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SYSTEMATIC REVISION OF THE TROPICAL ASIAN LABEOIN CYPRINID FISH GENUS *CIRRHINUS*, WITH DESCRIPTIONS OF NEW SPECIES AND BIOLOGICAL OBSERVATIONS ON *C. LOBATUS*

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ABSTRACT

Cirrhinus are labeoin cyprinids of mainland tropical Asia, ranging from the Indus to southern China and the Mekong and the Tapi drainage in peninsular Thailand. Fourteen species are recognized in the present revision. India has five species, Myanmar four (including one endemic to Lake Inle), Thailand eight, Cambodia, Laos and Vietnam each have seven, and China only one. Three species are described as new: *C. rubirostris* from Tenasserim basin, southeastern Myanmar; *C. inornatus* from Irrawaddy and Sittang basins; and *C. ornatipinnis* from the middle Mekong basin of Thailand. The replacement name *C. lu* is proposed for the endemic Inle Lake species *C. horai* (Banarescu, 1986), preoccupied in *Cirrhinus* by *C. horai* Lakshamanan, 1966 (a subjective junior synonym of *C. cirrhosus*). *Cyprinus cirrhosus* Bloch, 1795 is identified as the most senior synonym of *Cyprinus mrigala* Hamilton, 1822; *Cyprinus ariza* Buchanan, 1807 as the most senior synonym of *Cirrhinus reba* (Hamilton, 1822); and *Leuciscus molitorella* Valenciennes, 1844 as the most senior synonym of *Cirrhina chinensis* Günther, 1868. Thus the valid names for these species are *Cirrhinus cirrhosus, C. ariza,* and *C. molitorella. Cirrhinus jullieni* is a relatively rare species, almost invariably confused with *C. siamensis* by previous authors, with a restricted distribution in the lower Mekong and Chao Phraya (all previous records from Chao Phraya are based on *C. siamensis* or other species).

Cirrhinus cirrhosus is one of the most important cultured fish species in India, Bangladesh and Myanmar, and *C. molitorella* is cultured widely in China. Both have been introduced into other countries. Several other species are important in wild-capture fisheries, including *C. lobatus, C. microlepis,* and *C. siamensis* in the Mekong basin. Most species of *Cirrhinus* probably have direct sexual development, with sex ratios approaching 1:1. *Cirrhinus lobatus,* however, is a sequential (protogynous) hermaphrodite: all migrating individuals develop female gonads beginning at about 45 mm standard length; at about 65 mm, some individuals develop male gonads. It is suggested that *C. lobatus* migrating upstream for reproduction employ a strategy of "ever-changing leadership" to find their way past physical barriers such as Khone waterfalls in southern Laos. What appears to be a massive long distance migration of very large numbers of this species may represent numerous episodes of recruitment and falling out en route, so that individual fish (especially the smaller and move numerous females) travel only a fraction of the entire migratory route. Thus the so-called "long distance" migrations of *C. lobatus* and some other cyprinid species may differ fundantally from the true long distance migrations of many birds, mammals, and other fishes.

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INTRODUCTION

The tropical Asian labeoin cyprinid genus *Cirrhinus* includes species of major importance in aquaculture, wild capture fisheries, and ecology. The most important cultured species are *C. cirrhosus* (mrigal) and *C. molitorella,* both consequently transported beyond their natural ranges. Several other species are important objects of fisheries and/or are ecologically dominant species. *Cirrhinus microlepis* is an important species in wild capture fisheries of the middle and lower Mekong basin, including the Great Lake-Tonle Sap system in central Cambodia. Two of the smaller species, *C. siamensis* and *C. lobatus,* are perhaps the most abundant of all naturally occurring fish species in the Mekong basin. They are heavily fished during reproductive migrations occurring mainly in May–July and non-reproductive migrations occurring mainly in December–January (ROBERTS, 1993; ROBERTS & BAIRD, 1996)

Despite their importance in fisheries and ecology, the systematics and biology of most *Cirrhinus* species have not been extensively investigated. A systematic study of *Cirrhinus* species of Thailand by Sodsuk, 1988 is deficient because the author did not study type specimens of any of the described species, and hence the species are not well identified. The specimens that study was based upon are all deposited in the National Inland Fisheries Institute in Bangkok. As these collections are not generally available for examination by researchers, it has not been possible to re-examine or re-identify the specimens.

A general review of the biology, now somewhat out of date, is available only for *C. cirrhosus* (JHINGRAN & KHAN, 1979). Far less is known of other important species such as *C. microlepis.* Migrations of Mekong species are just beginning to be documented (ROBERTS, 1993; ROBERTS & BAIRD, 1996). Samples from spawning migrations of *C. lobatus* indicate that it is a precocious protogynous hermaphrodite (ROBERTS & BAIRD, 1996: 247–248, figs. 22–24). It also is an ecological keystone species, and probably the most abundant fish species in the Mekong basin.

This paper is concerned mainly with alpha level systematics of species in the genus *Cirrhinus. Henicorhynchus* Smith, 1945, regarded as a distinct genus by BANARESCU, 1972; 1983 and KOTTELAT, 1989 (but in any event a subjective junior synonym of *Cirrhinichthys* BLEEKER, 1863) is treated here as a subjective junior synonym of *Cirrhinus.*

MATERIALS AND METHODS

The specimens reported on are deposited in the following institutions: AMNH, American Museum of Natural History, New York; ANSP, Academy of Natural Sciences, Philadelphia; BMNH, British Museum of Natural History, London; CAS, California Academy of Sciences, San Francisco; MNHN, Muséum National d'Histoire Naturelle, Paris; MSNG, Museo Civico d'Storia Naturale, Genoa; USNM, National Museum of Natural History, Washington, DC; ZMA, Zoologische Museum, Universitet van Amsterdam; ZRCS, Zoological Reference Collections, National University of Singapore; and ZSI/SRS, Zoological Survey of India, Southern Regional Station, Madras.

Species synonymies in this paper (as in my papers generally) are intended to provide basic systematic references, not complete or even extensive bibliographies. They include

primary synonymy (original descriptions and designations of scientific names) and secondary synonymy (subjective name changes due to matters of taxonomic judgment). Additional synonymy may be provided, when the references themselves permit reasonably sure identification of the species, or when I have been able to examine voucher specimens upon which the identifications were based. Some important instances of "negative" synonymy are included, when species are reidentified as something else. Such entries are preceded with the neo-Latin term "nec" meaning "not" or "not of".

Type localities are cited as direct quotations from the original publications. Further explanation or interpretation of the localities, if not provided in the original publications, is clearly indicated as additional, by being placed in parentheses or brackets. Some detail has gone into listing the material examined, particularly in the matter of providing localities, dates, and name of collectors. The importance of such information will become increasingly evident as the ranges of species change more and more due to human impacts (including introductions).

As in most of my systematic revisions of genera, an account of the genus and generic type species is given first, followed by accounts of the other species in alphabetical order.

Cirrhinus Oken 1817

Cirrhinus Oken, 1817 : 1182a (type species by monotypy *Cyprinus cirrhosus* Bloch, 1795).
Isocephalus Heckel, 1843: 1029 (type species apparently never designated according to Eschmeyer, 1990: 200; type species by present designation *Cyprinus cirrhosus* Bloch, 1795).
Mrigala Bleeker, 1859: 427 (type species *Cyprinus mrigala* Hamilton, 1822, by absolute tautonymy; or *Cirrhina bengalensis* Bleeker, 1853 by subsequent monotypy of Bleeker = *Cyprinus mrigala* according to Bleeker, 1860: 226).
Cirrhinichthys Bleeker, 1863: 202 (type species by original designation and monotypy *Cirrhinus dussumieri* Valenciennes in Cuvier & Valenciennes, 1842 [=*Cirrhinus ariza* Buchanan, 1807] (senior synonym of *Henicorhynchus*).
Henicorhynchus Smith, 1945: 245 (type species by original designation and monotypy *Henicorhynchus lobatus* Smith, 1945).

Cirrhinus are small to moderately large labeoin cyprinid fishes. Large adults of the species range from around 100 mm *(C. lobatus, C. soi)* to 1 m *(C. cirrhosus).*

Cirrhinus either lack barbels entirely, or have one or two pairs of very small barbels. When only one pair of barbels is present, it usually is the rostral pair. In species (or individuals) in which only maxillary barbels are present, these are very small or minute. When both pairs of barbels are present, the rostral barbels are invariably larger than the maxillary barbels. Length of rostral barbels usually much less than eye diameter.

The soft mouth parts immediately associated with the jaws in *Cirrhinus* are a discrete rostral cap, upper and lower lips, and upper and lower horny jaw sheaths; the upper and/or lower lip may be very weakly developed or absent (nomenclature after ROBERTS, 1982). These structures are relatively simple compared to their counterparts in other labeoins, for they bear a minimum of horny tubercles and of papillae, fimbriae, plicae or other unculiferous structures.

When papillae do occur on the rostral cap, they are small and numerous, not arranged on deeply grooved fimbriae, but sufficiently developed to suggest the condition of the more highly developed papillose fimbriae on the rostral cap of the labeoin genera *Crossocheilus, Garra* and their close relatives (see ROBERTS, 1982, fig. 8). This explains why Day and other nineteenth century ichthyologists, particularly those working on Indian and Burmese fishes, tended to include species of *Cirrhinus* in the genus *Crossocheilus.*

The larger keratinous structures known as tubercles or "breeding tubercles" (which presupposes their function, usually unknown) are found in many cyprinids and especially in labeoins. They are relatively poorly developed in *Cirrhinus* but most of the species do have tubercles on the snout, especially on the rostral cap. Tubercles are perhaps least developed (absent?) in the lacustrine species *C. lu,* and most highly developed in *C. rubirostris.* In the latter species they are present in juveniles and adults of both sexes. In *Cirrhinus fulungee, C. lineatus,* and *C. lobatus,* the great majority of specimens have no tubercles or very weakly developed tubercles, but occasional individuals are strongly tuberculate.

Cyprinids of the labeoin group are distinguished by the presence of a soft gular or vomero-palatal organ. This usually consists of a paired series of fleshy lamellae, armed with posteriorly-directed fingerlike processes or fimbriae, on a discrete fleshy pad in the roof of the mouth. The vomero-palatal organ, possibly a diagnostic characters of labeoins, is present in all species of *Cirrhinus* (Fig. 1). In some species the lamellae are reduced but large fimbriae project downwards and backwards from the roof of the mouth.

Cirrhinus have long, thin, highly coiled intestines. The species are probably all iliophagous (feeding on mud and detritus) and/or suctorial feeders on small invertebrates. Virtually nothing, however, has been recorded on the feeding behavior of naturally-occurring *Cirrhinus.*

Dorsal fin with 3 or 4 simple rays and 8 to 16 branched rays. Last simple ray slender, without serrae on its posterior border. The anterior one or two simple rays usually are very small and difficult to detect without dissection or radiography. The number of simple rays conveys relatively little or no information useful in distinguishing species. The number of branched rays, however, is important. The smaller species of *Cirrhinus* (largest specimens about 100–120 mm standard length) and some moderately large species almost invariably have 8 branched dorsal fin rays, whereas larger species have from 9 to 16 (with last branched ray usually divided to its base). Anal fin branched rays 5. Pelvic fin rays 9. Principal caudal fin rays 10/9.

None of the species previously recognized as *Cirrhinus* were known to have 9 or 10 branched dorsal fin rays, and this was used by Banarescu and Kottelat as the principal basis for distinguishing *Henicorhynchus* (with 8 branched dorsal fin rays) from *Cirrhinus* (with 11 or more branched dorsal fin rays). Such a division, which separates almost all of the larger species from all of the smaller ones, does not seem phylogenetically valid. At least until phylogenetic relationships are better understood, it seems preferable to have one large (and perhaps polyphyletic) genus *Cirrhinus* than two smaller (and probably polyphyletic) genera.

Another problem with recognizing two generic groups on the basis of the supposed gap in number of branched dorsal fin rays is that the gap does not exist. Thus *Cirrhinus ariza* can have 8 or 9 branched dorsal fin rays, *Cirrhinus lu* and *C. inornatus* new species

always or usually have 9, and *C. rubirostris* new species 10.

Scales in the main longitudinal (lateral line) scale row, useful in distinguishing species, range from 32 to 60. Transverse scale rows, also useful, range from 6/1/4 (*C. lu* and *C. soi*) to 13/1/8 *(C. microlepis).*

Vertebral counts range from 32 to 41, with abdominal vertebrae about twice as numerous as caudal.

In most species the number of scales in the lateral line scale row is the same as or very close to the number of vertebrae. Thus *C. lobatus* normally has 32 vertebrae and 32–33 scales in the lateral line scale row, *C. lu* 39–41 vertebrae and 39–40 scales. There are two main exceptions, *C. fulungee* and *C. microlepis,* in which the scales are more numerous than the vertebrae. *Cirrhinus fulungee* has 36–37 vertebrae and 42–52 scales in the lateral line row, *C. microlepis* 40 vertebrae and 53–60 scales. No *Cirrhinus* have lateral line scales fewer than vertebrae.

Perhaps the most characteristic color feature of the genus is the pinkish, rosy, orangish or sometimes blood red color of the pectoral, pelvic, anal, and lower part of the caudal fin observed to some extent in all or nearly all species. Such coloration is not unique, but is more frequent in *Cirrhinus* than in any other labeoin genus. Several of the species have other distinctive color features.

The dorsal fin of all species of *Cirrhinus* has more or less strong interradial pigmentation, composed entirely of melanophores. In the Indian and Burmese species this interradial pigmentation tends to occupy nearly all of the interradial surface, while in Southeast Asian species it tends to be restricted to the middle or middle and distal portions. In some species, especially the smaller Southeast Asian ones, the dorsal fin has a black margin. With a single peculiar exception, the other fins lack any distinctive pigmentation features due to melanophores. The one exception is the caudal fin of the holotype of *C. caudiguttatus* which has a number of small but regularly arranged dusky spots. No additional material definitely referable to this species has come to light, and its status as a valid species is doubtful.

Several *Cirrhinus* species have humeral marks but others do not. In most species with a humeral mark it is black, but *C. molitorella* typically has a bluish green humeral mark. Most species have body whitish or silvery (rosy to bluish in *C. microlepis*), without any distinctive marks. Longitudinal stripes occur in three species, *C. lineatus, C. fulungee,* and *C. ariza.* In some Cyprinidae with longitudinal stripes (e.g. *Labiobarbus*) the stripes go down the center of the scale rows. In such species the stripe on the lateral line scale row runs right down the lateral line. In *Cirrhinus,* however, the stripes are aligned with the obliquely overlapping zone of the scale rows, so that the lateral line has stripes immediately above and below it, rather than a stripe straddling it. Some large specimens of *C. ariza* are unique for the genus in having a broad midlateral stripe.

Labeo yunnanensis Chaudhury, 1911, and *L. decorus* Peters, 1880, both described from Yunnan, were assigned to the genus *Cirrhinus* by Banarescu, 1972. These species probably do not belong in *Cirrhinus.* The systematic status of both has been considered in the recent monograph on Yunnanese Cyprinidae by Chu and Chen, 1989. These authors place *L. yunnanensis* in *Labeo* Cuvier, 1817, and *L. decorus* in *Sinilabeo* Rendahl, 1932. The only Yunnanese species of *Cirrhinus* they recognize is *C. molitorella.*

Mouthparts of *Cirrhinus* are similar in most respects to those of another tropical Asian labeoin genus, *Tylognathus* Heckel, 1843. But *Varicorhinus diplostomus* Heckel, 1838 (type species of *Tylognathus*) and other species provisionally referred to *Tylognathus* by Reid, 1985: 287 have a well developed ethmoid furrow (absent in *Cirrhinus*).

Key to Species of Cirrhinus

1 Dorsal fin branched rays usually 8 (9 in some *C. ariza*).....2
Dorsal fin branched rays 9 or more.....7

2 Scales in lateral series 32–35.....3
Scales in lateral series 42–52.....*C. fulungee*

3 Transverse scale rows 6/1/4 (Mekong).....*C. ornatipinnis*
Transverse scale rows more than 6/1/4.....4

4 Body with longitudinal stripes.....5
Body without stripes.....6

5 Rostral barbels present, well developed; maxillary barbels absent; to 30 cm (India, Bangladesh).....*C. ariza*
Rostral barbels absent; minute maxillary barbels present; to 12 cm (Mekong, Chao Phraya).....*C. lineatus*

6 Head large and broad; snout weakly or not projecting; total vertebrae 33 or more; to 20 cm (Mekong, Chao Phraya).....*C. siamensis*
Head smaller and narrower; snout often strongly projecting; total vertebrae usually 32; to 12 cm.....7

7 Caudal peduncle with more or less bold spot (Chao Phraya).....*C. caudimaculatus*
Caudal peduncle without spot (Mekong).....*C. lobatus*

8 Dorsal fin branched rays 11 or more.....9
Dorsal fin branched rays 9 or 10.....11

9 Rostral barbels absent; lateral line scales 53–60 (Mekong, Chao Phraya).....*C. microlepis*
Rostral barbels present; lateral line scales 39–46.....10

10 Body with reticulated pattern due to concentrations of melanophores aligned with overlapping zone of scales; to 40 cm (China, Indo-China, Thailand).....*C. molitorella*
Body without reticulate pattern.....11

11 Body elongate, predorsal profile nearly straight; pectoral, pelvic, anal and caudal fins colorless, dusky, or pinkish; to 1 m (native to Indian subcontinent including Myanmar, but widely introduced into China, Indo-China, Thailand).....*C. cirrhosus*

Body relatively truncate, predorsal profile steep; pectoral, pelvic, and anal fins, and lower caudal fin lobe usually bright red; to 20 cm (lower Mekong, Chao Phraya).... ..... *C. jullieni*

12 Branched dorsal fin rays usually 10; snout strongly tuberculate..... *C. rubirostris*
Branched dorsal fin rays usually 9; snout without tubercles or weakly tuberculate.... 13

13 Rostral barbels present, maxillary barbels absent..... *C. lu*
Rostral barbels absent, maxillary barbels present..... *C. inornatus*

Cirrhinus cirrhosus (Bloch, 1795)
Fig. 2

Cyprinus cirrhosus Bloch, 1795: 52, pl. 411 (reproduced here as Fig. 2) (type locality rivers and lakes of the coast of Malabar).

Cyprinus mrigala Hamilton, 1822: 279, 386, pl. 6, fig. 79 (type locality "ponds and fresh waters of the Gangetic provinces").

Cirrhina rubripinnis Valenciennes in Cuvier & Valenciennes, 1842: 288, pl. 479 (type locality "étangs de Calcutta").

Dangila leschenaulti Valenciennes in Cuvier & Valenciennes, 1842: 235, pl. 471 (type locality "eaux douces de Pondichéry").

Cirrhina plumbea Valenciennes in Cuvier & Valenciennes, 1842: 289 (type locality Irrawaddy).

Cirrhina blochii Valenciennes in Cuvier & Valenciennes, 1842: 290 (unwarranted substite name for *Cyprinus cirrhosus* Bloch).

Cirrhina mrigala, Valenciennes in Cuvier & Valenciennes, 1842: 294; Day, 1877: 547, pl. 129, fig. 4).

Mrigala Bleeker, 1859: 427.

Mrigala buchanani Bleeker, 1860: 226 (replacement name for *Cyprinus mrigala*).

Cirrhina leschenaultii, Günther, 1868: 36.

?*Cirrhina macrops* Steindachner, 1870: 636 (type locality Madras).

Cirrhina cirrhosa, Day, 1877: 547, pl. 131 fig. 3.

Cirrhinus horai Lakshmanan, 1966: 59 (type locality Godavari River at Rajahmundry, Andhra Pradesh).

Cirrhinus chaudhryi Srivastava, 1968: 30 (type locality "ponds near Naua Dumari, 11 miles south of Gorakhpur", Uttar Pradesh, northern India).

Type material examined.—MNHN A3362, 219 mm, Irrawaddy, Reynaud (holotype *C. plumbea*); MNHN 3854, 3: 160–255 mm, India (syntypes *C. rubripinnis*); MNHN 3852, 184 mm, Pondichery (holotype *C. leschenaulti*).

Non-type material examined.—CAS (SU) 41125, 163 mm, Bisrampur, Central Prov., India, 13 Dec. 1040, A.W. Herre; BMNH 1889.2.1.294–96, 3: 74.2–101 mm, Madras, F. Day; USNM 44790, 164 mm, Bhamo, upper Irrawaddy, 1885–89, L. Fea.

Diagnosis. Probably the largest species of *Cirrhinus,* attaining 90 cm or 1 m (Day, 1877: 548; Jhingran & Khan, 1979: 33); rostral barbels present, length about half eye diameter; maxillary barbels smaller than rostral barbels or absent; rostral cap without fimbriae or papillae, its oral margin entire; upper lip absent; lower lip absent or weakly developed, represented by a transverse series of small papillae near margin of lower horny jaw sheath; lateral line scales 39–46, transverse scale rows 7/1/6, circumpeduncular scales 20; branched dorsal fin rays 12–15; vertebrae 26+13=39.

Tubercles on rostral cap weakly developed, represented by small tubercle scars in most larger specimens examined.

Discussion. Recent authors have recognized three large species of *Cirrhinus* in India (JAYARAM, 1981; TALWAR & JHINGRAN, 1991). According to these authors, the species most commonly used in aquaculture and most widely distributed is *C. mrigala; C. cirrhosus,* also cultured, occurs in rivers of peninsular India flowing into the Bay of Bengal, from the Godavari to the Cauvery; while *C. macrops,* not used in aquaculture, is common in the fishery catches of the Godavari River at Rajamundry and also occurs at Madras (TALWAR & JHINGRAN, 1991: 172).

Cirrhinus cirrhosus supposedly differs from *C. mrigala* in having maxillary barbels well developed instead of small or absent (JHINGRAN & KHAN, 1979: 1), and 15–16 instead of only 12–13 branched dorsal fin rays (TALWAR & JHINGRAN, 1991: 170). Since its placement by Günther, 1868: 36 (with question mark) and then by Day, 1877: 547 (without question mark) as senior synonym of *C. leschenaultii, C. cirrhosus* almost invariably has been regarded as a valid species with two pairs of barbels. The problem is that Bloch's plate of the holotype of *C. cirrhosus* shows only two barbels, and they are both definitely rostral barbels (Fig. 2). The unavoidable conclusion is that *C. cirrhosus* is the most senior synonym for the species usually known as *C. mrigala.* The name *C. cirrhosus* should not be suppressed in favor of *C. mrigala* because *C. cirrhosus* has been recognized by many authors as a valid species, and is, in addition, type species of the genus.

The holotype of *C. leschenaulti* has a pair of rostral and a pair of maxillary barbels: length of rostral barbels about one-half eye diameter; maxillary barbels much thinner and not quite so long, length about 2/5 eye diameter; total gill rakers on first gill arch at least 73, perhaps a few missing at anterior end of lower arch, so total might be nearer 80; branched dorsal fin rays 14; vertebrae 26+13=39. I have compared this specimen directly with specimens of comparable size identified as *C. mrigala* (i.e., lacking maxillary barbels) and find them extremely similar.

Cirrhinus horai Lakshmanan, 1966 was based on presumably wild stocks of spawning fishes caught in the Godaveri River at Rajahmundry, Andhra Pradesh. TALWAR & JHINGRAN (1991) placed it as a synonym of *C. macrops* Steindachner, 1870, a species generally not recognized since its original description. I have not examined type material of either *C. horai* or *C. macrops.* Morphological differences between these two nominal taxa and the more readily available cultivated examples of *C. cirrhosus* might be due to intraspecific variation.

Distribution. *Cirrhinus cirrhosus* has been so widely transported in connection with aquaculture that its natural distribution no longer can be determined. Day, who regarded

Figure 1. Vomeropalatal organ (*Cirrhinus rubirostris*, 265 mm).

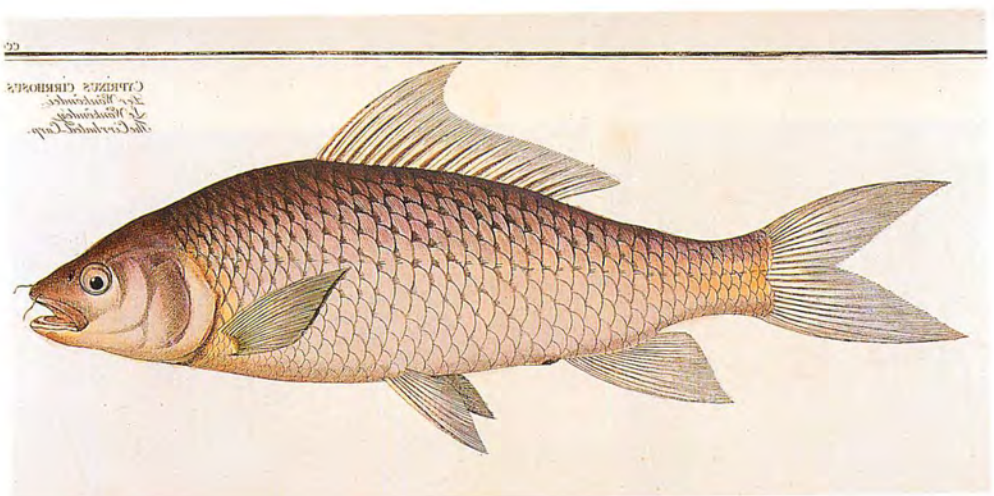

Figure 2. *Cirrhinus cirrhosus*. Bloch, 1795, pl. 411 (photograph courtesy Carl J. Ferraris). Note presence of only a single pair of barbels (rostral).

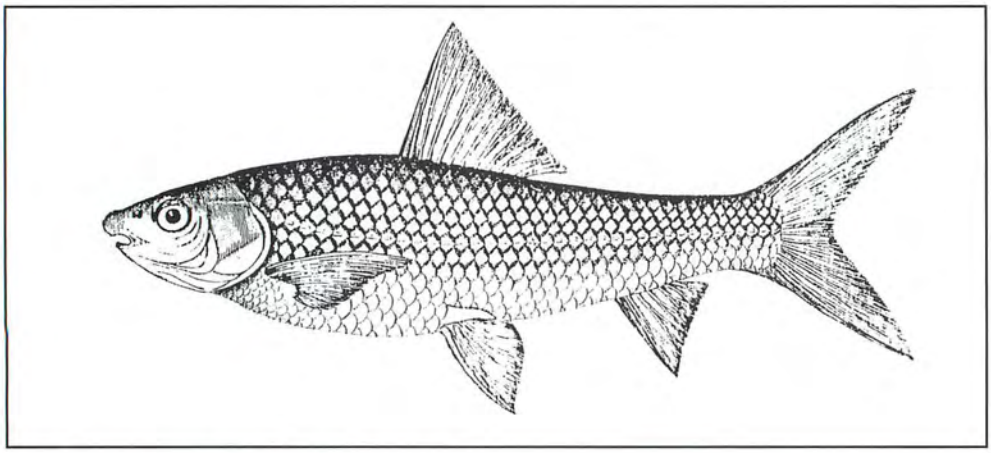

Figure 3. *Cirrhinus ariza.* Buchanan, 1807, pl. 31.

Figure 4. *Cirrhinus ariza,* 164 mm, Patna market (Ganges basin).

Figure 5. *Cirrhinus inornatus,* holotype, 115 mm, Mandalay.

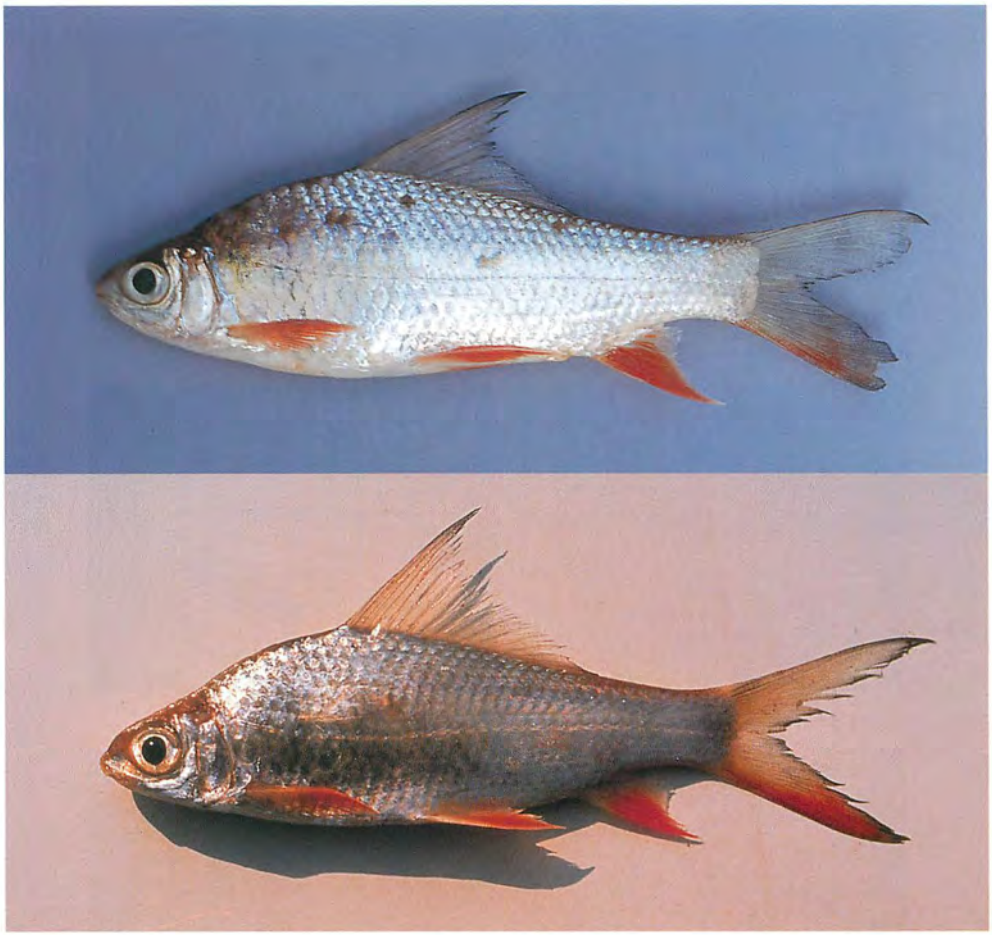

Figure 6. *Cirrhinus jullieni.* Above, Phnom Penh (Mekong basin); below, Sukhothai (Chao Phraya basin).

Figure 7. *Cirrhinus lineatus,* 80.4 mm, Mekong near That Phanom.

Figure 8. *Cirrhinus lobatus,* 70 mm gravid female, Mekong below Khone Falls.

Figure 9. *Cirrhinus lu,* 145 mm, Inle Lake.

Figure 10. *Cirrhinus microlepis.* Upper, juvenile from Great Lake, Cambodia; lower, violet or purplish hued adult, middle Mekong.

C. cirrhosus and *C. mrigala* as distinct species, gave the distribution of *C. mrigala* as "Cutch, Sind, Punjab, Bengal, and Burma" and "rivers and tanks in Bengal, Deccan, N.W. Provinces, Punjab, Sind, Cutch, and Burma" and that of *C. cirrhosus* as "Godavery, Kistna [=Krishna] and Cauvery rivers, and generally in south India" (Day, 1877: 547–548).

JHINGRAN & KHAN (1979) indicate that *C. cirrhosus* (called by them *C. mrigala*) has been widely introduced in southern India, which is certainly true. The point is, however, that the naturally occurring distribution is not known and is now unknowable. If there were formerly two distinct species, one more southerly with two well developed pairs of barbels and one more northerly with (usually) only a single pair of barbels, both have by now been repeatedly and massively introduced into each other's natural ranges. There has almost certainly been widespread introgressive hybridization of introduced and any naturally occurring stocks due to artificial production of seed for aquaculture by fisheries stations throughout India.

Cirrhinus ariza (Buchanan, 1807) new combination
Figs. 3–4

Cyprinus ariza Buchanan, 1807: 344, pl. 31 (reproduced as Fig. 3) (type locality "a small clear stream called the Vedawati", a tributary of the Tungabahdra R., Krishna basin; no type specimens).

Cyprinus ariza Hamilton, 1822: 286 ("rivers of Bengal as well as those of the peninsula of India").

Cyprinus reba Hamilton, 1822: 280, 386 (type locality Bengal; Behar; no type specimens).

?*Gobio limnophilus* McClelland, 1838: 279, pl. 55, fig. 3 (type locality "ponds in Bengal"; location of type material unknown).

?*Gobio isurus* McClelland, 1838: 277 (type locality upper Assam; location of Type material unknown).

Cyprinus bangon Buchanan, in McClelland, 1838, pl. 107, fig. 2 (figure only; no type specimens).

Cirrhina dussumieri Valenciennes in Cuvier & Valenciennes, 1842: 291, pl. 480 (type locality eaux douces de Mysore).

Chondrostoma gangeticum Valenciennes in Cuvier & Valenciennes, 1844: 399 (type locality Gange).

Cirrhina reba Day, 1877; 549, pl. 130, fig. 3.

Labeo ariza Day, 1877; 544, pl. 132, fig. 5 ("Wynaad and Bowany river at the foot of the Neilgherry hills in Madras, also Cauvery river").

?*Labeo ariza* Talwar & Jhingran, 1991: 198.

Type material examined.—MNHN 3153, 73.0 mm, Gange, Reynaud (holotype *C. gangeticum*).

Non-type material examined.—CAS 24237, 5: 63.7–103 mm, Indus R. 325 mi N of Karachi and 5 mi N of Sukkur, 1–11 Nov. 1968, E.S. Herald; CAS 29653, 85.8 mm, Arabian Sea off Karachi, Pakistan, 22 Oct. 1973, F.B. Steiner; CAS(SU) 52929, 6: 64.5–75.9 mm, Nepal, Biratnagar, 27–30 Nov. 1955, A.C. Taft; CAS 50369, 126 mm, Nepal, Terai,

Kalaiya market, 12 km E of Birganj, 1 May 1975, T.R. Roberts; CAS 91612, 5: 86.5–185 mm, Patna market, April–May, 1996, T.R. Roberts; CAS(SU) 41128, 117 mm, Tozpur market, Assam, no date, Zoological Survey of India; CAS(SU) 34568, 2: 74.0–83.0 mm, Mahanadi, Siliguri, 10 April 1937, A.W. Herre; CAS 79176, 128 mm, Hirakud Reservoir and Sambalpur market, Orissa state, Mahanadi basin, 22–24 Feb. 1985, T.R. Roberts; CAS 61823, 85.1 mm, India, Orissa State, Mahanadi basin, Sonepur market, Feb. 1985, T.R. Roberts; CAS(SU) 34569, 2: 136–146 mm, Deolali, Nasik Dist., Bombay, 1935–36, A.G.L. Fraser; BMNH 1938.2.22.86–87, 2: 131–180 mm, Godaveri R. headwaters, Deolali, Nasik Dist., Bombay Nat. Hist. Soc.; CAS 62067, 2: 102–106, and CAS 62093, 6: 88.5–217 mm, Tungabahdra R. and Reservoir at Hospet and Kampli, 28 Jan.–3 Feb. 1985, T.R. Roberts; CAS(SU) 34567, 3: 81.5–90.8 mm, near Kodur, Cuddapah, South India, 10 April 1937, A.W. Herre; CAS 62032, 9: 49.4–89.4 mm, Cauvery basin NW and WNW of Mysore, Karnataka State, 5–8 Jan. 1985, T.R. Roberts; CAS(SU) 34566, 124 mm, Pulta, India, April 1937, A.W. Herre.

Diagnosis. A moderately large species, attaining 30 cm (TALWAR & KHAN 1991: 174); body with thin stripes mostly above lateral line; larger fish sometimes with a broad midlateral stripe (not observed in any other *Cirrhinus*); lateral scale series 32–35; transverse scale rows 7–8/1/5–6; dorsal fin branched rays 8–9; vertebrae 22–24+11-12=34 (4), 35 (3). Color in life variable, overall dull dirty white or greyish, silvery or yellow; thin stripes vary from subdued to bold.

Comments. *Cyprinus ariza* Buchanan, 1807 is one of the earliest described freshwater fish species of India, and is included on the classic work on Gangetic fishes by Hamilton (1822). McClelland, 1838: 357 noted its similarity to his new species *Gobio isurus* and *G. limnophilus,* both subsequently recognized as junior synonyms of *C. reba.* Jerdon, 1849: 308 noted the similarity between *C. ariza* and *C. bangon* and suggested they might be conspecific. *Cyprinus bangon* has been placed as a synonym of *C. reba* by most authors, and I concur. Buchanan's drawing of *C. ariza* shows the exposed margins of the scales in all rows above the lateral line and two rows below it with very distinctive diamond-shaped dark outlines. Such a color feature, although not observed exactly as illustrated in any species of Indian freshwater fish known to me, is closely approached by some specimens of the species commonly identified as *C. reba,* in which the longitudinal stripes between the scale rows tend to zig-zag.

The original description of *Cyprinus ariza* by Francis Buchanan (1762–1829), who formally changed his name to Francis Hamilton in 1818, was based on a fish with exceptionally bold longitudinal stripes. In many individuals, especially those coming from muddy water or having been dead for some time, the stripes are much more subdued. Hamilton (1822) reported *C. ariza* from Bengal and southern India but did not compare his *Cyprinus reba* and *C. ariza* directly. His description of *C. reba* includes several characters not treated in that of *C. ariza,* such as variation in coloration. Two substantive differences he does mention are 11 instead of 12 dorsal fin rays [8 instead of 9 branched rays] and "minute" rostral barbels present instead of absent. These differences represent individual variation.

In the fish collection of the Southern Research Station of the Zoological Survey of India in Madras I examined two lots identified ad *C. reba* that may represent a distinct

species characterized by fewer transverse scale rows, i.e. only 6/1/4. The specimens consequently have fewer longitudinal stripes and thus look quite distinctive, but no additional differences were noted to distinguish them from *C. reba.* The lots are ZSI/SRS F. 4542, 2: 95–110 mm, Maruthar Damn, Tirunvelveli district, southern India, 2 April 95, M.B. Ragunathan; and ZSI/SRS F. 4255, 131 mm, Tampraparni R. near Palayam Kotai, 8 March 1995, M.S. Ravichandra.

Distribution. Indus plain and adjoining hilly areas (Pakistan); Ganges-Brahmaputra basin (India, Nepal, and Bangladesh); Mahanadi, Krishna, Cauvery, and some smaller basins in southern India; Karnapouli and adjacent smaller basins in Chittagong Hill Tracts (Bangladesh).

Cirrhinus caudimaculatus Fowler, 1934 new combination

Tylognathus caudimaculatus Fowler, 1934: 133, figs. 89–90 (type locality Chieng Mai).
Crossocheilus caudiguttatus Fowler, 1934: 137, fig. 103 (type locality Chieng Mai, north Siam [probably=Menam Ping]).
Cirrhinus (Henicorhynchus) caudiguttatus, Böhlke, 1984: 72.
Henicorhynchus caudimaculatus, Rainboth, 1996: 111.

Type material examined.—ANSP 58332, 42.5 mm, Chieng Mai, 1 Jan. 1933, R.M. de Schauensee (holotype *T. caudimaculatus*); ANSP 58333, 26.6 mm, collected with holotype (paratype *T. caudimaculatus*); ANSP 58452, 61.0 mm, Chieng Mai (no further locality=Menam Ping), 5 Feb. 1933, R.M. de Schauensee (holotype *C. caudiguttatus*); ANSP 59089–91, 3: 28.5–35.0 mm, same data as ANSP 58452 (paratypes *C. caudiguttatus*).

Additional material.—The following lots, all from the Chao Phraya basin, are identified as *C. caudimaculatus:* USNM 117769, 27: 45.0–78.5 mm, upper Nan River at Ban Khwang, northern Siam, 31 March 1936, H.G. Deignan; USNM 119493, 2: 59.6–60.5 mm, Chao Phraya at Bangsai, central Thailand, 27 Nov. 1923, H.M. Smith (paratypes *H. lobatus*); USNM 119491, 68.0 mm, Chao Phraya at Paknampo, 19 Nov. 1923, H.M. Smith (paratype *H. lobatus*); USNM 119494, 73.5 mm, Pasak R. at Dha Luang, central Thailand, 20 Aug. 1923, H.M. Smith (paratype *H. lobatus*); USNM 108093, 3: 70.2–73.3 mm, Menam Sak above Dha Luang, 10 Dec. 1923, H.M. Smith; USNM 107880, 6: 70.6–86.5 mm, Menam Nan at Nan, 29 March 1936, H.G. Deignan; USNM 119514, 57.3 mm, Menam Kon, tributary of Menam Nan, 21 April 1936, H.G. Deignan; USNM 108092, 4: 60.6–73.2 mm, Phetchabun, Chao Phraya above Bangkok, 4 Jan. 1925, H.M. Smith; USNM 108094, 45.7 mm, Bung Borapet, 19 Nov. 1923, H.M. Smith; USNM 109783, 7: 72.1–90.7 mm, Nan River, 23 April 1930, Luang Praserth Aksorn; CAS 91781, 55.2 mm, Menam Wang 79 km by road N of Lampang and 6 km E of highway 1035, 28 Feb. 1991, T.R. Roberts.

Comments. *Cirrhinus caudimaculatus* appears to be a valid species known only from the Chao Phraya basin. It is very similar to the Mekong species *C. lobatus,* from which it consistently differs in having a dark round spot on the caudal peduncle (a feature not present in any *C. lobatus* observed by me from the Mekong basin of Thailand, Laos or Cambodia). Like *C. lobatus,* it is a small, small-headed species, often (but not always)

with a strongly projecting snout not observed in other species. *Cirrhinus siamensis* from the Chao Phraya basin occasionally has a peduncular mark like *C. caudimaculatus,* but its head is much bigger and the mark is (always?) faint. Coloration in life not recorded.

I have not found any additional specimens that agree with the holotype of *C. caudiguttatus* as described and figured by Fowler. When I examined it in November 1992, the caudal fin of the holotype still showed the distinctive pattern of small round spots (not known in any other specimen of *Cirrhinus*) described and figured by Fowler. Fowler did not specifically mention these spots in the paratypes, which are much smaller specimens than the holotype, and the spots were not evident in the paratypes when I examined them at the same time as the holotype.

Except for the caudal fin coloration of the holotype, the type specimens of *C. caudiguttatus* are similar to much larger type specimens of *C. caudimaculatus*, also described from Chieng Mai by Fowler. The holotype of *C. caudiguttatus* has vertebrae 21+11=32. This is the first time that *C. caudimaculatus* and *C. caudiguttatus* have been identified as being the same species. As both were described in the same paper by Fowler, 1934, I hereby select *C. caudimaculatus* as the senior objective synynom.

Cirrhinus caudimaculatus is said to be extremely common in central Thailand (RAINBOTH, 1996: 111), but I have collected few specimens in the Chao Phraya since I began collecting there in 1970. The species apparently is greatly reduced and may be nearing extinction.

Distribution. *Cirrhinus caudimaculatus* is known only from the Chao Phraya basin.

Cirrhinus fulungee (Sykes, 1841)

Chondrostoma fulungee, Sykes, 1841: 358 (type locality Dukhun).
Gymnostomus fulungee, Günther, 1868: 76.
Cirrhina fulungee, Day, 1877: 549, pl. 132, fig. 1.

Type material examined.—None. Apparently there is no extant type material of *C. fulungee.* In November 1992 Oliver Crimmen and I searched in the Sykes fish collection deposited in the BMNH (including his dried specimens) for type material but did not find any.

Non-type material examined.—CAS(SU) 41123, 5: 66.9–95.7 mm, Poona Dist., Bombay Pres., 3 April 1937, Zoological Survey of India; CAS(SU) 41124, 2: 88.0–91.8 mm, Mugao, Dharwar, Bombay Pres., 21 July 1937, Zoological Survey of India; CAS 61967, 2: 102–107 mm, Bedti or Gangavali River, about 15 km E of Yellapur, N Kannara Dist., Karnataka State, 25 Jan. 1985, T.R. Roberts; CAS(SU) 34563, 2: 63.5–80.2 mm, Kodur, Cuddapah, South India, April 1937, A.W. Herre; BMNH 1889.2.1.362, 88.3 mm, Malabar, F. Day.

Diagnosis. A small or moderatedly large species of (to 30 cm according to TALWAR & JHINGRAN, 1991: 171); rostral barbels present; body with thin stripes; scales in lateral series 42–52; transverse scale rows 10–11/1/7; dorsal fin branched rays 8; vertebrae 23–25+12–13=36 (5), 37 (6).

The two specimens from the Gangavali (CAS 61967, 102 and 107 mm) are markedly

tuberculate. The entire rostral cap, snout between nostrils, and lacrimal area is covered with large tubercles. All other specimens of *C. fulungee* examined are non-tuberculate.

The 80.2-mm specimen from Kodur, CAS(SU) 34563, appears to be a ripening female. This is remarkably small size for sexual maturity for a species supposedly attaining 30 cm.

Distribution. *Cirrhinus fulungee* occurs in "Poona and Deccan" according to Day, 1877: 549.

Cirrhinus inornatus new species
Fig. 5

Holotype.—CAS 91772, 115 mm, Myanmar, Mandalay market, 13–25 April 1993, T.R. Roberts.

Paratypes.—CAS 91776, 8: 76.8–129 mm, same data as holotype; CAS 88903, 106 mm, Pagan market, 13 April 1996, C.J. Ferraris and D. Catania; CAS 91774, 9: 63.3–86.8 mm, Pagan market (Irrawaddy R.), 8 Nov. 1996, C.J. Ferraris; CAS 91775, 122 mm, Myitkyina market (Irrawaddy basin), 20–21 April 1996, C.J. Ferraris; CAS 91773, 6: 94.6–116 mm, Taungoo market (Sittang R.), 7 April 1996, C.J. Ferraris and D. Catania.

Diagnosis. Total gill rakers on first gill arch 35; vomero-palatine organ with only 5 pairs of fimbriate lamella; lamellae comparatively broad, each with up to 20 short fimbriae; branched dorsal fin rays usually 9. Lateral scales 35; transverse scale series 7/1/5; circumpeduncular scales 20; vertebrae 22-24+12-13=35 (4), 36 (1), or 37 (2). Body dull white or silvery overall; fins dusky, colorless; humeral mark present, otherwise no distinctive markings.

Comments. In the Irrawaddy *Cirrhinus inornatus* co-occurs with a species of *Bangana,* possibly *B. devdevi* Hora, which it superficially resembles. The *Bangana* differs in having a more prominent snout, a vertically elongate peduncular mark, and 11 instead of only 9–10 branched dorsal fin rays.

Distribution. *Cirrhinus inornatus* is known only from the Irrawaddy and Sittang basins in Myanmar.

Cirrhinus jullieni Sauvage, 1878
Fig. 6

Cirrhina jullieni Sauvage, 1878: 237 (type locality Stung-Strang [=Stung Treng, Mekong basin, Cambodia]).

nec *Cirrhina jullieni,* Sauvage, 1881: 174, pl. 6, fig. 2 (=*Cirrhinus siamensis;* based on syntype of *Morara siamensis*).

Rohita sima Sauvage 1881: 177 (nec *Rohita sima* Sauvage 1878).

nec *Osteochilus spilopleura* Fowler, 1935 *(=C. molitorella).*

Cirrhina chinensis, Fang, 1942: 168.

nec *Cirrhinus jullieni,* Smith, 1945: 162 *(=C. siamensis).*
Cirrhinus jullieni Rainboth, 1996: 107.

Type material examined.—MNHN 8586, 109 mm, Fl. Mé-Kong, Cochinchine, 1874, Jullien (lectotype *C. jullieni,* designated by Banarescu, 1972); MNHN B. 2960, 5: 88.0–95.5 mm, Cochinchine, Jullien (paralectotypes *C. jullieni*); MNHN 3999, 90.2 mm, Cochinchine, Jullien (paralectotype *C. jullieni*).

Non-type material examined.—MEKONG BASIN: MNHN 1983.19, 145 mm, Tonle Sap, 7 Jan. 1963, F. d'Aubenton; MNHN 1983.129, 89.5 mm, Tonle Sap Km 9, 29 Jan. 1961, F. d'Aubenton; MNHN 1983.198, 84.5 mm, Tonle Sap km 9, 2 Nov. 1961, F. d'Aubenton; CAS 68202, 4: 83.6–110 mm; CAS 91610, 13: 94.7–104 mm, Phnom Penh market, 18 Jan.–20 Feb. 1994, K.E. Witte. CHAO PHRAYA BASIN: CAS 79168, 12: 80.2–101 mm, and MNHN 1990–621, 4: 78.0–109 mm, Sukhothai market (Menam Yom) 23 February 1989, T.R. Roberts; CAS 91748, 104 mm, Sawankhalok market (Menam Yom), 36 km N of Sukhothai, 2 Feb. 1989, T.R. Roberts.

Diagnosis. A medium-sized species, attaining at least 20 cm; predorsal profile relatively steep; rostral barbels well developed, length more than one-half eye diameter; maxillary barbels absent; branched dorsal fin rays 14–16; scales in lateral series 36; transverse scale rows 8/1/6; vertebrae 22-24+11=34-35.

Body overall silvery or bluish silvery, with or without faint humeral mark; no peduncular spot; pectoral, pelvic, and anal fins and lower one third or two-thirds of lower caudal fin lobe often blood red. In other *Cirrhinus* with red caudal fins, usually the entire fin is red.

Cirrhinus jullieni is somewhat similar to the much larger species *C. molitorella,* from which it differs markedly in coloration. Also, it is deeper bodied, especially anteriorly, and has a larger, more falcate anal fin, the distal end of which extends posteriorly to below posteriormost scales on caudal fin.

Discussion. This species was known for a long time only from the type specimens from the Lower Mekong basin. As pointed out by Fang, 1942: 168, the redescription and figure of *C. jullieni* by Sauvage, 1881 is not based on the type specimens of that species, but rather on specimens of a different species. The species subsequently was identified as *Henicorhynchus [=Cirrhinus] siamensis* by Banarescu, 1983: 16. Banarescu's identification is correct; the description and figure published by Sauvage, 1881 is actually that of a syntype of *C. siamensis* (originally described as *Morara siamensis,* a species not otherwise figured by Sauvage).

Specimens recently collected from the Chao Phraya basin were compared by me directly with types and other material of *C. jullieni* from the Lower Mekong in Cambodia and they are very similar.

Distribution. *Cirrhinus jullieni* occurs in the Chao Phraya basin in central Thailand and the lower Mekong basin in Cambodia and in southernmost Laos below Khone Falls. It seems to be absent in the Mekong above the waterfalls. Previous records from Thailand (e.g. SMITH, 1945; SODSUK, 1988) apparently are all based on *C. siamensis.*

Cirrhinus lineatus Smith, 1945
Fig. 7

Cirrhinus lineatus Smith, 1945: 163, fig. 25 (type locality Lam Ton Lang, a tributary of the Menam Sak, central Thailand [Chao Phraya basin]).

Henicorhynchus cryptopogon, Rainboth, 1996: 111 (Chao Phraya and middle Mekong; misidentification).

Type material examined.—USNM 107960, 118 mm, Lam Tong Lang, 19 July 1925, H.M. Smith (holotype *C. lineatus*); USNM 119484, 109 mm, Me Fang, tributary of Me Kok, Mekong basin, 12 July 1936, H.G. Deignan (paratype *C. lineatus*).

Non-type material examined.— CAS 79169, 5: 64.9–95.2 mm, mouth of Huay Ngao where it flows into Mekong R. 1 km S of Ban Chaem Pong (about 30 km S of Chiang Khong), 12 May 1990, T.R. Roberts; CAS 91764, 7: 50.1–63.1 mm, Menam Kok at Tha Ton and up to 5 km downstream, 15 May 1990, T.R. Roberts; CAS 91766, 9: 54.5–106 mm, Mekong mainstream from Pak Ing to Jom Paeng (about 4–5 km downstream from Pak Ing), 16–18 Jan. 1989, T.R. Roberts; BMNH 1980.12.17.121–122, 2: 48.2–55.7, Payao Lake, N Thailand, Oct. 1978, J. Karnasuta; CAS 91763, 4: 41.4–50.5 mm, Se Khone near Stung Treng, 6 Feb. 1994, T.R. Roberts; CAS 91765, 101 mm, O Changni, small stream on road from Ann Long Mea to Ban Lung, Ratanakiri prov., Cambodia, Feb. 1994, T.R. Roberts

Diagnosis. A small species of *Cirrhinus;* longitudinal stripes on body; no rostral barbels; small maxillary barbels; branched dorsal-fin rays 8; scales in lateral series 34–35; transverse scales rows 6/1/5; vertebrae 20–22+10–13=32 (5), 33 (6). The stripes vary individually from faint to very bold. When bold, they may assume a zig-zag course, as in the South Asian species *C. ariza,* which has very similar stripes.

Comment. The holotype of *Henicorhynchus cryptopogon* Fowler, 1935, is a *Lobocheilos.*

Distribution. *Cirrhinus lineatus* is known from the Chao Phraya and Mekong basins (from southern Yunnan to the Mekong delta).

Cirrhinus lobatus (Smith, 1945)
Fig. 8

Henicorhynchus lobatus Smith, 1945: 257, fig. 49 (type locality Me Kok near Chiengrai [Mekong basin]).

Cirrhinus lobatus Roberts and Baird, 1996: 247 (migrations at Khone Falls; sexuality).

Type material examined.—USNM 119490, 98.0 mm, Me Kok at Chieng Rai, 2 March 1934, H.M. Smith (holotype *H. lobatus*); USNM 108091, 107 mm, same data as USNM 119498 (paratype *H. lobatus*); USNM 119492, 3: 69.2–101 mm, Bung Borapet, 20 Nov. 1923, H.M. Smith (paratypes *H. lobatus*); USNM 119493, 2: 60.5–61.0 mm, Menam Chao Phraya at Bangsai, Central Thailand, 27 Nov. 1923, H.M. Smith (paratypes *H. lobatus*);

USNM 119494, 73.5 mm, Pasak R. at Dha Luang, Central Thailand, 20 Aug. 1923, H.M. Smith (paratypes *H. lobatus*); USNM 119491, 68.0 mm, Menam Chao Phraya, Paknampo, Central Siam, 19 Nov. 1923, H.M. Smith (paratypes *H. lobatus*).

Non-type material examined.—CAS 91769, 8: 56.9–102 mm, Menam Kok at Tha Ton and up to 5 km downstream, 15 May 1990, T.R. Roberts; CAS 91768, Menam Chi at Maha Chana Chai, 13 March 1991, T.R. Roberts; CAS 91770, 25: 41.7–85.6 mm, and CAS 91771, 24: 43.3–88.1 mm, Yasothon market [=Menam Chi], 13 March 1991, T.R. Roberts; CAS 91767, 4: 43.4–50.5 mm, Se Khone at Stung Treng, 6 Feb. 1994, T.R. Roberts.

Diagnosis. A small species, largest recorded specimen just over 100 mm in standard length; snout often but not always strongly projecting; head relatively small, especially compared to the closely related and somewhat larger species *C. siamensis;* branched dorsal fin rays 8; scales in lateral series 32–33; vertebrae usually 32; differs from all other species of *Cirrhinus* so far as known in being a protogynous hermaphrodite (see below).

Comments. In June–July 1993 I observed reproductive migrations of *Cirrhinus* and other small cyprinid species in the Mekong mainstream just below Lee Pee Waterfalls in southern Laos. It was immediately apparent that there were two extremely abundant small species of *Cirrhinus.* One of them was identified as *C. siamensis* and the other only as *C.* sp. by ROBERTS, 1993. *Cirrhinus* sp. was subsequently identified as *Cirrhinus lobatus* in ROBERTS & BAIRD, 1995.

The type material of *H. lobatus* comprises three species. Only the topotypic paratype from the Me Kok (USNM 108091) is conspecific with the holotype. The rest of the paratypes, all from the Chao Phraya basin, all examined and reidentified by me, are *C. caudimaculatus* and *C. siamensis.*

Biological observations. Sexually active Cyprinidae are among the easiest of fishes to sex accurately. Gravid females, with greatly distended abdomens, readily discharge eggs with slight finger pressure. The males discharge milky white milt equally readily. In live or very fresh fish it is often possible to sex accurately all sexually active individuals, even in very small species, without resorting to microscopic examination.

Migration of reproductively active *C. lobatus* was observed in June–July 1993 at Ban Hang Khone, a fishing village some 4 km below Lee Pee Waterfalls (the Spirit Trap) on the mainstream Mekong River in southern Laos (near the border with Cambodia). Nearly all individual fish caught at this time were in spawning condition. Two samples were sexed, one of 83 individuals taken on 22 June 1993 and the other of 302 individuals taken on 1 July 1993. These were caught in wide-mouthed basket traps or kah (see ROBERTS, 1993) and were examined within an hour removal of the traps from the water.

Results were reported in ROBERTS & BAIRD (1996). The smallest individuals in both samples, 45–70 mm Sl, were nearly all gravid females. A few fish within this size range could not be sexed; some of these appeared to be malnourished or otherwise in poor condition. In the 22 June sample all ripe males were over 80 mm SL, and in the 1 July sample all were over 70 mm SL. In both samples the few fish over 90 mm SL were all ripe males. In both samples ripe females outnumbered ripe males by more than 3 to 1. The data suggest that *C. lobatus* is a protogynous ("female first") hermaphrodite.

Distribution. *Cirrhinus lobatus* is known only from the Mekong basin.

Cirrhinus lu new name
Fig. 9

Cirrhina latia, Annandale, 1918: 46 (Inle Lake).
Crossocheilus horai Banarescu, 1986: 153, fig. 11 (type locality Inle Lake).

Type material examined.—USNM 191451, 121 mm, Inle Lake, Feb. 1958, C.J. Shontz (holotype *C. horai*); USNM 288034, 3: 101–112 mm, same collection data as USNM 191451 (paratypes *C. horai*).

Non-type material examined.—CAS 81548; 24: 95.9–155 mm, Inle Lake, 25 Feb.–7 March 1994, T.R. Roberts.

Diagnosis. *Cirrhinus lu* is one of the most distinctive members of the genus *Cirrhinus,* characterized by an exceptionally terete body form; largest known specimen 155 mm; rostral barbels present, maxillary barbels absent; dorsal fin branched rays 9; scales in lateral series 39–41; transverse scale rows 6/1/4; circumpeduncular scales 16–18; vertebrae 25–27+13–15=38(1), 39(5), 40(7), 41(1).

Discussion. In his original description, Banarescu referred this species to *Crossocheilus. Crossocheilus* and *Cirrhinus* are (at least superficially) very similar morphologically, and may be closely related to each other. Evidently the most important difference between them involves the rostral cap. In *Crossocheilus* (and in several closely related labeoin general including *Epalzeorhynchos, Garra,* and *Paracrossocheilus*) the rostral cap is enlarged and more or less deeply furrowed by a series of papillose fimbriae which project from its oral margin (see ROBERTS, 1982, fig. 8; BANARESCU, 1986, figs. 1–2). In *Cirrhinus* the rostral cap is not notably enlarged; it either has no papillose fimbriae at all, or has weakly developed papillose fimbriae that do not form furrows. The difference is very striking, and is related to feeding behavior. *Crossocheilus* are algal browsers, scraping algae from hard substrate (e.g. rocks, logs) by means of the rostral cap. *Cirrhinus,* on the other hand, feed mainly by means of suction, and do not use the rostral cap to scrape food from the substrate.

The rostral cap of *C. lu* does have a papillose margin, but the cap is much shorter and less overhanging than in *Crossocheilus,* and the papillae are not arranged on well developed fimbriae which project freely from its oral margin. The extent and development of the rostral papillae in this species occurs normally in some other species assigned to *Cirrhinus,* such as *C. fulungee* and *C. ariza.* In addition, individual specimens of still other *Cirrhinus* species, including *C. lobatus,* have comparably developed rostral papillae.

Banarescu suggested that the species might be the same species as specimens identified as *Crossochilus latius* from other parts of Myanmar, but this is very doubtful. In particular, he listed *Crossocheilus latius* of Vinciguerra from Meetan [Tenasserim province], Myanmar as possibly the same species. I have examined Vinciguerra's specimens (MSNG 17349, 2: 108–114 mm) and find that they are very typical *Crossocheilus,* with a large, broad rostrum and well developed rostral fimbriae and papillae.

Nomenclatural note. Transfer of *Crossocheilus horai* Banarescu, 1986 to the genus *Cirrhinus* makes it a junior homonym of *Cirrhinus horai* Lakshmanan, 1966. Because it has no existing replacement name, I have coined the new replacement name *C. lu.*

Etymology. The new scientific name *C. lu* is from the Intha vernacular name nga lu, reported by Annandale, 1918: 38), and still in use for this species at the time of my visit to Inle in 1994.

Distribution. This specialized species apparently occurs only in Inle Lake, a wonderful place justly famous for its beautiful and varied endemic fishes (Annandale, 1918).

Cirrhinus microlepis Sauvage 1878
Fig. 10

Cirrhina microlepis Sauvage, 1878: 236 (type locality Mé-Kong at Tma-Kré).
Cirrhina aurata Sauvage, 1878: 236 (type locality Pnom-Penh).
Labeo (Labeo) aurovittatus Sauvage, 1878:
Labeo pruol Tirant, 1885; Kottelat, 1986: 14 (designation of lectotype; placed as synonym of *C. microlepis*).

Type material examined.—MNHN 3849, 118 mm, Pnom-Penh, 1874, Jullien (syntype *C. aurata*).

Non-type material examined.—MNHN 1987–127, 2: 193–195 mm, Cochinchine, 1921, de Krempf; USNM 104935, 2: 122–146 mm, Chao Phraya at Nontaburi, 16 Dec. 1926, H.M. Smith.

Diagnosis. A large species with very small scales, no barbels, and distinctive coloration. Juveniles silvery with red caudal fin, larger fish with head and body violaceous, rosy, or bluish and caudal fin dusky. Scales in lateral series 56–60, transverse scale rows 13/1/8; dorsal fin rays iv 11-12 $\frac{1}{2}$; vertebrae 27+13=40(3).

Distribution. *Cirrhinus microlepis* occurs in the Chao Phraya and Mekong basins of Thailand, Laos, Cambodia, and Vietnam. A record from Chantabun in southeast Thailand (Smith, 1945: 164) is doubtful.

Cirrhinus molitorella (Valenciennes in Cuv. & Val., 1844)
Fig. 11–12

Leuciscus molitorella Valenciennes in Cuvier & Valenciennes, 1844: 359 (type locality China; based on previously unpublished painting made in Canton for Dussumier deposited in Bibliothèque Centrale, MNHN, Ms 5037, reproduced here as Fig. 11).
Leuciscus chevanilla Valenciennes in Cuvier & Valenciennes, 1844: 358 (type locality not given, but based on a Chinese painting, a copy of which is in the Bibliothèque Centrale, MNHN, Ms 515, document XVII C 44).
Cirrhina chinensis Günther, 1868: 36 (type locality China).
Labeo (Diplocheilichthys) garnieri Sauvage, 1884: 210, pl. 7, fig. 4 (type locality environs de Hanoi); Banarescu, 1972: 254, fig. 3 (designation and figure of lectotype).
Labeo jordani Oshima, 1919: 204, pl. 49 fig. 3 (type locality hatchery at Shori, Formosa; stock introduced from South China).

Cirrhina melanostigma Fowler & Bean, 1922: 4, fig. 1 (type locality Koroton, Formosa).
Labeo collaris Nichols & Pope, 1927: 362, fig. 28 (type locality Nodoa, Hainan).
Labeo pingi Wu, 1931: 20, fig. 3 (type locality presumably Ming River, Foochow).
Osteochilus prosemion Fowler, 1934: 116, figs. 66–7 (type locality Chiengmai [Chao Phraya basin]); Fowler, 1937: 183 (Kemarat, Mekong).
Osteochilus spilopleura Fowler, 1935: 115, figs. 52–3 (type locality Srisawat, Meklong basin).
Osteochilus macrosemion Fowler, 1935: 116 (type locality Srisawat, Meklong basin).
Labeo stigmapleura Fowler, 1937: 202, figs. 167–70 (type locality Kemrat=Mekong R. in Thailand); Böhlke, 1984: 91 (placed as synonym of *Cirrhinus prosemion*).
Cirrhinus mrigala prosemion, Banarescu, 1983: 14.
Cirrhinus macrosemion, Sodsuk, 1988: 31.

Type material examined.—BMNH 1971.12.30.2, 143 mm, China, J.R. Reeves (holotype *C. chinensis;* designated neotype *C. molitorella* below); MNHN 1884–81, 208 mm, Hanoi (Tonkin), Harmand (lectotype *L. garnieri*); USNM 84168, 3: 130–139 mm, Koroton, Formosa, H. Sauter (holotype and paratypes *C. melanostigma*); AMNH 8399, 197 mm, China, Kwangtung, Hainan Tao, Nodoa, 1922–23, C. Pope (holotype *L. collaris*); ANSP 59095, 91.8 mm, Chieng Mai, 15–23 Dec. 1932, R.M. deSchauensee (holotype *O. prosemion*); ANSP 59096–97, 2: 85.3–89.9 mm, same data as ANSP 59095, paratypes *O. prosemion;* ANSP 60808, 159 mm, Srisawat, July 1934, R.M. deSchauensee (holotype *O. spilopleura*); ANSP 60809, 138 mm, Srisawat, July 1934, R.M. deSchauensee (holotype *O. macrosemion*); ANSP 68169, 76.0 mm, Kemrat, 1936, R.M. deSchauensee (holotype *L. stigmapleura*); ANSP 68170–78, 9: 36.0–73.8 mm, same data as ANSP 68169 (paratypes *L. stigmapleura*).

Non-type material examined.—CHINA: AMNH 37020, 2: 90.5–130 mm, Foochow, Fukien Prov., March-Sept. 1926, C. Pope; MNHN B. 2643, 5: 126–140 mm, Kouang-Si; MEKONG BASIN: CAS 79171, 145 mm, Mekong R. near Ban Ha Bia, 30–40 km NW of Chiang Khan on highway 2186, 12 March 1990, T.R. Roberts; CAS 79172, 2: 136–147 mm, Nakorn Phanom market, 4–7 March 1991, T.R. Roberts; CAS 79173, 2: 107–113 mm, rapids in mainstream of Mekong R. about 12 km S of That Phanom, 6 April 1991, T.R. Roberts; CAS 79170, 2: 64.4–76.6 mm, mouth of Huay Ngao where it flows into Mekong R. about 30 km SE of Chiang Khang, 12 May 1990, T.R. Roberts; MEKLONG BASIN: CAS 79174, 10: 76.5–144 mm, Huay Kha Khaeng at Greung Grai, Huay Kha Khaeng Wildlife Sanctuary, Meklong basin, 21 Jan. 1991, T.R. Roberts; CAS 79175, 2: 82.8–93.7 mm, Huay Sangkalia 7 km N of Sangklaburi on road to Chedi Sam Ong, 11 Feb. 1989, T.R. Roberts; TAPI BASIN: CAS 81656, 2: 188–194 mm, Fish landing at S end of Chiao Lan Reservoir, 28 Feb. 1989, T.R. Roberts.

Diagnosis. A moderately large and distinctively colored species of *Cirrhinus,* attaining at least 40 cm standard length; rostral barbels relatively well developed, length half or more of eye diameter; branched dorsal fin rays 11–15; lateral line scales 38–40; transverse scale rows 8/1/5; vertebrae 23–25+11–13=34-38.

Cirrhinus molitorella differs from all other species of the genus in having more or less discrete marks on each scale on the upper, middle, and sometimes lower parts of the body.

The marks are formed by melanophores concentrated near the middle of the anterior scale shield where the scale is partially overlapped by the free distal margin of the scale in front of it. Such marks, visible in most freshly caught and recently preserved specimens, are sometimes intensely developed, giving the fish a markedly reticulated appearance. *Cirrhinus molitorella* often has a very intense humeral mark which is vivid bluish-green in life. In other *Cirrhinus* the humeral marks are black or bluish-black.

Comments. Part of the synonymy of *C. molitorella* given above was worked out by Banarescu, 1972: 253–54. Use of the junior synonym *C. chinensis* by Banarescu and some other authors for this species presumably is based on the notion that the senior synonym *C. molitorella* is a nomen nudum (see Banarescu, 1972: 251–52). Valenciennes's original account, although based on an unpublished figure, definitely includes a description so that the name *C. molitorella* is available.

The original illustration of *C. molitorella* (Fig. 11) is one of 24 fish paintings made for J.J. Dussumier in Canton in 1820. It is clearly of a *Cirrhinus,* and is an excellent likeness of the species called *C. chinensis* or *C. molitorella* by various authors. In order to remove any possible doubt as to the identity of the species represented by the well-known and available name *C. molitorella,* the holotype of *C. chinensis* (BMNH 1971.12.30.2, 143 mm) is hereby designated neotype of *C. molitorella.*

Wild and cultivated stocks of *C. molitorella* differ considerably in appearance and behavior. Wild stocks are strongly migratory, while the cultivated stocks probably have lost the migratory behavior. Cultivated stocks (and possibly also wild fish) from China typically have discrete marks on scales very bold, as opposed to fish from wild stocks in Southeast Asia. On one occasion in Bangkok I observed feeding behavior of a number of wild fish from Thailand and cultivated fish from China in a large cement holding tank with very clear water about 1.5 m deep. The cultivated fish were readily distinguished by their darker coloration. When fed with pellets, the wild fish dashed about, catching individual pellets in midwater, but were not interested in the pellets after they reached the bottom. The cultivated fish did not chase the pellets in midwater, and only fed on them after they settled on the bottom of the tank.

Distribution. *Cirrhinus molitorella* is widely distributed in southern China (where it is extensively cultured and has been widely transported). It occurs naturally in much of Thailand and Indochina, including the Meklong and middle and lower Mekong basins. It apparently has not been collected in the Chao Phraya basin. Introduced to Hainan, Hong Kong, Taiwan, Singapore, Indonesia. Aquacultural stock reportedly has been introduced recently from China into the Mekong basin in Laos.

Specimens reported here from the Tapi basin (peninsular Thailand) possibly represent the furthest southward range of any naturally occurring *Cirrhinus.* The Tapi is also the southernmost known locality for the large bagrid catfish *Mystus microphthalmus* (senior synonym of *M. wyckoides*). Both species might owe their presence in the Tapi to introduction, but no records of this have come to my attention and local Thai fisheries officers interviewed by me believe that both species occur naturally in the Tapi.

Cirrhinus ornatipinnis new species
Fig. 13

Holotype.—CAS 91756, 69.7 mm, roadside ditch on highway 24 at km 150 marker, 179 km by road E of Nakorn Ratchasima, 27 May 1991, T.R. Roberts.

Paratypes.—CAS 91762, 6: 51.5–67.3 mm, collected with holotype; CAS 91757, 27: 37.3° 60.1 mm, irrigation canal about 20 km S of Phibun Mangsahan, 16 Sept. 1990, T.R. Roberts; CAS 91760, 9: 55.7–90.5 mm, roadsidecnals 5–30 km S of Phibun Mangsahan, 16 Sept. 1990, T.R. Roberts; CAS 91759, 15: 58.6–73.2 mm, Nakhon Phanom market, 26–31 May 1990, T.R. Roberts; CAS 91758, 4: 83.7–93.9 mm, Nakhon Phanom market, 4–7 March 1991, T.R. Roberts; ANSP 172554, 2: 57.1–61.7 mm, and USNM 331212, 2: 63.8–76.5 mm, Phibun Mangsahan market, 15 Sept. 1990, T.R. Roberts.

Non-type material examined.—CAS 91761, 26: 49.0–67.3 mm, Phibun Mangsahan market, 15 Sept. 1990, T.R. Roberts.

Diagnosis. Perhaps the smallest species of *Cirrhinus* (largest known specimen 90.5 mm standard length); readily distinguished by its small head, short blunt snout, very deep caudal peduncle, and usually having the pectoral, pelvic, anal, but not the caudal fin red, reddish-orange, or at least rose-tinted; the pelvic and anal fins often tipped with white; barbels absent; dorsal fin branched rays 8; scales in lateral series 34–35; transverse scale rows 6/1/4; vertebrae 21–22+11–13=33(14), 34(10), or 35(2). In all other species of *Cirrhinus* the pectoral fins are colorless, dusky, or at most pale pink or rose-tinted.

Etymology. The specific name "ornatipinnis" (Latin) refers to the colorful fins.

Distribution. *Cirrhinus ornatipinnis* is known only from the Middle Mekong basin of northeastern Thailand (Isan). Unlike other *Cirrhinus* familiar to me, it seems to be restricted to marginal or temporary habitats, including roadside canals, where I observed it on numerous occasions. I have never seen it in flowing water habitats of the Mekong and its tributaries where *C. siamensis, C. lineatus,* and *C. lobatus* usually occur. So far as known it does not occur sympatrically with other species of the genus.

Cirrhinus rubirostris new species
Fig. 14

Holotype.—MNHN 1992.1043, 140 mm, Tenasserim River, 12 March 1992, T.R. Roberts.

Paratypes.—MNHN 1992.1044. 2: 116–118 mm, collected with holotype; ZRCS 22933, 138 mm, Tuler Kloh, Tenasserim basin, March 1992, T.R. Roberts; CAS 91753, 110 mm, backwater at huge rocky ledge in Tenasserim River midway between Htee-tah and Baowashung, 12 March 1992, T.R. Roberts; CAS 91754, 106 mm, Tenasserim River upstream from Htee-tah, 8–9 March 1992, T.R. Roberts; CAS 91755, 172 mm, Tenasserim River between Htee-tah and Baowashung, March 1992, T.R. Roberts.

Diagnosis. *Cirrhinus rubirostris* differs from all other *Cirrhinus* in having both sexes with well developed rostral tubercles, and rostral tubercles and snout pinkish or rosy red.

Rostral barbels absent, maxillary barbels present. Dorsal fin with 10 branched rays. Scales in lateral series 37, predorsal scales 12–13, transverse scale rows 7/1/6, circumpeduncular scales 21. Vertebrae 22+13=35 (3).

Palate anteriorly with numerous delicate folds, followed by palatal lamellar organ with 6 pairs of tuberculate lamellae (Fig. 1). Roof of branchial chamber with about 100 anteroventrally directed tuberculate digitiform papillae. Gill rakers on first gill arch 43.

Head and body iridescent greenish and bluish dorsally, yellowish laterally, and silvery white ventrally. Humeral mark bluish black. All fins reddish or pale rose except anal fin; anal fin very pale rose or whitish. Dorsal half of iris red, rest white.

Etymology. The species name rubirostris, a Latin adjective, refers to the red color of the rostral tubercles and of the snout generally; it also refers to the Karen name for this species, niya gwoh nadee, "red-nosed fish".

Distribution. *Cirrhinus rubirostris* is known only from the Tenasserim River basin of southeastern Burma.

Cirrhinus siamensis (Sauvage 1878)
Fig. 15

Morara siamensis Bleeker, 1865a: 35 (nomen nudum); Bleeker, 1865b: 175 (nomen nudum); Sauvage, 1881: 164, 187, pl. 6, fig. 2 (type locality Bangkok; figure erroneously labelled *Cirrhina jullieni*).

Aspidoparia siamensis, Smith, 1945: 124 (doubt expressed as to identity of genus and of species).

?*Tylognathus siamensis* (nec *Morara siamensis* Bleeker) de Beaufort, 1927: 9 (type locality Payao swamp [=Mekong basin] and Chao Phraya at Lopburi).

Tylognathus brunneus Fowler, 1934: 131, figs. 87–88 (type locality North Siam).

?*Tylognathus entmema* Fowler, 1934: 134, figs. 101–102 (type locality Bangkok).

Cirrhinus marginipinnis Fowler, 1937: 173, figs. 108–109 (type locality Phitsanulok=Chao Phraya basin).

Cirrhinus sauvagei Fang, 1942: 168 (type locality Mé-Kong).

Crossocheilus reba, Smith, 1945: 270–71 (Chao Phraya).

?*Crossocheilus thai* Fowler, 1944: 49 (type locality Bangkok; aquarium specimen).

Type material examined.—MNHN 1839, 4: 77.5–92.3 mm, Bangkok, 1862, Bocourt (syntypes *M. siamensis*); MNHN 8598, 93.0 mm, and MNHN B. 2961, 7: 76.6–96.8 mm, Cochinchine, Jullien (syntypes *C. sauvagei*); ANSP 58369, 72.3 mm, North Siam (holotype *T. brunneus*); ANSP 59092, 47.7 mm, Silom canal, Bangkok (holotype *T. entmema*); ANSP 68069, 115 mm, Phitsanulok, Thailand (holotype *C. marginipinnis*); ANSP 71336, 78.7 mm, Bangkok, A. Viehoever (holotype *C. thai*).

Non-type material examined.—MEKONG BASIN: MNHN 9546, 8: 79.8–98.5 mm, Cochinchine, 1874, Jullien; CAS 91751, 109 mm, Pak Mun, May 1991, T.R. Roberts; CAS 91750, 3: 79.8–83.7 mm, Yasothon market [Menam Chi], 13 March 1991, T.R. Roberts; CHAO PHRAYA BASIN: MNHN A. 5080, 4: 84.0–94.8 mm, Bangkok 1882, Harmand;

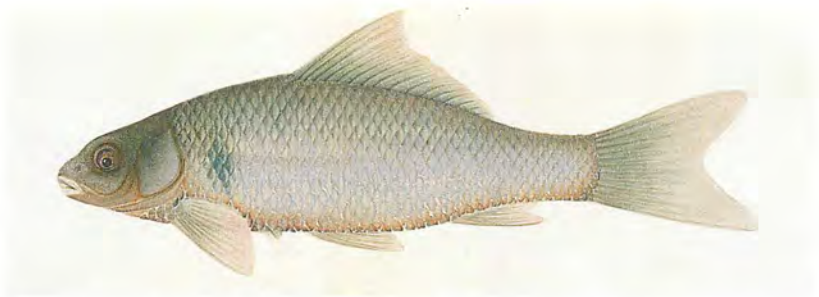

Figure 11. *Cirrhinus molitorella.* Painting on silk commissioned by Dussumier in Canton. Archives MNHN,Document 5037 (photo copyright Bibl. Centrale, MNHN, 1994).

Figure 12. *Cirrhinus molitorella,* Huay Kha Khaeng at Grueng Grai.

Figure 13. *Cirrhinus ornatipinnis,* 69.7 mm holotype, Thailand (Mekong basin).

Figure 14. *Cirrhinus rubirostris,* holotype, 140 mm, Tenasserim River.

Figure 15. *Cirrhinus siamensis,* 135 mm, Nakorn Sawan (Chao Phraya).

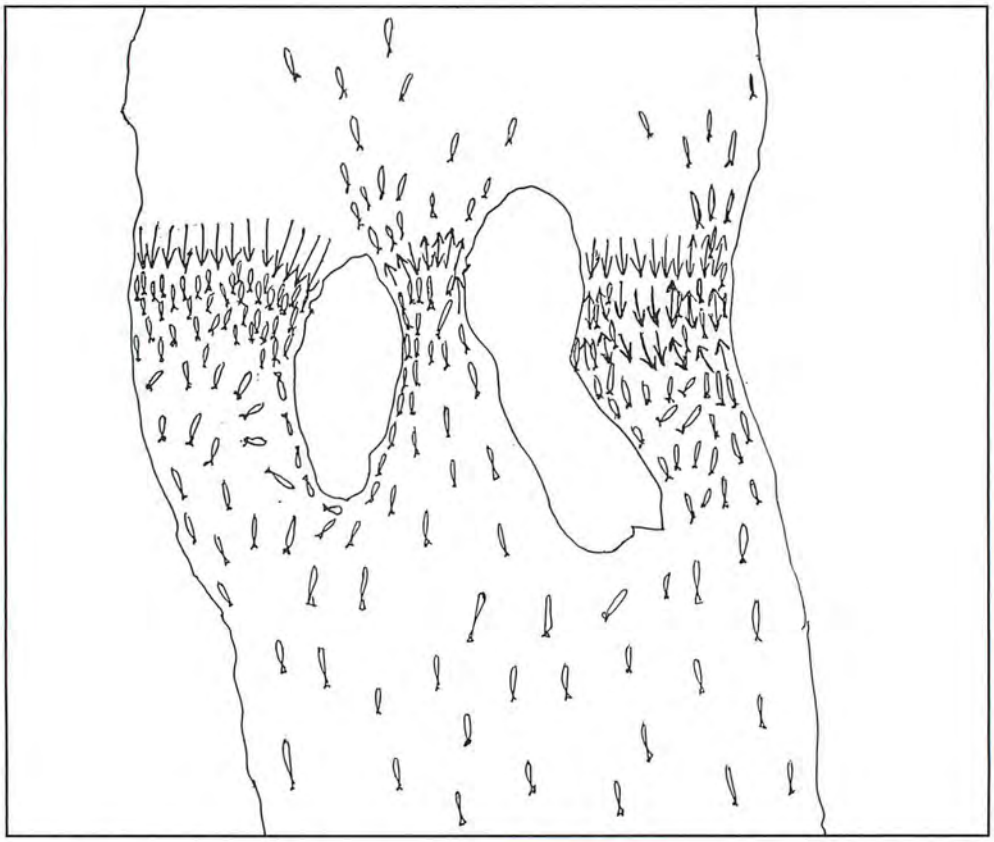

Figure 16. "Ever-changing leadership strategy" to find path of least resistance by schooling fish migrating upstream past waterfalls and rapids. Simplified diagram based on observed or suspected behavior of *Cirrhinus lobatus* at Khone Falls on the mekong mainstream in southern Laos. Arrows represent Khone faultline. Arrows pointing downstream represent high and otherwise impassable barriers to upstream fish movements. Arrows pointing downstream or in both directions indicate places fish can pass upstream, sometimes aided by countercurrents.

KUMF 656, 6: 61–67 mm, Sikuk River at Ban Dang, 26 Nov. 1923, H.M. Smith (orig. id. *Crossocheilus reba* by Smith); CAS 79177, 3: 107–118 mm, Uttaradit market (Nan R., Chao Phraya basin), 9 January 1989, T.R. Roberts; CAS 91752, 120 mm, Nakorn Sawan market, 5–6 Feb. 1989, T.R. Roberts; CAS 79178, 15: 78.2–116 mm, Nakorn Sawan market, 4 March 1990, T.R. Roberts; BANGPAKONG BASIN: CAS 79179, 74.5 mm, Menam Bangpakong near Prachinburi, 6 Dec. 1990, T.R. Roberts; CAS 91749, 4: 57.4–65.2 mm, Menam Bangpakong at Ban Khao Cha-chan, 19 km S of Sa Kaeo on highway 317, 23 March 1989, T.R. Roberts.

Diagnosis. *Cirrhinus siamensis* is a medium sized species (to 20 cm), usually with a much larger and broader head than smaller species such as *C. caudimaculatus, C. lineatus, C. lobatus* and *C. soi.* Freshly collected specimens of these species can be identified readily, but difficulties arise with older preserved specimens. Further study is needed to discover better diagnostic characters. Most radiographed specimens of *C. siamensis* have 33–34 vertebrae, while those of *C. lobatus* have only 32.

Discussion. Confusion in the identification of this very common species with *C. jullieni* (a relatively rare species) was caused by publication of the original figure of *Morara siamensis* mislabelled as *C. jullieni* (Sauvage 1881, pl. 6, fig. 2), while at the same time no figure was published of the true *C. jullieni,* a relatively rare species. For many years the type specimens of *"Morara" siamensis* were misplaced, which further compounded the problem.

The type specimens of *T. brunneus* and of *C. marginipinnis* are all typical large-headed *C. siamensis.* The *C. entmema* holotype has a relatively small head, not unlike *C. lobatus,* but without a projecting or pointed snout as in many *C. lobatus.* Specimens of *C. siamensis* and *C. lobatus* of this size are often difficult to distinguish.

Small *Cirrhinus,* known as pla soi in Thai, were the dominant fishes in the massive fish migrations that formerly occurred in central Thailand. An evocative description of the migrations is given by Smith, 1945: 270–71. Samples identified by Smith as *C. reba* have been examined by me and reidentified as *C. siamensis. Cirrhinus caudimaculatus* may also have been an important (perhaps the most important) component of these migrations.

Distribution. Chao Phraya and Mekong basins of Thailand, Laos, Cambodia, and Vietnam.

BIOLOGICAL OBSERVATIONS ON *CIRRHINUS LOBATUS*

Cirrhinus lobatus is endemic to the Mekong basin, where it may be the single most abundant fish species. It is certainly an ecological keystone species. Specimens have been collected in numerous tributaries as small as 2–3 m wide in widely separated localities in Thailand, Laos, and Cambodia. In terms of absolute numbers, it undoubtedly is the most abundant fish species in the major migrations that occur in the mainstream of the Mekong River below Khone Falls every December–February and May–July, where there is an important artisanal fisheries. It probably is the single most important forage or prey species for the many piscivorous fish species present there, and may also be heavily preyed

upon by the local population of the Irrawaddy dolphin, *Orcaella brevirostris*. The closely related species *C. caudimaculatus*, endemic to the Chao Phraya, might formerly have been the single most abundant fish species in that basin, but this hypothesis lacks adequate documentation.

Cirrhinus lobatus is one of the lead species in the massive migrations of cyprinid fishes moving up the Mekong mainstream in the Khone Falls area. Most of the falls represent an unpassable physical obstacle to the migrators, but they can be avoided by going up one or two of the large "hoo" or channels (most importantly Hoo Sahong) and smaller pathways, thus by-passing the impassable falls and more difficult rapids. The area involved has only recently been mapped, and the complexity of the migratory pathways documented (ROBERTS & BAIRD, 1996). Initially I hypothesized that the migrating fishes would "automatically" find or remember the pathways that would take them past the falls and rapids, but observations of large numbers of fishes repeatedly going up dead ends and being stopped by the most impassable falls caused this hypothesis to be rejected. Subsequent observations suggested that the migrating fish find their way upstream largely by trial and error. The fish evidently are employing a strategy, "the ever-changing leadership strategy for finding the pathway of least resistance", which can only be successful when very large numbers of individuals are migrating. As the migrating fish move upstream, and leading fish are blocked or fail to find a way onwards, some fish turn back and find other routes. Thus the leadership of the migrators is constantly changing, until some leaders are again successful in getting past obstacles and take large numbers of followers with them (Figure 16). This strategy bears a strong resemblance to, and may be derived from, the ever-changing leadership strategy of schooling fish involved in predator avoidance.

The conjunction of extreme abundance, key ecological role, and migratory behavior found in *C. lobatus* is associated with precocious sequential hermaphroditism. Data previously published indicate that all individuals become sexually ripe females at a small size (and presumed correspondingly young age), with only a relatively few changing into sexually ripe males at much larger sizes (ROBERTS & BAIRD, 1996: 247–248, figs. 22–23). Such a sexual strategy has not been identified in any other species of *Cirrhinus*, or indeed in any other Mekong species of Cyprinidae. It may also characterize the closely related species *C. caudimaculatus* in the Chao Phraya, but no data is available for that species. A possible explanation for the adaptation of sequential hermaphroditism in *C. lobatus* is the "size allocation model" (GHISELIN, 1969). In one version of this model, originally based on fish species, the advantage to large males is that they dominate the aggressive competition for females. In *C. lobatus*, the advantage in having small females and large males may involve male (and female) migratory strategy for mating more than male aggressive competition for mates. That is, males may still be competing for females, but do so primarily by being more "capable migrators". In the context of the "ever-changing leadership" hypothesis offered here, being better migrators may mean, in least in part, being better both as leaders and as followers. Also, males may migrate over longer distances than females, and participate in more spawning bouts.

Preliminary observations suggest that it is usually or always the smaller *C. lobatus* that are the migratory leaders. The females thus expend considerably more energy than the males finding pathways past physiographical barriers such as the rapids and waterfalls. It may also be that females migrate relatively shorter distances before spawning, that they

then spawn totally, and drop out of the migration, while the larger males may spawn with one group of females, then continue on upstream to spawn with other groups of females. While the spawning migrations of *C. lobatus* take place over hundreds or perhaps thousands of kilometers, it may be that the distances migrated by individuals are much shorter, with the smallest (and most numerous) females migrating the shortest distances, and with "new" migrators (male as well as female) regularly recruited along the route as the migration moves upstream. Such a migratory scenario fits well with the observation of precocious sequential hermaphroditism and the hypothesized size advantage model for *C. lobatus*. Another implication is that the so-called long-distance migration of some riverine fish species differ fundamentally from the true long distance migrations of some birds and marine fishes.

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