fin I, 5, rays sequentially branched although these individual branches may subsequently bifurcate, fourth and/or (usually) fifth ray(s) longest and of somewhat variable length, reaching posteriorly to a point between the anterior margin of the anus and the urogenital papilla; complete frenum and basal membrane; caudal fin 7 + 6 branched rays, vii - viii dorsal and vii - viii ventral unbranched caudal fin rays.

Scales cycloid, increasing in size from anterior to posterior on the body, those on predorsal region and anterior part of nape embedded. Lateral scales variable in number (possibly due to difficulty in counting accurately owing to irregular scale rows), about 73-80 (\( \bar{x} = 77.3 \)); anterior transverse scales 32-34 (\( \bar{x} = 32.7 \)); posterior transverse scales 26-31 (\( \bar{x} = 27.7 \)). Anterior extent of scales on nape somewhat variable, from above posterior otic pore to just posterior to this point; pectoral fin base naked or with small cycloid scales on ventral two-thirds of the fin base anterior to the fin rays; breast scales continuous with body scales; body scales extend anteroventrally to below the preopercular pores, and reach the extreme ventral margin of the pectoral fin base or dorsally above this.

First gill slit open; gill membranes fused to the sides of isthmus a little lateral to the midline; gill rakers on outer limb of first arch 3-5 + 12-13, (\( \bar{x} = 4.2 + 12.7 \)). Mouth slightly inclined dorsally, tongue broadly rounded. Teeth: upper jaw with a complete outer row of enlarged, curved caniniform teeth, decreasing in size posteriorly, with an inner row of about six smaller pointed teeth near the symphysis, about four irregular rows of small conical teeth in between; lower jaw teeth with a short row of 6-8 curved, enlarged caniniform teeth increasing in size from the symphysis, a complete innermost row of teeth subequal to the symphysial outer row, and 3-4 irregular rows of small, slender, slightly curved, conical teeth between them. Vertebræ 10 + 15 + ural complex = 26.

As percentage SL: head length 26.1-29.2 (27.9, \( \bar{x} = 27.9 \)); predorsal length 29.2-34.9 (32.4, \( \bar{x} = 32.4 \)); snout to origin of anal fin 56.8-64.9 (\( \bar{x} = 61.0 \)); caudal peduncle length 17.0-18.7 (18.3, \( \bar{x} = 18.0 \)); caudal peduncle depth 10.8-12.5 (\( \bar{x} = 11.5 \)).

As percentage head length: eye diameter 20.1-24.3 (\( \bar{x} = 23.4 \)); snout length 19.4-26.4 (22.9, \( \bar{x} = 21.6 \)); tip of upper lip to posterior end of upper lip 44.9-48.9 (47.4,

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**Fig. 2. Cryptocentrus pavoninoides**, 73.8 mm SL ♂, PMBC 16122, Phuket, Thailand. Photo by U. Satapoomin.
least distance between margin of upper jaw and eye 10.0-13.5 (11.2, \(x = 11.8\)).

Anterior nasal opening broad and at the tip of a short, posterior opening in the anterior half of a large pit. Cephalic sensory canal pores (all pores paired except where stated; Akihito et al.'s 1988 nomenclature in parentheses): nasal (B); median anterior (C) and median posterior (D) interorbital; supraotic (E); anterior (F) and posterior (G) otic; intertemporal (H); anterior (K) and posterior (L) temporal; dorsal (M), middle (N), and ventral (O) preopercular. Nasal openings, pores, and papillae positioned as shown in Fig. 3; up to three extra (ancilliary) lines may be interspersed between those radiating from the posteroverentral margin of the orbit shown in the figure.

**Colour pattern, freshly collected**

(Figs. 1-2, 4-5)

A 75.4 mm SL \(0\) (PMBC 16121; Fig. 1): head and body brownish (darker above), with three, eye-diameter-wide, vague bars (first below first dorsal fin, second below rays 1-4 of second dorsal fin, third below last two rays of second dorsal); a total of about 23 blue spots (some with darker rims) on cheek, jaws and opercle, approximately one-third pupil diameter in width, similar blue spots scattered on nape, pectoral fin base, and body as far back as the bases of the caudal fin rays. First dorsal fin rusty brown, tipped with a thin orange-yellow stripe, pale spots (similar in size to those on the head) on the proximal half of the fin; four vertically elongate, black, oval spots in the membranes between spines 1-5 about half-way up the length of the fin, the first and third about pupil diameter at their greatest axis, the second about equal to width of pectoral fin base (but ventral section diffuse and attenuated), fourth spot about pupil diameter in height. Second dorsal fin translucent with a narrow, irregular yellow stripe at its distal tip and four reddish stripes (interrupted by shafts of fin rays and becoming very irregular posteriorly), each stripe with a fain dark margin, proximal stripe narrowest and distal stripe broadest, stripes fragment posteriorly on fin. Caudal fin with upper principal rays margined with yellow, fin rays hyaline with narrow stripes of red or yellow separated by clear stripes in the interradial membrane parallel to the axes of the rays. Anal fin dusky purple, light yellow proximally. Pectoral fin hyaline; pelvic fin black, with lighter margins.

A 73.8 mm SL \(R\) (PMBC 16122; Fig. 2): essentially as above, but with the following differences: 10 distinct brown bars about one-fourth to three-fourths eye diameter in width (plus 3 faint bars in the peduncular region), widest bar beneath second to third rays of second dorsal fin, (the last bar, below three penultimate rays of the second dorsal fin, subequal in width but with diffuse edges), those below first dorsal fin about equal to interspaces, the two or three anterior-most bars slightly oblique, oriented anterodorsally to posteroverventionally; first dorsal fin without pale spots but with four dark oblong ovals between spines 1-5; no blue spots on body posterior to pectoral fin base; anal fin with a thin, diffuse yellow stripe at the base, dusky purple distal to this (but not as dark as in the male described above).

A 63.7 mm SL \(R\) (ROM 72475; Fig. 4): essentially similar, with eight brown body bars; only two dark oval spots in the first dorsal fin (between first and third spines), a few indistinct blue spots on body below origin of first dorsal fin, proximal two-thirds of anal fin yellowish, and outer third dusky purplish.

A 43.5 mm SL \(R\) (PMBC 16120; Fig. 5): with a yellow-brown cast, the body bars very faint and diffuse, fewer blue spots on head but scattered diffuse blue spots on the body posteriorly as far as the base of the last dorsal fin ray; margin of the first dorsal fin orange, the rest of the fin pale yellow-orange with scattered light spots, four dark spots, the third and fourth paler than in the other specimens with four such spots; and anal fin yellowish with a relatively narrow, diffuse, distal black stripe.

**Preserved coloration**

The basic patterns in ethanol remain the same, but the reds, blues, and yellows have faded to light straw-yellow or pale areas.

The first dorsal fin of the holotype (Fig. 6) exhibits no trace of the fifth dark spot between the fifth and sixth dorsal spines that is shown in Bleeker's (1983) illus-
tion, although the other four spots are still evident. It is not clear to us whether the illustration is inaccurate in this respect, whether this fifth spot has faded (unlikely in our opinion), or whether the section of the interradial membrane bearing the spot has been destroyed (a possibility we also view as unlikely because the remaining membrane appears to have been split rather than having had a section excised). Suffice it to say that we have not as yet seen any specimens in which a fifth spot in the first dorsal fin is observable.

The rest of the specimen is faded to yellow-brown, with no colour pattern discernible. The hyaline ocelli in the second dorsal fin mentioned in Bleeker’s original description we here regard as the background pattern to the reddish stripes in that fin mentioned above. We found sexing the holotype on the basis of the urogenital papilla ambiguous because the papilla forms an almost equilateral triangle; however, the colour pattern, as illustrated by Bleeker (1983), clearly identifies it as female, based on our other specimens.

**Fig. 4.** Cryptocentrus pavoninoides, 63.7 mm SL (ROM 72475), Phuket, Thailand. Photo by U. Satapoomin.

**Fig. 5.** Cryptocentrus pavoninoides, 43.5 mm SL (PMBC 16120), Phuket, Thailand. Photo by U. Satapoomin.

**Fig. 6.** Cryptocentrus pavoninoides, first dorsal fin of holotype (RMNH 4473, 105.1 mm SL), dashed lines indicate the extent of remaining interradial membranes. Scale = 1 cm. Drawing by R. Winterbottom.
Taxonomy
We place the species in Cryptocentrus primarily because the genus has traditionally been in wide use. At the present time we know of no synapomorphies to define it as monophyletic.

There are several genera of shrimp gobies with transverse rows of cheek papillae. Amblyeleotris is defined by having the bilateral pair of rows of sensory papillae on the chin reduced to a single papilla in a depression on each side. Stonogobiops may be defined by the presence of vomerine teeth. Myersina has yet to be demonstrated as monophyletic (Winterbottom, in press), but may be distinguished from Cryptocentrus by a combination of no head or predorsal scales, all scales cycloid, two preopercular pores, and in having the gill membranes either forming a free fold across the

Fig. 7. *Amblyeleotris fontanesii*, 86.5 mm SL (PMBC 16158), Phuket, Thailand. Photo by U. Satapoomin.

Fig. 8. *Cryptocentrus cyanotaenia*, 86.5 mm SL (PMBC 4814), Krabi, Thailand. Photographed after a few days in formalin. Photo by U. Satapoomin.

Fig. 9. *Cryptocentrus cyanotaenia*, 87.7 mm SL (PMBC 4815), Krabi, Thailand. Photographed after a few days in formalin. Photo by U. Satapoomin
Isthmus or narrowly attached to it. Other genera usually placed on the periphery of the shrimp gobies, but which have only longitudinal rows of cheek papillae, include Ctenogobiops, Mahidolia, Tomiyamichthys, and Vanderhorstia.

Koumans (1953) listed two nominal species of Cryptocentrus as synonyms of C. pavoninoides: C. venustus Seale, 1914 (type locality, Hong Kong) and C. cebuanus Herre, 1927 (type locality, Cebu, Philippines). Koumans (1953) further stated that he had examined the holotypes of both these species at the Bureau of Science in Manila; these collections were destroyed during World War II, and the types are no longer extant. Although we cannot be certain, we suspect that neither of these nominal species represents C. pavoninoides. However, we are not able to offer any other assignment for them at this time.

Cryptocentrus venustus was reported to have D VII, 10 (which we interpret as D VI + I, 10; one ray fewer than our material), A 11 (which we interpret as I, 10; consistent with our material), and “...spinous dorsal, ventral, and anal dark purplish;...” (Seale, 1914:77; consistent with our material for the pelvic fin, and perhaps the anal fin in one of our specimens). Koumans (1953) stated that the holotype of this species agreed fully with C. pavoninoides except for the colour description. However, we note the difference in number of soft dorsal fin rays, stress the failure to mention the prominent dark spots in the dorsal fin by both Seale and Koumans, and are of the opinion that the two are not conspecific. In addition, we strongly suspect that Seale’s (1914) statement that his specimen was 103 centimetres long is a lapsus.

Koumans (1941) had previously listed C. venustus as a questionable synonym of C. pavoninoides. In that paper, his description of the colour of the fins and the position of the spots in the first dorsal fin (from specimens he identified as C. pavoninoides, from Nancouri Harbour) agrees with our material. (We assume that “Nancouri Harbour, India” represents what we currently know as Nancowry Harbour, on the island of Nancowry (8°02’N, 93°34’E), in the Nicobar Islands). He makes

![Fig. 10. Cryptocentrus leptocephalus, 59.7 mm SL 0 (PMBC 16159), Phuket, Thailand. Photo by U. Satapoomin.](image)

![Fig. 11. Cryptocentrus leptocephalus, 48.2 mm SL R (PMBC 16160), Phuket, Thailand. Photo by U. Satapoomin.](image)
no mention of whether or where these specimens were retained, and we have not located them.

*Cryptocentrus cebuanus* was listed as a synonym of *C. pavoninoides* in both of Kouman's works (1941, 1953). However, Herre (1927:240-241), in his original description of this species, stated that "...near tip of membrane between first and second spines of first dorsal a deep black spot; the upper margin of caudal tip a broad black line;...". Our material (and the original description and subsequent figure of *C. pavoninoides* by Bleeker) suggests that the first dorsal fin has two (between spines 1-3), four (between spines 1-5) or possibly five (between spines 1-6) black spots at the middle of its height (not near the tip of the fin), and there is no black line on the upper margin of the caudal fin.

We are unable to assign *C. venustus* or *C. cebuanus* to any status within *Cryptocentrus*, and do not believe that either of these names has been unequivocally demonstrated to be a synonym of *C. pavoninoides*.

In conclusion, we suggest that our specimens, as well as those reported by Wongratana and Koumans, are conspecific with Bleeker's *Cryptocentrus pavoninoides*. The only difference we could find was that our specimens have two or four dark spots in the first dorsal fin, whereas Bleeker's illustration of the holotype shows five such spots. The fin membrane between the fifth and sixth dorsal fin spines of the holotype is torn, and it not possible to verify the presence of a fifth dark spot.

However, the variation in spot number in our specimens, coupled with the disparity of size between the holotype (105.1 mm SL) and our largest specimens (87.0 mm SL 0; 84.6 mm SL R) suggests to us that they are conspecific.

**Distribution**

As far as we have been able to establish, *Cryptocentrus pavoninoides* has been collected only from Indonesia (Madura Island, off the north-east coast of Java), the Gulf of Thailand, Singapore, the Nicobar Islands, and southwestern Thailand (Phuket).

**Habitat and ecology**

All specimens of shrimp gobies from the vicinity of Phuket were either collected or observed on a muddy sand or a sandy mud substrate in a depth range of 6-13 m in turbid coastal water (see also note below). They were observed to live in association with alpheid shrimps and usually positioned themselves close to the substrate when emerging from the burrow entrance. Although a detailed stomach contents analysis has not been performed, the fact that the species possesses enlarged and well developed caniniform jaw teeth, and the digested remains of a brachyuran crustacean (in PMBC 16123) and small gastropods (in ROM 72475; from X-ray) in the digestive tract of some specimens suggest that it is primarily carnivorous, feeding on...
benthic invertebrates (as is typical for Cryptocentrus - see Hoese and Allen, 1977). Adult fishes exhibit distinct sexual dichromatism which may play an important role in courtship behaviour. Nevertheless, they have not yet been observed in male and female pairs.

Other goboid fishes commonly seen or collected at the locality where C. pavoninoides occurs included: Amblyeleotris downingi, A. fontanesii, Oxyurichthys papuensis, Oxymetopon compressus, and Ptereleotris arabica. It seems likely that all these species prefer a similar seabed environment (ie, sediment type, visibility, hydrodynamic condition, depth gradients, etc.). Most of the co-occurring species mentioned above are known from greater depths in nearshore to offshore areas, and the same may prove true of C. pavoninoides.

Discussion
Our awareness of sexual dichromatism in goboid fishes is increasing rapidly, particularly among the shrimp gobies. Several other examples, in addition to C. pavoninoides, are evident from our recent observations of these fishes. Amblyeleotris fontanesii (Fig. 7) exhibits the same basic body coloration in both sexes, but only the males possess a pair of black spots on the chin (one either side of anterior isthmus), which are hidden when the jaws are closed.

In Cryptocentrus cyanotaenia, a species that is distinctive in having oblique, broken, blue streaks or dashes on the head and four broad and diffuse transverse bands on the body, females have 7-12 vertical thin blue lines on the body (Fig. 8 - less developed and restricted to the lower part of the body in some specimens), but males lack such lines (Fig. 9).

In C. leptocephalus, males have a series of rows of reddish-pink oval spots bordered with blue in the dorsal fin and dark ground colour in the anal fin (Fig. 10). Females have a few of the oval spots basally of the first dorsal fin with pinkish stripes along the distal one third of the first four spines bordered with similar horizontal
stripes in the middle third of the fin, and similar pinkish stripes bordered with thin blue lines in the interradial membrane parallel to the axes of the dorsal rays in the second dorsal fin; while the anal fin is more or less translucent with a pinkish border margined with dirty yellow (Fig. 11).

Females of Vanderhorstia ambanorohave a series of small black spots in the first dorsal fin and beneath the greyish submarginal band in the second dorsal fin (Fig. 12); males lack such spots and have only a yellowish submarginal band in the second dorsal fin (Fig. 13).

In Mahidolia mystacina, Yanagisawa (1978) pointed out sexual dimorphism with respect to the length of upper jaw, which is distinctly longer in males and reaches the posterior border of the preopercle. In addition, we found sexual dichromatism in the species. The males have dark spots, similar but somewhat larger and darker than those found on top and sides of head and pectoral fin base, extending onto the sides of the body as far back as below the end of the first dorsal fin (Fig. 14); in females this area is marked only with bands (nearly vertical to slightly oblique) (Fig. 15).

Cryptocentroides insignis is also reported to exhibit sexual dichromatism (see Akihito et al., 1988: plate 243, figs. A-B; Myers, 1991: 227 (stated in diagnosis)).

Winterbottom (in press) places Cryptocentrus crocatus in Myersina and provides evidence of sexual dichromatism in that species (Figs. 16 & 17).

Furthermore, different colour morphs of the same species have also been recognized in several other shrimp gobies. Some can be categorized as dark or blackish colour morph versus yellow to pale morph. Examples include Cryptocentrus cinctus (illustrated in Akihito et al., 1988: pl. 243, figs. H-I (the yellow morph (I) as C. flavus); Burgess et al., 1990: 547 (top right fig.) and 557 (third left fig.); Randall et al., 1990: 398; Myers, 1991: plate 119, figs. G-H; Kuiter, 1992: 229, fig. 4) and Cryptocentrus fasciatus (authors' observation, see also Randall et al., 1990: 398 (stated in description)). This is also apparent in an undetermined species, Cryptocentrus sp. 1 (Figs. 18-20). The species is distinctive, recognised by the presence of 3-4 transverse brown bands, each bordered by blue lines on a yellow to pale brown background colour, in the pelvic fins, and by a
pair of dark elongate spots (faded in yellow morph) on the cheek just above posterior edge of upper jaw. The dark brown male morph (Fig. 18) has also been illustrated by Allen and Steene, 1987 (plate 111, fig. 4 - mis-identified as C. fasciatus).

The yellow female morph (Figs. 19 & 20) has also been illustrated by several authors (Allen and Steene, 1987, plate 111, fig. 2 - mis-identified as C. cinctus; Burgess et al., 1990: 556, top left fig.; and Kuiter, 1992: 229, fig. C.).

A yellow morph of a Myersina, labelled as an undescribed species by Akihito et al. (1988: plate 244, figs. D-E), is considered to be conspecific with M. nigrivirgata by Winterbottom (in press). The gender of
Redescription of the Gobioid Fish Cryptocentrus pavoninoides (Bleeker, 1849), with Notes on Sexual Dichromatism in Shrimp Gobies

specimens of this yellow morph was not stated. Such different colour morphs have not yet been shown to be linked strictly to environmental or physiological stage, or to gender. Although not consistent, our recent observations suggest that the yellow or golden colour morph of Cryptocentrus sp. 1 is found predominantly in female fishes. The yellow coloration figured here for C. pavoninoides also seems to be restricted to females.

Given such striking sexual dichromatism and/or variation in colour morphs, it would not be surprising to find that many of these species have been described more than once in the literature. Careful observation of fishes in the wild, together with extensive and detailed examination of types and original descriptions of nominal species, may resolve at least some of the taxonomic problems of these gobioid fishes. These aspects should also be considered in phylogenetic context for gobioid systematic research.

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Halichoeres salmofasciatus, a new species of wrasse (Pisces: Labridae) from Isla del Coco, tropical eastern Pacific

Gerald R. Allen* and D. Ross Robertson

1) Department of Aquatic Vertebrates, Western Australian Museum, Francis Street, Perth, WA 6000, Australia
2) Smithsonian Tropical Research Institute (Panamá)
Mailing Address: Unit 0948 APO AA 34002-0948, USA - Email: Ross.Robertson@stri.org
* Author for correspondence
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Taxonomy, Halichoeres, new species, Isla del Coco, tropical eastern Pacific, Labridae

Abstract
Halichoeres salmofasciatus, n.sp., is described from 23 specimens, 28.5 - 62.9 mm SL, collected at Isla del Coco, Costa Rica, in 1997. Among the 12 other known species of this genus in the tropical eastern Pacific it appears to be most closely related to H. malpelo and H. melanotis, but differs from both those species in maximum size, colour pattern, and certain meristics. The terminal phase adult of H. salmofasciatus has an olive back, an indistinct dark olive stripe along the body at eye level, and a pale orange tail with a broad, grey terminal edge. The initial phase adult of H. salmofasciatus is pale grey and white with two salmon red stripes running along the length of the body (one at eye level and a narrower one along the upper back), two black spots within the midlateral stripe (one on the opercular membrane, the other on the caudal peduncle), and a pale orange tail.

Zusammenfassung

Résumé
Halichoeres salmofasciatus n. sp. est décrit d’après 23 spécimens, 28,5-62,9 mm de longueur standard, récoltés près de l’Isla del Coco, Costa Rica, en 1997. Parmi les douze autres espèces connues de ce genre dans le Pacifique tropical occidental, il apparait plus proche de H. malpelo et de H. melanotis, en différant toutefois par la taille maximale, le patron de coloration et certains caractères méristiques. La phase adulte terminale de H. salmofasciatus a le dos olive, une bande olive foncé indistincte le long du corps à la hauteur de l’œil et la caudale orange pâle avec une large bordure grise. La phase adulte initiale de H. salmofasciatus est gris pâle et blanche avec deux bandes rouge saumon le long du corps (l’une à la hauteur de l’œil et l’autre, plus étroite, sur le dos), deux taches noires sur la bande longitudinale principale (l’une sur la membrane opéculaire, l’autre sur le pédicule caudal), et la caudale orange pâle.

Sommarîo
Ventitré esemplari di 28.5 - 62.9 mm SL, raccolti nel 1997 a Isla del Coco, Costa Rica, hanno fornito materiale per la descrizione di Halichoeres salmofasciatus, n. sp. Tra le 12 specie presenti nel Pacifico orientale appartenenti allo stesso genere, questa nuova specie sembra più vicina ad H. malpelo e H. melanotis, da cui però si differenzia per le dimensioni, la livrea e alcuni dati meristici. La fase terminale di H. salmofasciatus ha il dorso oliva, una fascia olivastro indistinta che attraversa il corpo all’altezza dell’occhio e una pinna caudale arancione chiaro con un’ampia banda grigia lungo il margine. La fase iniziale adulta H. salmofasciatus ha, invece, il corpo di una tinta che va dal grigio chiaro al bianco ed è attraversato da due fasce longitudinali color rosso salmone (una a livello dell’oc-
chio, l'altra, più stretta, lungo la parte superiore del dorso), due macchie nere entro la fascia longitudinale mediale (una sull'opercolo e l'altra sul peduncolo caudale) e una pinna caudale arancione chiaro.

**Introduction**

The tropical eastern Pacific biogeographic region stretches from lower Baja California and the Gulf of California, at latitude 26°N, to just south of the Ecuador/Peru border, at latitude 30°S, and includes five offshore islands and groups of islands - the Revillagigedos, Clipperton, del Coco, Malpelo, and the Galapagos (Briggs, 1974). There are 12 described members of the labrid genus *Halichoeres* known from this region. These include 11 shallow-water species: *H. adustus* (Gilbert, 1890) (Isla del Coco and Islas Revillagigedos, with vagrants at the tip of the Baja peninsula and mainland Costa Rica); *H. aestuaricola* Bussing, 1972 (Gulf of California to Colombia); *H. chierchiae* Di Caporiacco, 1947 (Gulf of California to Colombia, plus the Galapagos); *H. discolor* Bussing, 1983 (endemic to Isla del Coco); *H. dispilus* (Günther, 1864) (Gulf of California to Peru, plus Isla del Coco and the Galapagos); *H. insularis* Allen & Robertson, 1992 (endemic to the Revillagigedos); *H. malpelo* Allen & Robertson, 1992 (endemic to Isla Malpelo); *H. melanotis* (Gilbert, 1890) (the mouth of the Gulf of California to Colombia, and, reportedly (Bussing, 1987), from Isla del Coco); *H. nicholsi* (Jordan & Gilbert, 1882) (Gulf of California to Ecuador, plus all the offshore islands except Clipperton); *H. notospilus* (Günther, 1864) (Gulf of California to Peru, plus the Galapagos, Malpelo, and the Revillagigedos); and *H. semicinctus* (Ayres, 1859) (California to lower Baja California and the upper 2/3 of the Gulf of California) (see Allen & Robertson, 1992; Allen & Robertson, 1994; Bussing 1987; Fischer et al, 1995; Grove and Lavenberg, 1997; Parenti & Randall, 2000). In addition a deep-water species, *H. raisneri* Baldwin & McCosker, 2001, has recently been described from the Galapagos, and may also occur at Cocos (Baldwin & McCosker, 2001).

This paper describes a new species of shallow-water *Halichoeres* collected by D. R. Robertson at Isla del Coco, a small (9 km diameter) isolated island 450 km offshore of the coast of Costa Rica, at 50°33′N, 87°03′W.

**Materials and Methods**

Type specimens of the new species are deposited at the US National Museum of Natural History, Washington DC (USNM), and the Museo Zoologica de la Universidad de Costa Rica (UCR).

Methods of counting and measuring specimens are as follows: standard length (SL) is the straight-line distance from the front of the upper lip to the base of the caudal fin (posterior end of the hypural plate); body depth is the maximum depth from the base of the dorsal spines; body width is measured just posterior to the gill opening; head length is taken from the front of the upper lip to the posteriormost point of the opercular flap; snout length is measured from the same anterior point to the fleshy edge of the orbit; orbit diameter is the greatest fleshy diameter of the orbit; interorbital width is the least bony width between the orbits; caudal peduncle depth is the least depth of the peduncle; caudal peduncle length is the horizontal distance from the rear base of the anal fin to the base of the caudal fin; pectoral and pelvic fin lengths are the lengths of the longest rays; pectoral ray counts include the

**Table I.** Proportional measurements of type specimens of *Halichoeres salmofasciatus* deposited in the USNM expressed as percentages of the standard length. TP = terminal phase, IP = initial phase

<table>
<thead>
<tr>
<th>Character</th>
<th>Holotype</th>
<th>Paratype</th>
<th>Paratype</th>
<th>Paratype</th>
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<th>Paratype</th>
<th>Paratype</th>
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<tbody>
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<td>Colour Phase</td>
<td>TP</td>
<td>TP</td>
<td>TP</td>
<td>TP</td>
<td>IP</td>
<td>IP</td>
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<tr>
<td>Standard length (mm)</td>
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<td>62.9</td>
<td>54.2</td>
<td>50.6</td>
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<td>45.0</td>
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<tr>
<td>Body depth</td>
<td>26.2</td>
<td>25.4</td>
<td>24.4</td>
<td>26.7</td>
<td>28.0</td>
<td>25.1</td>
<td>24.3</td>
<td></td>
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<tr>
<td>Body width</td>
<td>12.3</td>
<td>12.4</td>
<td>11.1</td>
<td>12.1</td>
<td>13.0</td>
<td>9.3</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Head length</td>
<td>32.6</td>
<td>33.4</td>
<td>34.1</td>
<td>35.0</td>
<td>35.0</td>
<td>32.7</td>
<td>34.8</td>
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<tr>
<td>Snout length</td>
<td>8.8</td>
<td>8.9</td>
<td>9.2</td>
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<td>9.4</td>
<td>8.4</td>
<td>8.0</td>
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<td>7.2</td>
<td>8.3</td>
<td>8.9</td>
<td>7.2</td>
<td>7.3</td>
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<td>Interorbital width</td>
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<td>4.9</td>
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<td>Caudal peduncle depth</td>
<td>11.0</td>
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<td>11.3</td>
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<td>13.6</td>
<td>11.6</td>
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<tr>
<td>Caudal peduncle length</td>
<td>9.6</td>
<td>10.3</td>
<td>10.9</td>
<td>10.9</td>
<td>12.6</td>
<td>10.2</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>Length 1st dorsal spine</td>
<td>7.4</td>
<td>7.2</td>
<td>5.2</td>
<td>5.9</td>
<td>6.0</td>
<td>6.2</td>
<td>5.5</td>
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<tr>
<td>Length last dorsal spine</td>
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<td>8.9</td>
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<td>8.5</td>
<td>8.4</td>
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<td>Longest dorsal soft ray</td>
<td>13.3</td>
<td>12.9</td>
<td>13.0</td>
<td>12.2</td>
<td>11.4</td>
<td>11.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length 2nd anal spine</td>
<td>4.3</td>
<td>4.4</td>
<td>4.6</td>
<td>4.5</td>
<td>4.6</td>
<td>4.1</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Length 3rd anal spine</td>
<td>7.5</td>
<td>7.8</td>
<td>7.2</td>
<td>6.9</td>
<td>7.2</td>
<td>5.7</td>
<td>5.6</td>
<td></td>
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<tr>
<td>Longest anal soft ray</td>
<td>12.3</td>
<td>11.8</td>
<td>11.0</td>
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<td>12.0</td>
<td>10.0</td>
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<tr>
<td>Caudal fin length</td>
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<td>22.9</td>
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<td>21.4</td>
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<tr>
<td>Pectoral fin length</td>
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<td>20.0</td>
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<td></td>
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<tr>
<td>Pelvic fin length</td>
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<td>17.3</td>
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<td>16.8</td>
<td>14.8</td>
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<td>13.5</td>
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</table>
rudimentary, splint-like, uppermost ray; lateral line scale counts are taken to the base of the caudal fin; the gill raker count is the total number of rakers, including all rudiments, on the first branchial arch (total counts are given due to difficulty deciding which raker lies at the angle of the gill arch).

Counts and morphometric proportions in parentheses refer to the range for paratypes where these data differ from those for the holotype.

**Halichoeres salmofasciatus** n. sp.
(Figs. 1-3 and Table I)

**Holotype:** USNM 350110, male, 62.6 mm SL, Chatham Bay, Isla del Coco (approximately 50°33'N, 87°03'W), collected by D. R. Robertson on November 1, 1997.

**Paratypes:** USNM 350111, 6 specimens, 45.0-62.9 mm SL; UCR 2517-1, 16 specimens, 30.0-54.8 mm SL; all collected with holotype.

**Diagnosis**
A species of *Halichoeres* with the following combination of characters: dorsal rays IX, 12; anal rays III, 12; pectoral rays 14; caudal rays 14; lateral line scales 27; scales above lateral line to origin of dorsal fin 4; scales below lateral line to origin of anal fin 8; circumpeduncular scale rows 16; gill rakers on first arch 18; terminal phase adult olive on back with diffuse dark mid-lateral stripe from head to tail; initial phase adult white on lower half of body with pair of salmon red stripes on upper half, a black spot on the opercular membrane and another on caudal fin base.

**Description**

Dorsal rays IX, 12; anal rays III, 12; pectoral rays 13; pelvic rays 1, 5; principal caudal rays 14 (middle 12 branched); upper and lower procurent caudal rays 4 or 5; lateral line scales 27; scales above lateral line to origin of dorsal fin 4; scales below lateral line to origin of anal fin 8; circumpeduncular scale rows 16; gill rakers on first arch 18; vertebrae 25.

Body moderately elongate, its depth 3.8 (3.6-4.1) in SL, and somewhat compressed, its width 2.1 (1.9-2.7) in depth; head length 3.1 (2.9-3.1) in SL; snout length 3.7 (3.7-4.3) in head; eye diameter 4.2 (3.9-4.9) in head; interorbital space convex, the least bony width 6.6 (5.7-6.8) in head; caudal peduncle depth 3.0 (2.6-3.0), caudal peduncle length 3.4 (2.8-3.5), both in head length.

Lower jaw slightly inferior, maxilla reaching to a vertical line in front of orbit or just slightly anterior to orbit; lower lip with a downward projecting flap along the side; inner surface of upper lip with dermal ridges. Gill membranes broadly attached to isthmus. Upper half of preopercle margin hidden under skin, lower half free and exposed.

Front of upper and lower jaws with one pair of large, projecting, slightly recurved canine teeth; remaining...
Halichoeres salmofasciatus, a new species of wrasse (Pisces: Labridae) from Isla del Coco, tropical eastern Pacific

Fig. 2. Terminal phase (a) and initial phase (b) adults of Halichoeres salmofasciatus in the field immediately after collection with rotenone ichthyocide. Photos by D. R. Robertson.

13-18 teeth on each side of upper and lower jaw conical with recurved tips, decreasing in size posteriorly, with last few teeth being notably smaller; rear of top jaw without canine teeth. No teeth on palate.

Nostrils small, in front of upper anterior edge of eye, the anterior nostril in a short membranous tube, the posterior nostril diagonally upward and behind the anterior nostril, covered by a flap from its anterior margin. Suborbital pores around rim of eye from mid-posteriorly to below front edge of orbit.

Head naked except for triangular zone of scales on each side of nape; scales on midside of thorax less than half as large as those on side of body, becoming even smaller ventrally and anteriorly; fins naked except for progressively smaller scales on basal portion of caudal fin; lateral line complete, the anterior part more or less straight, bending sharply ventrally beneath posterior portion of dorsal fin to straight peduncular portion; tubes of lateral line scales branched, except those on caudal peduncle, which are straight.

Origin of dorsal fin above second lateral line scale; dorsal spines progressively longer, the first 6.0 (4.7-6.6) and the ninth 4.0 (3.2-4.3) in head; fifth to eleventh dorsal rays about equal in height, 2.9 (2.5-2.9) in head; first anal spine slender and hidden under skin, its length 8.2 (7.4-8.2) in head; third anal spine 5.8 (4.2-5.8) in head; fourth to tenth soft anal rays longest, 3.3 (2.8-3.3) in head; caudal fin truncate to slightly rounded, 1.5 (1.4-1.6) in head; pectoral fin 1.8 (1.6-1.8) in head, the upper rays longest, the first (uppermost) ray rudimentary and splint-like, all rays branched except the two uppermost; origin of pelvic fin below pectoral fin base; pelvic spine slender, flexible distally; pelvic fin relatively short, falling well short of anus when depressed, its length 2.3 (1.9-2.6) in head.

Coloration in life

Terminal phase adult - (Figs. 1a, 2a, and 3a) upper half of body pale olive to pale brown, with an indistinct darker olive stripe extending from snout to the end of the caudal peduncle at eye level, the portion of that stripe between eye and end of operculum yellowish; an indistinct dark grey spot on the opercular membrane; lower face and belly pale grey with a faint lavender tint; iris red; a pale blue longitudinal line below eye; tail pale orange with terminal half dark grey; anal fin pale violet with outer edge pale orange and a pale orange stripe along centre of fin; dorsal fin pale violet, with an indistinct blackish blotch basally on the first 1-2 spines, pale orange outer edging and pale orange fin rays; pelvic fin pale pink; pectoral fin clear with dusky tip and a narrow sooty bar across the fin base. In sexually active, terminal phase fish (Fig. 3a) the rear half of the tail becomes blackened.

Initial phase adult - (Figs. 1b, 2b, and 3b) upper body and top of head pale grey; lower face white; belly silver white with pink blotch on side immediately above anus; iris red; two salmon red stripes, a broad
Fig. 3. (a) A terminal phase Halichoeres salmofasciatus courting several initial phase conspecifics; (b) a group of alarmed initial phase Halichoeres salmofasciatus displaying pale bars. Photos by D. R. Robertson.

one at eye level running from snout to end of caudal peduncle, a narrower one along the upper back from the head to the caudal peduncle; lower salmon stripe bordered below by a thin silvery white stripe on anterior half of body; two prominent black spots about size of eye, one on the rear of the opercular membrane, the other on caudal peduncle at the terminus of the midlateral salmon stripe; tail pale translucent orange; pectoral fin clear; pelvic fin clear; dorsal and anal fins clear with pale orange outer margins. When alarmed, initial phase fish can temporarily develop a pattern in which the salmon stripes are overlaid by seven thin whitish vertical bars, one on head, five on body and one on caudal peduncle (Fig. 3b).
Halichoeres salmofasciatus, a new species of wrasse (Pisces: Labridae) from Isla del Coco, tropical eastern Pacific

Fig. 4. Living terminal phase (a) and initial phase (b) adults of *Halichoeres malpelo* in the field. Photos by D. R. Robertson.

Fig. 5. Terminal phase (a) and initial phase (b) adults of *Halichoeres melanotis*, aquarium photographs shortly after collection in Panama. Photos by G. R. Allen.
Juvenile (smaller than about 20 mm SL) – the same basic colour pattern as the initial phase adult, but with a black, white-bordered, ocellus covering the base of the first two soft rays of the dorsal fin, a yellow rather than orange tail, a less distinct black spot on opercular membrane, and white patches on the upper and lower borders of the black spot on the caudal peduncle.

Coloration in alcohol

Terminal phase adult (holotype) – overall dusky brown with numerous tan vertical lines on side; head similar to body except operculum mostly dark brown; dorsal, anal, and pelvic fins translucent to tan; caudal fin light dusky brown on basal half, dark brown on outer half with narrow white margin; pectoral fin tan with prominent diagonal dark area from middle of fin to tip of uppermost rays, and a blackish blotch on base of uppermost rays; largest terminal phase specimen considerably darker than the holotype, particularly on its head and caudal fin, and with a faint broad pale bar behind the head.

Initial phase adult – similar to life coloration, except that the central dark stripe is broken into a series of 5-6 large dark blotches posteriorly.

Juvenile - overall tan with a midlateral row of 7-10 dark spots, including enlarged spot on the base of the caudal fin.

Size
Numerous underwater observations by D. R. Robertson during dozens of dives around Isla del Coco indicate that *H. salmofasciatus* grows to about 10 cm total length.

Habitat

*H. salmofasciatus* occurs commonly in areas of sand covered with a dense scattering of small scale rubble composed of either volcanic rock chips or calcareous algae, at depths of from 7 m to at least 30 m. It can also be found in small numbers on sand at sand/reef interfaces. *H. melanotis* and *H. malpelo* occur in similar habitat, on the continental mainland and at Isla Malpelo, respectively.

Affinities and remarks

Among the *Halichoeres* species in the region, *H. salmofasciatus* is most similar to *H. malpelo* (Fig. 4) and *H. melanotis* (Fig. 5) in its colour patterns. However, colours of adults and juveniles of these three species differ (see Table II). While the terminal phase colour pattern of *H. salmofasciatus* is intermediate between that of *H. melanotis* and *H. malpelo*, the initial phase colour patterns of the three species are clearly different. *H. salmofasciatus*, which reaches a maximum of approximately 10 cm total length, is also smaller than *H. melanotis* (reaches about 13 cm) and *H. malpelo* (reaches at least 18 cm). *H. salmofasciatus*, with only one pair of canine teeth at the front of the top and bottom jaws, differs in this regard from both *H. malpelo* (one pair of lower canines and two pairs of upper canines) and *H. melanotis* (two pairs on the top and bottom jaws). *H. salmofasciatus* also differs from *H. malpelo* and *H. melanotis* in having fewer pectoral rays (13 vs 14 in the latter two species). *H. salmofasciatus* further differs from *H. malpelo* in having fewer scales between the lateral line and the dorsal fin origin (4 vs 5) and between the lateral line and the anal fin origin (8 vs 9), as well as in having a relatively larger eye (20.4-25.6% of head length vs 15.9-19.2%) and a relatively longer tail (62.5-71.4% vs 52.6-58.8% of head length).

Five species of *Halichoeres* have been previously recorded from Isla del Coco (Bussing, 1987; Allen & Robertson, 1994; Fischer et al, 1995, Garrison, 2000) - *H. adustus*, *H. discolor*, *H. dispilus*, *H. nicholsi*, and *H. melanotis*. During two weeks spent in an intensive

<table>
<thead>
<tr>
<th>Species</th>
<th>Juvenile</th>
<th>Initial Phase Adult</th>
<th>Terminal Phase Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. salmofasciatus</em></td>
<td>as initial phase adult, plus invariably (n=65) with ocellus on dorsal fin</td>
<td>body pale grey with 2 salmon red stripes, black spot on operculum and another on caudal peduncle; belly white</td>
<td>upper body and head olive, body with indistinct midlateral darker olive stripe, dark spot on opercular membrane, tail pale orange with terminal half dark grey</td>
</tr>
<tr>
<td><em>H. melanotis</em> (Panama)</td>
<td>body bright yellow with two black stripes, occasionally (1 of 20) with ocellus on dorsal fin</td>
<td>body pale brown, two brown stripes, grey patch behind eye ending in black spot on opercular membrane, belly pink with white bars</td>
<td>similar to initial phase, but body stripes and dark area on cheek less distinct, belly white, tail pale orange with sooty outer edging</td>
</tr>
<tr>
<td><em>H. malpelo</em></td>
<td>no data</td>
<td>body and upper head pale pinkish brown; top of head and operculum yellowish; belly white, yellowish behind pectorals</td>
<td>body and head bluish green, tail bluish green with terminal half blackish</td>
</tr>
</tbody>
</table>
Halichoeres salmofasciatus, a new species of wrasse (Pisces: Labridae) from Isla del Coco, tropical eastern Pacific

Survey of that island's fish fauna in October/November 1997, D. R. Robertson observed the first three species, and thousands of individuals of *H. salmofasciatus*, but no individuals whose colours matched those of *H. melanotis* from the mainland. We therefore conclude either that previous records of *H. melanotis* from the island refer to *H. salmofasciatus*, or that *H. melanotis* was present only as a vagrant at Isla del Coco prior to 1997.

Allen and Robertson (1994) recorded the Indo-Pacific labrid *Pseudojulis cerasinus* as occasionally occurring in the tropical eastern Pacific, with their information indicating that it had been observed at Isla del Coco. That record is very likely incorrect: Firstly, it was based on observations alone (no specimens of *P. cerasinus* have been collected from Isla del Coco - W. Bussing, personal communication, 1998). Secondly, those observations may well refer to *Halichoeres salmofasciatus*, as *P. cerasinus* and *H. salmofasciatus* are both small species, occur in the same type of habitat, and have terminal phase colour patterns with the same basic structure (photograph of *P. cerasinus* in Allen and Robertson 1994; and observations on *P. cerasinus* at Hawaii and Christmas Island by D. R. Robertson).

**Etymology**

The specific name *salmofasciatus* refers to the two salmon red stripes on the body of initial phase fish. “Red-striped wrasse” is proposed as the common name of this species.

**Acknowledgements**

We thank the Ministerio del Ambiente y Energia de Costa Rica for permission to conduct research at Isla del Coco during 1997; the National Science Foundation for allowing the participation of D R Robertson in an expedition on the *RV Gyre* in 1992 (sponsored by grant OCE-8716726 to Peter W. Glynn of the University of Miami) when the new species was first observed; the Smithsonian Tropical Research Institute’s research vessel, the *RV Urraca*, for support during the 1997 expedition when it was collected; and J. Earle, M. Lang, A. Segura, and S. Swearer for field assistance during the latter expedition.

**References**


First record of cleaning activity in the slippery dick, *Halichoeres bivittatus* (Perciformes: Labridae), off northeastern Brazil.

Bertran M. Feitoza¹, Thelma L. P. Dias², Luiz A. Rocha³, and João Luiz Gasparini⁴

1&2) Universidade Federal da Paraíba, CCEN, Depto. de Sistemática e Ecologia, João Pessoa, PB 58059-900, Brasil; e-mail: 1) bertranfeitoza@hotmail.com; 2) thelmadias@hotmail.com
3) University of Florida, Dept. of Fisheries and Aquatic Sciences, 7922 NW 71st Street, Gainesville, FL 32653, USA; e-mail: rocha@gnv.ifas.ufl.edu
4) Universidade Federal do Espírito Santo, Depto. de Ecologia e Recursos Naturais, C.P. 5130, Vitória, ES, 29041-970, Brasil, e-mail: gaspa.vix@terra.com.br

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Keywords
Cleaning, symbiosis, *Halichoeres bivittatus*, following behaviour, Brazilian reef fishes, northeastern Brazil

Abstract
Cleaning behaviour is reported in *Halichoeres bivittatus* for the first time, off Paraíba coast, northeastern Brazil. Six species of clients were cleaned by one to three cleaners, similar in size, in one of two ways: stationary at a cleaning station or whilst swimming over a relatively large area. In each situation, the cleaning events lasted from 2 to 5 seconds. Following behaviour associated with mobile cleaning events was observed and the two activities seem to be related. On the basis of our observations of *Halichoeres bivittatus*, we consider this labrid to be a “substrate picker”, a non-specialized form of cleaner fish.

Zusammenfassung

Résumé
Le comportement de nettoyage est signalé pour la première fois chez *Halichoeres bivittatus*, au large de la côte du Paraíba au nord-est du Brésil. Six espèces différentes sont “traitées” par un à trois nettoyeurs de taille semblable, de une ou deux manières stationnaires sur une station de nettoyage, ou lors de la nage sur une relativement grande étendue. Dans chaque situation, l’opération dure de 2 à 5 secondes. Un comportement de suite associé au nettoyage mobile a été observé, et les deux activités semblent en relation l’une avec l’autre. En nous fondant sur les observations de *Halichoeres bivittatus*, nous considérons que ce labre est à l’origine un “brouteur de substrat”, forme non spécialisée de poisson nettoyeur.

Sommario
Viene descritto per la prima volta il comportamento di pesce pulitore di *Halichoeres bivittatus*, osservato lungo le coste di Paraíba nel Brasile nordoccidentale. Sei specie di clienti sono stati visitati da parte di uno-tre pulitori, di dimensioni simili, che hanno operato secondo due modalità: su specie ferme, nelle cosiddette stazioni di pulizia, o su specie natanti su un’area relativamente ampia. In entrambe le situazioni l’operazione di pulizia durava da 2 a 5 secondi. È stato inoltre osservato comportamento associativo durante la fase di pulitura mobile e le due attività sembrano correlate. Sulla base delle nostre osservazioni consideriamo *Halichoeres bivittatus* un labride classificabile come substrate picker, una forma non specializzata di pesce pulitore.

Resumo
Comportamento de limpeza foi registrado pela primeira vez para *Halichoeres bivittatus* na costa da Paraíba, nordeste do Brasil. Seis espécies de clientes foram limpas por um a três limadores, similares em tamanho, de duas maneiras: estacionária, em uma estação de limpeza ou nadando em áreas relativamente amplas. Em cada situação, os eventos de limpeza duraram de 2 a 5 segundos. Comportamento seguidor associado aos eventos móveis de limpeza foi observado, e as duas atividades parecem estar relacionadas. Baseando-se nas observações de *Halichoeres bivittatus*, nós consideramos este labrício como sendo um substrate picker uma forma não especializada de peixe limpar.

Introduction
Cleaning behaviour is one of the most highly developed interspecific communication systems known
First record of cleaning activity in the slippery dick, *Halichoeres bivittatus* (Perciformes: Labridae), off northeastern Brazil

**Methods**

The cleaning behaviour of *H. bivittatus* was observed during SCUBA dives at the sunken ship *Queimado* (07°05’S, 034°44’W), located about 9 km off João Pessoa city, Paraiba State, northeastern Brazil. The substrate surrounding the wreck was sandy to starboard, and calcareous rubble covered with red and brown algae to larboard, of the wreck. Water depth ranged from 15 to 17 m, and the visibility from 3 m (July) to 15 m (October and January). The average water temperature was 28°C. The study site was visited on 13 occasions between June 1999 and May 2000 and a total of 10 hours of underwater observations were made. During sessions of observation we used “focal animal” and “all occurrences” samplings (Altmann, 1974). Cleaning activity involving *H. bivittatus* and its clients was photographed during two of the visits. Total length (TL) of the fishes was estimated visually. There were three cleaning areas at the site (areas a, b, and c) occupied by initial phase coloured (white body with a black stripe on the middle of the side) *H. bivittatus*. The areas measured about 20, 180, and 525 m² respectively. All data reported herein were collected during the daylight hours, between 9:00 am and 5:15 pm.

**Results and discussion**

Cleaning was recorded for 15 juveniles of *Halichoeres bivittatus* with an estimated total length ranging from 4 to 10 cm. The client fishes were cleaned in one of two manners, stationary at a cleaning station or while swimming over relatively large areas. During both stationary and mobile cleaning, there were usually one, two, or rarely three, wrasses, similar in size, inspecting and nipping at the same client simultaneously. Both types of cleaning event lasted from 2 to 5 seconds. The wrasses cleaned throughout the day, mostly the flanks and fins of their clients.

There was only one stationary cleaning station, located on the starboard side of the hull, around the high profile part of the wreck (area a). The cleaners usually swam within a radius of approximately 1 to 2 m around the cleaning station, at about 30 to 60 cm from the bottom. When no client was present at the station, the cleaners remained there picking items from the substrate. Six species of client fishes were recorded for stationary cleaning: the surgeonfishes *Acanthurus bahianus*, *A. chirurgus*, and *A. coeruleus*; the goatfish *Pseudupeneus maculatus*; the parrotfish *Sparisoma axillare*; and the jack *Sellar crumenophthalmus*. Most clients (about 90%) that approached the station were cleaned after assuming a soliciting pose. However, sometimes the clients were approached before the soliciting pose was assumed. The most conspicuous pose assumed by most of the clients at the cleaning station was an oblique head-up posture, although some fishes assumed either a horizontal or a vertical head-up posture (see Losey, 1971, for classification of client poses).

According to Wilson and Wilson (1992), many fishes,

Fig. 1. A group of five individuals of *P. maculatus*, about 15 cm TL, four of them posing to an approximately 10 cm TL juvenile *Halichoeres bivittatus* at the sunken ship *Queimado*, off north-eastern Brazil. Based on a colour photograph by B. M. Feitoza.
always small in size and usually brightly coloured, have distinctive swimming motions that seem to advertise their service. Whilst the juvenile slippery dicks exhibited a distinctive black and white coloration when swimming in the vicinity of the cleaning station, no distinctive swimming pattern was observed. The wrasses moved quickly around the station in the usual labrid swimming style.

During mobile cleaning, the wrasses swam quickly over a relatively large area (areas b and c), alone, in pairs, or in small groups of up to four individuals, and cleaned both posing and non-posing clients. Four species of client fishes were recorded for this mode: Acanthurus bahianus, A. chirurgus, Pseudupeneus maculatus, and Sparisoma axillare. Most clients (about 70%) were cleaned without posing when first approached by swimming H. bivittatus individuals. Usually, just after being approached by the cleaner, the client stopped swimming and hovered in a characteristic pose, but on some occasions the client continued swimming while being nipped by the cleaner. Losey (1971) noted that either “pose” or “inspect” may be the initial action in a cleaning sequence, and that either of these actions may occur while the other organism is in a “non-cleaning” state. Similar cleaning behaviour has been reported for Halichoeres poeyi and H. brasiliensis, which also seem to wander over a relatively large area and approach and clean “posing” as well as “non-posing” clients (Sazima et al. 1998).

The clients Pseudupeneus maculatus and Sparisoma axillare exhibited a change in colour pattern during the cleaning events, during both stationary and mobile cleaning. According to Wilson and Wilson (1992), the fish being cleaned often pales in colour during the process. However, we have usually observed that posing individuals in groups of up to six P. maculatus darkened in colour while others members of the group remained pale (Fig. 1). By contrast, during most cleaning events S. axillare turned pale in colour while hovering in a vertical head-up posture (Fig. 2). The other clients did not show any change in colour while posing.

We have, incidentally, recorded a juvenile H. brasiliensis cleaning a 20 cm fish of the same species.

On many occasions, we have recorded Halichoeres bivittatus, as well as H. maculipinna and H. brasiliensis, following a mixed group composed of 4–6 specimens of the spotted goatfish Pseudupeneus maculatus, 3–5 specimens of the surgeonfishes Acanthurus chirurgus and A. bahianus, and 2–3 specimens of the redeye parrotfish Sparisoma axillare. The goatfishes used their barbels to dig in the sand and around the areas of rubble, searching for food, while the herbivores A. chirurgus, A. bahianus, and S. axillare grazed on algae attached to the bottom. The wrasses preyed upon organisms which were exposed during these activities. According to Strand (1988), following behaviour is an opportunistic strategy that allows small generalized

![Fig. 2](http://example.com/fig2.jpg)
predators (the followers) to capitalize upon the displacement or uncovering of prey items that occurs when potential predators, grazers, or sand-flat feeders (the followed species) disturb the habitat of the small organisms, creating feeding opportunities for follower species. While following, juveniles of *H. bivittatus* also performed cleaning, inspecting and nipping “posing” as well as “non-posing” clients. The following behaviour observed among *A. bahianus*, *A. chirurgus*, and *P. maculatus* has already been recorded by Earle (1972).

Juveniles of *H. bivittatus* were recorded in three distinct feeding activities during a short interval of few minutes: picking items from the substrate; feeding on items displaced by followed species; and cleaning. Losey (1987) grouped cleaners into three general types: “specialized cleaners”, “substrate pickers”, and “aggressive parasites”. Substrate pickers include a vast number of species that pick items from the substrate and, on occasion, pick items from another fish. On the basis of our observations of *Halichoeres bivittatus*, and because cleaning activity is not its typical behaviour, we consider this labrid to be a substrate picker.

Wicksten (1995) reported that cleaning stations of shrimps and gobies in Bonaire seemed to be frequented by demersal fishes or those that can rest on the bottom. By contrast, hogfishes and wrasses cleaned in mid water and ventured over 1 m from the bottom. The same author also suggested that the cleaning stations of different species of cleaners are frequented by different families of client fishes, and that pelagic fishes tend to visit labrids instead of gobies. In fact, during our observations *H. bivittatus* was not seen cleaning demersal species. Even *Pseudupeneus maculatus*, which sometime rests on the bottom, was cleaned only when it swam or posed in the water column. *H. bivittatus* cleaned mainly when the client species swam actively over the bottom (about 69% of all cleaning events), and its cleaning activity seems to be associated mainly with following behaviour. Whilst the herbivores fed on the algal covering, the goatfishes and *H. bivittatus* preyed upon organisms displaced by the foraging activities of the herbivores. At the same time the herbivores and goatfishes were cleaned by the slippery dicks. These patterns of behaviour result in benefits to both the followers and the followed species.

Another cleaning stations of other fish species have been observed at the Queimado wreck, and probably complement cleaning activity at that site. The barber goby *Elacatinus figaro* was seen cleaning *A. chirurgus* and *A. bahianus*, the damselfish *Chromis multilineata*, *S. axillare*, and the grouper *Cephalopholis fulva*. Juveniles of the grunt *Anisotremus virginicus* cleaned the boxfishes *Acanthostracion quadricornis*, *A. polygonius*, and *Lactophrys trigonus*, the yellow jack *Caranxoides bartholomaei*, and the bigeye scad *Selar crumenophthalmus*. The southern stingray *Dasyatis americana*, *C. bartholomaei*, and *S. crumenophthalmus* were cleaned by juveniles of the Spanish hogfish *Bodianus rufus*.

**Acknowledgements**

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**References**


Melichthys indicus x M. vidua, a hybrid triggerfish (Tetraodontiformes: Balistidae) from Indonesia

John E. Randall¹, Robert F. Myers², and Richard Winterbottom³

¹) Bishop Museum, 1525 Bernice St., Honolulu, Hawaii 96817-2704, USA
²) Robert F. Myers, 1423 SW 109th Way, Davie, Florida 33324-7181, USA.
³) Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6, Canada

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Keywords
- Hybrid, Balistidae, Melichthys, Indian Ocean

Abstract
The hybrid of the triggerfishes Melichthys indicus and M. vidua is reported from two underwater photographs taken at Bali, Indonesia and a single specimen collected in the Chagos Archipelago. This constitutes the first record of a hybrid for the family Balistidae.

Zusammenfassung

Résumé

Sommario
Si riporta la presenza di una forma ibrida tra due specie di pesci balestra, Melichthys indicus e M. vidua, documentata sulla base di due fotografie scattate a Bali, in Indonesia, e sulla cattura di un esemplare nell'Arcipelago Chagos. Si tratta del primo ibrido nell'ambito della famiglia Balistidae.

Introduction
As noted by Schwartz (1972), the great majority of records of hybrids of fishes are from fresh water, although the proportion of records from the marine environment has increased in recent years (Schwartz, 2001). Among the coral reef fishes, the butterflyfishes (Chaetodontidae) and angelfishes (Pomacanthidae) have the highest number of recorded hybrids (Pyle & Randall, 1994). This may be due to their popularity among underwater photographers and fish watchers, to their prevalence in the aquarium trade, and their distinctive colour patterns that enable intermediate patterns to be recognized more easily. Recent reports have documented eight examples of hybrids among surgeonfishes (Acanthuridae), most of which are uniquely coloured (Randall & Frische, 2000; Randall et al., 2001). In all of these cases, where the relative abundance of the parent species was known in the area where the hybrids were found, one of the species was much more common than the other. Under such circumstances the rarer species, failing to find a mate or spawning aggregation of its own species, may spawn with a close relative. The species of the above three families all lay pelagic eggs, so it is also possible for the sperm of one species to fertilize the ova of another if the two species are adjacent during the time of spawning.

Melichthys indicus x M. vidua

From the research of Fricke (1980) and our own observations, triggerfishes are known to spawn in pairs; therefore, hybridization would seem much less likely than for species that lay pelagic eggs, particularly those that are group spawners. The eggs of balistid fishes are laid in a nest prepared by the female who later guards it (though in some species she may be assisted by the male); two of the large species, Pseudobalistes fuscus (Bloch & Schneider, 1801) and Balistoides viridescens (Bloch & Schneider, 1801), have bitten humans who have ventured near the nest (Fricke, 1980; Randall & Millington, 1990).

It was therefore a surprise when the first and second authors each independently discovered a hybrid of the triggerfishes Melichthys indicus Randall & Klausewitz, 1973 (Fig. 1) and M. vidua (Solander, in Richardson, 1845) (Fig. 2) at Bali, Indonesia.

Melichthys indicus occurs in the Indian Ocean from the east coast of Africa to the Cocos-Keeling Islands, Christmas Island, and the southern islands of Indo-
nesia east to Bali where it appears to be a vagrant. *M. vidua* is wide-ranging in the Indo-Pacific region, from the east coast of Africa to the Hawaiian Islands and the islands of French Polynesia.

The hybrids of *Melichthys indicus* and *M. vidua* were spotted at Bali by virtue of the intermediate colour pattern. The one found by the first author (Fig.3). The feature that was encountered on a coral reef in 3 m off Tulamben on the northeast coast in October 2000 first attracted attention was the very broad black margin of the otherwise pale second dorsal and anal fins. These fins have a much narrower margin in *M. vidua* but are entirely black in *M. indicus*, except for a bluish white band at the base. A submarginal dusky pink streak was then noted in the upper and lower part of the caudal fin of the Tulamben fish. In *M. vidua* this fin is pink with a broad white bar at the base, whereas it is black with a narrow pale blue margin in *M. indicus*. Because Tulamben, a popular diving site, is off limits to fishermen, it was not possible to collect the fish.

The hybrid photographed by the second author (while snorkeling after running out of air in his SCUBA tank) (Fig. 4) was found at Menjangan Island, a small marine reserve off northwest Bali, in November 1999. This fish has the second dorsal and the anal fins of similar colour to the Tulamben hybrid, but the white band at the base of each fin is broader. The caudal fin has more pink, hence the hybrid is more intermediate to the parent species in its pattern than is the Tulamben hybrid.

*Melichthys vidua* is common for a triggerfish at Tulamben, but only a single individual of *M. indicus* was seen. *M. vidua* is present at Menjangan Island, but *M. indicus* was not observed.
Winterbottom et al. (1989) reported three lots of *Melichthys indicus* from the Chagos Archipelago in the western Indian Ocean. One of their adult specimens (ROM 40941, 170 mm SL, illustrated in their Figure 431) was regarded as a colour morph. It is unusual in having white second dorsal and anal fins with a broad black border. There would have been no reason to suspect that it was a hybrid, because *M. vidua* was not observed in the Chagos Archipelago and no hybrids of triggerfishes had been reported. We now identify this specimen as a hybrid of *M. indicus* and *M. vidua*.

Evidently *M. vidua* is not common in the Indian Ocean. It was reported as rare in southern Africa by Smith & Heemstra (1986); it was not found in the Maldives Islands by Randall & Anderson (1993), but it has been recorded from Réunion (Harmelin-Vivien, 1976).

Of the three species of *Melichthys*, only the circumtropical *M. niger* (Bloch, 1786) is easily distinguished morphologically by its emarginate caudal fin, higher pectoral ray count, and fewer head scale rows (Randall and Klausewitz, 1993). Other than colour, the only character to separate *M. indicus* from *M. vidua* is a shallow oblique groove, white in life, on the lower side of the head of *indicus*, beginning behind the corner of the mouth. The Chagos specimen ROM 40941 lacks this groove. The caudal fin, being mainly black, is reminiscent of *indicus*, but the colour of the second dorsal fin is closer to that of *vidua*. We have no hesitation in regarding this specimen as a hybrid in spite of *vidua* not being observed or reported from the Chagos Archipelago.

![Fig. 3. *Melichthys indicus x M. vidua*, Tulamben, Bali. Photo by J. E. Randall.](image1)

![Fig. 4. *Melichthys indicus x M. vidua*, Menjangan Island, Bali. Photo by R. F. Myers.](image2)
References


Fish Consumption in a medieval English bishop’s household, 1406-7

Daphne J. Martin

Macquarie University, Department of Modern History, New South Wales 2109, Australia

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Keywords
Food fishes in medieval England; English history; household accounts

Abstract
The accounts of a fifteenth-century English bishop give details of the fish eaten in his Wiltshire household on meatless days, comprising twenty-five species of fish, and seven types of crustaceans and gastropods. This reflects the advances in ship building and fishing methods. The servants were fed imported smoked and pickled North Sea herring, and salted and dried Icelandic cod, supplied by the Hanseatic league of German ports. The bishop, his guests and household officials ate a variety of fresh marine and freshwater species, caught in the English Channel and Severn estuary and in local rivers. The daily fish ration was 0.5-1 kg and the total annual cost of the fish was nearly 5% of the bishop's income.

Introduction
In medieval times, the whole of Christendom in Western Europe was directed by the Church to refrain from eating meat at least once a week. For poor people this was easy, since their diet was weighted towards cereals and vegetables. Those who were wealthy enough to eat meat daily, “fasted” on Fridays by eating fish instead. Clerical households regularly consumed a variety of fish three times a week, as well as on days of special religious significance and on every one of the forty days of Lent.

This paper examines the consumption of fish in the household of Richard Metford, Bishop of Salisbury in Wiltshire, England (Fig. 1), as recorded in the diet accounts of his household over a period from October 1406 to May 1407. They are perhaps the longest and most detailed set of household accounts for a
medieval English episcopal household of this period that have survived the accidents of time.

**Materials and methods**

The accounts, written in Latin on both sides of eighty large paper folios, are preserved in the British Library as MS Harley 3755. The original text in Gothic script was the work of several clerks in the bishop’s household, who daily recorded all the resources used. These included bread, ale, wine, candles and all the ingredients of the two daily meals, as well as hay and oats for the horses. Each folio was headed with the place of residence of the bishop, which for most of the period covered by the accounts was a large residence at Potteme, a village on one of the episcopal manors in central Wiltshire (Fig. 1). The number of portions of food served during the day was noted in the margin, together with the names of important guests, and the number of servants accompanying them, and other lesser visitors. At the end of each day’s entry there was a summary of expenditure, and a notation showing that it had been checked later by an accountant.

From Woolgar’s edition of the manuscript in the original Latin (Woolgar, 1992) it has been possible to construct a series of data bases for the various types of food and drink, and for the number of portions served each day. From the latter the number of persons dining each day could be deduced, how many of them were gentlefolk (the bishop, his important guests and the senior members of his staff) and how many were servants, and the size of the resident household.

In deciding the identity of the fishes recorded by the kitchen clerk, the English name was obtained from Woolgar’s 1992 glossary, and the scientific names from Wheeler (1969) with one exception. If the common name referred to more than one species, the one first identified by Linnaeus in 1758 was chosen, as being the kind most commonly caught at that period.
The identification of 'bream' is uncertain. The freshwater bronze bream (*Abramis brama*) was commonly bred in fishponds in medieval times, but in the accounts 'breme' was usually mentioned in association with marine gurnard; it was more probably sea-bream (*Spondyliosoma canthus*).

Estimating the average weight of the fishes was problematic. The smaller boats and gear of the period precluded fishing in very deep water, so that fish such as cod and haddock might be smaller than present-day catches. On the other hand, the intensity of fishing was relatively low compared to modern times, so that some fish such as herring and inshore species might be appreciably larger. Tentative weights were assigned, using data derived from Wheeler, 1969 and Wheeler, 1985 (Table I).

**Results**

The following twenty-six species of freshwater and marine fish and seven types of crustaceans and gastropods were regularly mentioned in the accounts.

**Marine**

**Bass** *Dicentrarchus labrax* (Linnaeus, 1758). Marine, but likes coasts, and is attracted to brackish water. Common in mouths of estuaries, creeks, and even well up rivers in summer. Also off sandy and shingle beaches in S. and W. coasts of British Is. In winter, it is scattered in rough weather. Caught on lines and in trawls.

**Bream** (sea bream) *Spondyliosoma canthus* (Linnaeus, 1758). Common on west coast of Britain. Especially plentiful on rocky reefs in summer.

**Cod** *Gadus morhua* Linnaeus, 1758. Distribution N. Atlantic and Baltic Sea, also in the North Sea and coasts of British Is. Shoals of cod are often found at c. 30 m depth, but may rise. Caught on lines and trawls. ‘Stokfish’ are cod caught off Iceland and dried in the Arctic wind.

**Conger eel** *Conger conger* (Linnaeus, 1758). Offshore, between tide marks on rocky shores and rough ground. In shallow water it is active only by night, hides in crevices by day. Migrates in mid-summer to warmer deep water to spawn. Off and on coasts of south and west of British Is.

**Dover Sole** *Solea solea* (Linnaeus, 1758). Flatfish, found off coasts of British Is. It likes fine sand and estuarine muds in summer, migrates offshore in winter. It lies partly concealed in mud during the day, feeds actively at night on bottom. Mostly trawled.

**Flounder** *Platichthys flesus* (Linnaeus, 1758). Coastal, or found well up estuaries in fairly fresh water, especially in summer. May almost hibernate in winter.

**Gurnard** *Eutrigla gurnardus* (Linnaeus, 1758). Abundant but "bony". Found on the shoreline to mid-depth, most common in 20-40m. All round the British Is., migrates shoreward in summer to sandy bays and estuaries, often very shallow. Caught in nets.

**Haddock** *Melanogrammus aeglefinus* (Linnaeus, 1758). Common off the west coast but less so in the English Channel. Feeds on the bottom at mid-depth (40m+), does not come right inshore. Mostly trawled, but some are caught on lines.

**Hake** *Merluccius merluccius* (Linnaeus, 1758). Stays in deep water in winter and spring, but migrates into shallower water in summer. Off coasts of British Is., eats smaller fish and squids. Fished on lines.

**Herring** *Clupea harengus* Linnaeus, 1758. Originally extremely common, mainly from the North Sea but also off the English coast. Pelagic, in shoals which are caught in nets. May come inshore after food which it follows.

**Huss** (Nurse hound, dogfish) *Scyliorhinus stellaris* (Linnaeus, 1758). Rocky bays and off-shore, south and west of British Is. in the algal zone. Another species, (*S. caniculus*) is very common, comes inshore on bottom. This shark is easily caught on lines.

**Mackerel** *Scomber scombrus* Linnaeus, 1758. Common off the English coast in summer and autumn, near the surface in enormous shoals. Caught in nets and on lines.

**Merling** *Merlangius merlangus* (Linnaeus, 1758). Whiting. Extremely common in shallow water and close inshore in sandy bays, it can be caught in a few feet of water with nets and lines.

**Mullet** probably *Chelon labrosus* (Risso, 1827) as this appears to be the most common mullet species in English waters. Estuarine and inshore, common especially in spring and summer. Hibernates in winter. Caught with nets.

**Plaice** *Pleuronectes platessa* Linnaeus, 1758. Flat fish, very abundant on the coastal shelf, near coasts in c. 20-40m, but not far into estuaries. Younger ones live closer inshore. Taken in nets and on lines.

**Red Gurnard** *Aspitrigla cuculus* Linnaeus, 1758. Similar to gurnard, but not so common close inshore. Found on the south-west coast of the British Is. More active than common gurnard.

**‘Skate’** (Thornback ray) *Raja clavata* Linnaeus, 1758. The most common British species of ray, dorsally covered with coarse prickles. On a variety of bottom, migrates inshore in winter.

**Turbot** *Scophthalmus maximus* (Linnaeus, 1758). Large flat fish, found on British coasts, especially the North Sea, close inshore but not in estuaries. Sandy and gravel bottoms.

**Fresh Water**

**Eel** probably *Anguilla anguilla* (Linnaeus, 1758). Common in most rivers and estuaries. Active at night, hides in mud or weed by day. Migrates to the sea when mature to spawn. Caught on line and in nets and traps.

**Grayling** *Thymallus thymallus* (Linnaeus, 1758). Lives in clear swift streams in shoals, but in spring
pairs up to spawn. Omnivorous, and is caught on lines.

**Perch** *Perca fluviatilis* Linnaeus, 1758. Common in ponds, lakes and slow streams. Hides against stones, tree roots, reeds, etc. Caught on lines with worms.

**Pike** *Esox lucius* Linnaeus, 1758. A large carnivorous fish of rivers, streams and lakes. Small ones can be caught with a hand net. The pike hides until a fish swims past, then pounces. Caught on lines with live bait.

**Roach** *Rutilus rutilus* (Linnaeus, 1758). Lives in all types of fresh water, large lakes to slow rivers and weedy marshes. Best for eating in summer and autumn. Caught on lines and in nets. This fish may be confused with **rudd**, *Scardinius erythrophthalmus* (Linnaeus, 1758), another common freshwater fish which may be distinguished from the roach by its more golden tint and the position of its dorsal fin. The two species are known to interbreed when living together.

**Salmon** *Salmo salar* Linnaeus, 1758. Young are found in freshwater, migrate to the sea to develop and remounts the same river when mature. Formerly taken in the Thames and other estuaries such as the Severn.

**Trout** *Salmo trutta* Linnaeus, 1758. Lives in rivers and lakes. The fish is small in the upper reaches, where the water is well oxygenated and usually colder. Grows bigger in turbid, warmer lakes and rivers. Caught by line fishing and fixed nets.

Lobsters, crabs, shrimps, oysters, mussels, whelks and cockles were also eaten.

Herring, cod, conger eel and salmon were preserved by salting, smoking or drying. The average weight of preserved fish, marine and freshwater fish eaten weekly varied seasonally. The number of diners also varied daily, with very large numbers of people present at the Christmas-tide feasts, when up to 100 tenants were entertained. A servant's daily ration was one herring or a portion of salt cod or salmon, weighing about 0.5 kg. The cost of the various types of fish (Table I) was given in units of pennies and half-pennies.

**Discussion**

The variety and numbers of marine fish eaten in the household (Figs. 2 and 3) reflect both the advances in ship design (facilitating fishing in off-shore waters), and the extensive influence on trade of the Hanseatic League of North German and Baltic towns (Postan, 1951). By the early fourteenth century the cog, a small ship of about 150 tons displacement, was the main carrier for the Hanseatic trade, providing relatively low cost transport. Herring caught in the Baltic Sea and packed in brine (white herring) at Scania, S. Sweden, were exported by the Hanse to western Europe and London. The growth of the herring trade led to competition between the Hanse and England. Fleets from ports such as Newcastle, Grimsby and Great Yarmouth fished the shallow North Sea for herring in

| Table I. Average weights and prices of the fish eaten by the Bishop of Salisbury's household and guests. The prices of white and red varieties of herring are derived from the price per cade, a barrel containing 600 fish. A firkin was a small barrel of c. 3.7 dl capacity. ? shows that no separate price was recorded. |

<table>
<thead>
<tr>
<th><strong>Marine</strong></th>
<th><strong>Littoral</strong></th>
<th><strong>Freshwater</strong></th>
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<td><strong>Name</strong></td>
<td><strong>Kgs</strong></td>
<td><strong>Price each</strong></td>
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</tr>
<tr>
<td>Bass</td>
<td>5.5</td>
<td>3¼d.</td>
<td>Cockles</td>
</tr>
<tr>
<td>Bream</td>
<td>1.4</td>
<td>3½d.</td>
<td>Crab 6d.each</td>
</tr>
<tr>
<td>Cod</td>
<td>11</td>
<td>?</td>
<td>Lobster 5d.each</td>
</tr>
<tr>
<td>Conger eel</td>
<td>31</td>
<td>35d.</td>
<td>Mussel 3d.</td>
</tr>
<tr>
<td>Dover sole</td>
<td>0.5</td>
<td>2d.</td>
<td>Oysters 2d.</td>
</tr>
<tr>
<td>Flounder</td>
<td>2.5</td>
<td>2d.</td>
<td>Shrimp ?</td>
</tr>
<tr>
<td>Gurnard</td>
<td>1</td>
<td>2d.</td>
<td>Whelks 2½d.</td>
</tr>
<tr>
<td>Haddock</td>
<td>3</td>
<td>7d.</td>
<td></td>
</tr>
<tr>
<td>Hake</td>
<td>11</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Herring</td>
<td>0.5</td>
<td>24d./100</td>
<td></td>
</tr>
<tr>
<td>Huss (dogfish)</td>
<td>9</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Mackeral</td>
<td>1</td>
<td>1d.</td>
<td></td>
</tr>
<tr>
<td>Merling</td>
<td>10</td>
<td>½d.</td>
<td></td>
</tr>
<tr>
<td>Mullet</td>
<td>4</td>
<td>5½d.</td>
<td></td>
</tr>
<tr>
<td>Plaice</td>
<td>3</td>
<td>2½d.</td>
<td></td>
</tr>
<tr>
<td>Red gurnard</td>
<td>1</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Skate</td>
<td>16</td>
<td>7½d.</td>
<td></td>
</tr>
<tr>
<td>Turbot</td>
<td>6</td>
<td>30d.</td>
<td></td>
</tr>
<tr>
<td>Whiting</td>
<td>1.5</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>
large quantities (Unger, 1980). Agents in London bought barrels of white herring and smoked red herring for the bishop's household. They were sufficiently cheap to form the main part of the fish for the servants. Sturgeon was another salted fish from the major northern European rivers, which the Hanse organisation exported to London; in the bishop's household small pieces were served to the gentlefolk as a delicacy on special occasions.

During the fourteenth century, England imported much cod ('salt fish') from Norway, and also fished for it themselves out of Cromer and Blakeney on the Norfolk coast. By the end of the century the dominance of the Icelandic codfish trade by the Wendish group of the Hanse, raised prices. The English defied the Hanseatic monopoly and traded direct with Iceland for the freeze-dried cod called stokfish (Carus Wilson, 1951, p. 161). They could be stored for several years, but when used had to be beaten with a mallet for a long time to soften it. Conger eels were usually eaten salted, but these would have been caught locally, probably in the Severn estuary.

Although the greater part of the marine fish consumed was already preserved in some fashion, fresh marine fish was purchased regularly and transported rapidly by pack horse. The bishop's household favoured the market at Warminster for purchases of fresh fish, but occasionally sent to Devizes or Salisbury. These fish were caught in the estuaries of the Severn River or of the Test River (now Southampton Water) and off the coast. Fish could be transported quite long distances packed in wet grass or rushes, especially in cold weather (Stean, 1988).

The most common fresh sea fishes purchased by the household (Fig. 3) were merling, gurnard, skate and whiting. When plentiful and cheap, some formed part of the servants' meals. Fresh herrings, mackerel and conger eel also figured on the menu at Potterne. Smaller purchases of the more desirable fishes were reserved for the gentlefolk. Porpoise (then categorised as a fish) was served on just one occasion at the beginning of Lent. It was probably a Harbour Porpoise (Phocoena phocoena), which was relatively common within protected anchorages such as Bristol, then a small port not far from the mouth of the River Avon which flows into the Severn estuary. Archaeological evidence shows that fish traps set in the Severn Estuary were used to catch skate, gurnard, sea bream, salmon, mullet and plaice (Stean & Foreman, 1988, p. 118), species which were all mentioned in the accounts. Conger eel is a shallow water marine species, whose large size is reflected in the high price paid for them.

Lobsters and crabs were delicacies bought a few at a time, and reserved for the high table. Shellfish such as oysters,whelks, mussels and cockles were bought...
in very large numbers for only a few pence per hundred. This allowed the inclusion of shellfish in the dishes for the servants. The price per hundred probably reflected the low cost of gathering them from the shore, as opposed to the use of boats and nets or rods in fishing at sea, together with the danger involved. Women and children were probably set the relatively light work of chipping or pulling them from the rocks, or digging in the sand (cockles). Preliminary excavations at Potterne revealed large quantities of oyster shells (McGlashan & Sandell, 1974).

Carefully constructed manorial and monastic fishponds were common by the thirteenth century, both for breeding young fish and for harvesting mature fish. During the thirteenth and fourteenth centuries the king made gifts of breeding pairs of breams from ponds on royal manors (Stean, 1988). However, by Metford’s time fish breeding on the bishop’s manors had ceased: only roach was recorded ‘from stock’. The Abbey at Sherborne (another of his manors) still had fish-ponds containing pike and eels which were sent to Potterne, and trout could be fished with rod and line from some local streams. Freshwater species were caught in fish-weirs in rivers, where eels were particularly numerous. These also abounded in natural ponds and millponds, and the ‘sticks of small eels’ bought cheaply at Potterne were probably small freshwater eels caught in traps in the local mill ponds. Eel-traps made from wicker-work baskets woven with a plug at the end for emptying the catch, and with a non-return valve pointing towards it were used in the tidal reaches of the Lower Severn river (Stean & Foreman, 1988). Just such a trap was illustrated in the Luttrell Psalter (Fig. 4), an illuminated devotional book made for a wealthy country gentleman (Backhouse, 1989).

Grayling, pike, roach, salmon and trout were the most commonly purchased types of freshwater fish. These were high-status foods, because of the large expense of constructing and maintaining fishponds (Woolgar, 1999). Freshwater fish, other than roach were obtained from market. Pike provided the greatest weight of freshwater fish consumed, eels and roach were the most numerous.

The proportions of preserved, marine and freshwater fish eaten by the household varied seasonally (Fig. 2). The high totals of February and March reflected the abstinence from meat during Lent. Consumption of fresh marine fish decreased during the autumn and winter as fishing was increasingly discouraged by bad weather. However, the low fish consumption in January was a reflection of the big Yuletide feasts of meat. Only part of May is represented, before the household moved to Salisbury for the bishop’s funeral.

Some of the variation was due to the varying number of persons present. On ‘fast’ days when fish was served (Fig. 5) the number of resident gentlefolk was commonly between three and ten, exceeding ten on only seven occasions. Guests of gentle status seldom exceeded six. The servants were commonly fewer than on ‘meat’ days, seldom were more than eighty, and commonly ranged between thirty and seventy.
Fig. 4. Eel traps set in a mill pond, with an eel entering one of them. The traps, made of wicker-work, were tethered to a stake and weighted to keep them on the bottom. From the Luttrell Psalter, by courtesy of the British Library.

Fig. 5. The attendance at meals in the bishop’s residence at Potterne. The gentlefolk included the bishop’s principal household officers and important guests, while those given servants’ portions included household servants, visitors’ attendants and less important guests such as tradesmen and pilgrims.
The fact that fewer servants worked on fast days might be due to the shorter cooking time of fish than meat and the consequent smaller consumption of firewood. Cooking on open fires consumed enormous quantities of wood, which had to be carried to the kitchen from a barn.

If we assume that the preserved fish was fed to the servants, the visitors’ men and the ‘other’ visitors, the daily ration of fish for these persons varied between 0.5 kg and 1 kg. The lower figure might have been supplemented by shellfish, which were not included in the calculations. On days when more than this amount of preserved fish was consumed, some of it was presumably included in a dish for the gentlefolk.

In the accounts the prices for whole fish (Table I) are in the currency units of the time, commonly as pennies, halfpennies and farthings (e.g. 3½d.), occasionally in shillings. It is not possible to give a present-day equivalent, but for comparison the bishop’s head cook was paid 2d. for a twelve-hour day, and the falconer (the highest paid servant) had 4d., which included an allowance for food. A skilled carpenter would earn 4d. per day (Farmer, 1991, p. 517). Unskilled servants in the household worked for their food alone, which was considerably better than the average peasant diet.

The total cost of shellfish, marine fish excluding whiting, and freshwater fish amounted to £25 12s. 4½d. The fish eaten by the bishop's gentle visitors cost him £15 10s. 5d. of this sum, while the salt fish eaten by their servants cost him £7 0s. 2½d. The ‘other’ visitors’ fish meals cost £9. 12s.3d. The bishop’s expenses for those who enjoyed his hospitality on days when fish was eaten were at least £32 2s.10½d. during the time covered by the accounts. That is equivalent to about £52 per year, or about 5 % of the bishop's annual income. This sum does not cover the cost of bread, a major item; however the wheat was supplied by the estate administration. Neither does it include the costs of wine, ale or ingredients such as cheese, milk, spices (extremely expensive) or the various condiments such as verjuice and mustard. The visitors’ horses and dogs had to be fed too. When consideration is given to the even higher expenses of hospitality on days when meat and poultry were eaten, it can be appreciated that Richard Metford conformed to the medieval ideal of a generous noble host.

Acknowledgements
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References

Fish Consumption in a medieval English bishop's household, 1406-7
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Cover photo: *Cryptocentrus leptocephalus*, 59.7 mm SL 0 (PMBC 16159), Phuket, Thailand. Photo by U. Satapoomin.

Salmon (now Atlantic Salmon), *Salmo salar*. Hand coloured engraving by W. H. Lizars after a drawing by William Jardine, pl. 1 from Jardine’s *British Salmonidae*, 1839-41. The engraving represents one of the 25 species of fish eaten in a 15th century English bishop household on meatless days. (Contribution in this issue by Daphne J. Martin on pages 81-88).