

LOWER VERTEBRATE FAUNA FROM THE UPPER SIWALIKS OF SURAI KHOLA, DANG VALLEY, WESTERN NEPAL

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ABSTRACT

The upper Siwaliks of Surai Khola (West Nepal) have yielded a lower vertebrate assemblage which is represented by four types of pharyngeal teeth of fishes and two types of reptilian teeth. About 500 specimens were recovered from the fossiliferous horizon which has earlier been palaeomagnetically dated as ca. 4.2 Ma. Vertebrate fauna of the Surai Khola is similar to that earlier reported from the Tatrot/Pinjor Siwalik succession of India.

INTRODUCTION

Vertebrate fossils in the Siwalik Group rocks are extremely useful for studies concerning biostratigraphic correlation and origin and evolution of the Cenozoic terrestrial vertebrates. We describe the Upper Siwalik fossil fish and reptile remains and discuss palaeo-ecology during the Upper Siwalik sedimentation in the western Nepal.

The Surai Khola area, south of Dang Valley in west Nepal (fig. 1a) is chosen for the study. The Surai Khola profile is well exposed with massive outcrops along the National Highway between Surai Naka and Rang Sin

Khola covering a distance of about 16 km. A detailed litho-biostratigraphic study of the surveyed area has earlier been carried out by dividing the complete succession into five litho-units, e.g., Bankas Formation, Chor Khola Formation in ascending order with a total thickness of about 5500m (Corvinus, 1988; Corvinus and Nanda, 1994). On the basis of the magnetostratigraphic studies, a time span of ca 13-1 Ma has been indicated for the deposition of the complete Siwalik succession in the area (Appel *et al.*, 1989, 1991). The Surai Khola profile shows gradual coarsening upward cycle from fine clasts and mudstones intermixed with thinly micaceous sandstones to gravels and conglomerates in the upper part.

Microvertebrate remains were collected from a 5.4m thick fossiliferous horizon, about 3500 m above the base of the succession (figs. 1b,c), forming a part of the Surai Khola Formation. The sediments have a general dip of 65-75 degrees to the NNW, striking more or less in WSW-ESE. The lower part of the fossiliferous horizon is a 4m thick fine grained, friable, yellowish sandstone showing current ripples and cross laminations. It is overlain by a fine to coarse grained brownish and compact sandstone showing small scale planer cross-beddings and small concretions. This sandstone is overlain by thinly bedded (10-21 cm), highly crushed blackish claystone. The claystone is followed by a 1.3 m thick, compact, dark grey and highly fossiliferous mudstone with concretions and showing parallel laminations. It has yielded a number of fossils and the material described herein was collected from this horizon. An age of about 4.2 Ma has been assigned to the fossil horizon on the basis of palaeomagnetic studies by Appel *et al.* (1991; see fig. 1b).

MATERIAL AND METHODS

Washing and screening method was employed for recovering the assemblage described herein. Drawings of specimens were made under M-5 (Wild) stereomicroscope and high resolution studies were done under Scanning Electron Microscope (Jeol, SEM 25). Dental

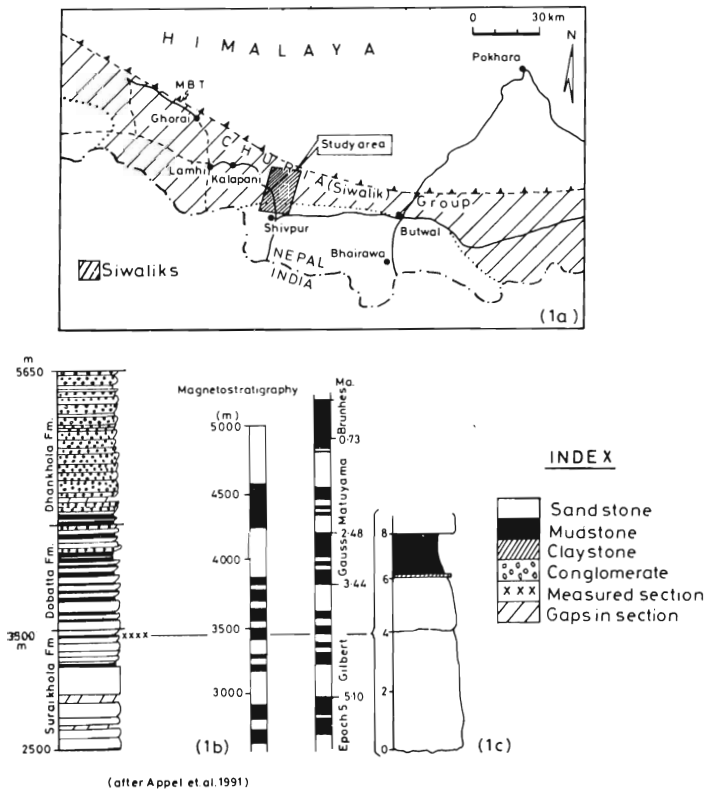


Fig. 1 a. Location map of the area.
 b. Magnetostratigraphy of the Upper Siwaliks of Surai Khola.
 c. Measured fossiliferous horizon.

morphology for fishes and reptiles is taken from Sahni *et al.* (1978, 1984). For morphology of fossil fish scale elements, Bone (1979) is followed. The collection is housed in the Department of Geology, Kumaun University, Nainital. NSP stands for Nepal Siwalik Pisces and NSR stands for Nepal Siwalik Reptiles. The material includes numerous isolated elements, e.g., teeth, scales, spines and broken skeletal elements. For comparison of fossil fishes, available fossil and Recent material was used.

SYSTEMATIC DESCRIPTION

Superorder Ostariophysi

Order Cypriniformes

Family Cyprinidae

1. Teeth

Type A (Cyprinid pharyngeal teeth) (figs. 2-3)

Referred Material : NSP/ 206-215, isolated pharyngeal teeth.

Horizon and age : Compact greyish mudstone of the Surai Khola Formation (figs. 1b-c), age 4.2 Ma.

Description and remarks : Characteristic features of mostly unworn teeth are: anteriorly pointed and posteriorly broader teeth, cylindrical in outline with hook-shaped pointed apex, grinding surface usually beneath the hook, pointed to rounded crown in outline characteristically enveloped in the thick enameloid covering, anterior margin convex while the antero-posterior slopes steep towards the base, roots hollow and oval in cross-section and filled with matrix, and presence of striations and wrinkles at the base. The maximum and minimum length of the teeth is 3.60 mm and 1.60 mm respectively, and maximum and minimum width is 1.84 mm and 0.60 mm respectively.

Similar forms have been reported from the Upper Dharamsala Formation (Tiwari *et al.*, 1991, pl. 1, figs. 9-13) and from the Oligo-Miocene Kukso Formation of the Indus Group, Ladakh (Sahni *et al.*, 1984, pl. 1, fig. 2). The Surai Khola fauna shares a few characters with both the Dharamsala and Ladakh fauna in having cylindrical and hook-shaped teeth, very well developed crown with enameloid cover and cylindrical antero-posterior slopes. However, it can be differentiated from both the Dharamsala and Ladakh fauna by larger size, pointed to sub-rounded apex with much broader grinding surface beneath the hook covering thick enameloid layer and striations and wrinkles at the base.

Type B (cyprinid pharyngeal teeth) (figs. 4-5)

Referred Material: NSP/ 307-309, 311, all isolated pharyngeal teeth.

Description and remarks : The teeth are high crowned, conical, anteriorly broader and posteriorly narrower with flattened crown. In lateral view, the occlusal plane of crown is strongly oblique to longer axis with folded enameloid, and in occlusal view, the grinding surface is broader, oval in shape and curved laterally. The maximum and minimum length of the teeth is 3.20 mm and 1.56 mm respectively and maximum and minimum width is 3.32 mm and 0.92 mm respectively.

The fauna is similar to that of the upper Siwaliks of Pinjor, described by Raghawan (1988, pl. 10, figs. 34-42, pl. 11, figs. 1-5), to that of the Plio-Pleistocene Karewas, described by Kotlia (1989, pl. 3, figs. 1-2, plate 4, figs. 1-2), and to that of the upper Dharamsala, described by Tiwari *et al.* (1991, pl. 1, figs. 7-8) in the following characters, (1) conical shape, (2) anteriorly broader and posteriorly narrower, (3) flattened crown, oblique to the longer axis with folded enameloid and, (4) broader occlusal surface of the crown. However, the Surai Khola material can be differentiated from the above by, being comparatively bigger in size, strongly oblique crown to the longer axis, and the crown having thick enameloid covering on the lateral side. Only one isolated and broken tooth similar to the present teeth has also been reported from the Siwaliks of west Nepal by West *et al.* (1991, fig. 5a).

The present material is compared with a few known Recent fishes of Nepal and India. Out of the six genera of South Asian Cyprinids (Shrestha, 1990), only *Catla* and *Labeo* have such elongated teeth. The present material resembles the Recent *Labeo* by broad occlusal surface of the crown with thick enameloid envelope. However, it differs from *Labeo* by, conical shape of teeth and strongly curved crown. It may be mentioned that the Pinjor and Karewa fauna have anteriorly rounded teeth with slightly circular crown with very gentle curvature.

Type C (cyprinid pharyngeal teeth) (figs. 6-7)

Referred Material : NSP/ 404-411, isolated pharyngeal teeth.

Description and remarks : The teeth are bigger in size, conical to cylindrical in outline, sometimes globose with well exposed grinding surface and crown elliptical to semi-circular. The crown is unicusate and sometimes acute, occasionally triangular in outline. In a few specimens, there are ridges on the crown extending along the antero-posterior diameter of teeth. The

peripheral margin of crown is smooth. The maximum and minimum length of teeth is 3.20 mm and 1.20 mm respectively and maximum and minimum width is 1.60 mm and 0.80 mm respectively.

The teeth, earlier reported from the Pinjor Siwaliks (Raghawan, 1988, pl. 10, figs. 23-33, 35) and the Karewas (Kotlia, 1989, pl. 2, figs. 1-8) appear to show similarity with the present teeth by some what globose shape and unicusate and sometimes acute crown.

Type D
(figs. 8-9)

Referred Material : NSP/ 21-29, all isolated teeth.

Description and remarks : The large cardiform teeth are anteriorly narrower, posteriorly broader, conical in shape, inclined apically and constricted sub-basally. The crown is blunt, tapers upwards and is enveloped with a thin layer of enameloid, and faint vertical striations are seen on it. The anterior margin of the crown is rounded and looks like a ridge in lateral view. A few teeth are strongly inclined from the apex while some are almost straight with pointed crown. Generally, the roots are broken, some are filled with clay matrix. The maximum and minimum length of teeth is 3.60 mm and 1.28mm respectively and the maximum and minimum width is 1.48 mm and 0.60 mm respectively.

The Surai Khola material has similarity with the fauna described from the Pinjor Siwaliks by Raghawan (1988, pl. 10, figs. 4-22) in having, long and conical teeth which are anteriorly narrower and posteriorly broader with well developed and blunt crown having a thin layer of enameloid. However, the present teeth may differ from the Pinjor teeth by comparatively bigger size, teeth broader at the base and rounded anterior margin, lesser degree of inclination on the curvature in apical region, and presence of wrinkles and striations at the base. Similar kind of teeth are present in the Recent *Channa* (*C. stratus* and *C. mullius*) which has numerous conical teeth of different sizes present on the premaxilla and prevomer. The present teeth show similarity with those of Recent *Channa* by smooth and conical shape of anteriorly narrower and posteriorly broader teeth, well developed crown covered with thin transparent enameloid layer, curved or inclined apex and broader base with wrinkles and striations. However, it differs from the Recent *Channa* by larger teeth, blunt crown with well developed anterior margin and presence of vertical striations on the crown as well as at the base.

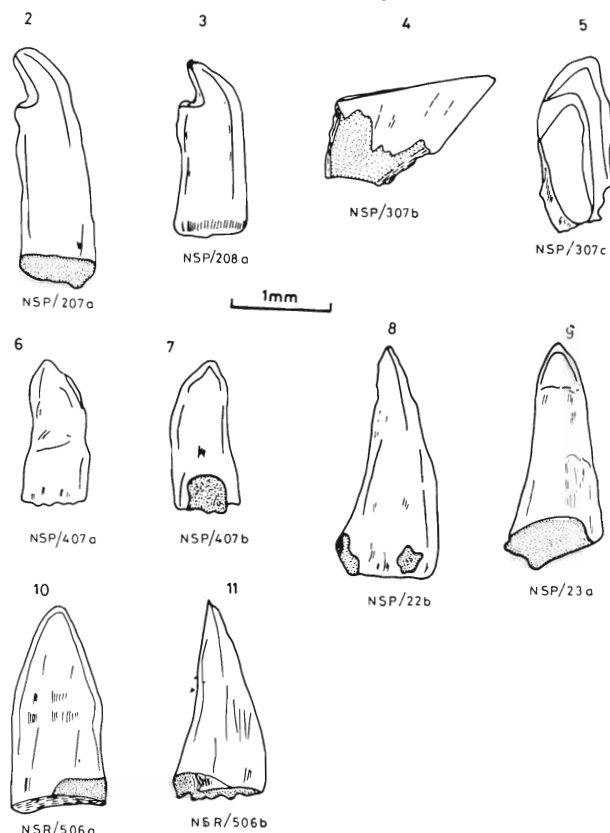
2. Scale Fragments

Type A
(Pl. I, figs. 1-2)

Referred material : NSP/ 1001, 1002, 1005, 1045, 1057, 1061, 1063, 1076, 1077, all isolated scale fragments.

Description and remarks : The scales are sub-circular to circular in outline with their basal margin narrower than apical margin with serrated edge. The circuli are closely packed in the apical region (as in NSP/ 1001, 1055; pl. I figs. 1-2) and are somewhat straight in the centre. In the basal region, the circuli become much thicker forming a ridge like structure (as in NSP/1001, 1005; pl. I figs. 1-2) and are sparsely packed. The focus is well preserved and spindle shaped (as in NAP/1001, 1005; pl. I figs. 1-2) In a few specimens, the basal region is ornamented with numerous minute nodules of different sizes arranged in rows (NSP/1001; pl. I fig. 1) with regular interspaces.

The scales reported from the Upper Dharamsala Formation (Tiware *et al.*, 1991, pl. 2, figs. 1-5) show close similarity with present material by almost similar size



Figs. 2-3. Pharyngeal teeth of Type A, a= left view.
Figs. 4-5. Pharyngeal teeth of Type B, a= right view, c= occlusal view
Figs. 6-7. Pharyngeal teeth of Type C, a= right view, b= left view.
Figs. 8-9. Conical teeth of Type C, a= occlusal view, b= lateral view.
Figs., 10-11. Reptilian teeth of Type A, a= occlusal view, b= lateral view

and shape with serrated segtes, well developed sharp circuli in apical region, chromatophores in form of ridges in the basal portion and well developed spindle shaped focus. However, Surai Khola scales differ from those of the Dharamsala scales by the arrangement of circuli (thicker towards the basal part), broader ridges in the basal portion, and better developed and bigger focus.

The present fossil elements are compared with the scales of the recent fishes, e.g., *Tor tor* and *Labeo rohita* and appear to resemble the both by bigger and more or less circular scales, well preserved circuli in apical portion of the scale and a well developed focus. However, *Tor tor* and *Labeo rohita* differ from the present material by smooth edges of scales, very thin and closely packed circuli, shape of focus, presence of oblique radii both in apical and basal regions, thicker and irregular circuli because of radii in the basal region and absence of tubercles/ nodules in the basal region. A comparative study reveals that the present scales certainly have some distinct characters, e.g., broader and serrated edged scales, very thick and broader circuli and presence of tubercles forming a ridge-like structure.

Type B
(Pl. I, figs. 3-4)

Referred Material: NSP/1004, 1006, 1007, 1008, 1016, 1023, 1025, all isolated scale fragments.

Description and remarks: The scales, thick at centre and thin towards the margin, are characterised by thin circuli becoming circular towards the focus and are sparsely placed in the basal region, presence of the characteristic oblique circuli (radii) in the posterior portion forming a comb like structure (Pl. I, figs. 3-4), and the arrangement of tubercles or ctenii of different shapes and sizes in the apical part in different manners.

Similar scales, recovered from the Pinjor Siwaliks (Raghawan, 1988, plate 13), have been referred to *Nandus* (family Nandinae) and *Badis badis* (subfamily Pristolepidinae). The Surai Khola scales resemble the Pinjor fauna by thin and closely packed circuli, and characteristic oblique radii running towards the margin. Similar scales have also been reported from the Plio-Pleistocene Cache Formation of the Lake County (Casteel and Rymer, 1975, fig. 2d) under *Archoplites interruptus* (family Centrarchidae). The present material shares some characters with the Lake County fauna, e.g., thin and closely packed circuli, well developed radii in the basal region, and circular focus and numerous ctenii in the apical portion. However, the present scales differ by shape and size, orientation of circuli and radii in the apical and basal portion and position of the focus.

3. Spines

Type A
(Pl I, fig. 5)

Referred Material: NSP/ 701, 702, 706, 712, 714, all spine fragments.

Description: The large sized spines, broken from anterior and posterior sides without any sign of proximal end, are broad. No articulating head is preserved. Denticulations are almost at right angle to longer axis of the spines. They are long, conical, widely spaced and directed anteriorly. Longitudinal striations are present on the dorsal side. The Surai Khola spines have posteriorly directed denticles and there is comparatively wider pace between two denticles compared to that in *Schizothorax esocinus* and *Oreinus*, reported by Kotlia (1989, pl. 6, figs. 1-11). The spines have broader antero-posterior axis with strong serrations on the dorsal side. The Karewa spines, referred to as *Schizothorax* and *Oreinus*, show similarity with the Surai Khola spines.

Type B
(Pl. I, figs. 6-7)

Referred Material: NSP/802, 804, 812, 813, 816, all spine fragments.

Description and remarks: The spines are medium to long, conical in shape and without denticulation. The proximal end bears a well developed and strong articulating head with ridges and furrows along antero-posterior axis. The distal part is smooth and median valley is deep. The present spines are differentiated from the Pinjor material (reported by Raghawan, 1988) by broader spines, broader and rounded articulating head, broader median valley, and smooth and broader distal part.

Class Reptilia

Order Crocodilia

Family Crocodylidae

Genus Crocodylus Laurenti, 1768

Crocodylus Type A
(figs. 10-11)

Referred Material: NSR/501-506, all isolated teeth.

Description and remarks: Teeth are longer relative to their cross-section diameter, bicarinate and vertically faceted with the average length 3.04-4.00 mm (mean 3.54 mm) and average width 1.60-1.88 mm (mean 1.70mm). The carina of the teeth lie in about the same plane as the plane of curvature. The saber-shaped apical portion has expanded base. The crown surface is smooth, non wrinkled and non serrated and the tip is pointed. The enamel is smooth. On the anterior and posterior mar-

gins, a ridge is present which acts as cutting edge. Wrinkles, faintly visible, are present at the base.

A few isolated crocodylian teeth have earlier been reported from the Upper Dharamsala Formation (Tiwari *et al.*, 1991, pl. 2, figs. 10-13). The Surai Khola teeth are similar to the Dharamsala material in having conical, longer and broader teeth, smooth crown with pointed tips, and the ridges on the anterior and posterior margins. However, the Nepal fauna differs greatly by comparatively longer and broader teeth, more pointed tips, conical and smooth crown surface, sharper and more flattened cutting edges, smooth antero-posterior area, and broader base.

Crocodylus Type B
(Pl. I, figs. 8-9)

Referred Material: NSR/601-603, 605-608, 611-613, all isolated teeth.

Description and remarks: Teeth are longer, conical, anteriorly narrower and posteriorly broader. The crown is fairly high, smooth, pointed and straight, sometimes slightly curved in the lateral view. The fluting is prominent, vertically oriented, widely spaced and is restricted up to the lower half of the teeth forming a ridge-like structure. Since the teeth possess prominent fluting and are longer than broader, these can be differentiated from the specimens described from elsewhere in India. However, they resemble *Type B* category of Sahni *et al.*, (1978, pl. 1, figs. 1-11) by conical shape, long and curved, prominent fluting and well developed crown surface, but differ by comparatively bigger size, strongly conical, non-serrated, smooth crown surface fluting restricted to the lower half of the teeth.

DISCUSSION

A majority of species present in the fossil material belongs to the family Cyprinidae which is essentially freshwater and has the widest continuous distribution in the world's freshwaters. The members of this family thrive best in pools, ponds and other bodies of stagnant

and slow flowing muddy waters. However, a few members prefer clean stretches of water with sandy bottom. The Recent members of this family are found in the Himalayan streams/ rivers of Nepal (Shrestha, 1990) and India. On the other hand, the presence of reptiles indicates a large body of water with plenty of vegetation. They prefer warmer conditions with swampy vegetation.

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EXPLANATION OF PLATE

Plate I

- 1-2. scale type A, x 45.
- 3-4. scale type B, 3 x 45 & 4 x 30.
5. spine type A, x 30.
- 6-7. spines type B, x 20.
- 8-9. Reptilian teeth type B, x 30.

