

Systematic Revision of the Catfish Genus *Silurus*, with Description of a New Species from Thailand and Burma

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Abstract On the basis of external morphology and anatomy, 17 species of the genus *Silurus* Linnaeus including a new species, *S. torrentis* from Thailand and Burma, are recognized as valid. *S. bedfordi* Regan is synonymized with *S. asotus*, and *S. goae* Haig is transferred to the genus *Ompok*. From an anatomical study of 12 species, the diagnostic feature of the genus *Parasilurus* Bleeker is revealed to be invalid, and the genus is synonymized with *Silurus*. From the phylogenetic analysis, the genus *Silurus* is divided into two major species groups, the *cochinchinensis* group which is distributed mainly in Southeast Asia, and the *glanis* group which is further separated into three subgroups occurring separately in East Asia and Europe. The pattern of distribution and relationships between ontogeny and phylogeny in the genus *Silurus* are briefly discussed.

The catfishes of the genera *Silurus* Linnaeus and *Parasilurus* Bleeker are distributed throughout Eurasia except for its central regions (Nikolsky, 1961). Many authors have recognized these two genera solely on the basis of a difference in a single character: *Silurus* having two pairs of mandibular barbels while *Parasilurus* having only a pair (Bleeker, 1862; Nichols, 1943; Berg, 1949; Nikolsky, 1961; Tomoda, 1961). Haig (1950) and Chen (1977), however, claimed that the number of mandibular barbels was not a valid criterion for differentiating these two genera, since intraspecific variation in this character was found within some species.

Although the genus *Silurus*, including *Parasilurus*, has been reviewed by Haig (1950), her study was made only as part of a revision of the family Siluridae as a whole, and, except for one regional work (Chen, 1977), no detailed revisional work on this genus has ever been conducted during the past thirty years. Consequently, the actual number of species assigned to this genus is currently unclear and the systematic relationships among species of the genus *Silurus* are still quite poorly understood. This is partly due to the difficulty in obtaining several rare species, and partly because no attempt has ever been made to apply advanced taxonomic techniques such as Hennigian phylogenetic analysis (Hennig, 1966; Wiley, 1981) to this group.

In this study I review the species of *Silurus* and *Parasilurus* on the basis of external and anatomical

characteristics, examine the taxonomic validity of the latter genus, and then discuss phylogenetic relationships among the species and the zoogeography of the genus *Silurus*.

Materials and methods

Specimens of the following 19 nominal species were examined: *Silurus afghana*, *S. aristotelis*, *S. asotus*, *S. bedfordi*, *S. biwaensis*, *S. cochinchinensis*, *S. gilberti*, *S. glanis*, *S. goae*, *S. grahami*, *S. lanzhouensis*, *S. lithophilus*, *S. mento*, *S. meridionalis*, *S. microdorsalis*, *S. soldatovi*, *S. torrentis* sp. nov., *S. triostegus*, and *S. wynaadensis*. Dissections were made of all these species except *S. afghana*, *S. bedfordi*, *S. lanzhouensis*, *S. soldatovi*, *S. triostegus*, and *S. wynaadensis*. *S. lanzhouensis* and *S. soldatovi* were skinned in the head region to examine the shape of the skull.

For meristic data, including counts of vertebrae, caudal, anal and dorsal fin rays, maximum use of radiograph material was made. The last two rays of the pectoral fin were considered as one. In the anal fin, all the rays that possessed a pterygiophore were counted. In the pelvic and dorsal fins, all the rays were counted, while in the caudal fin only branched rays were counted. The vomerine tooth band was observed either by casting in paraffin sheet, or through radiographs. The measurements were taken after Masuda et al. (1984). Standard length (SL) was measured to the nearest 1 mm with a divider and scale. Measurements less than

100 mm were made to the nearest 0.1 mm. All the measurements less than 10 mm were made under a binocular microscope with an ocular micrometer.

The locality names in China follow Ditu Chubanshe (1977). In cases where the exact localities of sites could not be determined on the map, the original records attached to the specimens were described. The materials examined are deposited in the following institutions: British Museum of Natural History (BMNH); California Academy of Sciences (CAS, and SU); Laboratory of Fisheries Biology, Kyushu University (FBKU); Institute of Hydrobiology, Academia Sinica (IHAS); Kunming Institute of Zoology (KIZ); Muséum National d'Histoire Naturelle (MNHN); Swedish Museum of Natural History (NHRM); National Inland Fisheries Institute, Thailand (NIFI); National Science Museum, Tokyo (NSMT); Department of Zoology, University Museum, University of Tokyo (ZUMT).

Materials examined. *S. afghana*: BMNH 1860.3.19: 755, Afghanistan, 110 mm SL, holotype. *S. aristotelis*: NSMT-P 50248–50249, 2 specimens, Lake Greece Occidental, 195 mm and 227 mm SL. *S. asotus*: FBKU, uncatalogued, 9 specimens, Lake Biwa, Japan, 176–458 mm SL; ZUMT 55085–55087, 3 specimens, China, 134–253 mm SL; ZUMT 55088–55101, 14 specimens, Taedong River, Pyongyang, North Korea, 154–224 mm SL; ZUMT 2511, 1 specimen, Tanshui River, Taiwan, 203 mm SL; ZUMT 12887, 1 specimen, Korea, 194 mm SL; ZUMT 48561, 48562, 2 specimens, 188 mm and 406 mm SL; NHRM JGA/1920. 026. 3011, 2 specimens, Tang Hu Fish Market, Jiangning Xian, Jiangxi, China, 244 mm and 246 mm SL; NHRM JGA/1919. 515. 4011, 3 specimens, Chang Jiang, Nanjing, Jiangxi, China, 144–196 mm SL; NHRM JGA/1921. 143. 3012, 4 specimens, Hsin-Chino, Changting Xian, Fujian, China, 120–191 mm SL. *S. bedfordi*: BMNH 1907. 12. 10: 66, Korea, 250 mm SL, holotype (radiograph). *S. biwaensis*: FBKU, uncatalogued, 14 specimens, Lake Biwa, Japan, 165–778 mm SL. *S. cochinchinensis*: MNHN B. 602, Cochinchina, 93.3 mm SL, holotype; BMNH 1938. 12. 1: 135–136, 2 specimens, near Ting-wu, Guangdong, China, 99.6 mm and 115 mm SL; IHAS 1320096, 7 specimens, Hainan, Guangdong, China, 89.1–192 mm SL; FBKU, uncatalogued, 7 specimens, Shantou, Guangdong, China, 60.3–156 mm SL; *S. giilberti*: IHAS 13200103, 7 specimens, Changjing, Hainan, Guangdong, China, 94.3–123 mm SL. *S. glanis*: FBKU, uncatalogued, Danube River, West Germany, 956 mm SL; NSMT-P 50243, 1 specimen (skull), Danube River, Srino, Rumania, 133 mm HL; NSMT-P 50244, locality unknown, 277 mm SL; SU 20587, radiograph, 2 specimens, Volga River, Russia,

248 mm and 254 mm SL; CAS 23338, radiograph, 2 specimens, Danube River, near Braila, Rumania, 269 mm and 287 mm SL. *S. goae*: SU 41889, Goa, India, 234 mm SL, holotype; CAS 60707, 1 specimen, Karnataka, India, 223 mm SL. *S. grahmi*: IHAS 13200109, 5 specimens, Fuxian Hu, Kunming, Yunnan, China, 246 mm SL; KIZ 7711002, 8312476, 8410701, 3 specimens, 395–426 mm SL. *S. lanzhouensis*: IHAS 13200115, 5 specimens, Gansu, China, 150–174 mm SL; IHAS, 3 type specimens (radiograph), Lanzhou, Gansu, China, 127–271 mm SL. *S. lithophilus*: FBKU, uncatalogued, 9 specimens, Lake Biwa, Japan, 124–411 mm SL. *S. mento*: HIAS 3200106, 3200115, 18 specimens, Dian Chi, Kunming, Yunnan, China, 66.6–312 mm SL; KIZ 00084, 1 specimen, Dian Chi, Kunming, Yunnan, China, 256 mm SL. *S. meridionalis*: IHAS 13200119, 8 specimens, Yichang, Hubei, China, 52.6–147 mm SL; IHAS 13200129, 1 specimen, Cheng Hai, Kunming, Yunnan, China, 249.1 mm SL; IHAS 13200132, 2 specimens, Hechuang, Sichuang, China, 92.4 mm and 106 mm SL, 1 specimen, Yichang, Hubei, China, 264 mm SL; 1 specimen, Wan Xian, Sichuang, China, 342 mm SL, 1 specimen, Jiangjin, Sichuang, China, 296 mm SL, 1 specimen, Fuling, Sichuang, China, 318 mm SL; IHAS 63VII77, 1 specimen, Wuchang, Hubei, China, 394 mm SL. *S. microdorsalis*: NSMT 50245, 9 specimens, Younkok River, Gule, South Korea, 117–189 mm SL; NSMT-P 50246, 4 specimens, Namdae River, Yangyang, South Korea, 115–163 mm SL; NSMT 50247, 1 specimen, Hangang River, South Korea, 134 mm SL. *S. soldatovi*: ZUMT 55084, 1 specimen, Manchuria, China, 249 mm SL; IHAS 13200123, 6 specimens, China, 216–283 mm SL; IHAS 13200117, 5 specimens, Liao He, China, 52.4–147 mm SL. *S. torrentis* sp. nov.: NIFI 00414, 3 specimens, Krating Waterfall, Chantaburi, Thailand, 168–198 mm SL; NIFI, uncatalogued, locality unknown, 2 specimens, 130 mm and 167 mm SL; NSMT-P 50234–50239, 7 type specimens, Lampae Stream, Trang, Thailand, 92.0–179 mm SL; NSMT-P 50240–50242, 3 specimens, Krating Waterfall, Chantaburi, Thailand, 161–187 mm SL; FBKU, uncatalogued, 3 specimens, Lampae Stream, Trang, Thailand, 101–161 mm SL; FBKU, uncatalogued, 2 specimens, Klong Bang Son, Trang, Thailand, 146 mm and 161 mm SL; NHRM MAL/1934. 168. 3225, 7 specimens, Patao, Kachin State, Burma, 88.6–160 mm SL; NHRM MAL/1934. 467. 5007, 3 specimens, Muhlweidaung, Ye State, Burma, 150–178 mm SL. *S. triostegus*: BMNH 1920. 3. 3: 168–176, 3 specimens, Basrah, Iraq, 205–220 mm SL. *S. wynaadensis*: BMNH 1889. 2. 1. 2512–2522, 1 specimen, Madras, India, 79.5 mm SL, syntype.

The terminology of the skull elements follows Patterson (1975), the suspensorial bones Lundberg (1970) and Howes (1983), the caudal skeleton



Fig. 1. *Silurus afghana*, BMNH 1860.3.19: 755, 110 mm SL.

Lundberg and Baskin (1969), and the shoulder girdle Brousseau (1976).

The colouration of the specimens is described under the preserved condition unless otherwise noted. Morphometric values are given by mean \pm standard deviation ($\bar{x} \pm SD$).

The phyletic analysis was undertaken on the basis of cladistic methods (Hennig, 1966; Wiley, 1981).

Genus *Silurus* Linnaeus, 1758

Silurus Linnaeus, 1758: 304 (type species, *Silurus glanis* Linnaeus, 1758, by Bleeker's (1862) subsequent designation).

Glanis Agassiz, 1856: 333 (type species, *Glanis aris-totelis* Agassiz, 1856, by monotypy).

Parasilurus Bleeker, 1862: 392 (type species, *Silurus japonicus* Temminck et Schlegel, 1847, by original designation).

Herklostella Herre, 1933: 179 (type species, *Herklostella anomala* Herre, 1933, by original designation).

Dorsal fin rays 1–6; pectoral fin rays I, 8–16; pelvic fin rays i, 6–12; anal fin rays 56–88; total vertebrae 52–74; branchiostegals 10–17; gill rakers 2–16.

This genus is differentiated from other silurids by the following sets of characteristics: dorsal fin very small; anal fin confluent with caudal fin with a distinct notch between them; anterior surface of pectoral spine smooth, granulated, or serrated, but its posterior surface strongly serrated in males and weakly serrated or smooth in females; lower jaw longer or shorter than the upper; eyes not visible from underside of head, covered with skin, or surrounded with a free orbital rim and lying above level of corner of mouth; maxillary barbels

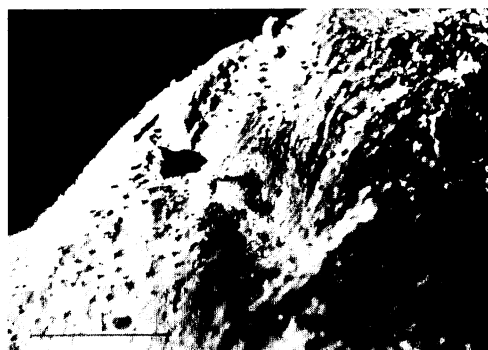


Fig. 2. Tubercles on the head region of *Silurus afghana*. Scale bar indicates 3 mm.

well developed and extending over gill opening; mandibular barbels two or four.

Distribution. Eurasia.

Silurus afghana Günther, 1864

(Fig. 1)

Silurus afghana Günther, 1864: 34; Day, 1878: 481. *Silurus dukai* Day, 1873: 239.

No specimen was dissected.

Dorsal fin rays 2; pectoral fin rays I, 11; pelvic fin rays i, 8; anal fin rays 74; caudal fin rays 7+8; vertebrae 15+45=60.

Upper jaw longer than lower; head 5.26 in standard length; numerous minute tubercles scattered on body surface, especially abundant on head region (Fig. 2); head remarkably flat; snout rounded; eye without free orbital rim and covered with skin; whole body uniformly dark brown; vomerine tooth band separated into a pair of patches; mesethmoid slender and narrowed at base of its slender lateral process.



Fig. 3. *Silurus aristotelis*, NSMT-P 50248, 227 mm SL.

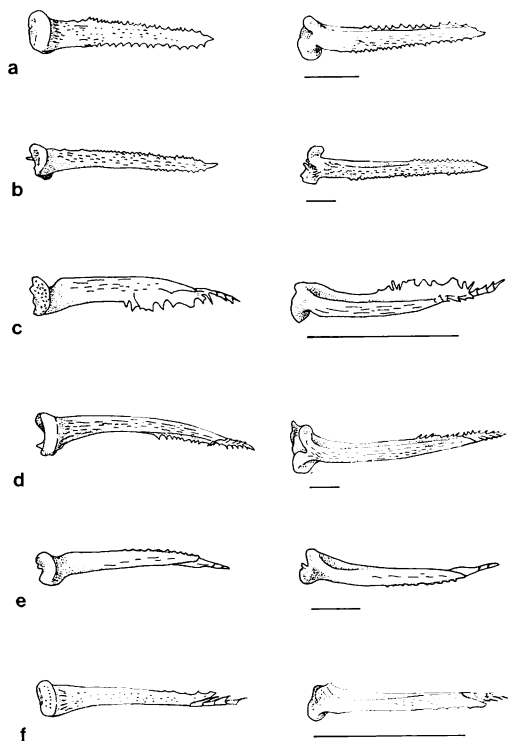


Fig. 4. Right pectoral spine. Left row dorsal view, and right row ventral view. Upper side in left row shows anterior. a, *Silurus aristotelis*; b, *S. biwaensis*; c, *S. cochinchinensis*; d, *S. glanis*; e, *S. grahami*; f, *S. microdorsalis*. Scale bars indicate 1 cm.

Distribution. Afghanistan.

***Silurus aristotelis* (Agassiz, 1856)**

(Fig. 3)

Glanis aristotelis Agassiz, 1856: 333.

Silurus aristotelis: Garman, 1890: 8; Haig, 1950: 97.

Parasilurus aristotelis: Hoffman and Jordan, 1892: 241; Thompson, 1947: 46.

One specimen (227 mm SL) was dissected for anatomical study.

Dorsal fin rays 2, 3; pectoral fin rays I, 11; pelvic fin rays i, 8; anal fin rays 75; caudal fin rays 7+7-8; vertebrae 15+45, 46=70, 71; branchiostegals 13; gill rakers 2, 3+11, 13.

Lower jaw longer than upper; head 4.1 in standard length; whole body mottled black and white; a single pair of mandibular barbels; maxillary barbel extending beyond operculum but not reaching tip of pectoral fin; anterior margin of pectoral spine strongly serrated (Fig. 4a); vomerine tooth band widely separated into a pair of patches (Fig. 5b).

Skull (Fig. 5): Anterior margin of mesethmoid curved gently and antero-median indentation not remarkable; posterior part of frontal and supraoccipital rising gently; sagittal crest confined to posterior part of supraoccipital.

Suspensorium (Fig. 6): Hyomandibular process well developed as a small pterygoid process separating adductor mandibulae and levator arcus palatini muscles.

Shoulder girdle (Fig. 7): Upper part of anterior half of cleithrum inwards with a ridge; ventral coracoid lamina extending ventrally; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton (Fig. 8): All hypurals separated from each other; hypurapophysis and secondary hypurapophysis poorly developed, and not fused with each other; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Balkan Peninsula of Greece.

***Silurus asotus* Linnaeus, 1758**

(Fig. 9)

Silurus asotus Linnaeus, 1758: 304; Haig, 1950: 97; Chen, 1977: 205.

Silurus punctatus Cantor, 1842: 485.

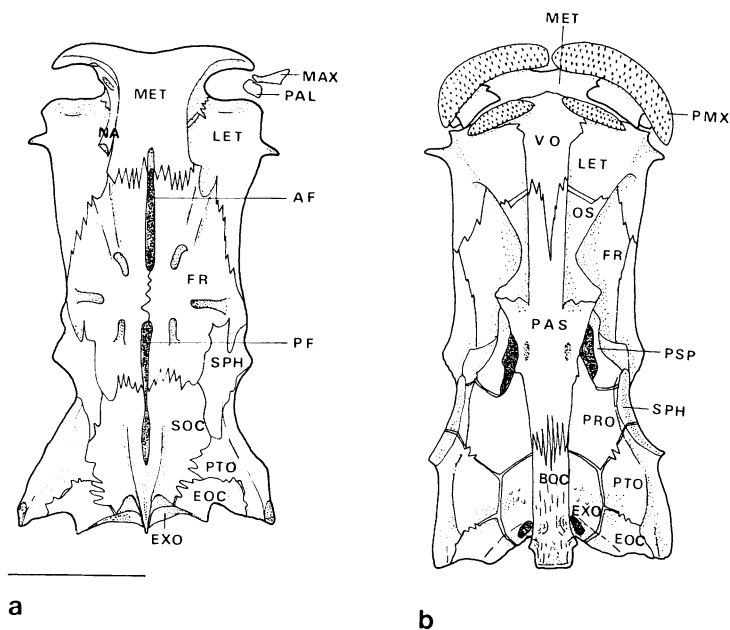


Fig. 5. Skull of *Silurus aristotelis*. a, dorsal view; b, ventral view. AF, anterior fontanel; BOC, basioccipital; EOC, epioccipital; EXO, exoccipital; FR, frontal; LET, lateral ethmoid; MAX, maxilla; MET, mesethmoid; NA, nasal; OS, orbitosphenoid; PAL, palatine; PF, posterior fontanel; PMX, premaxilla; PRO, prootic; PTO, pterotic; SOC, supraoccipital; SPH, sphenotic; VO, vomer. Scale bar indicates 1 cm.

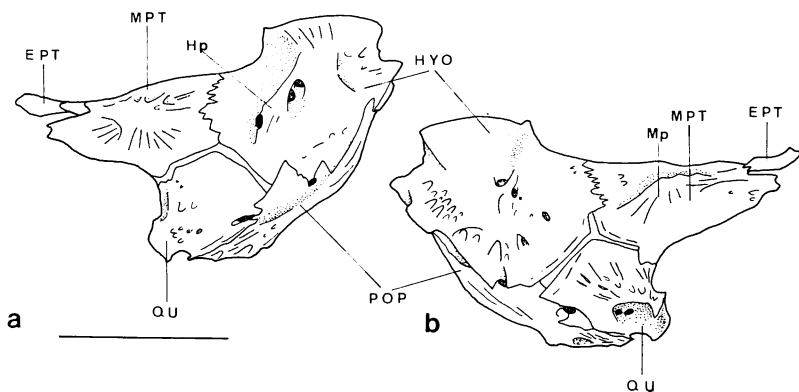


Fig. 6. Suspensorium of *Silurus aristotelis*. a, lateral view; b, medial view. EPT, entopterygoid; HYO, hyomandibular; Hp, hyomandibular process; MPT, metapterygoid; POP, preopercular; Qp, quadrate process; QU, quadrate. Scale bar indicates 1 cm.

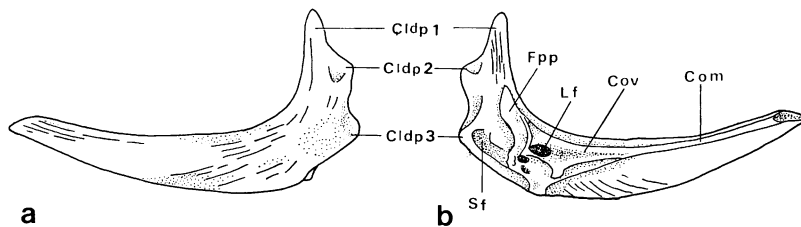


Fig. 7. Shoulder girdle of *Silurus aristotelis*. a, lateral view; b, medial view. Pectoral fin is removed. Cldp 1-3, dorsal prong of cleithrum 1-3; Com, medial coracoid lamina; Cov, ventral coracoid lamina; Fpp, foot-plate of primary girdle; Lf, locking foramen of primary girdle; Sf, spinal fossa of cleithrum. Scale bar indicates 1 cm.

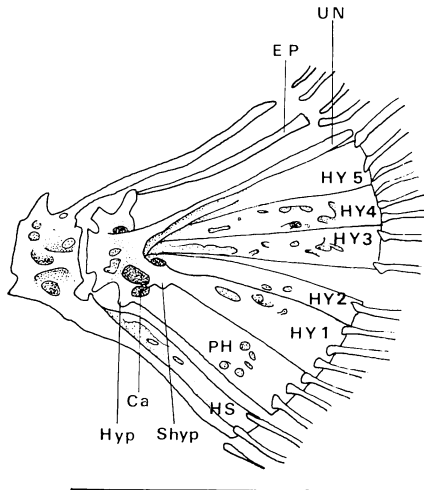


Fig. 8. Caudal skeleton of *Silurus aristotelis*. Ca, point of emergence of caudal artery; Ep, epural; HS, haemal spine; HY 1-5, hypurals 1-5; Hyp, hypurapophysis; PH, parhypural; Shyp, secondary hypurapophysis; UN, uroneural. Scale bar indicates 1 cm.

Silurus japonicus Temminck and Schlegel, 1847: 226.

Parasilurus japonicus: Bleeker, 1862: 392.

Silurus cinereus Dabry de Thiersant, 1872: 189.

Parasilurus asotus: Abbott, 1901: 483; Uchida, 1943: 2.

Silurus bedfordi Regan, 1908: 59.

Parasilurus asotus asotus: Nichols, 1943: 34.

Parasilurus sp.: Liu, 1965: 99.

Nine specimens from Lake Biwa (132-458 mm SL) were dissected for anatomical study.

Lake Biwa (N=9): Dorsal fin rays 4-6; pectoral fin rays I, 10-13; pelvic fin rays i, 10-11; anal fin rays 71-88; caudal fin rays 6-8+6-7; vertebrae 13-15+46-50=60-64; branchiostegals 13-16; gill rakers 1-3+8-10.

Korea (N=14): Dorsal fin rays 4-5; pectoral fin rays I, 10-13; pelvic fin rays i, 8-10; anal fin rays 59-82; caudal fin rays 7-8+7-8; vertebrae 12-15+45-50=59-64; branchiostegals 13-16; gill

rakers 0-3+6-10.

China (N=14): Dorsal fin rays 4-6; pectoral fin rays I, 10-13; pelvic fin rays i, 9-11; anal fin rays 70-85; caudal fin rays 6-8+7-8; vertebrae 13-15+46-50=60-64; branchiostegals 13-16; gill rakers 1-2+6-10.

Taiwan (N=1): Dorsal fin rays 4; pectoral fin rays I, 13; pelvic fin rays i, 11; anal fin rays 79; caudal fin rays 7+7; vertebrae 14+49=63; branchiostegals 13; gill rakers 2+10.

Lower jaw longer than the upper; head 4.78 ± 0.1 (Lake Biwa), 4.57 ± 0.25 (Korea), 4.45 ± 0.44 (China), and 4.37 (Taiwan) in standard length; eye surrounded by a free orbital rim; body in life completely mottled dorsally and sparsely marbled ventrally; one pair of mandibular barbels; maxillary barbel extending beyond pectoral fin; lateral line arranged in several rows horizontally as well as vertically; anterior margin of pectoral spine strongly serrated; three types of vomerine tooth band—1) gently curved continuous band, 2) continuous band with its posterior margin notched forward at a sharp angle, and 3) band of very narrowly separated patches. Most of the specimens (Lake Biwa: 88.9%) represent the first type.

Skull: Indentation of antero-median part of mesethmoid narrow and deep; sagittal crest broad but not prominent, rising from posterior part of frontal.

Suspensorium: Hyomandibular process forming a ridge for attachment of adductor mandibulae 3 and levator arcus palatini; entopterygoid rod-like, connected to postero-lateral margin of vomer by a ligament.

Shoulder girdle: Cleithrum bending inward forming a vertical ridge; ventral coracoid lamina poorly developed; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton (Fig. 10): Three types of fusion of hypural bones—1) all hypurals separated from each other, both hypurapophysis and secondary



Fig. 9. *Silurus asotus*, FBKU, uncatalogued, 273 mm SL.

hypurapophysis poorly developed, and secondary hypurapophysis forming a shelf on hypural 1, 2) hypurals 3, 4 and 5 fused with each other, both hypurapophysis and secondary hypurapophysis poorly developed, 3) parhypural bone fused with hypurals 1 and 2, uroneural fused with hypurals 3, 4 and 5 (a small hypurapophysis is observed in this type). The first type occurred in 89% of the specimens from Lake Biwa. The radiograph of the holotype of *S. bedfordi* was examined. Vertebrae $14+48=62$; anal fin rays 73. Anterior surface of pectoral spine serrated. Three characters fell within the variation range of *S. asotus*.

Distribution. Eastern Asia.

Silurus biwaensis (Tomoda, 1961)
(Fig. 11)

Parasilurus biwaensis Tomoda, 1961: 348.

All the specimens were dissected for anatomical inspection.

Dorsal fin rays 4-6; pectoral fin rays I, 13-15; pelvic fin rays i, 9-12; anal fin rays 71-83; caudal fin rays 6-7+7-9; vertebrae 13-17+49-52=63-68; branchiostegals 14-16; gill rakers 2-3+9-12.

Lower jaw prominently longer than upper; head 4.28 ± 0.15 in standard length; dorsal surface of body black and ventral surface white; a single pair of mandibular barbels, rather short and feeble; maxillary barbels not reaching base of pectoral fin in adult, but reaching about half of pectoral fin in juveniles or young specimens; outer surface of pectoral spine granulated (Fig. 4b); upper lobe of caudal fin longer than lower; vomerine teeth in one continuous band whose posterior margin is sharply indented.

Skull: Depression in anterior border of mesethmoid rather weak, forming a gentle curve; sagittal crest originating from posterior one-third of the frontal, and vertically elevated on the posterior part of skull; free margin of pterotic bending upwards and forming a depression for origin of epaxial muscles.

Suspensorium: Hyomandibular process to which adductor mandibulae 3 and levator arcus palatini attach forming a horizontal ridge in front of facial canal; developed quadrate process to which levator arcus palatini attaches connecting to hyomandibular process.

Shoulder girdle: Outer surface of cleithrum

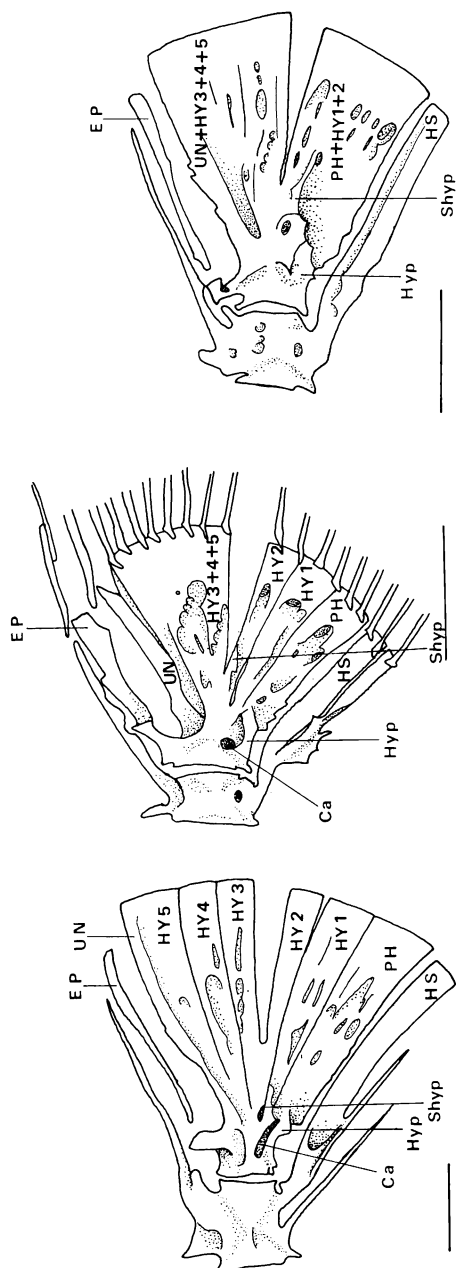


Fig. 10. Three types of caudal skeleton of *Silurus asotus*. Abbreviations as in Fig. 8. Scale bars indicate 1 cm.

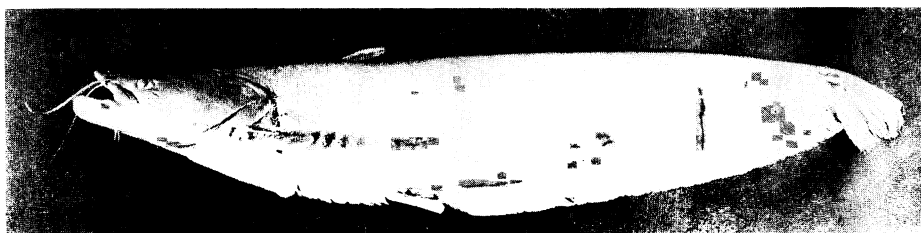


Fig. 11. *Silurus biwaensis*, FBKU, uncatalogued, 672 mm SL.

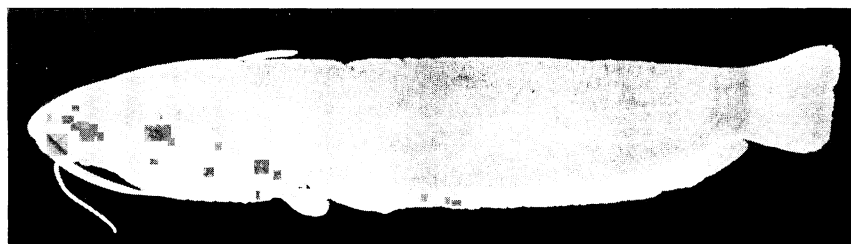


Fig. 12. *Silurus cochinchinensis*, FBKU, uncatalogued, 82 mm SL.

nearly flat; pterygoid process of coracoid remarkably developed ventrally; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: Hypurals not fused; both hypurapophysis and secondary hypurapophysis well developed; the former almost reaching the latter and forming a ring-like bridge; secondary hypurapophysis forming a shelf on hypurals 1 and 2.

Distribution. Endemic to Lake Biwa Basin, Japan.

Silurus cochinchinensis

Valenciennes, 1839

(Fig. 12)

Silurus cochinchinensis Valenciennes in Cuvier and Valenciennes, 1839: 352; Günther, 1864: 34; Haig, 1950: 99; Chen, 1977: 202.

Silurus punctatus (not of Cantor, 1842): Day, 1868: 155.

Parasilurus cochinchinensis: Nichols, 1943: 35.

Five specimens (60.3–156 mm SL) were dissected for anatomical study.

Dorsal fin rays 4; pectoral fin rays I, 8–10; pelvic fin rays i, 7–8; anal fin rays 58–66; caudal fin rays 6–7+7–8; vertebrae 11–13+41–45=53–57; branchiostegals 10–14; gill rakers 0–3+3–4.

Upper jaw longer than lower; head 5.27 ± 0.41 in standard length; mandibular barbels a single pair and longer than head (specimens less than

65 mm SL had two pairs); maxillary barbel extending beyond base of pectoral fin, not reaching its tip in adult but extending beyond pectoral fin in juvenile or young specimens; dorsal surface of body mottled brown, with border of anal fin white; eye covered with skin and without rim; caudal fin nearly truncated; anterior surface of pectoral spine completely smooth (Fig. 4c), with posterior surface serrated (serration more remarkable in males); gill raker long and slender; testis branched into thin lobes; vomerine tooth band separated into a pair of small patches.

Skull (Fig. 13): Base of lateral process of mesethmoid narrowed remarkably; posterior part of skull not elevated, sagittal crest absent, and broad rise formed in the postero-median part of supraoccipital where epaxial muscles originate; skull roof in frontal region completely flattened.

Suspensorium (Fig. 14): Hyomandibular process well developed, forming a pterygoid process separating adductor mandibulae 3 and levator arcus palatini; entopterygoid not rod-like but a long sheet of bone.

Shoulder girdle (Fig. 15): Ventral coracoid lamina poorly developed; vertical part of cleithrum short and bending inward with a ridge; coracoid connected without forming a complex suture.

Caudal skeleton (Fig. 16): Hypurals not fused with each other, but base of hypurals 3, 4 and 5

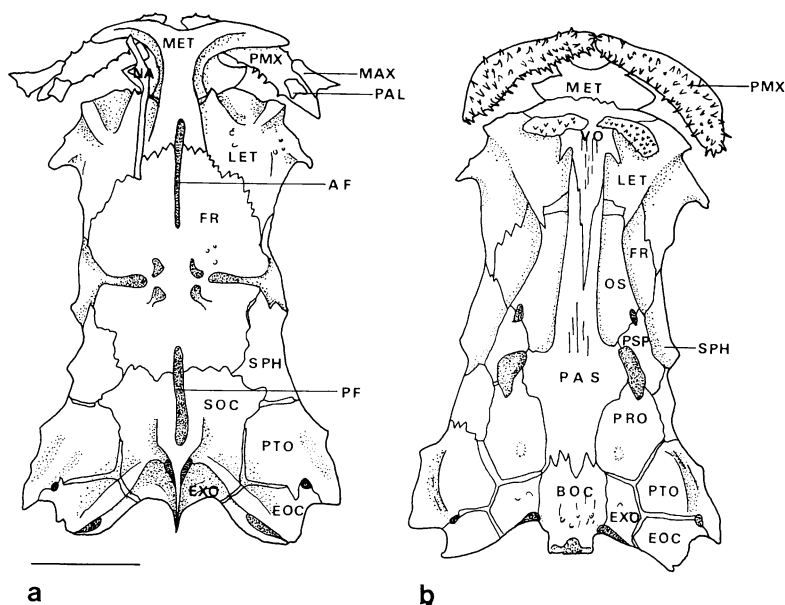


Fig. 13. Skull of *Silurus cochinchinensis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

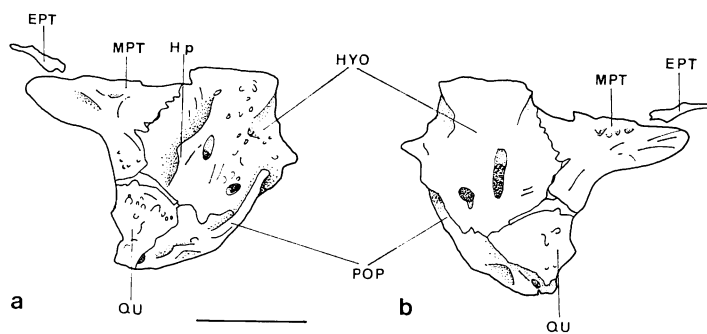


Fig. 14. Suspensorium of *Silurus cochinchinensis*. a, lateral view; b, medial view. Abbreviations as in Fig. 6. Scale bar indicates 1 cm.

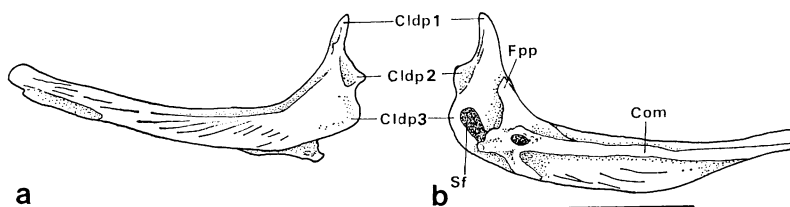


Fig. 15. Shoulder girdle of *Silurus cochinchinensis*. a, lateral view; b, medial view. Pectoral fin is removed. Abbreviations as in Fig. 7. Scale bar indicates 1 cm.

partially fused ; hypurapophysis not developed, secondary hypurapophysis forming small pterygoid process on hypural 2.

Distribution. Eastern China and Thailand.

Silurus gilberti Hora, 1938
(Fig. 17)

Silurus wynaadensis (not of Day, 1873): Tchang, 1936:
35.

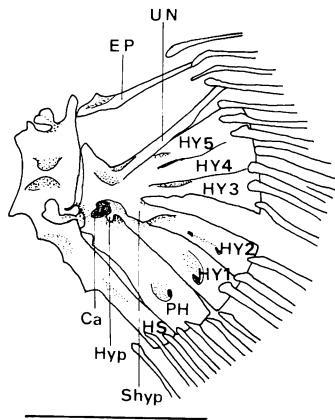


Fig. 16. Caudal skeleton of *Silurus cochinchinensis*. Abbreviations as in Fig. 8. Scale bar indicates 1 cm.

Silurus sinensis (not of McLelland, 1844): Hora, 1937: 341.

Silurus gilberti Hora, 1938: 351; Haig, 1950: 100; Chen, 1977: 201.

One specimen (120 mm SL) was dissected for anatomical study.

Dorsal fin rays 4; pectoral fin rays I, 10–11; pelvic fin rays i, 7–8; anal fin rays 57–66; caudal fin rays 5–7+7–8; vertebrae 11–12+39–42=50–54; branchiostegals 10–12; gill rakers 0–1+4–6.

Upper jaw slightly longer than lower; head 5.25 ± 0.19 in standard length; whole body mottled with black and brown, with paler ventral surface; border of anal fin white; mandibular barbel usually two pairs (in six out of seven specimens), and rarely one pair; longer mandibular barbel reaching base of pectoral fin but not extending beyond it; maxillary barbel extending over pectoral fin, almost reaching tip of ventral fin; anterior edge of pectoral spine smooth; caudal fin almost truncated; eye covered with skin and not with free orbital rim; needle-like gill rakers poorly developed; testis branched into slender ribbons from its basement.

Skull: Base of lateral process of mesethmoid narrowed remarkably; posterior part of supraoccipital having a broad and low crest for origin of epaxial muscles; frontal completely flat, and posterior part of supraoccipital and epioccipital forming a bump and a small depression for origin of epaxial muscles; posterolateral part of vomer having a small process with which entopterygoid is connected by a ligament; supraorbital canal on frontal not forming a complete canal but a mere

groove.

Suspensorium: Hyomandibular process poorly developed; entopterygoid rather large and forming a flat sheet.

Shoulder girdle: Cleithrum slightly curved, with short horizontal part; ventral coracoid lamina poorly developed; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: Hypurals 1 and 2 fused with each other; hypurapophysis fused with well-developed secondary hypurapophysis, forming a bridge; secondary hypurapophysis forming a shelf on hypurals 1 and 2.

Distribution. Hainan, China.

Silurus glanis Linnaeus, 1758

Silurus glanis Linnaeus, 1758: 304; Berg, 1949: 470; Haig, 1950: 100; Nikolsky, 1961: 307.

One specimen (NSMT-P 50244) was dissected.

Dorsal fin rays 3–4; pectoral fin rays I, 15–16; pelvic fin rays i, 11–12; anal fin rays 83–87; caudal fin rays 7+8; vertebrae 18–19+54–56=72–74; branchiostegals 15–16; gill rakers 2+10.

Lower jaw longer than upper; head 4.65 in standard length; body well mottled even on ventral surface; adult retains two pairs of mandibular barbels; outer surface of pectoral spine smooth, and inner surface serrated (Fig. 4d); eyes with free orbital rim; vomerine tooth band broad and continuous; posterior margin of the band angularly indented.

Skull: Skull remarkably narrowed at level of lateral process of sphenotic; antero-median part of mesethmoid indented posteriorly; mesethmoid broad and not narrowed at base of its lateral process; wide and low sagittal crest elevated from posterior half of frontals.

Suspensorium: Small bump to which the levator arcus palatini attaches formed just in front of facial canal on hyomandibular, but no process on quadrate.

Shoulder girdle: Cleithrum curving gently, rather flat, but not as flat as in *S. biwaensis*; pterygoid process of coracoid not extending horizontally but bending dorsally; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: All hypural bones separated from each other; hypurapophysis and secondary hypurapophysis not fused with each other; secondary hypurapophysis forming a shelf on hypu-

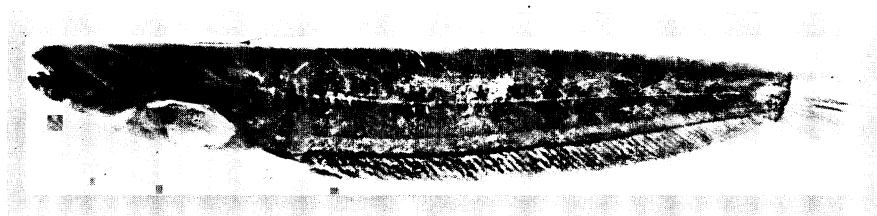


Fig. 17. *Silurus gilberti*, IHAS 13200103, 120 mm SL.



Fig. 18. *Silurus grahami*, KIZ 7711002, 426 mm SL.

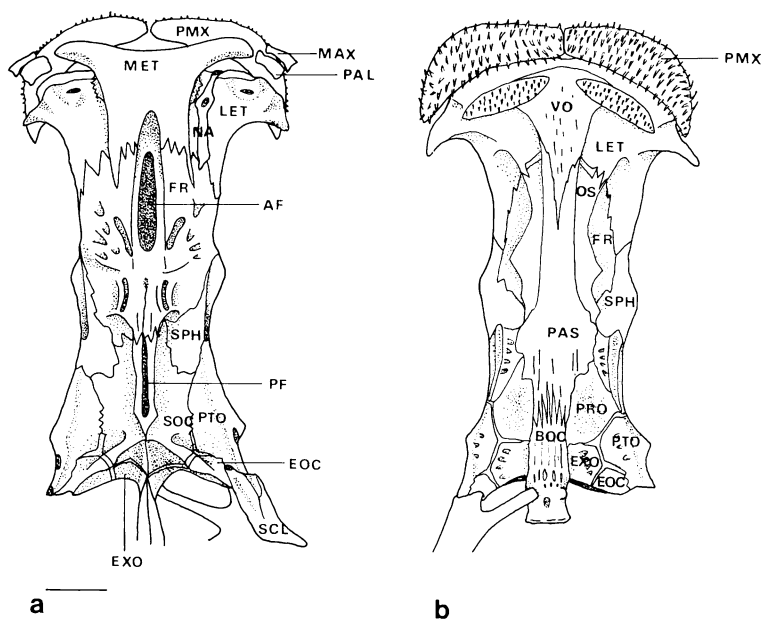


Fig. 19. Skull of *Silurus grahami*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

ral 1.

Distribution. Europe, Asia Minor, and Central Asia.

Silurus grahami Regan, 1907
(Fig. 18)

Silurus grahami Regan, 1907: 64.

Silurus mento grahami: Chen, 1977: 205.

One specimen (395 mm SL) was dissected.

Dorsal fin rays 4–5; pectoral fin rays I, 10–12; pelvic fin rays i, 8–10; anal fin rays 67–75; caudal fin rays 7–8+7–8; vertebrae 14–15+46–49=61–63; branchiostegals 13–15; gill rakers 1–2+8–11.

Lower jaw longer than upper; head 4.35 ± 0.14 in standard length; maxillary barbel never extend-

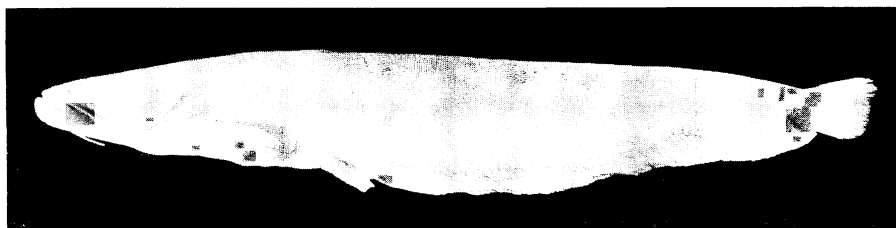


Fig. 20. *Silurus lithophilus*, FBKU, uncatalogued, 212 mm SL.

ing over half of pectoral fin; a single pair of mandibular barbels; remarkable horizontal lateral lines on body surface in addition to vertical one running along middle of body; dorsal surface of body slightly mottled and ventral surface white; outer surface of pectoral spine granulated in a single row, and its inner surface in males weakly serrated, but completely smooth in females (Fig. 4e); upper lobe of caudal fin slightly longer than lower; vomerine teeth in two widely separated patches.

Skull (Fig. 19): Indentation of antero-median part of mesethmoid very weak and its anterior border forming a gentle curve; posterior end of supraoccipital and epioccipital elevated and forming depression for epaxial muscles.

Suspensorium: Small process for insertion of adductor mandibulae 3 and origin of levator arcus palatini formed in front of facial foramen.

Shoulder girdle: Cleithrum bending medially; pterygoid process of coracoid not remarkable; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypurapophysis and secondary hypurapophysis well developed but not fused with each other; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Endemic to Yunnan, China.

Silurus lanzhouensis Chen, 1977

Silurus lanzhouensis Chen, 1977: 210.

No specimen was dissected for anatomical inspection, but one specimen was skinned in the skull roof region to examine the shape of the mesethmoid and sagittal crest of the supraoccipital. Considering that this species grows over 1 m, the specimens observed here were young.

Dorsal fin rays 4-5; pectoral fin rays I, 11-13; pelvic fin rays i, 8-10; anal fin rays 70-88; caudal fin rays 7-8+6-8; vertebrae 16+52-53=68-69

(radiographs of three type specimens); branchiostegals 13-15; gill rakers 1-2+8-11.

Lower jaw longer than upper, head 4.55 ± 0.37 in standard length; eye with free orbital rim; body sparsely mottled in preserved specimens; anterior surface of pectoral spine granulated in a single row; a single pair of mandibular barbels; maxillary barbel reaching tip of pectoral fin; upper lobe of caudal fin slightly longer than, or as long as lower one; vomerine teeth in two closely separate patches, lateral projection of mesethmoid short and slender; sagittal crest rising from supraoccipital and not well-developed; posterior end of epioccipital and supraoccipital elevated, forming depression for origin of epaxial muscles.

Distribution. Upper Yellow River Basin, China.

Silurus lithophilus (Tomoda, 1961)

(Fig. 20)

Parasilurus lithophilus Tomoda, 1961: 350.

All specimens were dissected for anatomical study.

Dorsal fin rays 4-5; pectoral fin rays I, 10-12; pelvic fin rays i, 9-11; anal fin rays 77-82; caudal fin rays 7-8+7-8; vertebrae 14-15+48-55=62-66; branchiostegals 14-17; gill rakers 1-2+8-10.

Lower jaw longer than upper; head 4.62 ± 0.23 in standard length; golden brown patterns scattered on lateral and dorsal sides of body, and ventral surface of body sparsely mottled with black and white spots in life; a single pair of mandibular barbels; maxillary barbel extending beyond half of pectoral fin, but never reaching its tip in adults (extending beyond tip of pectoral fin in young); length of upper and lower lobes of rounded caudal fin nearly equal; pectoral spine strongly serrated; vomerine tooth band separated into a pair of close-lying patches.

Skull: Antero-median part of mesethmoid indented deeply; sagittal crest broad and not pro-



Fig. 21. *Silurus mento*, IHAS 3200106, 213 mm SL.

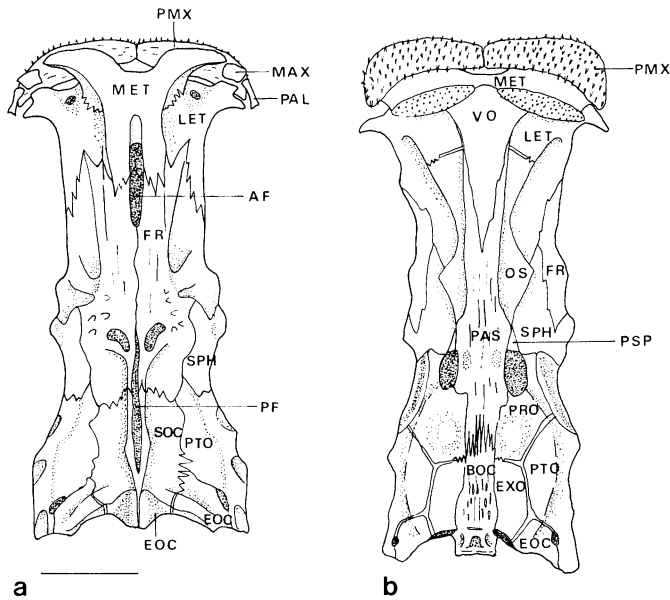


Fig. 22. Skull of *Silurus mento*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

minent, rising from middle of frontal, and postero-medial part of skull elevated gently.

Suspensorium: Hyomandibular process poorly developed, continuing to quadrate process where levator arcus palatini attaches.

Shoulder girdle: Upper half of anterior part of cleithrum bending inward and forming a ridge; ventral coracoid lamina well developed horizontally; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypurals not fused with each other; both hypurapophysis and secondary hypurapophysis poorly developed; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Endemic to Lake Biwa Basin, Japan.

Silurus mento Regan, 1904
(Fig. 21)

Silurus mento Regan, 1904: 192; Haig, 1950: 100; Chen, 1977: 203.

Parasilurus mento: Nichols, 1943: 34.

One specimen (KIZ 00084) was dissected for anatomical inspection.

Dorsal fin rays 3–4; pectoral fin rays I, 9–11; pelvic fin rays i, 7–9; anal fin rays 61–73; caudal fin rays 6–7+6–8; vertebrae 12–15+41–46=54–60; branchiostegals 12–15; gill rakers 2–3+9–13.

Lower jaw longer than upper; head 4.11 ± 0.21 in standard length; a single pair of mandibular barbels, but two pairs in young specimens less than 80 mm SL; maxillary barbel rather short and not reaching end of opercle; outer margin of



Fig. 23. *Silurus meridionalis*, FBKU, uncatalogued, 182 mm SL.

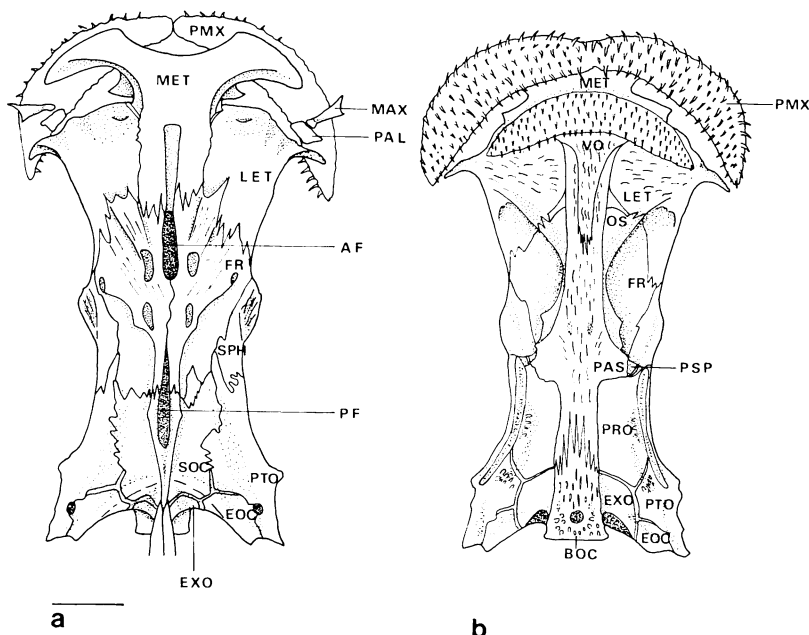


Fig. 24. Skull of *Silurus meridionalis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

pectoral spine granulated in a single row; body depth suddenly decreasing, and a slight depression formed at caudal peduncle in lateral aspect; whole body surface mottled with black finger patterns in preserved specimens, but sparse on ventral surface of body; in addition to vertical line several horizontal lateral lines distributed on dorsal and lateral body surface; vomerine teeth in two separated patches.

Skull (Fig. 22): Antero-median part of mesethmoid indented backward remarkably; sagittal crest, broad and not prominent, beginning from posterior end of frontals.

Suspensorium: Hyomandibular process lacking, but small edge of bump formed in front of facial canal.

Shoulder girdle: Ventral part of coracoid forming a horizontal pterygoid process, but its median part slender; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypural bones not fused, and hypurapophysis not remarkable; secondary hypurapophysis developed in triangular process and forming a shelf on hypural 1.

Distribution. Endemic to Yunnan, China.

Silurus meridionalis Chen, 1977
(Fig. 23)

Silurus soldatovi meridionalis Chen, 1977: 210.

One specimen (IHAS 63VII77) was dissected for anatomical study. This species grows over

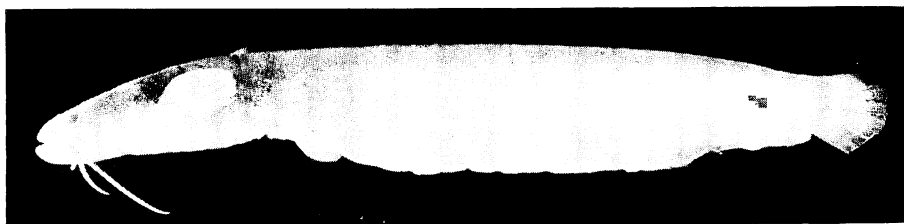


Fig. 25. *Silurus microdorsalis*, FBKU, uncatalogued, 163 mm SL.

1 m when adult stage, but only young of smaller size were available for the present study.

Dorsal fin rays 5–6; pectoral fin rays I, 13–16; pelvic fin rays i, 9–11; anal fin rays 71–85; caudal fin rays 7–8+7–8; vertebrae 15–18+50=64–68; branchiostegals 12–17; gill rakers 3+9.

Lower jaw remarkably longer than upper; head 4.15 ± 0.51 in standard length; dorsal surface of body slightly mottled and brownish; a single pair of mandibular barbels, but two pairs present in younger specimens less than 150 mm SL; maxillary barbels long and extending over pectoral fin but not reaching end of pelvic fin; upper lobe of caudal fin slightly longer than lower; outer margin of pectoral spine granulated; vomerine teeth in one broad continuous band of which posterior margin gently notched.

Skull (Fig. 24): Conspicuously narrowed at level of sphenotic; mesethmoid remarkably broad and its lateral projection well developed; sagittal crest rising from posterior half of frontals.

Suspensorium: Hyomandibular process for insertion of levator arcus palatini and adductor mandibulae 3 forming a sharp edge, and a triangular process for insertion of levator arcus palatini developed on outer surface of quadrate; rod-like entopterygoid connected with metapterygoid posteriorly and with vomer anteriorly by a ligament.

Shoulder girdle: Cleithrum flattened and median part of coracoid not forming a pterygoid process; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton: Hypurapophysis forming a narrow bridge which is nearly connected with well-developed secondary hypurapophysis; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Middle Yangtze River Basin, China.

Silurus microdorsalis (Mori, 1936)

(Fig. 25)

Parasilurus microdorsalis Mori, 1936: 671; Uchida, 1943: 9.

Silurus microdorsalis: Haig, 1950: 100.

Two specimens, 115 mm SL and 189 mm SL, were dissected for anatomical study.

Dorsal fin rays 1–3; pectoral fin rays I, 9–11; pelvic fin rays i, 8–10; anal fin rays 61–74; caudal fin rays 7+7–9; vertebrae 13–14+45–47=59–60; branchiostegals 12–13; gill rakers 1+5–7.

Lower jaw slightly longer than upper; head 5.58 ± 0.22 in standard length; a single pair of mandibular barbels; body uniformly dark brown, and the ventral surface, edge of anal and pectoral fins white; caudal fin nearly truncated; eye covered with skin and not with free orbital rim; gill rakers long, as long as the gill filament; pectoral spine short and its anterior surface weakly serrated (Fig. 4f); posterior surface of pectoral spine completely smooth in females, serrated in males; testis branched into many long lobes; vomerine tooth band separated into a pair of distant patches.

Skull (Fig. 26): Lateral process of mesethmoid remarkably long and slender; mesethmoid narrowed at base of its lateral process; sagittal crest confined to posterior part of supraoccipital, thus skull roof completely flattened.

Suspensorium (Fig. 27): Hyomandibular process poorly developed, and quadrate process absent; entopterygoid a long and sheet-like bone.

Shoulder girdle (Fig. 28): Horizontal part of cleithrum very short; ventral coracoid lamina absent; median coracoid lamina sutured with cleithrum.

Caudal skeleton (Fig. 29): Hypurals 1 and 2 fused in larger specimens; neither hypurapophysis nor secondary hypurapophysis present.

Distribution. Korea and the Yalu River, China.

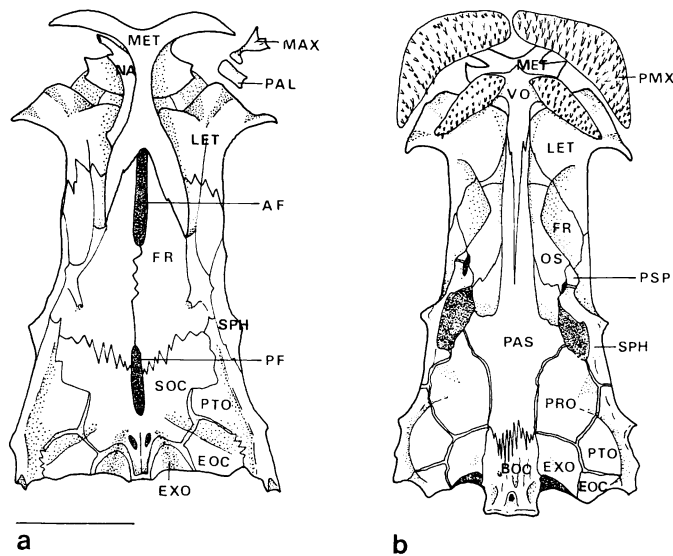


Fig. 26. Skull of *Silurus microdorsalis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

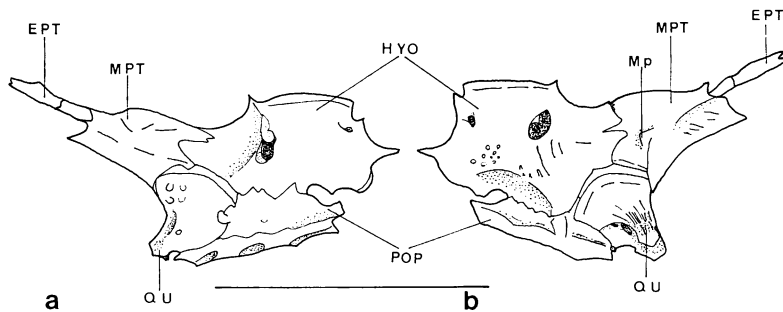


Fig. 27. Suspensorium of *Silurus microdorsalis*. a, lateral view; b, medial view. Abbreviations as in Fig. 6. Scale bar indicates 1 cm.

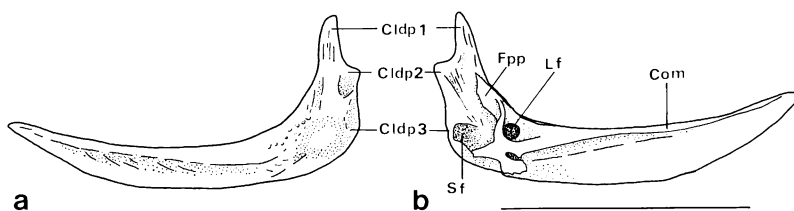


Fig. 28. Shoulder girdle of *Silurus microdorsalis*. a, lateral view; b, medial view. Pectoral fin is removed. Abbreviations as in Fig. 7. Scale bar indicates 1 cm.