Fauna and palaeoenvironment of a Late Quaternary fluvio-lacustrine basin in Central Kumaun Himalaya

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In recent years, vertebrate faunas recovered from the Late Quaternary lake deposits have become increasingly important, especially for phylogenetic relationship, evolutionary pattern, comparison with the Recent counterparts, palaeoecology and palaeoenvironment. We describe the Late Quaternary fauna from a tectonically formed palaeolake basin at Dulam, Kumaun Central Himalaya. The age of the fossil horizon is estimated as ca. 30 ka BP. Murids and other faunal elements have been recovered from the Kumaun Himalaya. The large mammals are represented only by Bovidae, whereas the small ones are dominated by murid rodents. The bones have greater frequency compared to the teeth. Based on the faunal components, four palaeocommunities are proposed. The savanna grassland community is represented by the large mammals, the lacustrine community by Cyprinidae fishes, ostracods and freshwater gastropods, the upland community by Soriculus and Mus, and semi-arid bushland community by Golunda and lizards.

The rising of the Himalayan mountain chain in response to crustal foreshortening has caused the accumulation of stress throughout the Himalaya and is manifest in episodic neotectonic upheavals along the thrusts and faults that delimit the boundaries of the Himalayan terrain. One of the consequences of the tectonism during the Quaternary period has been the reactivation of faults/thrusts, resulting in the blockade of the ancient drainage and impoundment of rivers/streams and formation of palaeolakes or dams. In the Kumaun Lesser Himalaya, neotectonic displacements, particularly in the Quaternary period, took place not only along the intracrustal boundary thrusts, but also on the faults parallel or oblique to the boundary thrusts. The revival of later movements led to the failure of these palaeolakes and their ultimate disappearance. The present work was carried out in a tectonically formed palaeolake at Dulam (30°06'05"N; 79°55'30"E), Kumaun Lesser Himalaya (Figures 1 a and b). The basin was formed by block-ade of the river Saryu due to upliftment on the Dulam Gadhra Fault (Figure 1 b). This event of tectonic activity may have been responsible for depositing the huge and unsorted gravel consisting of heavy boulders to small rock fragments of country rocks just below the fluviolacustrine section. The lake was breached out because of the deposition of another huge and far thicker gravel, probably triggered by a further event of the tectonic activity (J. Sanwal, unpublished). Thus, neotectonics played an important role in the formation as well as closure of the Dulam palaeolake. A number of geomorphic features, e.g. abrupt changes in the course of the river, terraces, waterfalls, fault scarps, etc. in the study area suggest the role of tectonic activity. Numerous later-developed faults are also responsible for off-setting the country rocks, which are composed of Rautarga, Deoban, Mandlai and Bieringa Formations.

The 5.03 m thick profile (Figure 1 c) is bounded by two huge gravels. The profile (excluding both gravels) is divided into the following units; Unit-1 (sand, 0-40 cm); Unit-2 (carbonaceous mud, 40-225 cm); Unit-3 (sand, 225-262 cm); Unit-4 (sandy mud, 262-272 cm) and Unit-5 (sand, 272-503 cm; J. Sanwal, unpublished). The fossil horizon, 40-45 cm above the base (Figure 1 c), is dark greyish carbonaceous mud in which are embedded the bluish coloured and medium-to-coarse-grained sand lenses. These lenses are rich in fossil fauna. Occasional burrow structures are also present.

Two radiocarbon dates were obtained on charcoal layers (Figure 1). Using the dates, an accumulation rate of about 43 cm/1000 yr can be approximated for the homogeneous part of the section; hence the base of the profile can be approximated as ca. 32 ka BP and the age of the fossil horizon as ca. 32 ka BP. The formation of Dulam lake may be contemporaneous to the Wadda lake in Pithoragarh that was formed about 36 ka BP.

So far, the only report of a Quaternary vertebrate assemblage from the Kumaun Himalaya is from the Upper Pleistocene fluvio-lacustrine deposits, exposed at Bilaspur near Bhimtal. The fossil micromammalian horizon with an age of ca. 50 ka BP, has yielded fossil Soricidae (Sorex) and Muridae (Mus). The discovery of Late Quaternary mammalian assemblage from the Kumaun Himalaya has opened avenues for better understanding of the evolutionary history as well as the phylogenetic relationships between the Upper Pleistocene and Recent genera of a number of micromammals.

The present collection comprises both vertebrate and invertebrate fossils. Fossil vertebrates include both large...
(Bovidae) and small mammals, lizards and fishes. The faunal list is presented in Table 1. Among invertebrates, ostracods are most abundant. A few broken and unidentifiable shells of gastropods and gyrogonites of Charophyta also form a small part of the collection. The total number of well-preserved elements is 1205, including 1110 specimens of vertebrates, 86 of ostracods (belonging to two genera), 5 broken gastropod shells and 4 charophyte gyrogonites. Among vertebrates, only identifiable teeth are used although broken fragments are also counted and used for palaeoecological reconstruction. Although complete bones are identifiable, main emphasis is given to jaws, molars, incisors, lizard dentaries, including teeth and fish teeth.

*Mus indicus* is characterized by strongly distorted and moderately elongated M₁ with prominent conules in front of the t₃, higher magnitude of stephanodonty (between t₁ and t₄ and between t₁ and t₆), moderately reduced M₃ (about 56% of M₂ length) and stronger connection between the cusps. A number of characters make this species very close to present-day *M. booduga* and *M. dumni* and probably closer to *M. dumni*. We suggest that *M. auctor*, *M. flyni*, *M. jacobsi*, *Mus* sp., *M. indicus* and *M. dumni*
are related to each other and that (i) increase in anterior expansion in M₁, (ii) stephanodonty and strong relation of cusps in the molars, (iii) narrowing of the upper first molars that can be observed in the position of t₁ in the first chevron, and (iv) forward bending of the cusps in the lower molars may be considered as derived characters in the genus. Comparing measurements, morphological features and all the known evolutionary characters, a tentative phylogeny of Mus at least in the Indian subcontinent, can be suggested as Progonomys debruijini–M. auctor–M. jacobi–Mus sp.–M. indicus sp. nov.–M. booduga (Figure 2). Thus, M. indicus sp. nov. is comparatively more derived than M. auctor, M. jacobi and Mus sp., and it probably gave rise to the species very close to more specialized and extinct M. booduga/M. dunni. The great diversity of Mus in terms of both taxa and numbers indicates that the probable place of its origin was the Indian subcontinent and it may have migrated to the African continent during the Pliocene times.

Golunda dulamensis has highly derived characters, e.g. stephanodonty, cusps in M₁ strongly inclined backward giving the molars a stretched aspect, and metaconid and entoconid in M₃ forming almost straight lingual row of cusps. We suggest that that highly specialized molars of G. dulamensis sp. nov. and present day G. elioti are derivable through G. kelleri. We propose that G. kelleri gave rise to G. dulamensis sp. nov., which in turn possibly evolved into present-day G. elioti. G. dulamensis sp. nov. has an APR (anterostyle position ratio) of 0.58 falling in the Karnimata stock and is very close to G. elioti (APR = 0.56). Today, Golunda is a monotypic genus occurring only in India and Pakistan. The oldest Golunda (G. tatroticus) has been recovered from Asia and not from Africa; it is quite unlikely that the African G. gurai was a probable ancestor of the Asiatic Golunda. Moreover, some workers have already shown that African G. gurai should not be included in the Golunda stock, as it shows closer affinity to Parapelomys charhensiso. It is therefore suggested that Golunda may have originated in Asia prior to 4–5 Ma and migrated westwards during the time of the extensive murid migration in the Pliocene from Asia to Africa (through Arabia) instead of Africa to Asia as was thought by earlier workers. Reports of Golunda from Egypt and Ethiopia from comparatively younger rocks also indicate that it migrated westwards.

Although using only a couple of molars, the first fossil Soriculus (Tribe Soriculini) in the Indian subcontinent has also been reported from the study area. It is distinct from the Recent species in having a definitive metapoph and rounded postero-lateral edge. Although the present material is too little to ensure a definite conclusion, the two characters, absence of metapoph and postero-lateral edge becoming elongated, seem to be involved in the progressive evolution in Soriculus. Based on the detailed comparison of the present specimen with nearly all the present-day species of the genus and a large number of dental elements of Episoriculus repenningi from the Kherekas, we suggest that the E. repenningi may be included in Soriculus as it is in the living range of present day Soriculus.

Among the lizards, the first well-illustrated Uromastix was reported from the Indian Siwalik by Raghavan. Subsequently, a few teeth of Calotes and Uromastix were reported from the Upper Siwalik sediments. Excepting these small reports, nothing so far is known from the Indian subcontinent about the fossil lizards. This study reports of the fossil lizards from the fluvio-lacustrine deposits of India and Ablepharus from India. The dentary is much smaller compared to other genera of the subfamily, excepting Ablepharus. In the lingual view, a longitudinal prominent groove is found. Most bicuspid teeth, almost equal in

Table 1. Faunal list of palaeontological remains from Dulami, Kumaun Himalaya

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Extant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammalia</td>
<td>Artiodactyla</td>
<td>Bovidae</td>
<td>Bovidae indet.*</td>
<td>M. indicus</td>
</tr>
<tr>
<td>Rodentia</td>
<td>Muridae</td>
<td>Mus</td>
<td>Golunda dulamensis</td>
<td>M. auctor</td>
</tr>
<tr>
<td>Insectivora</td>
<td></td>
<td>Soriculus</td>
<td>Soriculus sp.*</td>
<td>M. jacobi</td>
</tr>
<tr>
<td>Reptilia</td>
<td>Sauria</td>
<td>Ablepharus</td>
<td>Ablepharus sp.*</td>
<td>M. shortridgei</td>
</tr>
<tr>
<td>Osteichthyes</td>
<td>Cypriniformes</td>
<td>Cyprinidae</td>
<td>Conical teeth Sub-type A*</td>
<td>M. musculus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conical teeth Sub-type B*</td>
<td></td>
</tr>
<tr>
<td>Crustacea</td>
<td>Pododocopida</td>
<td>Cyprididae</td>
<td>Candonopsis kingslei*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Candoninida</td>
<td>Cyprinidae</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parastenocypris</td>
<td>Kumaunensis*</td>
<td></td>
</tr>
</tbody>
</table>

*First report from Kumaun Himalaya.

Figure 2. Tentative phylogeny of Mus in the Indian subcontinent based on a number of characters.
the crown height, are closely packed with sub-rounded and unstriated crown. Nearly all the genera, except Ablepharus are much bigger than the present material and therefore, it can be compared only with Ablepharus which has long and slender dentary with bicuspoid teeth.

A major part of the present vertebrate faunal assemblage comprises Rodentia forming about 86.9% of the total collection. It is followed by Pisces (3.23%) and Reptilia (1.58%). Insectivores (0.33%) and bovids (0.08%) are less representative groups. Among invertebrates (7.88%), the most abundant group is Ostracoda forming 7.13% of the collection, followed by gastropods together with charophytes forming 0.75% of the assemblage. The relative frequency of occurrence of various components of a fauna is best estimated by calculating the minimum number of individuals belonging to a particular taxon. However, it must be pointed out here that this method gives only an approximate idea of the community structure and relative frequency of occurrence of component taxa. Although the bones have greater frequency (74.4%), a good frequency of teeth (23.2%) may be due to durability of these elements, especially thick enamel which can withstand the abrasion and weathering during transportation. Among bones, the lighter ones are few. This may be because of their fragile nature. The vertebrae (1.53%) and jaws (0.8%) are poorly represented. There are no cracked teeth, no tooth crushing marks and no etching in tooth enamel. This suggests that the remains were not exposed subaerially for some time and also that the assemblage was probably not subjected to long transportation.

According to the ecological niches of various fossil forms, four palaeocommunities can be distinguished in the present faunal collection (Figure 1a). The savanna grassland community is represented by Bovidae, which shows varied adaptations ranging from grasslands to savanna and woodlands. The lacustrine community is represented by Cyprinidae fishes. The area may have had forested cover inhabited by the large and small mammals and was intersected by streams having cyprinid fishes together with fresh water ostracods and gastropods, which are the major invertebrate elements in the present material. For example, Parastenocypris prefers the shallow channels or smaller lakes, ponds and pools. Candonopsis kingslei is generally found in permanent, small freshwater bodies and lakes as well as weedy margins of shallow and boggy ponds. Although the gastropod shells are broken, they seem to be very similar to those of Sttocinella, which is indicative of lacustrine conditions. Gaur and Chopra have included small fishes, charophytes and gastropods in pond populations of the aquatic community of the Siwalik deposits in Ramnagar. The upland community is represented by Soricus and Mus. Today, S. (E) caudatus lives in the altitude between 2300 and 4300 m, whereas S. nigrescens is found between 2300 and 3200 m altitude. Most of the living forms of this genus reach up to the Alpine zone. It seems that the remains of Soricus were washed down into the Dulum basin from surrounding mountains. Mus has a wide ecological range, from moist forests to arid scrub, and seems to be successful in the areas of ecological diversity as long as they have sufficient vegetation. The semi-arid bushland community is represented by Golunda and lizards. Golunda reflects savanna woodlands and savanna grasslands, although G. elliotti lives in thickets of bushes. Ablepharus (common name ocellated skink) lives in the Mediterranean ecozone, where it inhabits open areas of pine forests in semi-arid climatic conditions. It is found in Southeast Europe, Central Asia, Russia and the Middle East.

RESEARCH COMMUNICATIONS


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