



Two new species in the spike-fin fairy-wrasse species complex (Teleostei: Labridae: *Cirrhilabrus*) from the Indian Ocean

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Abstract

The western and central Indian Ocean population of the fairy wrasse, *Cirrhilabrus rubriventralis*, is here split into three allopatric species: the type species from the Red Sea; *C. rubeus*, n. sp., a new central Indian Ocean species from Sri Lanka and the Maldives; and *C. africanus* n. sp., a new east African coastal species. The three species are mainly differentiated by the color patterns of terminal-phase (TP) males. The two new species diverge from *C. rubriventralis* in the sequence of the barcode-mtDNA COI marker by 2.6% and 0.5%, respectively (pairwise distance; 2.7% and 0.5% K2P distance). The Indian Ocean species complex made up of the 8 spike-fin species allied with *C. rubriventralis* is now one of the larger species complexes among labrid reef fishes, showing an interesting pattern of allopatric sibling species dividing up the region, as well as the occurrence of localized microendemic species in Indonesia and the Timor Sea. The species complex includes some species that share mtDNA lineages (phenovariant species), as well as others up to 2.9% divergent in sequence. A neighbor-joining tree and genetic distance matrix is presented for 7 of the 8 known species in the complex.

Key words: coral-reef fishes, ichthyology, taxonomy, systematics, Africa, Red Sea, biogeography, DNA barcoding.

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Introduction

Some widespread Indo-Pacific coral-reef fish species break up into sets of regional mtDNA lineages when broad phylogenetic surveys are conducted. Typically, many (but not all) distinct lineages show corresponding phenotypic differences indicating they are species: in wrasses, these differences are most pronounced in the color patterns of the mating display of the dominant terminal-phase (TP) males. In the case of the Longfin Fairy Wrasse, *Cirrhilabrus rubriventralis* Springer & Randall, 1974, with a Red Sea type location, some of these far-flung populations have already been identified as different and named as species before genetic analyses, while

others have been considered part of a wide-ranging nominal *C. rubriventralis* in the western and central Indian Ocean. Several closely related species in the eastern Indian Ocean, which share the spike-fin morphology in TP males, have been recently described from very small ranges: i.e. *C. morrisoni* Allen, 1999 from the western Timor Sea; *C. joanallenae* Allen, 2000 from the Andaman Sea and western Sumatra; *C. naokoae* Randall & Tanaka, 2009 from Nias Island, western Sumatra; *C. humanni* Allen & Erdmann, 2012 from the eastern Sunda Islands of Indonesia; and *C. hygroxerus*, Allen & Hammer, 2016 from the eastern Timor Sea.

The spike-fin fairy-wrasse species complex allied to *Cirrhilabrus rubriventralis* is an interesting case study of the taxonomy and evolution of coral-reef fishes. Two recent advances have permitted more focused examination of the differences between populations and assist in the decision to elevate regional variations to species status. One is wide-scale mtDNA sequencing which has generally encouraged more splitting of species. However, there is a risk of making facile decisions based on finding divergent DNA lineages, especially in fishes that are rare, or found in difficult-to-sample habitats, or highly variable in appearance. In these cases, the temptation to accept a difference based on a couple of photographs or specimens of different sizes or from different habitats can be strong. It is then especially important to critically evaluate the range of appearances and assemble as large a variety of specimens or images as possible to document the pertinent differences. The closeness of sibling species makes this a difficult task, since it would be expected that the ranges of appearances would be very likely overlapping in most, if not all, characters. Without non-overlapping and consistent characters, species should not be split.

The second advance is the proliferation of underwater photography, which permits a more comprehensive evaluation of color-pattern characters; notably, it is specifically these characters, especially mating displays, that would be expected to be the first features to diverge in the process of speciation of sibling species. Furthermore, the expansion of available images can help evaluate the range of appearances for a population, which can often be extreme in coral-reef fishes, where size, gender, mating phase, habitat, and mood can change the appearance dramatically. In the labrids of *Cirrhilabrus* and *Paracheilinus*, TP males have spectacular nuptial displays, which differ from the resting TP-male color patterns, and emphasize species-specific differences (e.g. Allen *et al.* 2016).

Both of these advances are important for evaluating the *Cirrhilabrus rubriventralis* species complex; these fishes vary in TP-male color patterns within populations, from mottled to colorful to the nuptial display, and putative differentiating characters can dissolve with additional images. Only when a wide variety of images are examined can a generalization be made with some confidence. Genetic analyses can help distinguish which populations are divergent, thus presumably reproductively isolated, which can help in the assessment, but in no way decide whether two populations are different species. Indeed, in many recent cases, especially in these colorful harem wrasses, clearly different species have been shown to share mitochondrial haplotypes (phenovariant species; e.g. Allen *et al.* 2015, Tea *et al.* 2016). Conversely, in other reef fishes, genetically divergent populations have been found to not differ in phenotype (genovariant populations; e.g. Victor 2016).

Materials and Methods

Specimens have been examined on loan from the Bernice P. Bishop Museum, Honolulu (BPBM) and by Gerald Allen at the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). In addition, ethanol-preserved specimens (or tissues and/or sequences) of comparison species were collected by the author and various contributors for mtDNA sequencing from the Red Sea at Eilat (Israel), Bali and Sumatra (Indonesia), Andaman Sea, Timor Sea (Australia), and South Africa, as well as obtained via the aquarium trade from Kenya, Sri Lanka, and Maldives (see Appendix 1). A series of photographs of Indian Ocean specimens in the Japanese aquarium trade was made available by Hiroyuki Tanaka (pers. comm.).

DNA extractions were performed with the NucleoSpin96 (Machery-Nagel) kit according to manufacturer specifications under automation with a Biomek NX liquid-handling station (Beckman-Coulter) equipped with a filtration manifold. A 652-bp segment was amplified from the 5' region of the mitochondrial COI gene using a variety of primers (Ivanova *et al.* 2007). PCR amplifications were performed in 12.5 μ l volume including 6.25 μ l of 10% trehalose, 2 μ l of ultra pure water, 1.25 μ l of 10 \times PCR buffer (10mM KCl, 10mM (NH₄)₂SO₄, 20mM Tris-HCl (pH 8.8), 2mM MgSO₄, 0.1% Triton X-100), 0.625 μ l of MgCl₂ (50mM), 0.125 μ l of each primer (0.01mM), 0.0625 μ l of each dNTP (10mM), 0.0625 μ l of *Taq* DNA polymerase (New England Biolabs), and 2 μ l of template

DNA. The PCR conditions consisted of 94°C for 2 min., 35 cycles of 94°C for 30 sec., 52°C for 40 sec., and 72°C for 1 min., with a final extension at 72°C for 10 min. Specimen information and barcode sequence data from this study were compiled using the Barcode of Life Data Systems (BOLD; Ratnasingham & Hebert 2007). The sequence data is publicly accessible on BOLD and GenBank. Sequence divergences were calculated using BOLD with the Kimura 2-parameter (K2P) model generating a mid-point rooted neighbor-joining (NJ) phenogram to provide a graphic representation of the species' sequence divergence. Genetic distances were calculated by BOLD, both as uncorrected p-distances and as K2P distances. The lineage comprising the sequences, as calculated by a BOLD clumping algorithm, is presented in the description with a Barcode Index Number (BIN) number.

The length of specimens is given as standard length (SL), measured from the median anterior end of the upper lip to the base of the caudal fin (posterior end of the hypural plate); body depth is the greatest depth from the base of the dorsal-fin spines to the ventral edge of the abdomen (correcting for any malformation of preservation); body width is measured just posterior to the gill opening; head length from the front of the upper lip to the posterior end of the opercular flap; orbit diameter is the greatest fleshy diameter of the orbital rim, and interorbital width the least bony width; snout length is measured from the median anterior point of the upper lip to the nearest fleshy rim of the orbit; caudal-peduncle depth is the least depth, and caudal-peduncle length the horizontal distance between verticals at the rear base of the anal fin and the caudal-fin base; predorsal, prepelvic and preanal lengths are oblique measurements; lengths of spines and rays are measured to their extreme bases; caudal-fin and pectoral-fin lengths are the length of the longest ray; pelvic-fin length is measured from the base of the pelvic spine to the tip of the longest soft ray. The rudimentary uppermost pectoral-fin ray is included in the count. Lateral-line scale counts include as "plus one" the last pored scale that overlaps the end of the hypural plate (the giant scales on the base of the caudal fin are not pored). The count of gill rakers is made on the first gill arch and includes all rudiments. Proportional measurements in the text are rounded to the nearest 0.1. The counts and range for the paratypes are shown in parentheses following data for the holotype, if different. Proportional morphological measurements as percentages of the standard length are presented in Tables 1 and 2.

Live color description of *Cirrhilabrus rubriventralis* Springer & Randall, 1974

Most descriptions of species in the spike-fin complex allied to *Cirrhilabrus rubriventralis* are based on few specimens and especially few, if any, in-situ underwater photographs. This is likely because these fishes typically frequent deeper non-reef habitats that are uncommonly visited by divers, and traditionally the number of photographs are limited when publishing species descriptions. In addition, the first character to diverge among closely related harem wrasses is the TP-male spawning colors (the nuptial display), which is critical for species recognition in mating, and this display is fleeting. Also, this set of fishes have a mottled phase, a more camouflaged pattern present when not mating and perhaps in more turbid conditions. As a result, the complete color description has not been assembled for species such as *C. rubriventralis* and the color differences between species have sometimes been based on incomplete documentation and inconsistent features. The recent proliferation of high-quality underwater photographs permits more complete descriptions, including the rare nuptial-male display, and many more photographs than those presented here have been reviewed (for the Red Sea species *C. rubriventralis* by S.V. Bogorodsky, E. Bojanovsky, E. Brokovich, J. De Vroe, R. Field, D. King, J.E. Randall, and H. Sjoeholm).

The juveniles of *C. rubriventralis* are orange-red with thin, dark-outlined alternating stripes and rows of small spots, blue or pinkish, running from the snout to the base of the caudal fin; in addition, there is a patch of bright white on the upper snout and a black blotch on the upper caudal peduncle, both typical of juvenile *Cirrhilabrus* of many, if not all, species (Fig. 1). The iris is bright orange-red and the fins are transparent and unmarked.

As juveniles grow into the initial phase (IP), the white patch becomes smaller and disappears and the upper snout becomes yellowish (Fig. 1). The black blotch on the upper part of the caudal peduncle becomes less defined and progressively fades away. A bright yellow patch becomes prominent around the pectoral-fin base. The thin bluish lines of the juveniles become more pinkish to lavender to reddish on IP females, and the mid-lateral stripe breaks up into spots and, in some, additional short vertical lines. The ventral part of the head and body lightens, becoming pale yellow on the head and whitish on the ventral body. The fins remain transparent and unmarked.



Figure 1. *Cirrhilabrus rubriventralis*, initial-phase, Red Sea: top: juvenile, Sha'abrur Umm Gamar, Hurghada, Egypt (J. De Vroe); upper middle: small IP, Marsa Abu Galawa, Hurghada, Egypt (J. De Vroe); lower middle: IP female, Eilat, Israel (J.E. Randall); bottom: large IP, Jeddah, Saudi Arabia (R. Field).

The transition to the TP male begins with the development of iridescent bluish spotting on the median fins and intensified colors on the head and body (Fig. 2). In TP males, a prominent row of large bluish spots develops on the enlarged scales overlying the base of the dorsal-fin membranes. In addition, thin blue lines run across the upper head and one, more prominent, line runs just under the eye. These stripes do not continue onto the body as in the IP fish, but break up into rows of bright bluish spots and short vertical lines along the sides of the body extending to the base of the caudal fin (Fig. 3). The pattern of thin stripes and spots can range from blue to lavender or crimson. Some individuals do not show the arrays of spots and lines on the body (Figs. 4 & 5). A

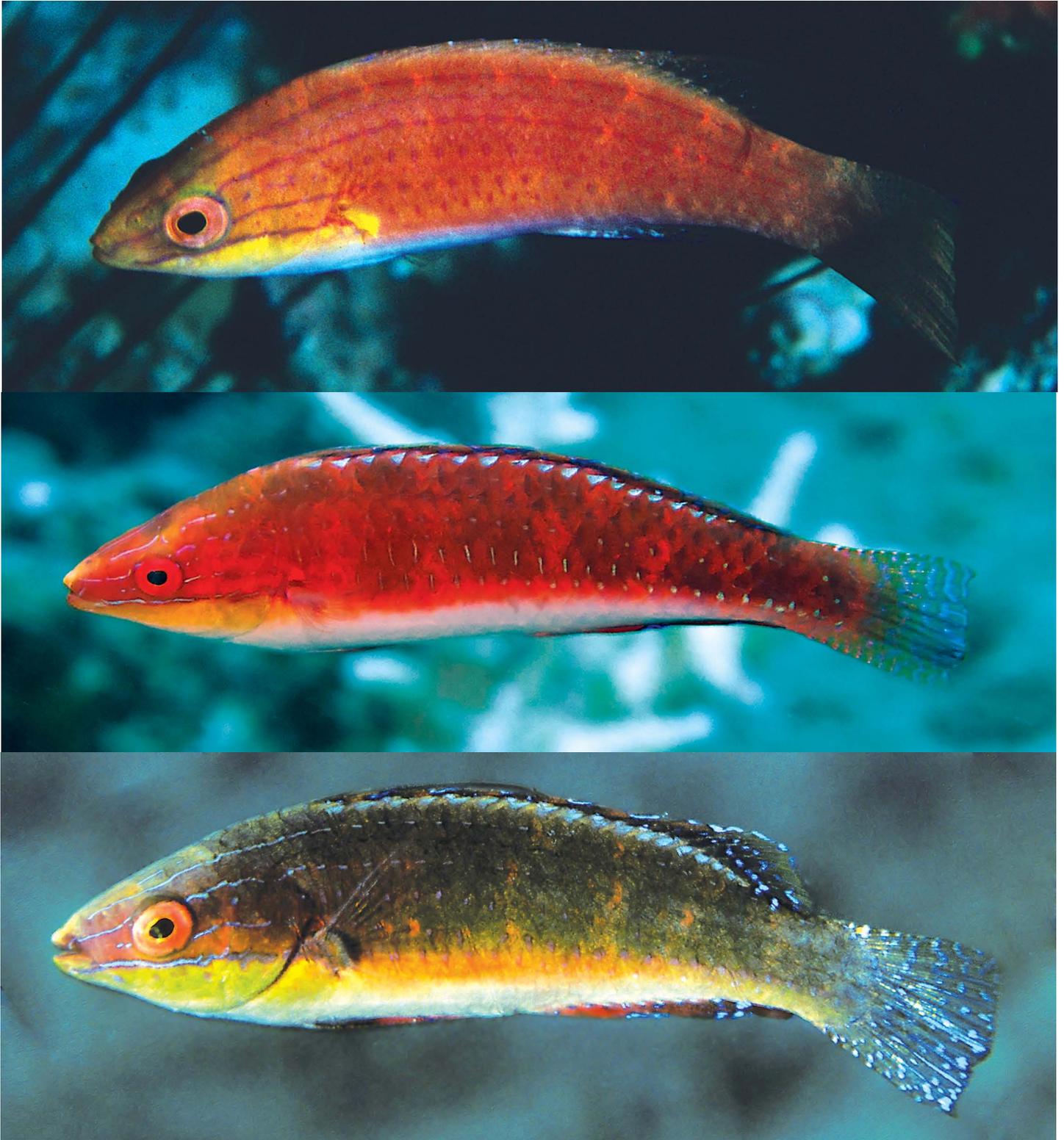


Figure 2. *Cirrhilabrus rubriventralis*, likely transitional phase, Red Sea- top: Eilat, Israel (J.E. Randall); middle: Naama Bay, Sharm el-Sheikh, Egypt (S.V. Bogorodsky); bottom: mottled TP, Eilat, Israel (J.E. Randall).

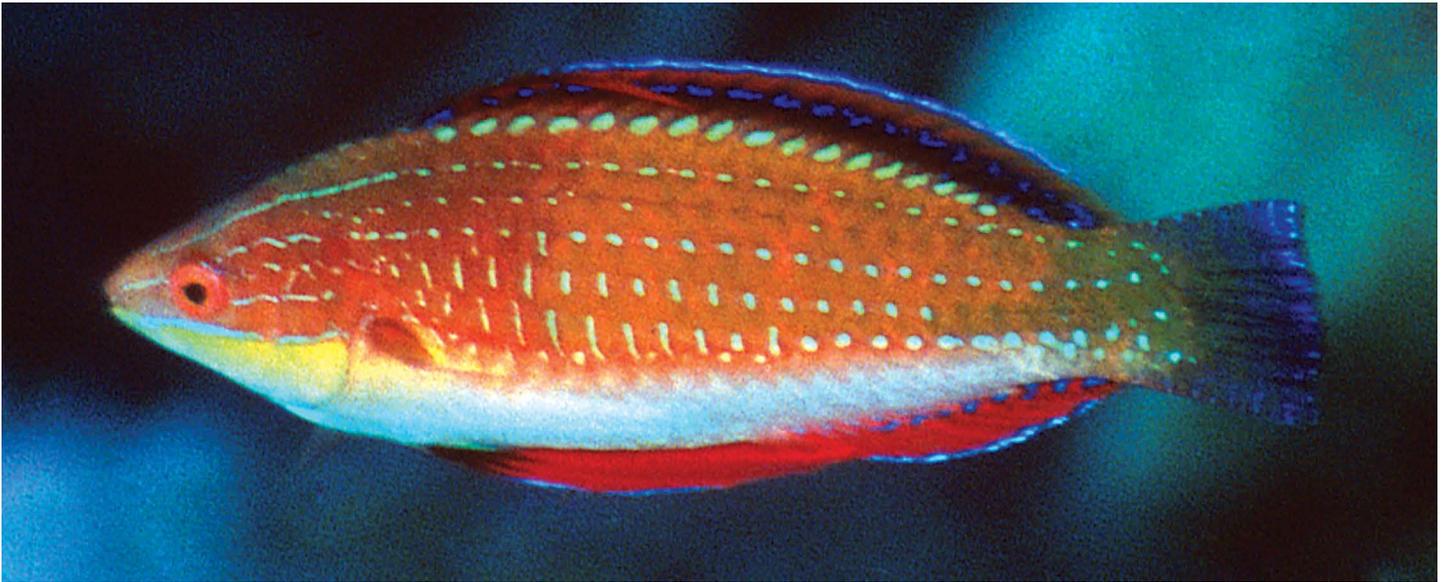


Figure 3. *Cirrhilabrus rubriventralis*, TP male, Red Sea, Eilat, Israel (E. Brokovich).

less common pattern of TP male is darker and mottled with subdued colors, including a faint barred pattern, and overall more yellow and the stripes and spots are darker purple; this “mottled” phase is likely adopted when there is no spawning activity and this more camouflaged pattern may occur in more turbid habitats (Fig. 2C).

Well-developed TP males have brightly contrasting colors, especially the contrasting bands of a dark dorsal fin, an orange-red upper body, a white ventral body and red band of pelvic and anal fins. The most significant morphological change in the TP male is the development of elongated fins: the first two dorsal-fin spines and membranes become long thin colorful filaments and the pelvic fins expand into large paddle-like extensions reaching back to the mid-portion of the anal-fin base (Figs. 3, 4 & 5). The dorsal-fin filaments vary greatly in length, usually long and extending to the level of the mid-dorsal fin, but sometimes shorter, only two or three times the height of the remaining dorsal-fin spines (as in Fig. 5 lower). The dorsal-fin membranes are mostly dark, with the anterior filamentous extensions black at the base and reddish along the thread-like distal portion; the remaining dark dorsal fin is divided along the midportion by an irregular row of bright blue spots and the edge of the fin has a thin blue rim. The caudal fin is mostly rounded, sometimes with slight extensions of the upper and lower tips, and shows an iridescent blue-green sheen densely speckled with bright blue spots and short lines. The anal fin ranges from bright red-orange to crimson with a row of bluish spots near the base of the fin and a thin blue rim along the edge. The large pelvic fins are broadly bright red-orange to crimson with a variable thin blue rim and black on the base, but the black is limited in extent to, at most, the proximal third of the fin.



Figure 4. *Cirrhilabrus rubriventralis*, TP male, Red Sea, Jeddah, Saudi Arabia (R. Field).



Figure 5. *Cirrhilabrus rubriventralis*, fresh photographs, TP males, Red Sea: paratype, 63.4 mm SL, BPBM 16851 (upper); holotype, 54.1 mm SL, USNM 212007, (lower), both Eilat, Israel (J.E. Randall).



Figure 6. *Cirrhilabrus rubriventralis*, TP male displaying to IP female or transitional phase, Jeddah, Saudi Arabia (R. Field).

Displaying TP males intensify their colors, and the white ventral third of the body contrasts strongly with the colored bands above and below (Fig. 6). In the rarely documented nuptial display photographed by S.V. Bogorodsky at Dahab, Egypt, a different color pattern is documented: as TP males prepare for the spawning rush, they flash a more contrasting and iridescent color display (Fig 7). In this species, the rear upper body turns bright yellow, the pelvic fins are expanded fully and bright crimson, and an iridescent patch of yellowish green develops below the erected first dorsal-fin spines.



Figure 7. *Cirrhilabrus rubriventralis*, TP male in nuptial display, Dahab, Egypt (S.V. Bogorodsky).



Figure 8. *Cirrhilabrus rubeus*, fresh holotype, BPBM 41297, TP male, 49.3 mm SL, aquarium trade, Sri Lanka (B.C. Victor).

***Cirrhilabrus rubeus*, n. sp.**

Ruby Longfin Fairy Wrasse

urn:lsid:zoobank.org:act:CDC67A9C-9B1C-4208-8638-7B55B61B6D08
BIN BOLD:AAJ0977

Figures 8–11, 13, 23C; Table 1.

Cirrhilabrus rubriventralis [non Springer & Randall] Michael 2009: 148, 1 fig. (Sri Lanka); Kuitert 2010: 143, figs. A & C (aquarium trade, reported as Red Sea origin, but probably Sri Lanka or Maldives).

Holotype. BPBM 41297, 49.3 mm SL, TP male, Sri Lanka, aquarium trade, about 1 September 2013.

Paratypes. BPBM 41298, 50.3 mm SL, TP male, same collection data as holotype. BPBM 41299, 53.5 mm SL, TP male, Maldives, aquarium trade, about 1 November 2013.

Diagnosis. Dorsal-fin rays XI,9; anal-fin rays III,9; pectoral-fin rays 15; pored lateral-line scales 15–17 + 6–8 (+1 over caudal-fin base); 3 or 4 median predorsal scales; 5 or 6 scales in single row on cheek below eye; uniserial row of suborbital pores; gill rakers 13–15. Morphometrics for TP males: body depth 3.7–3.8 in SL; body width in depth 2.0; head length 3.0–3.4 in SL; first two dorsal-fin spinous membranes greatly elongated and filamentous, 1.6–3.4 and 1.3–3.0 in SL, respectively; caudal fin rounded with extended upper and lower tips, 1.1–1.3 in HL; pelvic fins of TP male greatly elongated and broadly fan-like, reaching posteriorly to about middle of anal fin, 2.0–2.1 in SL. Upper head and body of TP male bright red to red-orange, divided from whitish lower head and body by a usually unbroken, bluish to lavender full-length stripe; anterior part of dorsal fin reddish, rear of fin dark basally and yellowish distally (variable extent of yellow on fin), divided mid-way out by a dark-outlined blue stripe breaking into spots (after a variable distance) posteriorly; caudal fin with blue-green sheen and numerous small bluish spots and lines; anal fin reddish to dark with an often incomplete row of bluish spots near base of fin; pelvic fins greatly elongated and mostly red on outer portion and mostly black on inner rays, with black streaks typically extending full length, with black fin tips.



Figure 9. *Cirrhilabrus rubeus*, fresh paratype, BPBM 41298, TP male, 50.3 mm SL, aquarium trade, Sri Lanka (B.C. Victor).

Description. (based on 3 TP male types, 49.3–53.5 mm SL) Dorsal-fin rays XI,9; anal-fin rays III,9; all dorsal and anal-fin soft rays branched (first can be unbranched), last ray usually split to base (counted as one); pectoral-fin rays 15, the uppermost vestigial, the next unbranched; pelvic-fin rays I,5; segmented caudal-fin rays 15, uppermost and lowermost one or two rays unbranched; upper and lower procurrent visible caudal-fin rays 3 or 4; lateral-line interrupted, pored scales 16–17 + 6–7 (+1 over caudal-fin base)(15–17 + 6–8; +1 over caudal-fin



Figure 10. *Cirrhilabrus rubeus*, aquarium photograph, TP male, approx. 60 mm SL, aquarium trade, Sri Lanka (H. Tanaka).



Figure 11. *Cirrhilabrus rubeus*, fresh paratype, BPBM 41299, TP male, 53.5 mm SL, aquarium trade, Maldives (B.C. Victor).

base); scales above lateral line to origin of dorsal fin 2; median predorsal scales 3 (3–4); 5 (5 or 6) scales in single row on cheek below eye; gill rakers 13 (14–15).

Body moderately elongate, body depth 3.8 (3.7–3.8) in SL; body moderately compressed, width 2.0 (2.0) in depth; dorsal profile of head nearly straight, becoming slightly convex on nape; HL 3.1 (3.0–3.4) in SL; snout short and pointed, length 3.9 (3.6–4.6) in HL; orbit diameter 4.4 (4.2–4.3) in HL; interorbital width 3.8 (3.8–4.1) in HL; caudal-peduncle depth 2.5 (2.2–2.5) in HL; caudal-peduncle length 1.9 (1.7–1.9) in HL (unlike many other labrid genera, this distance from the last anal-fin ray insertion to the caudal-fin base is distinctly longer than the dorsal distance). Mouth small, terminal, and oblique; dentition typical of the genus with three pairs of canine teeth on each side of anterior upper jaw, progressively longer, stouter, and more laterally recurved posteriorly, followed by a row of about 18–25 small conical teeth; lower jaw with single moderately enlarged canine on each side, projecting forward and outwardly curved, fitting between first and second upper-jaw canines, followed by an irregular row of about 16–20 small conical teeth in lower jaw; tongue short with rounded anterior edge; gill rakers short, longest on first arch about one-third length of longest gill filament. Posterior margin of preopercle with 31–33 (30–34) small serrae, mostly bridged by bone as to be barely serrate; margin of posterior edge of preopercle free to level of middle of pupil, margin of ventral edge of preopercle free nearly to below anterior margin of pupil; anterior nostril small, in short membranous tube with posterior flap; head pores in a uniserial row around orbit, a series of 14–18 (14–16) from anterior mid-eye to posterior rim of orbit, followed by a line of 3 (3–4) more along upper rear edge of orbit; 10–11 (11–13) pores along preopercle forward to mandible, in an irregular inner row and shorter outer row along ventral rim of preopercle.

Scales cycloid; head scaled except snout, interorbital region, lips, chin, and posterior and ventral edges of preopercle; cheek below eye with a single row of large embedded cycloid scales; base of dorsal and anal fins with row of large, pointed, elongate scales; base of caudal fin with three very large unpored scales; two elongated, pointed, median ventral scales between pelvic fins.

Origin of dorsal fin above second lateral-line scale; first two dorsal-fin spines moderately longer than subsequent spines, with greatly elongated and filamentous membranes, first dorsal-fin spine 2.2 (2.1–2.9) in HL; second dorsal-fin spine 2.2 (2.5–2.8) in HL; last dorsal-fin spine 2.6 (2.2–2.5) in HL; first filamentous dorsal membrane 1.6 (1.6–3.4) in SL, second filamentous dorsal membrane broken (1.3–3.0) in SL; each dorsal-fin spine

TABLE 1

Proportional measurements of TP male type specimens of *Cirrhilabrus rubeus*, n. sp.
as percentages of the standard length

	holotype	paratypes	
	BPBM 41297	BPBM 41298	BPBM 41299
Standard length (mm)	49.3	50.3	53.5
Body depth	26.2	26.8	26.0
Body width	12.8	13.3	13.3
Head length	32.0	32.8	29.5
Snout length	8.3	9.1	6.4
Orbit diameter	7.3	7.6	7.1
Interorbital width	8.5	8.5	7.3
Caudal-peduncle depth	13.0	12.9	13.5
Caudal-peduncle length	17.0	17.3	17.6
Predorsal length	31.4	33.6	31.0
Preanal length	61.3	61.0	60.9
Prepelvic length	31.4	32.6	31.6
Base of dorsal fin	57.0	56.9	55.3
First dorsal-fin spine	14.6	11.3	14.0
Second dorsal-fin spine	14.6	12.9	10.5
Third dorsal-fin spine	13.0	9.7	10.8
First filamentous dorsal-fin membrane	63.9	63.6	29.5
Second filamentous dorsal-fin membrane	broken	74.6	33.6
Eleventh dorsal-fin spine	12.2	13.3	13.5
Longest dorsal-fin ray	16.4	17.1	18.3
Base of anal fin	22.1	23.9	23.6
First anal-fin spine	5.3	4.8	5.0
Second anal-fin spine	7.5	6.4	6.7
Third anal-fin spine	9.3	8.5	9.2
Longest anal-fin ray	15.2	15.1	17.4
Caudal-fin length	26.4	26.2	27.7
Pectoral-fin length	18.1	18.1	17.4
Pelvic-spine length	13.4	12.5	14.0
Pelvic-fin length	47.9	47.3	49.5

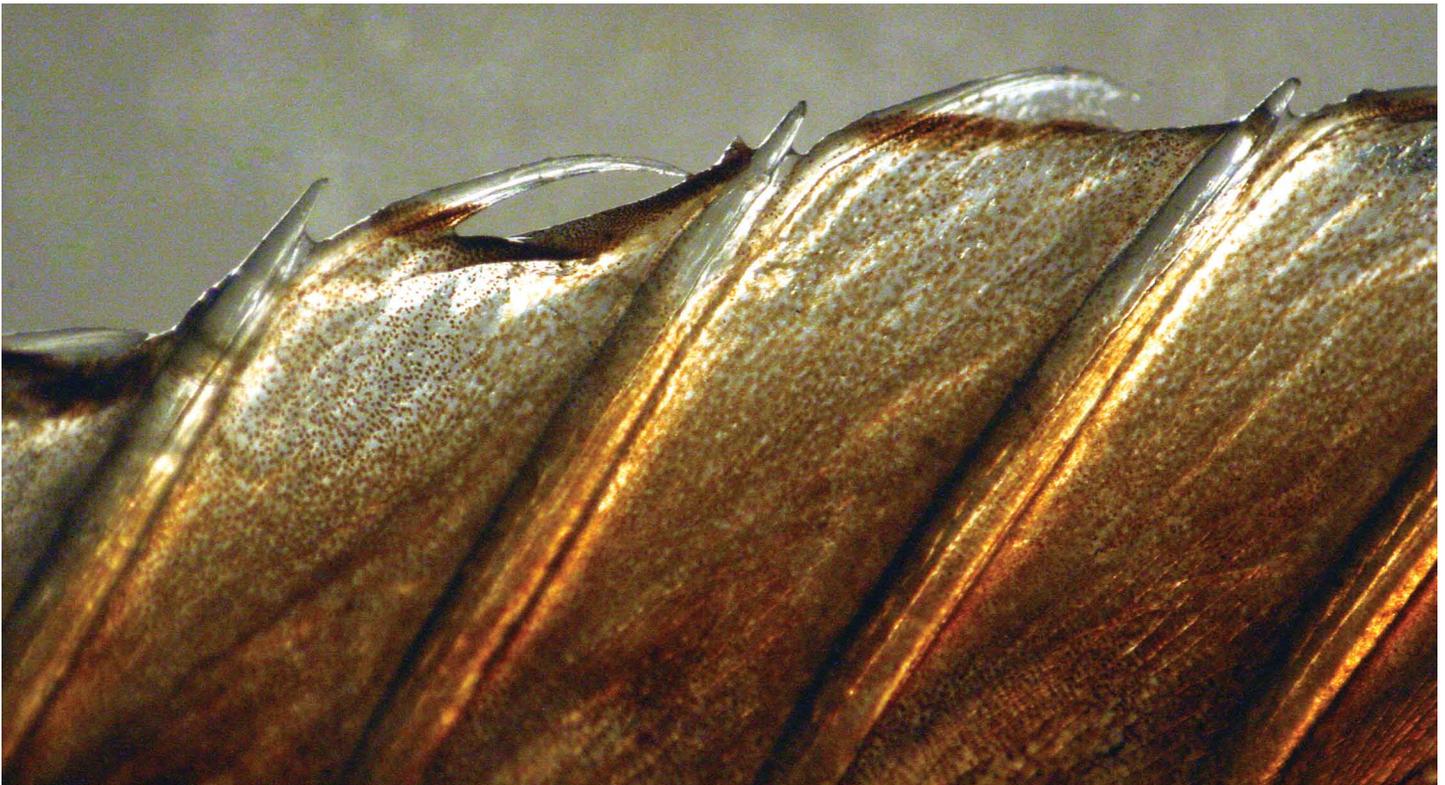


Figure 12. *Cirrhilabrus rubriventralis*, detail from preserved paratype showing segmented-ray-like extensions behind and beyond mid-dorsal-fin spines, BPBM 444444, TP male, 44.4 mm SL, Eilat, Israel (B.C. Victor).

tip followed by segmented-ray-like extension with associated membrane (as in Fig. 12); first dorsal-fin soft ray 2.1 (1.8–2.0) in HL; longest dorsal-fin soft ray 2.0 (1.6–1.9) in HL; origin of anal fin below base of penultimate dorsal-fin spine; first anal-fin spine 6.1 (5.9–6.9) in HL; second anal-fin spine 4.3 (4.4–5.2) in HL; third anal-fin spine 3.4 (3.2–3.8) in HL; longest anal-fin soft ray 2.1 (1.7–2.2) in HL; caudal fin rounded, 1.2 (1.1–1.3) in HL (measured at midline); pectoral-fin length 1.8 (1.7–1.8) in HL; origin of pelvic fins below upper pectoral-fin base; pelvic fins of TP males greatly elongated and fan-like, reaching to about middle of anal fin, 2.1 (2.0–2.1) in SL.

Color in life. (Figs. 8–11, 13, 23C) Upper head and body of TP males bright red to red-orange, often grading to dusker posteriorly on body; ventral aspect of head and body, below level of mid-cheek and pectoral-fin base, yellowish white; a prominent thin bluish-to-lavender stripe divides red upper body from white ventrum, running from corner of jaw across head, in an oblique segment below pectoral-fin base, and continuing horizontally along body to base of caudal fin, notably stripe does not break up into spots at mid-body (occasional exception photographed in aquarium trade); several rows of relatively inconspicuous bluish to purple spots run across red upper body and on the enlarged scale row along dorsal-fin base; first two dorsal-fin spines and filamentous membranes variably red and black, remaining spinous-fin membranes red grading to yellow-orange at a variable distance rearwards and distally, proximal portion of posteriormost dorsal fin black; a dark-outlined blue stripe runs midway out along dorsal fin, breaking into spots after a variable distance rearwards; a thin dark-underlined blue line runs along dorsal-fin margin; caudal fin mostly with a blue-green sheen and numerous small bluish spots and lines; anal fin reddish to dusky maroon to blackish posteriorly, with an often incomplete row of dark-outlined bluish spots near base of fin; a thin dark-underlined blue line runs along anal-fin margin; fan-like pelvic fins mostly red on outer portion and mostly black on inner rays, with black streaks typically extending full length with black fin tips, and a variable thin blue rim is present on both outer and inner fin margins. Iris bright reddish orange.

Nuptial display of TP males (Fig. 13) is more contrasting: upper body, a broad wedge behind eye, and base of caudal fin become bright yellow-orange (isolating red oval at pectoral-fin base), lower body flashes bright white and dividing line is prominent as a red and blue stripe; soft dorsal fin becomes bright yellow with a black proximal blotch, anal and pelvic fins are bright red, and iridescent blue spots and edging on median fins are more conspicuous.

Color in alcohol. Body of alcohol-fixed and preserved TP males light tan above, grading to white ventrally; original bluish stripes on head and rows of spots on upper body and dorsal and anal fins persist as reflective pigmented markings; dorsal, anal, and caudal fins mostly translucent but outlined bluish stripes and spots persist as dark markings and dark areas on fins persist as dusky markings; pectoral fins translucent; pelvic fins with full-length dark streaks.

Etymology. The new species is named *rubeus* (Latin for red, derived from the name of the bramble bush which bears red raspberries) for its bright red color, as a masculine nominative singular adjective of the second declension.

Distribution. The new species is described from specimens from Sri Lanka and the Maldives. There are no records of species in the spike-fin *Cirrhilabrus* complex from Seychelles, Chagos Archipelago, Madagascar, or Mauritius, although the former three locations, at least, have not been well surveyed for deep-dwelling reef-fish species. Chabiraj (Yam) Gurroby, a long-time diver and reef-fish collector in Mauritius, confirms he has never seen a member of the complex in Mauritius and that only the two congeners *C. exquisitus* and *C. sanguineus* occur there.

Barcode DNA sequence. A 652-nucleotide sequence of the segment of the mitochondrial COI gene used for barcoding by the BOLD informatics database (Ratnasingham & Hebert 2007) was obtained for the holotype. Following the database management recommendation of the BOLD, the sequence of the holotype (GenBank accession number KY033479) is presented here as well:

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CCTCTATCTCGTATTTGGTGCTTGAGCTGGAATAGTAGGTACAGCCCTGAGCCTTCTTATGCA  
GAACTTAGTCAACCAGGTGCACTCCTGGGCGACGATCAAATCTATAATGTGATCGTCACTGC  
ACACGCTTTTGTGATAATTTTCTTCATAGTAATACCTATTATAATTGGAGGATTTGGAAACTGG  
CTTATCCCTTTAATAATTGGAGCCCCAGACATGGCATTTCCTCGAATAAATAATATGAGTTTCT  
GGCTTCTTCCCCCCTCCTTTCTTCTTCTTCTTGCCTCATCAGGGGTTGAAGCCGGAGCAGGA  
ACAGGTTGGACTGTGTACCCTCCTTTAGCTGGCAATCTTGCACATGCTGGTGCCTCTGTAGA  
TTTAACTATTTTTTCCCTTCACCTTGCAGGTATCTCCTCAATTCTAGGTGCAATCAATTTTATT  
ACAACAATTATTAATATAAAACCTCCAGCTATTTCCAATATCAAACACCTTTGTTTGTCTGA  
GCGGTGTTAATTACTGCTGTCCTGCTCCTGCTCACTCCCTGTCCTAGCTGCCGGAATTACA  
ATACTTTTAACTGACCGAAATCTAAATACCACTTTCTTTGACCCAGCTGGGGGAGGGGACCC  
TATTCTTTACCAGCACTTG
```



Figure 13. *Cirrhilabrus rubeus*, aquarium photograph, TP male in nuptial display, aquarium trade to Japan (H. Tanaka).



Figure 14. *Cirrhilabrus africanus*, fresh holotype, BPBM 41295, TP male, 53.0 mm SL, aquarium trade, Kenya (B.C. Victor).

***Cirrhilabrus africanus*, n. sp.**

African Longfin Fairy Wrasse

urn:lsid:zoobank.org:act:88CD8B3B-3A34-4DAF-B3DE-5A7795ED63CA
BIN BOLD:ACJ1940

Figures 14–20, 23B; Table 2.

Cirrhilabrus sp. Heemstra & Heemstra 2004: 342 (KwaZulu-Natal, South Africa).

Cirrhilabrus sp. 2 Kuitert 2010: 143 lower, figs. A, B & C (KwaZulu-Natal, South Africa).

Cirrhilabrus sp. 3 Kuitert 2010: 145 upper, figs. A & B (aquarium trade, from Kenya).

Holotype. BPBM 41295, 53.0 mm SL, TP male, Kenya, aquarium trade, about 1 August 2013.

Paratypes. BPBM 41296, 55.6 & 65.2 mm SL, TP males, 51.0 & 43.5 mm SL, females, Kenya, aquarium trade, about 1 November 2013.

Diagnosis. Dorsal-fin rays XI,9; anal-fin rays III,9; pectoral-fin rays 15; pored lateral-line scales 15–18 + 6–7 (+1 over caudal-fin base); 3 or 4 median predorsal scales; 5–7 scales in single row on cheek below eye; uniserial row of suborbital pores; gill rakers 14–16. Morphometrics for TP males: body depth 3.2–3.8 in SL; body width in depth 1.8–1.9; head length 3.0–3.1 in SL; first two dorsal-fin spinous membranes moderately elongated and filamentous, 3.7–4.3 and 5.4–7.7 in SL, respectively; caudal fin rounded without extended upper and lower tips, 1.1–1.3 in HL; pelvic fins of TP male greatly elongated and broadly fan-like, reaching posteriorly to about middle of anal fin, 2.1–2.3 in SL. Upper head and body of TP male reddish orange, lower head and body yellow to white, about three rows of small, well-spaced, bluish-to-lavender or reddish spots (not a stripe) across upper body; dorsal fin mostly dark to dusky red, divided mid-way out by a row of separated rounded spots (after first two membranes); caudal fin mostly dark with coppery-to-greenish sheen and numerous small pale spots and lines; anal fin mostly dark to dusky reddish; pelvic fins greatly elongated and mostly dark to dusky reddish.



Figure 15. *Cirrhilabrus africanus*, fresh paratype, BPBM 41296, TP male, 55.6 mm SL, aquarium trade, Kenya (B.C. Victor).



Figure 16. *Cirrhilabrus africanus*, aquarium photograph, TP male, aquarium trade, Kenya (K. Kohen).

Description. [based on 3 TP male types, 53.0, 55.6 & 65.2 mm SL, and 2 female types, 51.0 & 43.5 mm SL: morphometrics presented as holotype (male range; female range)] Dorsal-fin rays XI,9; anal-fin rays III,9; all dorsal and anal-fin soft rays branched (first can be unbranched), last ray usually split to base (counted as one); pectoral-fin rays 15, the uppermost vestigial, the next unbranched; pelvic-fin rays I,5; segmented caudal-fin rays 15, uppermost and lowermost one or two rays unbranched; upper and lower procurrent visible caudal-fin rays 3 or 4; lateral-line interrupted, pored scales 16–17 + 6–7 (+1 over caudal-fin base)(15–18 + 6–7; +1 over caudal-fin base); scales above lateral line to origin of dorsal fin 2; median predorsal scales 4 (3–4); 5 (5–7) scales in single row on cheek below eye; gill rakers 15 (14–16).

Body moderately elongate, body depth 3.5 (3.2–3.8; 2.9–3.5) in SL; body moderately compressed, width 1.8 (1.8–1.9; 1.9–2.0) in depth; dorsal profile of head nearly straight, becoming slightly convex on nape; HL 3.0 (3.1–3.4; 2.9–3.0) in SL; snout short and pointed, length 4.5 (3.9–4.4; 4.1–4.3) in HL; orbit diameter 4.1 (4.2–4.4; 3.7–4.2) in HL; interorbital width 4.0 (4.1–4.3; 4.6) in HL; caudal-peduncle depth 2.2 (2.3–2.4; 2.4–2.5) in HL; caudal-peduncle length 1.8 (1.8–2.0; 2.1–2.2) in HL (unlike many other labrid genera, this distance from the last anal-fin ray insertion to the caudal-fin base is distinctly longer than the dorsal distance). Mouth small, terminal and oblique; dentition typical of the genus with three pairs of canine teeth on each side of anterior upper jaw, progressively longer, stouter, and more laterally recurved posteriorly, followed by a row of about 18–26 small conical teeth; lower jaw with single moderately enlarged canine on each side, projecting forward and outwardly curved, fitting between first and second upper-jaw canines, followed by an irregular row of about 17–29 small conical teeth in lower jaw; tongue short with rounded anterior edge; gill rakers short, longest on first arch about one-third length of longest gill filament. Posterior margin of preopercle with 30–34 (30–40) small serrae, mostly bridged by bone as to be barely serrate; margin of posterior edge of preopercle free to level of middle of pupil, margin of ventral edge of preopercle free nearly to below anterior margin of pupil; anterior nostril small, in short membranous tube with posterior flap; head pores in a uniserial row around orbit, a series of 12–15 (11–19) from anterior mid-eye to posterior rim of orbit, followed by a line of 4 (3–5) more along upper rear edge of orbit; 11–12 (11–14) pores along preopercle forward to mandible, in an irregular inner row and shorter outer row along ventral rim of preopercle.

Scales cycloid; head scaled except snout, interorbital region, lips, chin, and posterior and ventral edges of preopercle; cheek below eye with a single row of large embedded cycloid scales; base of dorsal and anal fins with row of large, pointed, elongate scales; base of caudal fin with three very large unpored scales; two elongated, pointed, median ventral scales between pelvic fins.

Origin of dorsal fin above second lateral-line scale; first two dorsal-fin spines moderately longer than subsequent spines, with greatly elongated and filamentous membranes, first dorsal-fin spine 2.8 (2.5–2.9; 4.3–4.6) in HL; second dorsal-fin spine 3.2 (3.0–3.1; 4.0–4.4) in HL; last dorsal-fin spine 2.5 (2.5–2.6; 2.6–2.7) in HL; first filamentous dorsal membrane 4.3 (3.7–3.8; 9.8–10.1) in SL, second filamentous dorsal membrane 7.7 (5.4–7.6;



Figure 17. *Cirrhilabrus africanus*, aquarium photograph, IP, likely female starting transition (darkening dorsal fin, patterned fins, fading caudal-peduncle blotch), aquarium trade, Kenya (H. Tanaka).

TABLE 2

Proportional measurements of type specimens of *Cirrhilabrus africanus*, n. sp.
as percentages of the standard length

	holotype		paratypes		
	BPBM 41295	BPBM			
		41295		41296	
		TP males	females		
Standard length (mm)	53.0	55.6	65.2	51.0	43.5
Body depth	28.5	26.6	31.0	34.5	28.7
Body width	15.8	15.1	16.3	17.5	14.9
Head length	33.6	32.2	32.2	33.5	34.7
Snout length	7.5	7.4	8.3	7.8	8.5
Orbit diameter	8.1	7.7	7.4	8.0	9.4
Interorbital width	8.3	7.6	7.8	7.3	7.6
Caudal-peduncle depth	14.9	14.0	13.5	14.1	14.0
Caudal-peduncle length	19.1	18.0	16.1	16.3	15.6
Predorsal length	33.6	33.8	33.3	34.5	34.7
Preanal length	60.2	59.7	62.9	61.8	62.1
Prepelvic length	32.1	32.6	34.4	33.7	34.5
Base of dorsal fin	56.2	61.3	62.1	58.2	52.9
First dorsal-fin spine	12.1	11.0	13.0	7.3	8.0
Second dorsal-fin spine	10.4	10.6	10.3	7.6	8.0
Third dorsal-fin spine	10.8	10.6	9.2	10.8	8.7
1 st filamentous dorsal-fin membrane	23.2	27.2	26.5	10.2	11.0
2 nd filamentous dorsal-fin membrane	13.0	13.1	18.4	8.4	9.9
Eleventh dorsal-fin spine	13.6	13.1	12.4	12.9	12.9
Longest dorsal-fin ray	16.8	16.9	16.0	17.1	17.9
Base of anal fin	25.1	24.5	21.3	19.8	23.2
First anal-fin spine	4.7	5.0	6.4	5.1	5.5
Second anal-fin spine	7.2	7.4	8.1	6.9	8.7
Third anal-fin spine	10.4	9.9	9.2	8.8	10.8
Longest anal-fin ray	15.8	16.9	16.0	15.5	15.6
Caudal-fin length	25.8	28.1	24.1	24.7	23.9
Pectoral-fin length	20.4	19.4	19.6	20.0	19.8
Pelvic-spine length	14.7	14.0	13.3	13.1	13.3
Pelvic-fin length	48.3	44.1	43.1	19.4	19.1



Figure 18. *Cirrhilabrus africanus*, aquarium photographs, mottled IP female & TP male (above), mottled transitional phase (below), aquarium trade, Kenya (A. DeJong).

9.7–11.9) in SL; each dorsal-fin spine tip followed by segmented-ray-like extension with associated membrane (as in Fig. 12); first dorsal-fin soft ray 2.0 (2.0–2.1; 2.2–2.4) in HL; longest dorsal-fin soft ray 2.0 (1.9–2.0; 1.9–2.0) in HL; origin of anal fin below base of penultimate dorsal-fin spine; first anal-fin spine 7.1 (5.0–6.4; 6.3–6.6) in HL; second anal-fin spine 4.7 (4.0–4.4; 4.0–4.9) in HL; third anal-fin spine 3.2 (3.3–3.5; 3.2–3.8) in HL; longest anal-fin soft ray 2.1 (1.9–2.0; 2.2) in HL; caudal fin rounded, 1.3 (1.1–1.3; 1.4–1.5) in HL (measured at midline); pectoral-fin length 1.6 (1.6–1.7; 1.7–1.8) in HL; origin of pelvic fins below upper pectoral-fin base; pelvic fins of TP males greatly elongated and fan-like, reaching to about middle of anal fin, 2.1 (2.3; 5.2) in SL.

Color in life. (Figs. 14–20, 23B) Upper head and body of type specimens of TP males reddish orange, grading to dusky posteriorly on the body; ventral aspect of head and body, below level of mid-cheek and pectoral-fin base, yellowish, grading to white on abdomen; several rows of well-spaced small spots across upper body (not merging into a stripe), spots can be blue or lavender or dark red; enlarged scale row along dorsal-fin base bluish or darker red. First two dorsal-fin spines and filamentous membranes variably red and black, remaining spinous-fin membranes mostly dark to dusky red, divided midway out along fin by a row of blue or dark red spots, clearly rounded and spaced apart after first two membranes; a thin dark-underlined blue or reddish line runs along dorsal-fin margin; caudal fin mostly brownish green with numerous pale spots and lines, sometimes with a coppery sheen (blackish with blue iridescence in South African TP males); anal fin dusky red, darker posteriorly, with a row of bluish spots near base of fin; a thin dark-underlined blue line runs along anal-fin margin; fan-like pelvic fins mostly dark with red streaking. Iris bright reddish orange.

Nuptial display of TP males not documented underwater, but displaying male in Fig. 16 shows intensified black dorsal fin with strongly contrasting iridescent bright blue spots and rims on fins and body and a more dusky upper body and more yellowish lower body.

Mottled TP-male phase (Fig. 18 upper) brownish yellow with dark upper body in an irregular barred pattern, stripes on head and rows of spots on upper body dark purple; dorsal fin dusky, pelvic and anal fins blackish. Mottled transitional phase (Fig. 18 lower) individual dusky red with indistinct bars, slightly extended first dorsal-fin spines and dark membranes along first dorsal-fin spine membranes and midway out along spinous portion of dorsal fin; remaining fins speckled reddish except pectoral fin translucent.

Initial-phase fish (Figs. 17 & 18 upper) reddish orange grading to pinkish ventrally, with yellowish orange head and bright yellow oval patch at base of pectoral fin; bluish to lavender stripes run across upper head and upper body, breaking up into rows of spots along midlateral body; smaller females have a dark blotch on upper caudal peduncle. Median fins mostly translucent to reddish orange with darker red speckling. Some IP individuals have a dark spot on first dorsal-fin membrane, it is uncertain whether this means the fish are entering a transition phase to TP.

Color in alcohol. Body of alcohol-fixed and preserved TP males light tan above, grading to white ventrally; original bluish stripes on head and rows of spots on upper body and dorsal and anal fins persist as reflective pigmented markings; dorsal, anal, and caudal fins mostly translucent but outlined bluish stripes and spots persist as dark markings and dark areas on fins persist as dusky markings; pectoral fins translucent; pelvic fins with full-length dark streaks. Head and body of initial phase tan dorsally grading to white ventrally, lateral stripes dark brown, caudal-peduncle blotch black; a small black spot at upper rim of pectoral-fin base. Fins are translucent.

Etymology. The new species is named for the continent, as a noun in apposition.

Distribution. The new species is described from specimens from Kenya. The population in South Africa and Mozambique have the same mtDNA sequences (see below), but no specimens are available and they are considered here to be the same species. That population is known to range from Protea Banks, off southern KwaZulu-Natal, northward to Pomene, Mozambique; areas farther north have not been surveyed. The documented depth range for collected specimens is 18–26 m, for photographs, 25–50 m (Dennis King, pers. comm.).

Barcode DNA sequence. A 652-nucleotide sequence of the segment of the mitochondrial COI gene used for barcoding by the BOLD informatics database (Ratnasingham & Hebert 2007) was obtained for the holotype. Following the database management recommendation of the BOLD, the sequence of the holotype (GenBank accession number KY033481) is presented here as well:

```
CCTCTATCTCGTATTTGGTGCTTGAGCTGGAATAGTTGGTACAGCCCTGAGCCTTCTTATTTCG
AGCAGAACTTAGTCAACCAGGTGCACTCCTGGGCGACGATCAAATCTATAATGTGATTGCAC
ACGCTTTTGTATAATTTTCTTCATAGTAATGCCTATTATAATTGGAGGGTTTGGAAACTGGCT
TATTCCTTTAATAATTGGAGCCCCAGACATGGCATTTCCTCGAATAAATAATATGAGTTTCTGG
CTTCTTCCCCCTCCTTTCTTCTTCTTCTTGCTTCATCAGGAGTTGAAGCCGGAGCAGGAACA
GGTTGGACTGTGTACCCTCCTTTAGCAGGCAATCTTGCACATGCTGGCGCCTCTGTAGATTTA
ACTATTTTTTCCCTTCACCTTGNAGGTATCTCCTCAATTCTGGGTGCAATCAATTTTATTACAA
CAATTATTAATAAAAACCTCCAGCTATTTCCAGTATCAAACACCCTTGTTTGTCTGAGCAGT
ATTAATTAAGTGTCTGCTCCTCCTGTCCTGCTGCTGCTGGAATTACAATACTT
TTAACTGACCGAAATCTAAATACCACTTTCTTTGACCCAGCTGGGGGGGGGGACCCTATTCT
TTACCAACACTTA
```

Remarks. The populations from South Africa and Mozambique have the same mtDNA barcode sequence as the Kenyan specimens and are here treated as *Cirrhilabrus africanus*. The species was first discovered 19 years ago by Dennis King, who photographed the species at its southernmost known range at Protea Banks, Kwazulu-Natal, South Africa, south of Durban (Fig. 19). Subsequently, many additional specimens and fresh photographs (e.g. Fig. 20) have been obtained from farther north, around Aliwal Shoals, and near the Mozambique border off the iSimangaliso Wetland Park. The Mozambican specimens are from near Pomene, collected by Allan D. Connell.

Additional photographs of fresh SAIAB specimens (via Elaine Heemstra, pers. comm.) and live fish in the uShaka Marine World aquarium (via Dennis King, pers. comm.) show the same features as Kenyan specimens. There is some indication that occasional South African TP males may have a longer dorsal-fin membrane filament (e.g. Fig. 20). Based on the photograph of the barcoded specimen (Fig. 20 middle) and the photographs by Dennis King from Protea Banks (Fig. 19), TP males can have a black caudal fin with bright blue iridescence and fully

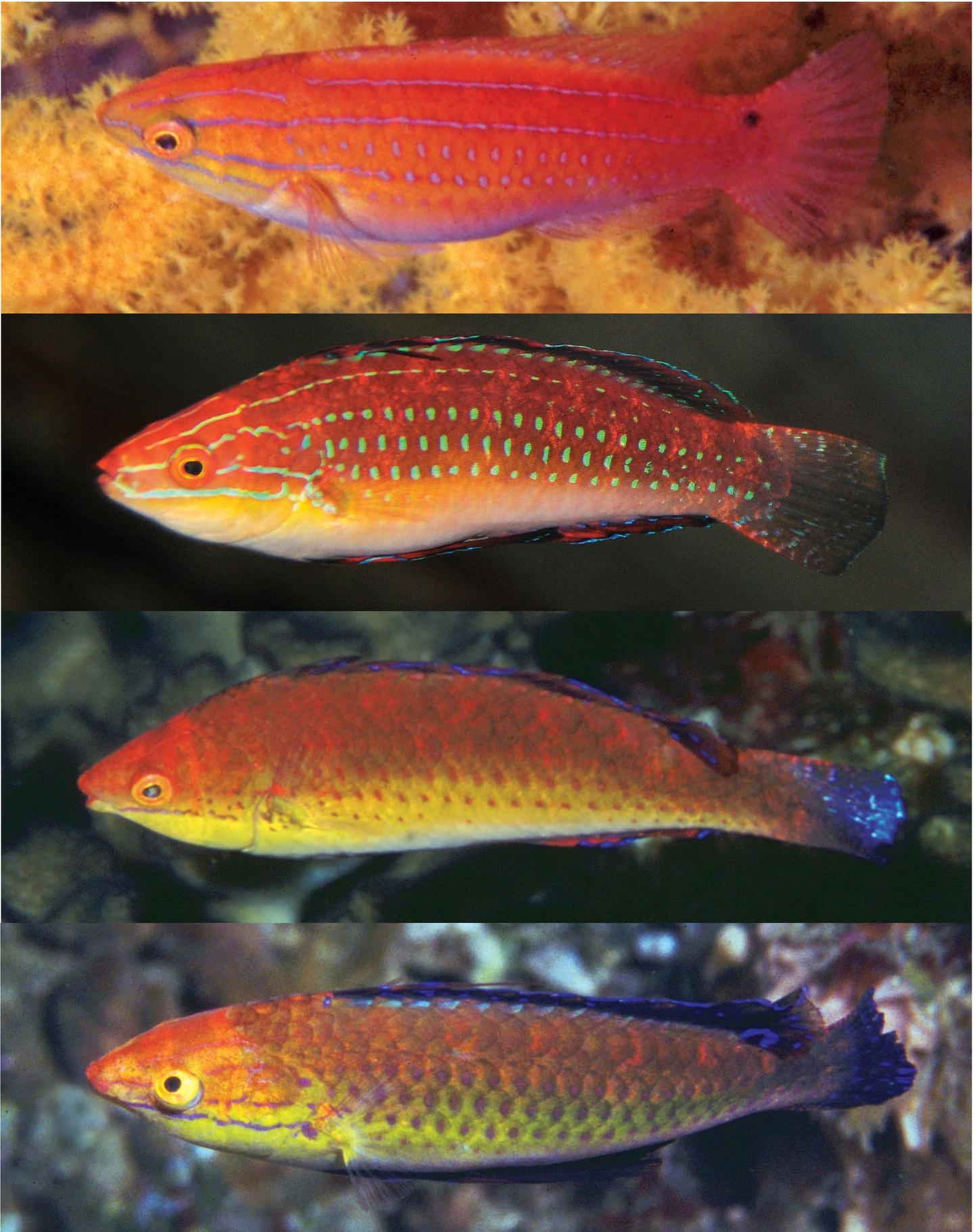


Figure 19. *Cirrhilabrus africanus*, underwater photographs, IP female, Protea Banks, South Africa (top); TP males- uShaka Marine World aquarium (upper middle), Protea Banks, South Africa (lower middle and bottom) (D. King).



Figure 20. *Cirrhilabrus africanus*, fresh photographs, TP male (top), Pomene, Mozambique (not sequenced); TP male (middle) and IP female (bottom), DNA-identified in BOLD database, KwaZulu-Natal, South Africa (A.D. Connell).

black dorsal and anal fins. Given the dearth of collections from other populations, and no underwater photographs of the Kenyan population, it remains to be resolved whether these subtle differences are sufficiently consistent for consideration as a “phenovariant” species (i.e. with shared mtDNA haplotypes).

DNA analysis of the spike-fin *Cirrhilabrus* species complex

The neighbor-joining phenetic tree based on the COI mtDNA sequences of 7 of the 8 spike-fin *Cirrhilabrus* species complex, following the Kimura two-parameter model (K2P) generated by BOLD (Barcode of Life Database), shows a closely related set of monophyletic lineages with relatively small divergences of one to three percent between most species and little variation within species (Fig. 21 & Table 3). In two cases of species with adjacent and perhaps overlapping ranges, there were shared haplotypes among the neighbors, i.e. among *C. naokoae* and *C. joanallena*e around Sumatra, Indonesia and among *C. hygroxerus* and *C. humanni* in southern Indonesia. The two new species’ COI sequences differ from *C. rubriventralis*; in the case of *C. rubeus* by 2.67%

TABLE 3

K2P distances for mtDNA COI sequences of the spike-fin *Cirrhilabrus* species complex

Minimum Interspecific and Maximum Intraspecific Distances (%)

	<i>afri</i>	<i>huma</i>	<i>hygr</i>	<i>joan</i>	<i>naok</i>	<i>rube</i>	<i>rubr</i>
<i>C. africanus</i> , n. sp.	0						
<i>C. humanni</i>	2.25	NA					
<i>C. hygroxerus</i>	2.20	0	0.31				
<i>C. joanallena</i> e	2.32	1.58	1.48	NA			
<i>C. naokoae</i>	2.20	1.55	1.40	0	NA		
<i>C. rubeus</i> , n. sp.	2.92	2.95	2.84	2.82	2.67	0.16	
<i>C. rubriventralis</i>	0.49	2.25	2.04	1.98	1.88	2.67	NA

P-distances (uncorrected pairwise) for mtDNA COI sequences of the spike-fin *Cirrhilabrus* species complex

Minimum Interspecific and Maximum Intraspecific Distances (%)

	<i>afri</i>	<i>huma</i>	<i>hygr</i>	<i>joan</i>	<i>naok</i>	<i>rube</i>	<i>rubr</i>
<i>C. africanus</i> , n. sp.	0						
<i>C. humanni</i>	2.20	NA					
<i>C. hygroxerus</i>	2.15	0	0.31				
<i>C. joanallena</i> e	2.27	1.55	1.46	NA			
<i>C. naokoae</i>	2.15	1.52	1.38	0	NA		
<i>C. rubeus</i> , n. sp.	2.85	2.88	2.76	2.75	2.61	0.16	
<i>C. rubriventralis</i>	0.49	2.20	2.00	1.94	1.84	2.61	NA

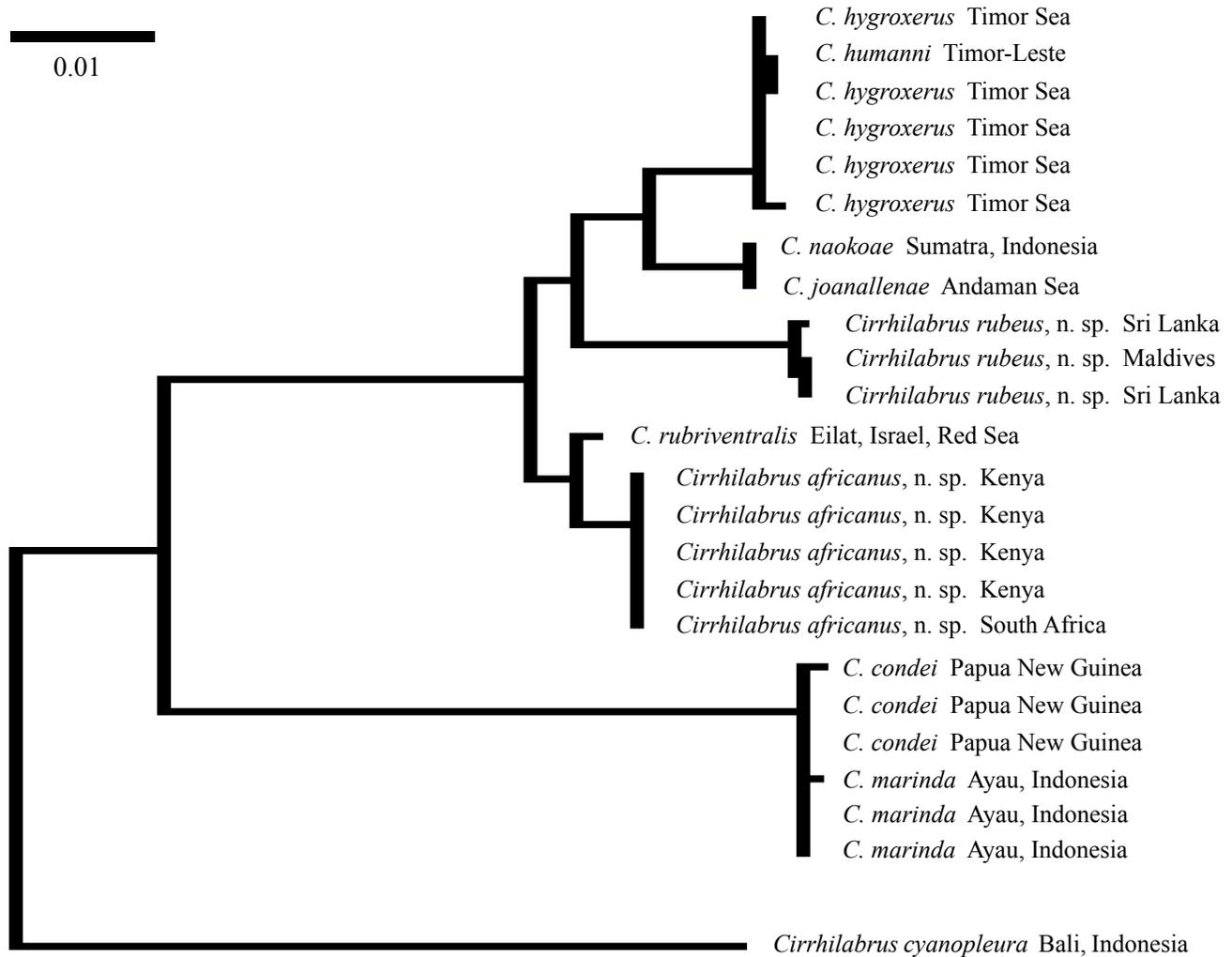


Figure 21. The neighbor-joining phenetic tree of the spike-fin *Cirrhilabrus* species complex following the Kimura two-parameter model (K2P) generated by BOLD (Barcode of Life Database). The scale bar at left represents a 1% sequence difference. Collection locations for specimens are indicated. The related species *C. condei* and *C. marinda* are included and *C. cyanopleura* from Bali is included as an outgroup. GenBank accession numbers and collection data for the sequences in the tree are listed in Appendix 1.

by K2P (2.61% uncorrected pairwise) and by only 0.49% in the case of *C. africanus* (by K2P and uncorrected pairwise). The species complex is well delineated from other *Cirrhilabrus* species, with the nearest relative among the approximately 30 other species that have been sequenced being the *C. condei*/*C. marinda* lineage recently described from nearby parts of Indonesia and Papua New Guinea (Allen *et al.* 2015), about 6.9% divergent from the spike-fin species complex. Interestingly, *C. marinda* also has extended spines and membranes in the dorsal fin, but it is the midportion of the spinous dorsal fin that is elevated.

The species within the spike-fin *Cirrhilabrus* complex show relatively lower genetic divergence than the majority of reef-fish species, which, with numerous exceptions, differ by more than 2% from their nearest relatives (Steinke *et al.* 2009, Ward *et al.* 2009, Victor 2015). This feature, along with shared haplotypes between closely related neighboring, or even sympatric, species (i.e. phenovariant species), is characteristic of this genus (Allen *et al.* 2015, Tea *et al.* 2016), as well as of the flasherwrasses of *Paracheilinus* (Allen *et al.* 2016). Both of these labrid genera comprise sets of species with relatively small ranges and harem mating systems with exceptionally elaborate TP-male displays— both of which may be associated with a recent radiation of numerous closely related species.

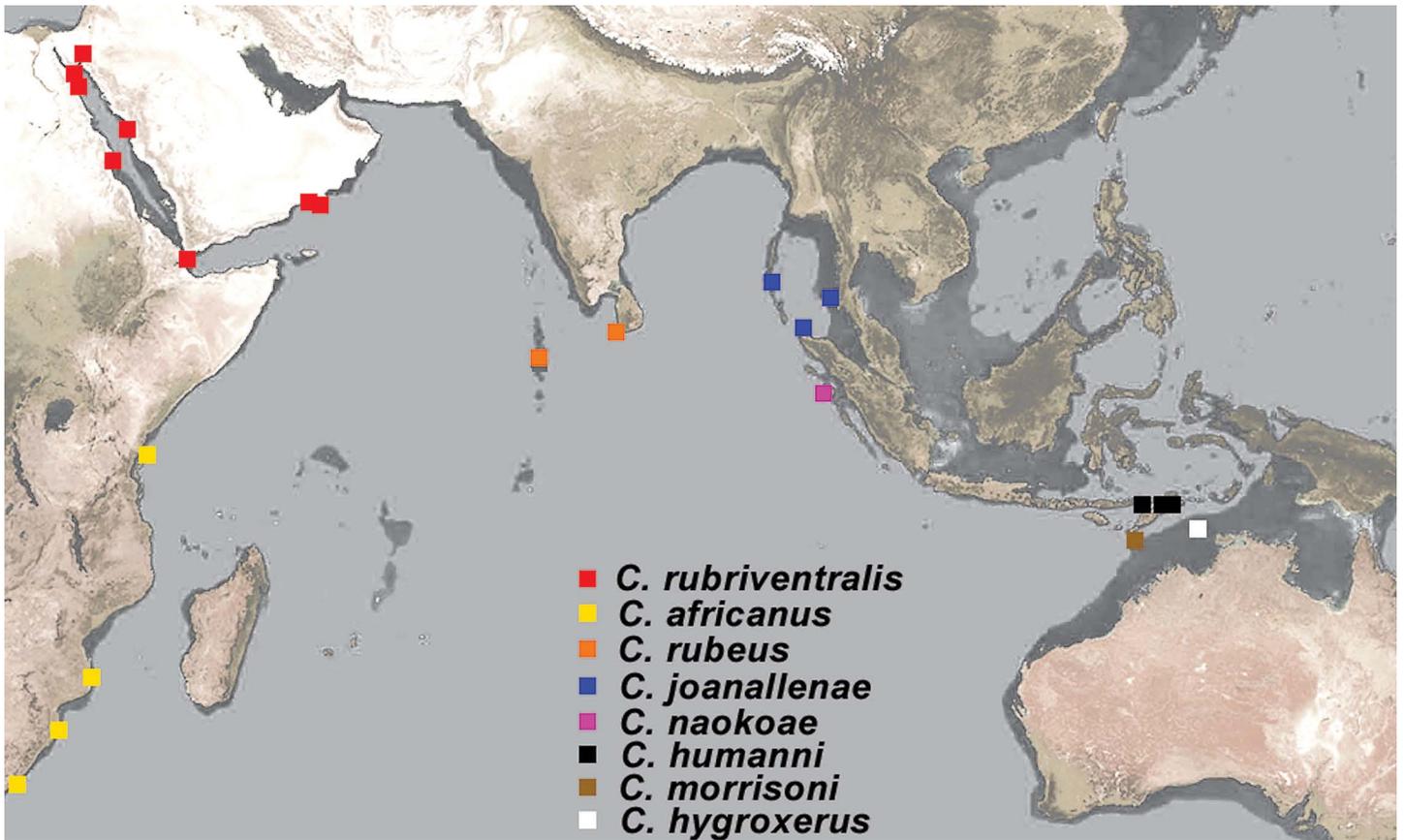


Figure 22. Geographic distribution of the spike-fin species complex of *Cirrhilabrus*; records include from literature, museum collections, BOLD records, confirmed photographs, and reported aquarium-fish collection locations.

Biogeography of the spike-fin *Cirrhilabrus* species complex

The species complex extends over most of the periphery of the Indian Ocean where coral reefs occur, but is curiously absent from the more central islands of Mauritius and the Mascarene Islands, the Chagos Archipelago, Seychelles, and apparently Madagascar, although the latter location has not been well-surveyed for deeper water species (Fig. 22). In Indonesia, the species appear to be limited to the Indian Ocean rim, likely replaced by other species complexes in the internal Coral Triangle and the western Pacific Ocean. The species' documented ranges are allopatric, with no overlap (but this has not been fully assessed in Sumatra, Java, Bali, and the Timor Sea, where species ranges may abut or even overlap).

The western Indian Ocean species have relatively wide ranges, with *C. rubriventralis* present throughout the Red Sea and apparently extending to Oman (Randall 1995), *C. africanus* ranging along the east coast of Africa from at least Kenya down to South Africa, and *C. rubeus* in both Maldives and Sri Lanka. In contrast, the eastern Indian Ocean species appear to have relatively small ranges, with *C. joanalleneae* from around the Andaman Sea; *C. naokoae* thus far collected only by the aquarium trade from Nias Island, western Sumatra; *C. morrisoni* from Hibernia Reef in the western Timor Sea; *C. humanni* only from the eastern Sunda Islands of Indonesia; and *C. hygroxerus* recently described from a single location in the eastern Timor Sea. The ranges of these species may be wider than presently documented, but are very likely to be quite limited in extent.

Comparisons

The complex of species allied to the first named representative, *Cirrhilabrus rubriventralis*, share a monophyletic set of mtDNA lineages and several distinctive morphological features of the TP male, including a “spike-fin” extension of the membranes of the first two dorsal-fin spines into filaments or, in some species, a

shorter pennant or, in *C. naokoae*, a banner of several of the first dorsal-fin membranes (Fig. 23). In addition, all have a greatly extended pelvic fin, either broadly lobe-like or fan-like, typically brightly colored and/or black (other members of the genus have TP males with either a short pelvic fin or long with a pointed or filamentous tip). Additional characters typical, but not exclusive to, the spike-fin species complex include a single row of large scales under the eye (shared with *C. marinda* and *C. condei*; Allen *et al.* [2015]).

As in many closely related species-complexes, there are few meristic or morphometric characters that clearly differ between species; many characters that appear to differentiate species are artifactual, due to different observers, small sample sizes, or different-sized fish (larger fish appear to have more pores, teeth, and some scale counts). In the case of the spike-fin species complex, the difference in dorsal and anal-fin ray counts can be rejected: the count of D-XI,10 and A-III,10 for *C. rubriventralis* was reported by Springer & Randall (1974), but, on present reexamination, that count included the split last ray as two rays, and, when counted using the same technique, the count is consistent with all other members of the complex, i.e. XI,9 and III,9. Notably, Randall (1995) subsequently reported the XI,9 and III,9 count for *C. rubriventralis* in his *Fishes of Oman*. Another distinctive count for *C. rubriventralis* is the 19 of 20 type specimens with 14 pectoral-fin rays, vs. a mode of 15 for all other members of the complex (and indeed for virtually all species of *Cirrhilabrus*); in this case, all types were from the northern tip of the range near Eilat, Israel, while three additional specimens examined here from Sudan and Oman have the standard 15 pectoral-fin rays (Randall [1995] also reports 15 as the pectoral-fin ray count for the species in Oman). There are some indications of slightly differing scale counts among species, but those require larger sample sizes for confirmation.

There appears to be slightly different body shapes among species: for example, TP males of *C. africanus* are stouter than other TP males, but the variation in TP-male body shape (and TP-male size) may be associated with habitat and population densities (as found in other labrid fishes with sex change and complex mating systems), and thus subject to the vagaries of exactly where collections have been made. Comparisons of small samples collected from single locations should be treated with caution.

The primary differences between species within the spike-fin species complex are in color patterns of the TP males (e.g. Allen & Hammer 2016), as well as in the degree of development of the elongated first dorsal-fin spines (Fig. 23). A set of color patterns and markings distinguish the three western Indian Ocean species (Table 4). The nuptial displays of the many species are even more different, although not documented *in situ* for all eight

TABLE 4

Comparison of salient color-pattern features of TP males of *Cirrhilabrus rubriventralis*, *C. africanus*, n. sp., and *C. rubeus*, n. sp.

Character	<i>C. rubriventralis</i>	<i>C. africanus</i>	<i>C. rubeus</i>
Mid-lateral markings	row of spots and short bars	row of small spots	usually complete stripe
Dorsal-fin color	mostly dark	mostly dark to black	red then yellow-orange
Dorsal-fin markings	row of spots	row of spots	usually stripe then spots
Caudal-fin shape	tips usually with extensions	rounded	tips with extensions
Caudal-fin color	blue sheen	dark with coppery sheen	blue to blue-green sheen
Anal-fin color	mainly red	dusky reddish to black	red to dusky reddish
Pelvic-fin color	mainly red, at most proximal third black	red and black to mostly black	red and black, usually black tips



Figure 23. The TP-male color patterns in the spike-fin *Cirrhilabrus* species complex of the Indian Ocean: (A) *Cirrhilabrus rubriventralis*, Red Sea, Jeddah, Saudi Arabia (R. Field); (B) *Cirrhilabrus africanus*, aquarium, from Kenya (K. Kohen); (C) *Cirrhilabrus rubeus*, aquarium, from Sri Lanka (H. Tanaka); (D) *Cirrhilabrus joanallенаe*, aquarium, from Sumatra (H. Tanaka); (E) *Cirrhilabrus naokoae*, aquarium, from Sumatra (H. Tanaka); (F) *Cirrhilabrus humanni*, Timor (G.R. Allen); (G) *Cirrhilabrus morrisoni*, western Timor Sea (G.R. Allen); (H) *Cirrhilabrus hygroxerus*, eastern Timor Sea (M.P. Hammer).

members of the complex, including *C. africanus*. The colors of initial-phase fishes, mostly females (depending on mating systems), are typically not well established, but it is likely they are similar, or the same, among all species, especially when the underwater photographs in this study show that the colors of the stripes in IP females of *C. rubriventralis* can vary from blue to pink to lavender to reddish. Although *C. joanalleneae* were described as having IP fish without the caudal-peduncle blotch (Allen 2000), additional aquarium-trade specimens do have the blotch (H. Tanaka, pers. comm.). Furthermore, some larger IP fishes of all species in the complex have one or more of a set of features, i.e. a dark blotch on the first dorsal-fin membrane(s), darker dorsal fins, patterned caudal fins, and/or have lost the black blotch on the caudal peduncle, likely indicating they are transitioning into TP males—these patterns should not be considered diagnostic differences without full documentation of color stages and habitat variation in IP fish, data presently lacking for all species.

Comparisons of the degree of color and fin-development differences vs. genetic divergences shows a typical inconsistency between the degree of phenotypic and genotypic differences (see Victor 2015). Most significantly, *C. joanalleneae* and *C. naokoae* share mtDNA haplotypes, but have very different dorsal-fin shapes and body coloration (Fig. 23 D & E). In addition, *C. africanus* and *C. humanni* closely resemble each other in overall color pattern (Fig. 23 B & F), but are one of the more distantly related pairs in the species complex (diverging by 2.25% in mtDNA sequence, by K2P; 2.20% uncorrected pairwise). The species with the greatest apparent meristic difference, *C. rubriventralis*, is very close genetically to *C. africanus* (diverging by 0.49% in mtDNA sequence, by K2P and uncorrected pairwise). Geographic distance appears to explain more of the genetic divergence among species, with adjacent species generally showing shared or more similar mtDNA sequences.

Remarks. One of the reviewers, John E. Randall, points out that he would have considered the possibility that the new species described here are subspecies of *C. rubriventralis*, especially since the status of potential intermediate populations in the wide gaps between the sampled ranges is unknown. With the present material, I have described them as species, since the degree of phenotypic and genetic differences are comparable to the other species already described within the species complex and no other subspecies have been described in the genus.

Other material examined. *Cirrhilabrus rubriventralis*- BPBM 16851, paratype, 64.5 mm SL, Eilat, Gulf of Aqaba, Israel; BPBM 16852, paratype, 40 mm SL, same location; BPBM 19756, 42 mm SL, Port Sudan, Sudan; BPBM 34410, 32 & 40 mm SL, Sudh, Oman; (following examined by Gerald R. Allen) USNM 212007, holotype, 54.1 mm SL, Eilat, Gulf of Aqaba, Israel; USNM 212008, paratype, 52.0 mm SL, Eilat, Gulf of Aqaba, Israel; USNM 212010, 7 paratypes, 24.2–34.1 mm SL, Eilat, Gulf of Aqaba, Israel.

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Appendix 1. Specimen data and GenBank accession numbers for the mtDNA COI barcode sequences used to generate the phenogram in Fig. 21, following the order in the tree. Holotypes in bold.

Genus	species	Collection site	Voucher	GenBank #	Collector/Source
<i>Cirrhilabrus</i>	<i>hygroxerus</i>	Northern Territory, Australia	NTM S.17975-003	KY033474	Tim Green/M.P. Hammer
<i>Cirrhilabrus</i>	<i>humanni</i>	Com, Timor-Leste	MB065501	KR052205	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>hygroxerus</i>	Northern Territory, Australia	NTM S.17975-002	KY033467	Tim Green/M.P. Hammer
<i>Cirrhilabrus</i>	<i>hygroxerus</i>	Northern Territory, Australia	NTM S.17934-031	KY033472	Tim Green/M.P. Hammer
<i>Cirrhilabrus</i>	<i>hygroxerus</i>	Northern Territory, Australia	NTM S.17975-003	KY033470	Tim Green/M.P. Hammer
<i>Cirrhilabrus</i>	<i>hygroxerus</i>	Northern Territory, Australia	NTM S.17975-001	KY033475	Tim Green/M.P. Hammer
<i>Cirrhilabrus</i>	<i>naokoae</i>	aq. trade, Nias, Sumatra	qm16cn3	KY033471	aq. trade/B. Victor
<i>Cirrhilabrus</i>	<i>joanalleneae</i>	Andaman Sea	MB020401	KY033468	M.V. Erdmann/IBRC
<i>Cirrhilabrus</i>	<i>rubeus</i> , n. sp.	aq. trade, Sri Lanka	BPBM 41298	KY033463	aq. trade/B. Victor
<i>Cirrhilabrus</i>	<i>rubeus</i> , n. sp.	aq. trade, Maldives	BPBM 41299	KY033469	J.M.B Edward/B. Victor
<i>Cirrhilabrus</i>	<i>rubeus</i>, n. sp.	aq. trade, Sri Lanka	BPBM 41297	KY033479	J.M.B Edward/B. Victor
<i>Cirrhilabrus</i>	<i>rubriventralis</i>	Eilat, Israel, Red Sea	TAU 15309	KY033465	N. Kimmerling
<i>Cirrhilabrus</i>	<i>africanus</i>, n. sp.	aq. trade, Kenya	BPBM 41295	KY033481	J.M.B Edward/B. Victor
<i>Cirrhilabrus</i>	<i>africanus</i> , n. sp.	aq. trade, Kenya	BPBM 41296 51.0	KY033478	A. de Jong/B. Victor
<i>Cirrhilabrus</i>	<i>africanus</i> , n. sp.	aq. trade, Kenya	BPBM 41296 65.2	KY033480	A. de Jong/B. Victor
<i>Cirrhilabrus</i>	<i>africanus</i> , n. sp.	aq. trade, Kenya	BPBM 41296 43.5	KY033476	A. de Jong/B. Victor
<i>Cirrhilabrus</i>	<i>africanus</i> , n. sp.	KwaZulu-Natal, South Africa	ADC2013 220.39A #1	KU176338	A.D. Connell/SAIAB
<i>Cirrhilabrus</i>	<i>condei</i>	Milne Bay, PNG	MB0617102	KR052202	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>condei</i>	Milne Bay, PNG	MB0617201	KR052204	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>condei</i>	Milne Bay, PNG	MB0617103	KR052203	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>marinda</i>	Ayau, Indonesia	MB0618404	KR052207	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>marinda</i>	Ayau, Indonesia	MB0618403	KR052206	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>marinda</i>	Ayau, Indonesia	MB0615701	KR052201	G.R. Allen & M.V. Erdmann
<i>Cirrhilabrus</i>	<i>cyanopleura</i>	Bali, Indonesia	NBE1267	JF435009	B. Victor