The genus *Cotylopus* (Teleostei: Gobioidei) endemic to the rivers of islands of the Indian Ocean with description of a new species from Mayotte (Comoros)

PHILIPPE KEITH¹, THIERRY HOAREAU², & PIERRE BOSC³

¹Laboratoire d’ichtyologie, Muséum national d’Histoire naturelle, 57, rue Cuvier, F-75231 Paris Cedex 05, France, ²UMR 5119, Université Montpellier II, CC093 Place E. Bataillon, 34095 Montpellier Cedex 5, France, and ³ARDA—Centre des Eaux Douces, Z.I. Les Sables, 97 427 l’Etang Salé, Île de la Réunion

(Accepted 2004)

Abstract

*Cotylopus rubripinnis*, new species, is described on the basis of nine specimens collected from the Island of Mayotte (Comoros), Indian Ocean. *Cotylopus rubripinnis* differs from the only other known species in the genus (*C. acutipinnis* Guichenot, 1863) in usually having fewer scales in lateral (LS), transverse back (TRB), transverse forward (TRF), and zigzag series (ZZ), and in having pectoral, dorsal and caudal fins reddish. The genus was previously only known from the Mascarene Islands (Réunion and Mauritius). The discovery of a second species for that rare and endemic genus 1400 km farther to the north-west in the Indian Ocean is discussed.

Keywords: Comoros, *Cotylopus rubripinnis*, Gobiidae, Mayotte, new species

Introduction

The freshwater ichthyofauna of the Comoros Islands (Grande Comore, Moheli, Anjouan, and Mayotte), in the Indian Ocean to the north of Madagascar, is poorly known, in particular for Mayotte island. One of the first mentions was by Sclater (1864) who cited four species of freshwater fishes in Johanna island (ancient name for Anjouan). Playfair and Günther (1867) described a new species of eel, *Anguilla johannae* (synonym of *A. marmorata* Quoy and Gaimard, 1824) from the island of Anjouan. Later, Pellegrin (1933), in his work on freshwater fishes of Madagascar and surrounding islands, cited five species from the Comoros, and, for the first time, an amphidromous goby, *Sicydium laticeps* Valenciennes in Cuvier and Valenciennes, 1837 from Anjouan. In 1954, Fourmanoir, who worked on the fisheries of the Comoros, reported the presence of five species in the rivers, including one goby, an *Awaous* species. Benson (1960) was the first author to mention a species from Mayotte island, an eel, in Dziani Caréhani lake. Starmühler (1976, 1979) recorded a species of goby, *Sicyopterus lagocephalus*, from Anjouan. In 1983, a specific survey of the MRAC (Royal Museum of Central Africa of Tervuren) of Mohéli and Anjouan listed 14 species (Thys van den Audenaerde and Teugels 1984; Teugels et al.)
Among them, two species of goby were caught, *S. lagocephalus* and *Awaous aeneofuscus* (Peters, 1852). Later, Balon and Bruton (1994) reported *S. lagocephalus* in Anjouan.

Finally, Mayotte and Grande Comore were the least surveyed islands of the Comoros, but recently, two environmental studies were made in Mayotte. The first one, made before dam construction, cited five species including *S. lagocephalus* (Anonymous 1997), and the second one, studying rivers (Louette and Louette 2000), reported 12 species including three species of Gobiidae: *S. lagocephalus*, *Stenogobius polyzona* (Bleeker, 1867) and *Awaous aeneofuscus*.

During November 2003, the Réunion Association for Aquaculture Development (ARDA), the University of La Rochelle and the National Museum of Natural History, Paris (MNHN), made specific inventories of the rivers of the island of Mayotte to improve knowledge of freshwater biodiversity. During this survey, 15 species of fishes were collected in the rivers and one new species of *Cotylopus* (Gobiidae, Sicydiinae), the second known for the genus, was caught.

*Cotylopus* Guichenot, 1863 differs from all other Gobiidae Sicydiinae in possessing few large teeth to either side of symphysis. Though *Cotylopus* has been confused with *Sicyopterus* in the past, it differs in having 15–17 pectoral rays (versus 18–21); 9–10 segmented rays in the second dorsal fin (versus 11); anterior aspect of each tooth in upper jaw orientated outwards, teeth with a side-by-side appearance (versus anterior aspect of each tooth in upper jaw orientated anteriorly, all teeth overlapping); bands of teeth in upper jaw curved versus bands of teeth in upper jaw in straight rows (Watson 1995; Watson et al. 2000).

There is only one species known in that genus, *Cotylopus acutipinnis* Guichenot, 1863, from the Mascarene Islands (Réunion and Mauritius) (Watson 1995; Keith et al. 1999; Keith 2002) and it is rare in those two islands (Keith et al. 1999).

In 1995, Watson suggested, on the basis of the examination of one specimen caught in Mauritius, that the species of this island could be different from that on Réunion; but he said “this specimen may be aberrant and more specimens will be needed to resolve whether a new species does indeed exist”. In November 2002, a survey was conducted by ARDA and the MNHN on the rivers of Mauritius. Further *Cotylopus* were caught and their examination showed that they were *Cotylopus acutipinnis* (see comparative material).

In other areas of the Indian Ocean, some previous papers on Madagascar seemed to note the occurrence of *C. acutipinnis* in this country (Pellegrin 1933; Kiener 1963), but a careful reading of these papers shows that the authors, for this species, spoke about “surrounding islands” (in particular Réunion island) and not about Madagascar itself. On the other hand, a recent study of freshwater biodiversity of Madagascar does not mention any *Cotylopus* (Sparks and Stiassny 2003). Nevertheless, it is possible that a new species of *Cotylopus* exists in Madagascar, particularly on the north-east coast, which is difficult to survey (R. E. Watson, personal communication).

The purpose of this paper is to describe a new species of *Cotylopus* found on Mayotte Island (Comoros), and to discuss the discovery of a second species in that genus.

**Material and methods**

Fishes have been collected by electric fishing, put in formalin (5%) for fixation and in alcohol (70%) for conservation.

Methods follow those utilized by Watson (1995), unless otherwise noted. Preanal length, distance from origin of anal fin to tip of snout; predorsal length, distance from origin of first dorsal fin to tip of snout; jaw length, distance from posterior edge of upper jaw to anterior
edge of upper jaw at symphysis; caudal peduncle length, distance from base of posterior ray of second dorsal fin to central hypural base; caudal peduncle depth, vertical distance across narrowest point of caudal peduncle; body depth, vertical distance from origin of second dorsal fin to belly, value only given in males because females may vary considerably from gravid to non-gravid condition; second dorsal and anal fin lengths, distance from base of spine to tip of last ray when depressed; caudal fin length, distance from central hypural base to tip of longest ray. Teeth include counts from right of symphysis.

Abbreviations used to designate institutions and collections cited follow Leviton et al. (1985) and Kottelat et al. (1993). Abbreviations used for cephalic sensory pore system follow Akihito (1986).

Abbreviations used in the descriptive account follow Watson (1995), with a few additions: A, anal fin; C, caudal fin (only branched rays are reported); D, dorsal fins; D1, first dorsal fin; D2, second dorsal fin; LS, scales in lateral series counted from upper pectoral base, or anteriormost scale along lateral midline, to central hypural base; P, pectoral fin; PD, predorsal midline counted from scale directly anterior to first dorsal fin insertion to the anteriormost scale; TRB, transverse series back, refers to scales counted from the first scale anterior to second dorsal fin, in a diagonal manner, posteriorly and ventrally to the anal fin base or ventralmost scale; TRF, transverse series forward refers to scales counted from the first scale anterior to second dorsal fin, in a diagonal manner, anteriorly and ventrally to the centre of belly or ventralmost scale; ZZ, zigzag series, refers to scales on the narrowest region of the caudal peduncle counted from the dorsalmost scale to the ventralmost scale in a zigzag (alternating) manner.

Meristics and morphometrics are summarized in Tables I–IV.

Comparative material

Réunion: MNHN 0000-1321, Holotype, male (104.9 mm SL); 1854, Maillard coll. MNHN 0000-0770, male (64.9 mm SL); Leschenault coll. MNHN 0000-1320, female (105.9 mm SL); 1854, Maillard coll. MNHN A-1456, four males (76.3–101.4 mm SL). MNHN 1984-0809, 20 specimens (16.3–69.9 mm SL); 1982, Kiener coll. MNHN 1985-1084, female (53.1 mm SL); November 1982, Gruchet coll. MNHN 1985-1085, one male, two females (46.9–63.3 mm SL); May 1983, Moussac coll. MNHN 1985-1086, nine specimens (16.4–19.8 mm SL); May 1983, Moussac coll. MNHN 1985-1087, female (53.4 mm SL); May 1983, Moussac coll. MNHN 1999-0557, eight males, two females (30.96–56.45 mm SL); Langevin river, 17 September 1998, Keith and Vigneux coll.

Mauritius: MNHN 2004-837, three females, one male (37.8–47.1 mm SL); rivière du Poste, 12 November 2002, Keith, Marquet and ARDA coll. MNHN 2004-838, one male, one femelle (34.9–35.7 mm SL); rivière des Galets, 14 November 2002, Keith, Marquet and ARDA coll.

*Cotylopus rubripinnis* n. sp.
(Figures 1, 3; Tables I–IV)

Material examined

Nine specimens from Mayotte (Comoros, Indian Ocean), size range 28.9–47.5 mm SL.

Holotype: MNHN 2004-0560, female (49.4 mm SL); Koulé river, Mayotte, 3 November 2003, G. Marquet, P. Valade, E. Feunteun, P. Bosc, and T. Hoareau coll.
Table I. Scale counts in *Cotylopus rubripinnis* and related species.

| Lateral series | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|----------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| *C. acutipinnis* | 1  | 2  | 2  | –  | 3  | 3  | 2  | 4  | 2  | 3  | 2  | 1  | –  | 2  | –  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| *C. rubripinnis* | 1  | –  | –  | –  | 1  | –  | –  | 3  | –  | –  | –  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |

| Predorsal midline series |
|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| *C. acutipinnis* | 24 | – | – | – | – | – | 1 | – | – | 1 |
| *C. rubripinnis* | 9  | – | – | – | – | – | – | – | – | – |

| Transverse backwards series |
|----------------------------|
| 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| *C. acutipinnis* | 5 | 2 | 2 | – | 4 | 1 | – | 1 | 1 | 3 | 1 | 4 | 4 | 4 | 4 | 1 |
| *C. rubripinnis* | 1 | – | 1 | 1 | 4 | 2 |

| Transverse forward series |
|---------------------------|
| 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| *C. acutipinnis* | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 1 | – | – | 1 | – | 1 | 1 | – | – | – | 1 | – | – | – | – | – | 1 |
| *C. rubripinnis* | 1 | 2 | 2 | 3 | 1 |

| Zigzag series |
|---------------|
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| *C. acutipinnis* | 2 | 1 | 2 | 4 | 2 | 3 | 9 | 1 | 3 | 1 | – | 2 |
| *C. rubripinnis* | 4 | 2 | 2 | 1 |
Paratypes: MNHN 2004-0561, four males, four females (28.9–47.5 mm SL), Kouale´ river, Mayotte, 3 November 2003, G. Marquet, P. Valade, E. Feunteun, P. Bosc, and T. Hoareau coll.

**Diagnosis**

Slender body, lateral scales 37–51, transverse back series 6–11, transverse forward series 6–10, zigzag series 13–16. Pectoral fins orange to red, dorsal and caudal fin orange to red with black rays; a black band on upper edge of caudal fin. Posterior part of body yellowish to reddish.
Table IV. Fin lengths in females of *Cotylopus rubripinnis* and related species expressed to the nearest whole per cent of standard length

| Second dorsal fin length | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|--------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| *C. acutipinnis*          | 1  | 2  | –  | 1  | –  | 4  | 3  | 1  | –  | 2  | 1  | 2  | 1  | 1  | 1  |    |
| *C. rubripinnis*          | 1  | –  | 2  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |

| Anal fin length           | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| *C. acutipinnis*          | 2  | –  | 1  | 1  | 5  | 3  | 1  | 1  | 3  | 1  |    |    |    |    |    |    |
| *C. rubripinnis*          |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

| Caudal fin length         | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---------------------------|----|----|----|----|----|----|----|----|----|----|----|
| *C. acutipinnis*          | 3  | –  | 2  | 5  | 3  | 4  | 1  |    |    |    |    |
| *C. rubripinnis*          | 1  | 1  | 2  | 1  |    |    |    |    |    |    |    |

Figure 1. Diagrammatic illustration of head in *Cotylopus rubripinnis*. (a) Dorsal view; (b) lateral view; (c) ventral view.
**Description**

Body elongate, slightly compressed between second dorsal and anal fins, and caudal peduncle, becoming slightly cylindrical, and then slightly depressed anterior to first dorsal fin. Mouth inferior and slightly oblique, jaws not protractile. Opercle and preopercle without spines and edges smooth. First dorsal fin free from second dorsal fin with six spines; second dorsal fin with one spine and 9–10 rays; anal fin with one spine and 10 rays; pectoral fin rays 15–16, and slightly rounded along posterior margin; pelvic fin I, 5, fifth rays of each fin joined together their entire length to form a cup-like disk strongly adherent to belly between all five rays. Caudal fin usually with 15 branched rays, rounded along posterior margin. Lateral scales 37–51. Predorsal scales 0, transverse back series 6–11, transverse forward series 6–10 and zigzag series 13–16. Cutaneous sensory papillae orientated transversely, each papilla in a shallow depression. Scales sexually dimorphic with males having more ctenoid scales than female: scales laterally cycloid on the first third of body and ctenoid on the posterior two-thirds for female and mostly ctenoid for male. Head, nape, belly, pectoral base, and usually one-third of anterior part naked. Upper jaw with 11–16 large trilobic teeth in curved bands with a gap at the symphysis. Teeth point posteriorly with one or two rows of replacement teeth protruding through gum before primary row. Lower jaw with a single row of small conical teeth (four to six). Upper lip broad, smooth along edge, lacking cleft. Gill opening restricted to pectoral base; isthmus broad extending ventrally to pectoral base. Anterior nostril in short tube, posterior nostril without tube; cephalic sensory pore system in adults mainly A, B, C, D, F, K, L, N and O, some juveniles also with H (Figure 1), all paired except for D which is singular; oculoscapular canal is not divided into posterior and anterior canals. Second dorsal, anal and caudal fins slender in males. Males with urogenital papilla triangular in appearance with distal tip rounded (Figure 2a). Females with bulbous urogenital papilla (Figure 2b).

**Colour in life (Figure 3)**

Background of body grey or bluish in anterior part and reddish to yellowish in posterior part. All scales with dusky spot posteriorly. Belly whitish to bluish. Back of head grey to reddish brown; cheek and opercle sometimes with grey to brown streaking. First dorsal fin

---

Figure 2. Diagrammatic illustration of urogenital papilla in *Cotylopus rubripinnis*. (a) Male; (b) female. 1, Anus; 2, urogenital papilla; 3, anal fin.
with orange to reddish membrane and dusky spines. Second dorsal fin with rays and spine dusky, and a black margin; membrane orange to reddish. Caudal fin generally yellowish in females, orange to reddish in males with some parts of rays dusky; upper margin with a blackish band. Anal fin with dusky rays, membrane slightly cream, distally with a blackish margin. Pectoral fin yellowish to reddish.

**Colour in preservation**

Background of body grey to yellowish; mid-laterally a thin dusky line or band. All scales with dusky spot posteriorly; dorsum generally evenly dusky from nape to upper caudal peduncle; belly yellowish. Background of head grey to brown; cheek and opercle sometimes with dusky streaking. Snout and upper lip anteriorly dusky; head yellowish ventrally. First dorsal fin with spines dusky. Second dorsal fin with rays and spine dusky, a black margin and a greyish membrane. Caudal fin generally greyish with dusky rays, upper margin with blackish band. Anal fin with dusky rays, membrane slightly cream, distally with a blackish margin. Pectoral fin greyish; pelvic disk generally without pigment.

**Ecology**

*Cotylopus rubripinnis* is reported from a swift clear high gradient and well-oxygenated freshwater stream (Koualé river), where it feeds on algae. The substrate may be entirely rocky with little or no gravel (depth 0.3–0.6 m).

**Distribution**

*Cotylopus rubripinnis* is actually only known from Mayotte island (Comoros, Indian Ocean). It seems very rare.

![Figure 3. Cotylopus rubripinnis n. sp., MNHN 2004-0561 (live specimen), Koualé river, Mayotte, 3 November 2003, G. Marquet, P. Valade, E. Feunteun, P. Bosc, and T. Hoareau coll. (photograph: P. Bosc).](image-url)
**Affinities**

*Cotylopus rubripinnis* differs from *Cotylopus acutipinnis* in having fewer scales in lateral series 37–51 versus 48–63, fewer scales in transverse back series 6–11 versus 7–24, fewer scales in transverse forward series 6–10 versus 10–34, and fewer scales in zigzag series 13–16 versus 15–26. It differs also in having more ctenoid scales laterally, colours of the fins in living fish reddish versus dusky, posterior part of the body yellowish to reddish versus grey to brown, and the body and fins more elongated.

**Etymology**

The new species is named *rubripinnis* from *ruber* which means red in Latin and *pinna* for fin, with reference to red dorsal, caudal and pectoral fins.

**Discussion**

In the Indo-Pacific and the Caribbean regions, insular river systems are colonized by Gobiidae, in particular Sycidiinae, with a life cycle adapted to the conditions in these distinctive habitats, which are young oligotrophic rivers subject to extreme climatic and hydrological seasonal variation. These species spawn in fresh waters, the free embryos drift downstream to the sea where they undergo a planktonic phase, before returning to the rivers to grow and reproduce (McDowall 1997; Keith 2003), hence they are termed amphidromous (McDowall 1997). The practical details of their biological cycle and the parameters leading to such extreme evolution in amphidromous gobies are poorly known, despite the fact that these gobies contribute most to the diversity of fish communities in the Indo-Pacific and the Caribbean insular systems, and have the highest levels of endemism (Keith 2003).

Because the upstream migration of larvae is so massive at fixed periods in the year, these species can also be of importance on many archipelagos as food resources for local human populations (Bell 1999). But this food resource is fragile, often bordering on extinction, on account of both the complexity of the species’ life cycles and the hydrological specificities of these islands. In Réunion island, post-larvae of *C. acutipinnis* are overfished when returning to the rivers and the stocks are decreasing (Keith et al. 1999).

Amphidromous gobies belong mainly to 11 genera and comprise nearly 170 species (Keith 2003). The biodiversity is highest in the New Guinea region and progressively diminishes westwards from this area (Springer 1982). So, further genera are mainly endemic to the Pacific Ocean (*Lentipes* Günther, 1861; *Stiphodon* Weber, 1895; *Sicyopus* Gill, 1863; *Schismatogobius* de Beaufort, 1912), but only one is strictly endemic to the Indian Ocean, *Cotylopus* Guichenot, 1863. The only species formerly known, *C. acutipinnis*, is endemic to the Mascarene Islands (Réunion and Mauritius). The discovery of a new species in the Comoros, 1400 km farther to the north-west on the Indian Ocean, is very interesting from both biogeographic and conservation points of view.

First, the presence of a second species in the Comoros has shown that this genus is more diversified than was thought, although these islands are distant from the supposed biodiversity dispersion centre in the New Guinea region (Springer 1982). The dispersion of the larval marine phase in the Indian Ocean was of a great importance to the colonization of these islands. The Comoros are, at this time, the northernly limit of the distribution area of the genus *Cotylopus*. Indeed, a recent survey in the Seychelles islands failed to find any
Gobiidae Sicydiinae and showed that the rivers are colonized by other types of fishes (Bosc et al. 2004).

Second, the current state of knowledge on the life cycles of amphidromous gobies (biology, ecology), the length of the larval phase and the part it plays in the dispersal of larvae, is of direct relevance for management and conservation. The management and the conservation of amphidromous species must take into account both the dependency of adult populations on the larval pool for replacement, and the contribution of each reproductive population to the larval pool. The length of the marine phase might increase the probability of finding a river for colonization, as will the strength and the direction of marine currents (Radtke et al. 2001). The survival of the species depends also on the ability of existing populations to provide enough larvae to maintain appropriate numbers of adults. The Koualé river, the only river where C. rubripinnis was found in Mayotte, has a dam and all the specimens were caught between the estuary and this dam; no specimens were caught above the dam. Its conservation is thus a matter of concern. It is to be hoped that this species also exists on the other islands of the Comoros, but it has not been found by different surveys (Thys van den Audenaerde and Teugels 1984; Teugels et al. 1985; Balon and Bruton 1994).

Seasonal variables (e.g. rainfall, drought, floods, typhoons) have a major impact on the survival of populations: biological events such as reproduction, spawning and the dispersal of larvae are dependent on these events and are synchronized with them (Keith 2003). On islands, the impact of humans on aquatic habitats is highly significant, particularly on estuarine habitats which are crucial to amphidromous species. These have to undertake two migrations between fresh waters and the sea. The success of such a life cycle, i.e. production of larvae and restocking rivers, depends on maintaining the mountain–ocean corridor open to allow movements between both habitats (Radtke et al., 2001). As a result of industrialization and the development of tourism, island rivers have been channelled, reconfigured and degraded. Habitats have been reduced and species are often included in red data books (Keith 2003). Only just discovered, this new species seems to be already endangered. It is therefore necessary to understand its biology to the best of our ability, and to develop management and restoration strategies in order to preserve stocks of Cotylopus, a unique and rare genus of the Indian Ocean, for the future (Keith and Marion 2002).

Acknowledgements

We thank the following persons for their help during the expedition: Mr Marquet for the collection of the specimens, Mr Valade from ARDA, and Mr Feunteun from University of La Rochelle. Thanks to R. E. Watson for his comments about Sicydiinae.

References

Akihito [Prince] 1986. Some morphological characters considered to be important in gobiid phylogeny. In: Ichthyological Society of Japan, editor. Indo-Pacific fish biology: proceedings of the Second International Conference on Indo-Pacific Fishes. Tokyo, 629–639.

Anonymous. 1997. Retenue collinaire de Combani: étude d’impact sur l’environnement. Nîmes: Rapport Stucky and Mecasol. 90 p.

Balon EK, Bruton MN. 1994. Fishes of the Tatinga River, Comoros, with comments on freshwater amphidromy in the goby Sicyopterus lagocephalus. Ichthyological Exploration of Freshwaters 5:25–40.

Bell KNI. 1999. An overview of goby-fry fisheries. Naga Manila 22(4):30–36.

Benson CW. 1960. The birds of the Comoro Islands. Results of the British ornithologists Union Centenary expedition 1958. Ibis 103b:5–106.
Bosc P, Valade P, Keith P. 2004. Inventaire des poissons et de macrocrustacés d’eau douce des principales rivières pérennes des îles Mahé et Praslin. Rapport ARDA/MNHN. 55 p.

Fourmanoir P. 1954. Ichthyologie et pêche aux Comores. Mémoires de l’Institut des Sciences de Madagascar A, (IX):187–239.

Keith P. 2002. Freshwater fish and decapod crustacean populations on Réunion Island, with an assessment of the results of species introductions. Bulletin Français de la pêche et de la Pisciculture 364:97–107.

Keith P. 2003. Biology and ecology of amphidromous Gobiidae in the Indo-pacific and the Caribbean regions. Journal of Fish Biology 63(4):831–847.

Keith P, Marion L. 2002. Methodology for drawing up a Red List of threatened freshwater fish in France. Aquatic Conservation 12:169–179.

Keith P, Vigneux E, Bosc P. 1999. Atlas des poissons et crustacés d’eau douce de la Réunion Paris: MNHN Patrimoines naturels 39, 136 p.

Kiener A. 1963. Poissons, pêche et pisciculture à Madagascar Nogent sur Marne: Publication CTFT 24. 244 p.

Kottelat M, Nielsen JG, Niijssen H. 1993. Survey of ichthyological resources in European museums and collections: Societas Europaea Ichthyologorum. Munich: Verlag Dr. Friedrich Pfeil. 23 p.

Leviton AE, Gibbs RH, Heal E, Dawson CE. 1985. Standards in herpetology and ichthyology: Part 1. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. Copeia 1985, 802–832.

Louette M, Louette G. 2000. Inventaire de la faune d’une rivière à Mayotte. Rapport MRAC-CTM. 44 p.

McDowall RM. 1997. Is there such a thing as amphidromy? Micronesica 30(1):3–14.

Pellegrin J. 1933. Les poissons des eaux douces de Madagascar et des îles voisines (Comores, Seychelles, Mascareignes). Mémoires de l’Académie Malgache 14:1–222.

Playfair RL, Günther A. 1867. The fishes of Zanzibar, with a list of the fishes of the whole east coast of Africa London: Newton K. Gregg 153 p. (Reprinted in 1971).

Radtkie RL, Kinzie RA, Shafer DJ. 2001. Temporal and spatial variation in length of larval life and size at settlement of the Hawaiian amphidromous goby Lentipes concolor. Journal of Fish Biology 59(4):928–938.

Sclater PL. 1864. On the birds of Comoro islands. Ibis 1864:292–307.

Sparks JS, Stiassny M. 2003. Introduction to the freshwater fishes. In: Goodman SMBenstead JP, editors. The natural history of Madagascar Chicago: The University of Chicago Press. p 849–882.

Springer VG. 1982. Pacific plate biogeography with special reference to shorefishes. Smithsonian Contribution to Zoology 367:1–182.

Starmühler F. 1976. Contribution to the Knowledge of the freshwater fauna of the isle of Anjouan (Comores). Cahier ORSTOM, Hydrobiologie 10(4):255–265.

Starmühler F. 1979. Results of the Austrian hydrobiological mission 1974, to the Seychelles, Comores and Mascarene Archipelago: part 1. Annaler des Naturhistorischen Museum in Wien 82:621–742.

Teugels GG, Janssens LJM, Bogaert J, Dumalin M. 1985. Sur une collection de poissons des rivières des Comores. Cybium 9(1):41–56.

Thys van den Audenaerde D, Teugels G. 1984. De zoetwatervissen van de comoren een merkwaardigegrep. Africa-Tervuren 30(1–4):58–65.

Watson RE. 1995. Review of the freshwater goby genus Cotylopus (Teleostei: Gobiidae: Sicydiinae). Ichthyological Exploration of Freshwaters 6(1):61–70.

Watson RE, Marquet G, Pöllabauer C. 2000. New Caledonia fish species of the genus Sicyopterus (Teleostei: Gobioidae: Sicyidiinae). Aqua 4(1):5–34.