



Osteology of some catfishes of the genus *Glyptothorax* (Teleostei: Siluriformes) of northeastern India

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Author Contribution: The study: AD - survey, collection, morphometric and anatomic study of catfishes of northeastern India and their phylogenetics; NA - survey, collection, morphometric and anatomic study of catfishes of northeastern India and their phylogenetics; WV - supervision of taxonomy and phylogeny of freshwater fishes of northeastern India.

Current paper: AD - detailed examination of collections, comparison with specimens in ZSI and preparation of drawings; NA - detailed examination of the collections of *Glyptothorax* in MUMF and osteological studies; WV - supervision of the work, interpretation of the results and comparison with available literature.

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Abstract: The morphology of the premaxilla, dentary, Weberian lamina, infraorbital series, vomer and frontal bones were observed in eight species of *Glyptothorax* of northeastern India. In *G. botius*, *G. granulus*, *G. manipurensis*, *G. ngapang*, *G. striatus* and *G. ventrolineatus*, the premaxilla consists only of proximal and distal tooth plates, the anterior portion of the dentary is slender and its dorsal surface bears villiform teeth, the lateral extension of posterior portion of Weberian lamina terminates at the level of the lateral margin of its anterior portion, and the frontal has a shallow orbital notch. In *G. cavia* and *G. chindwinica*, the premaxilla consists of proximal, distal and posterior elements on the roof of the oral cavity; the anterior portion of the dentary bears posterior extension of dentary tooth-plate; the lateral extension of the posterior portion of Weberian lamina extends almost to the distal tip of the fifth parapophysis; there are nine or ten infraorbital bones with a longer and broader body of the lacrimal; greatly enlarged vomerine head; and frontal bears a deep orbital notch. The jaw structure of *G. burmanicus* is discussed.

Keywords: *Glyptothorax*, osteology, Sisorid fish, tooth plates

INTRODUCTION

Blyth (1860) described the genus *Glyptothorax*, for which Bleeker (1862-63) designated *Glyptosternon striatus* McClelland as the type species. *Glyptothorax* is the most species-rich and widely distributed genus of the family Sisoridae. The genus has as many as 81 valid species (Ferraris 2007; Gopi 2007; Vishwanath & Linthoingambi 2007; Ng & Freyhof 2008; Ng & Kottelat 2008; Ng & Rainboth 2008). de Pinna (1996) casts doubt on the monophyly of the genus *Glyptothorax*, citing the lack of unambiguous synapomorphies to diagnose it. However, his phylogenetic analysis of the Sisoroidea still recovered a monophyletic Sisoridae.

Although there are reports on the osteological studies of *Glyptothorax*, viz., Gauba (1966) on *G. cavia* (Hamilton) and Diogo et al. (2002) on *G. fukiensis* (Rendahl), there are no reports of the comparative accounts on the osteology of the genus.

This study attempts to identify the variation of bones i.e., premaxilla, dentary, infraorbital series, frontal, vomer and articulation of complex centrum with remaining vertebral column in eight species of *Glyptothorax* of north east India, viz. *Glyptothorax botius* (Hamilton), *G. cavia* (Hamilton), *G. chindwinica* Vishwanath & Linthoingambi. *G. granulus* Vishwanath &

Abbreviation: MUMF - Manipur University Museum of Fishes; dp - distal element; prp - proximal element; pop - posterior element; vt - villiform teeth; Pdtp - posterior extension of dentary bony tooth-plate; wl - Weberian lamina, ppwl - posterior portion of Weberian lamina; cc - complex centrum; vc5 - fifth vertebral centrum; ns4 - fourth neural spine; sop - spine of supraoccipital; lac - lacrimal (first infraorbital); io_n - infraorbital 1-10; Af - anterior cranial fontanelle; afp - articular facet for palatine; bo - basioccipital; e - mesethmoid; epo - epeotic; exo - exoccipital; f - frontal; le - lateral ethmoid; n - nasal; on - orbital notch; pf - posterior cranial fontanelle; po - prootic; pt - pterotic; pts - pterosphenoid; scl - supraclathrum; so - supraoccipital; s - sphenotic; v - vomer.

Linthetaingambi, *G. manipurensis* Menon, *G. ngapang* Vishwanath & Linthetaingambi, *G. striatus* (McClelland), and *G. ventrolineatus* Vishwanath & Linthetaingambi. The results are presented in this study and discussed.

MATERIAL AND METHODS

Fresh specimens of *Glyptothorax* were collected from different areas of northeastern India. Measurements of antero-posterior length and lateral-extent of upper jaw tooth band follow Vishwanath & Linthetaingambi (2007). Specimens were cleared and stained following Hollister (1934). Terminology and nomenclature of bones follow Chen & Lundberg (1995) and de Pinna (1996). Components of premaxillary bones are named as proximal, distal and posterior elements based on their positions.

Visible jaw structures of holotype of *Glyptothorax burmanicus* in ZSI Kolkata was also observed and compared.

RESULT

Premaxilla: In six species, viz., *Glyptothorax botius*, *G. granulus*, *G. manipurensis*, *G. ngapang*, *G. striatus*, and *G. ventrolineatus*, the premaxilla (Figs. 1A & 1B) consists of four bony elements, i.e., a pair of medially located proximal elements (prp) and another pair of distal elements (dp), located lateral to the proximal element. The convex anterior margin of the distal element articulates with the corresponding concavity along the posterolateral margin of the proximal element. The distal element is firmly united to the proximal end by rigid connective

tissue. However, in *G. cavia* and *G. chindwinica*, the premaxilla comprises of numerous distal (Fig. 1D: dp) and posterior elements (Fig. 1D: pop) in addition to a pair of proximal elements (Fig. 1D: prp). The distal and posterior elements are attached respectively to the lateral and the posterior parts of the proximal elements. All the subunits of the proximal, distal and posterior elements are tightly fastened by connective tissue to form the premaxilla. The sutures among the elements that comprise the premaxilla are not visible ventrally because the presence of numerous villiform teeth (Fig. 1C: vt) on this surface obscures it. Ventrally the premaxilla is seen as a single structure on the roof of the oral cavity (Fig. 1C).

Dentary: In the six species, viz., *Glyptothorax botius*, *G. granulus*, *G. manipurensis*, *G. ngapang*, *G. striatus*, and *G. ventrolineatus*, the anterior portion of the dentary is slender, with villiform teeth on its dorsal surface (Figs. 2A & 2B). However in *G. cavia* and *G. chindwinica*, the dentary is a stout, long, curved bone with a very broad anterior two-third portion. This broadness is manifested by a posterior extension of the tooth-bearing surfaces on the dentary (Fig. 2C & 2D: pdtp) which bears villiform teeth at its dorsal surface. Gauba (1966) also reported the tooth-bearing portion of the dentary to be very much flattened in *G. cavia*. The dentary tooth plate of *G. burmanicus* is also similar to that of *G. cavia* and *G. chindwinica*.

Posterior portion of Weberian lamina: The transverse process or parapophysis of complex centrum was named the Weberian lamina by de Pinna (1996). In the present study, all the examined species of *Glyptothorax* (except, *G. cavia* and *G. chindwinica*) have an extended posterior portion of Weberian lamina (Figs. 3B & 3C:

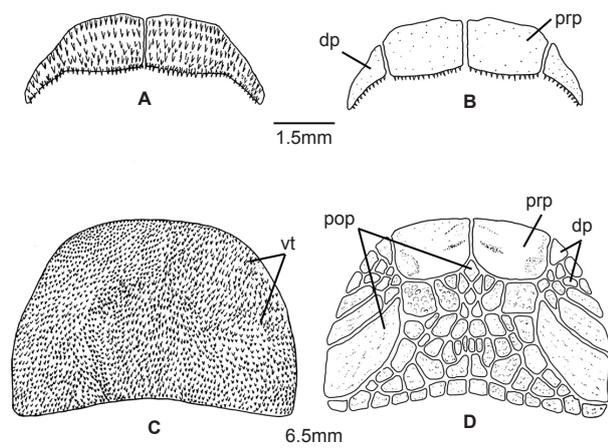


Figure 1. Premaxillary: A - ventral, B - dorsal view of *Glyptothorax manipurensis* (MUMF 4030); C - ventral, D - dorsal view of *G. chindwinica* (MUMF 9997)
dp - distal element; prp - proximal element; pop - posterior element; vt - villiform teeth.

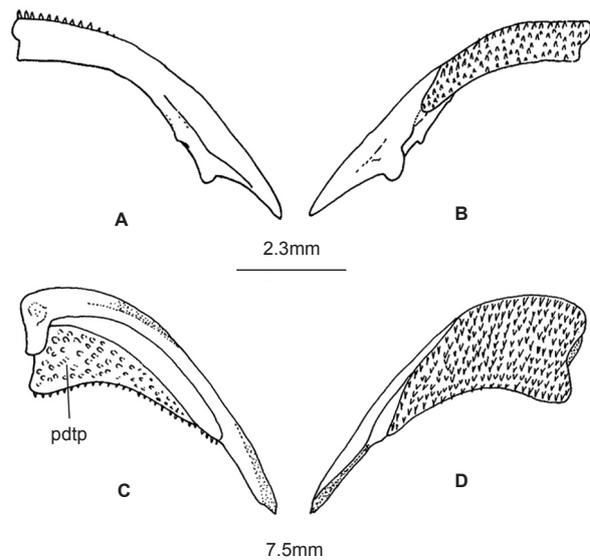


Figure 2. Dentary (left): A - ventral view, B - dorsal view of *G. manipurensis* (MUMF 4030); C - ventral view, D - dorsal view of *G. chindwinica* (MUMF 9997).
Pdtp - posterior extension of dentary bony tooth-plate.

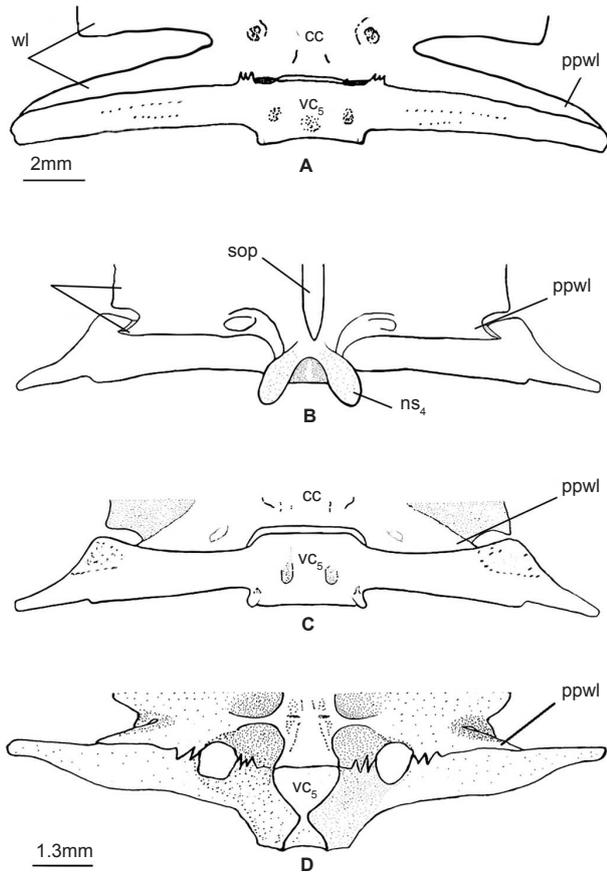


Figure 3. Weberian lamina: A - ventral view of *G. chindwinica* (MUMF 9997); B - dorsal, C - ventral of *G. ngapang* (MUMF 6141); D - ventral view of *G. botius* (unscale) (MUMF 9520).

wl - Weberian lamina; ppwl - posterior portion of Weberian lamina; cc - complex centrum; vc5 - fifth vertebral centrum; ns4 - fourth neural spine; sop - spine of supraoccipital.

ppwl) to the level of lateral margin of its anterior portion. In *G. botius*, there is a large rounded space between the articulation of the fifth parapophysis and the posterior portion of the Weberian lamina (Fig. 3D). Tight suturing is also observed at the adjoining parts of the space. In *G. cavia* and *G. chindwinica*, the lateral expansion of the posterior portion of Weberian lamina (Fig. 3A: ppwl) extends beyond the lateral margin of the anterior portion of the lamina, reaching almost to the distal tip of the parapophysis of the fifth vertebra.

Infraorbital: The number of infraorbital bones is variable. *Glyptothorax botius* has six infraorbital bones; of which the sixth is longest while the fifth, the shortest. Both *G. ngapang* and *G. chindwinica* have nine infra-orbital bones, while *G. cavia* has ten. In the remaining species, there are eight bones in the series. The third infra-orbital in *G. ngapang* (Fig. 4B: io₃) bears a broad ventral laminar process. Both *G. cavia* and *G. chindwinica* have a larger and broader body of the lacrimal (Fig. 4A: lac) when compared to other species examined.

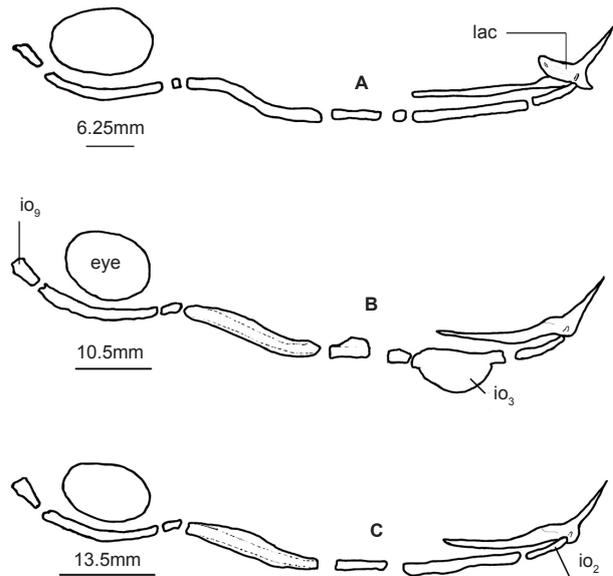


Figure 4. Lateral view of infraorbital series: A - *G. chindwinica* (MUMF 9997); B - *G. ngapang* (MUMF 6141); C - *G. granulus* (MUMF 9991). lac - lacrimal (first infraorbital); io_n - infraorbital 1-10.

Orbital notch: The orbital notch of the *Glyptothorax* is formed at the lateral margin of frontal as a shallow depression, forming an arc smaller than a semicircle (Fig. 5C: on). *G. honghensis* Li (Zhou & Zhou 2005: Fig. 6B), *G. fukiensis* (Diogo et al. 2002: Figs.1 & 2) and *G. major* (de Pinna 1996: Fig. 13) have also shallow orbital notches. However, in *G. cavia* and *G. chindwinica*, the notch is deep and forms an arc larger than a semicircle (Figs. 5A & 5B: on).

Vomer: The head of the vomer of *Glyptothorax* is edentulous and extended laterally along the entire length of the articular process of lateral ethmoid, reaching the articular facet for palatine at the lateral tip of each lateral ethmoid. In all the species examined (except in *G. cavia* and *G. chindwinica*), the anterolateral margin of the head of the vomer is concave resulting in the formation of a thin lateral process and another sharply pointed medial anterior tip (Fig. 6 B & C). In *G. cavia* and *G. chindwinica*, the head of vomer is very large and broad with roughly convex anterior margin (Figs. 5A & 5B: v; 6A).

DISCUSSION

Among the Siluriformes, the premaxilla of *Glyptothorax* (Tilak 1963; de Pinna 1996) and *Bagarius* Bleeker (Gauba 1962) is characteristic in having separate distal elements connecting laterally to the proximal element. Diogo et al. (2002) also reported the same structure in *G. fukiensis* (Rendahl). A subdivided premaxilla has also been reported in *Glyptosternum reticulatum* McClelland (Gauba 1969), and fragmentation of the distal element of premaxilla

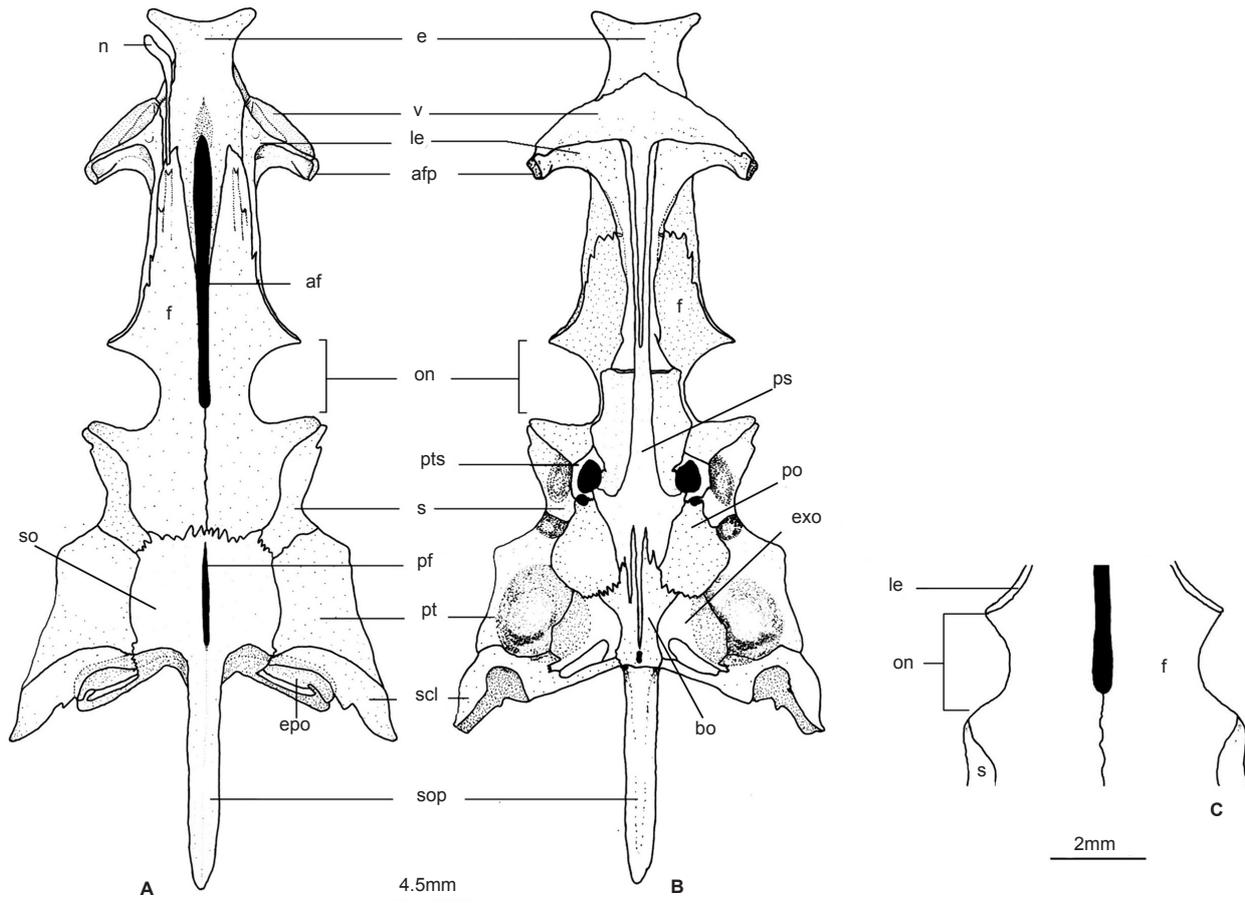


Figure 5. Views of skull: **A** - dorsal, **B** - ventral of *G. chindwinica* (MUMF- 9997); **C** - part of dorsal of *G. ngapang* (MUMF- 6141). Af - anterior cranial fontanelle; afp - articular facet for palatine; bo - basioccipital; e - mesethmoid; epo - epeotic; exo - exoccipital; f - frontal; le - lateral ethmoid; n - nasal; on - orbital notch; pf - posterior cranial fontanelle; po - prootic; pt - pterotic; pts - pterosphenoid; scl - supraclathrum; so - supraoccipital; s - sphenotic; v - vomer.

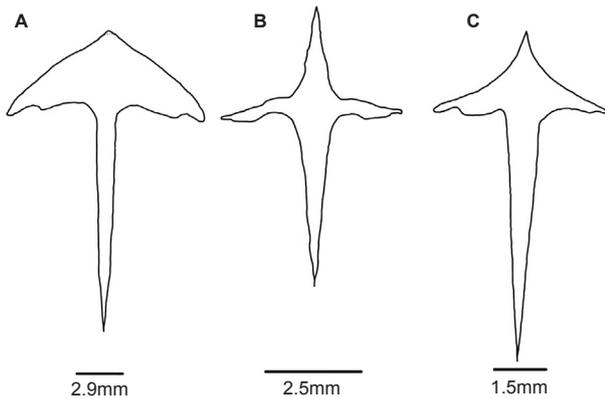


Figure 6. Ventral view of vomer: **A** - *G. chindwinica* (MUMF 9997), **B** - *G. manipurensis* (MUMF 4030) and **C** - *G. ngapang* (MUMF- 6141).

into tripartite or multipartite structures have also been reported in *Euchiloglanis kishinouyei* Kimura (de Pinna 1996). This study shows that structure of premaxilla in most of the examined species have a pair of medially located proximal elements and another pair of distal

elements situated laterally. However, the premaxilla in *G. cavia* and *G. chindwinica* is markedly different, consisting of numerous posterior elements and distal elements in addition to proximal elements. Gauba (1966) recorded the premaxilla of *G. cavia* as being generally segmented or fused to form an enormously broad band that extends a considerable distance posteriorly across the palate. However, he failed to notice the numerous individual tooth plates tightly attached by connective tissue.

The holotype of *Glyptothorax burmanicus* Prashad & Mukherji (Image 1A) has been examined. It has a central depression in the thoracic adhesive apparatus (Image 1B) and a premaxilla in the form of a broad patch with minute villiform sharp teeth and a dentary with broad teeth-bearing plate (Image 1C), the characters, similar to those of *G. cavia* and *G. chindwinica*.

Among the representatives of family Sisoridae, the posterior portion of the Weberian lamina is reported to extend along the anterior margin of the fifth vertebra in *Bagarius*, *Gagata* Bleeker, *Glyptosternoids*, *Glyptothorax*, *Nangra* (Day), *Pseudecheneis* Blyth and *Sisor* Hamilton (de Pinna 1996). This study indicates that the extension



Image 1. *Glyptothorax burmanicus*, ZSI F10877/1, holotype, 100.8mm SL, Burma: Sankha. **A** - lateral, **B** - thoracic adhesive apparatus, **C** - tooth band on jaw

of the posterior portion of the Weberian lamina is not equal within the genus *Glyptothorax*. In the species under study, the posterior portion of the Weberian lamina is extended laterally to the level of the lateral margin of its anterior portion, except in case of *G. cavia* and *G. chindwinica*. A similar condition has been reported in *G. major* (de Pinna 1996: Fig. 26A) and in *G. honghensis* Li (Zhou & Zhou 2005: Fig. 6B). In *G. cavia* and *G. chindwinica*, the lateral expansion of the posterior portion of the Weberian lamina is long and reaches almost to the distal tip of the parapophysis of the fifth vertebrae.

Large variations in osteological characters of the Weberian lamina, infraorbital series, the shapes of the vomer and frontal have been observed among the members of the genus. However, pending examination of more species of the genus, it is not possible to establish the paraphyly of *Glyptothorax*. This study will help future workers to some extent in the study of phylogenetic relationships within *Glyptothorax*.

Comparative Materials

Glyptothorax striatus: Uncat., 2 exs., 79.7-83.0 mm SL, ICAR Complex for northeastern region, Barapani, Meghalaya, India, coll. B.K. Mahapatra; 31.x.2005, 4

exs. 40.2-123.9 mm SL, Siren River, Rotung, East Siang District, Arunachal Pradesh, India, coll. K. Nebeshwar, MUMF 9040.

Glyptothorax cavia: 2 exs. 86.4-98.0 mm SL, left Bank of Kosi River, two furlongs down the confluence with the Arun River at Tribeni, Nepal, Kosi survey, F218/2; 2 exs., 82.8-80.3 mm SL, Same data, F219/2; 06.xi.2006, Uncat., 1 ex. 87.5 mm SL, Barak River, Tamenglong District, Manipur, India, coll. Kingson.

Glyptothorax manipurensis: 10.xii.1998, 10 exs., 69.0-104.0 mm SL, Barak river, Vanchengphai, Manipur, India, coll. K. Nebeshwar, MUMF 4029-4032.

Glyptothorax ventrolineatus: 15.i.2003, holotype, 85.8mm SL, Iril River, Ukhrul District, coll. I. Linthoingambi, MUMF L0221; 5 exs., Paratypes, 85.1-94.5 mm SL, data same as holotype, MUMF L0222/5; 10.iv.2003, 4 exs., 67.2-83.2 mm SL. Lokchao River, Moreh, Chandel District, Manipur, India, coll. K. Nebeshwar and party, MUMF 4300/4.

Glyptothorax ngapang: 06.vi.2001, holotype, 82.7mm SL, Iril River, Bamonkampu, Manipur, India, coll. I. Linthoingambi, MUMF 6131; paratypes, 9 exs, 61.7-99.5mm SL, same data as holotype, MUMF 6132; 10.iv.2003, 65.0-98.5mm SL, 10 exs., Lokchao River,

Moreh (Indo-Myanmar border), coll. W. Vishwanath, MUMF 6141.

Glyptothorax granulatus: 10.i.2004, holotype, 76.6mm SL, Iril River, Phungdhar, Ukhrul District, Manipur, India, coll. I. Linthoingambi, MUMF 6151; 06.vi.2003, paratypes, 10 exs., 61.7-76.6mm SL, same data as holotype, MUMF 6152; 12.xi.2003, 1ex., 96mm SL., Iril River, Urup, Manipur, India (Chindwin basin), coll. Linthoi, MUMF 9991; 03.iv.2004, 10exs., 80.5-89.8 mm SL Lokchao river, Moreh (Indo-Myanmar border), coll. W. Vishwanath, MUMF 6156.

Glyptothorax chindwinica: 26.viii.2002, holotype, 145.4mm SL, Iril River, Urup, Manipur, India, coll. I. Linthoingambi, MUMF 6366; 03.iv.2004, 115.6-145.5 mm SL, paratypes, 4 exs., Lokchao River, Moreh (Indo-Myanmar border), Chandel District, Manipur, India, coll. W. Vishwanath, MUMF 6368; 15.i.2004, 5 exs, 100.2-123.6 mm SL, Thoubal River, Nongpok Keithelmanbi, Thoubal District, Manipur, India, coll. I. Linthoingambi, MUMF 6369.

Glyptothorax burmanicus: holotype, 100.8mm SL, Sankha, a large hill-stream, midway between Kamaing and Mogaung, Myitkyina District, Upper Myanmar, coll. Dr. B.N. Chopra, ZSI F10877/1.

Glyptothorax botius: 16.iii.2006, 75.2mm SL, Dibru River, Dibrugarh, Assam, India, coll. Santosh, MUMF 9520.

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