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PREDATOR-PREY RELATIONSHIP (CERVIDAE & CARNIVORA) AND ITS IMPACT ON FOSSIL PRESERVATION FROM THE SIWALIKS OF PAKISTAN

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ABSTRACT

This paper deals with an introduction of new method that is a predator- prey relationship for preservation of fossils. For this purpose fossil record of order Carnivora and family Cervidae (order Artiodactyla) from late Miocene-Pleistocene times were studied. Our findings extend the idea that the predator-prey relationship is also an additional source for the preservation of fossils being preyed by predators. This test method is applied for the collected fossil material (carnivores and cervids), available at Abu Bakr Fossil Display and Research Centre, Department of Zoology, University of the Punjab, Lahore.

Keywords: Predator-prey relationship, Family Cervidae, Order Carnivora, Fossils.

INTRODUCTION

The fossils of order Carnivora and family Cervidae were studied to interpret a predator- prey relationship from the late Miocene- Pleistocene times from the Siwalik Hills of Pakistan (Barry *et al*., 2002; Holt, 2000) to understand the fossilization processes. Paleoecological analysis has been applied on these groups in fossil form and the preservational completeness of fossil assemblages has been estimated using taphonomic analysis. Some groups of postcranial elements are represented in several recent and archaeological bone assemblages accumulated by carnivores, rodents and hominids (Palmqvist and Arribas, 2001). The se results strongly suggested that these bones were collected mainly by hyaenids (Mazza *et al.*, 2004). It is also proved that hyaena was a bone cracking scavenger which fed largely on carcasses of ungulates preyed upon and partially consumed by flesh eating carnivores such as Saber-toothed felids and wild dogs (Arribas and Palmqvist, 1998). Fossils of *Cervus elaphus* occur in both interglacial/woodland and glacial/steppe faunal complexes suggesting that the species has broad tolerance of different habitats (Sommer *et al*., 2008). Large accumulation of faunal remains from European archaeological sites show that the *Cervus elaphus* was hunted and used as a natural resource by hominines indicating an important step in a food chain and food web. The members of family Cervidae are primary consumers of vegetation and themselves consumed by carnivores, so food web dynamics, both top-down (predation) and bottom – up (food and climatic effects) are prominent in theoretical and applied research involving this family. All living species of family Cervidae may be placed with in a trophic hierarchy (Szmidt, 2008; Schmitz *et al*., 2000). Cervids presumably held similar behavioral and evolutionary characteristics and were susceptible to the same kinds of natural ecological pressures operating today. Predator-prey relationship is an important factor for maintenance of the food chain and food web in natural environments today and this is also true for the past environments. From the Siwalik fossil collections made in the last four decades, we studied fossils of Cervidae and Carnivora. There are almost equal numbers of fossils of these two groups but in the Siwaliks, Cervidae is represented by one genus, *Cervus*, comprising five species: *C. simplicidense*, *C. triplidense*, *C. sivalensis*, *C. punjabiensis* and *C. rewati*, while Carnivora is a diverse group having large number of species and genera, but in this study the fossils of three families including six genera and nine species are discussed as a result of fossil collection (Akhtar *et al*., 1999; Ghaffar and Akhtar, 2004; Bakr, 1986).

Besides this, the excellent fossil record of herbivores or primary consumers and a fragmentary fossil record of carnivores or secondary, tertiary and hyper carnivores indicate that the fossils of primary consumers have an extra additional preservation factor that is lacking

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for the carnivore group. Therefore, we argue that this additional preservation factor is a function of the predator-prey relationship. This predator- prey relationship supports the life of predator while ends the life of prey and enhances the preservation potential of prey while lowering that of the predator.

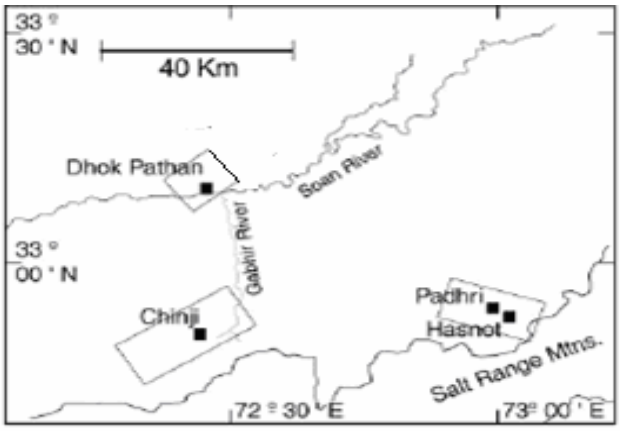

Figure 1: Map of Pakistan showing the study areas of the Siwalik group on Potwar Plateau for the fossils of family Cervidae and order Carnivora (after Barry *et al*., 2002).

The gray wolf (*Canis lupus*) is the most significant predator of ungulates, including family Cervidae, by virtue of their widespread geographic distribution, group hunting nature, and year round activity. From the near past, the additional large predators coexist with wolves along with human hunters, it is possible to assume that predation by these different species is at least an additional factor for fossilization. Large carnivore species resulted in a stepwise reduction in different species of ungulates (Peterson *et al.*, 2003). These types of relationships are fairly well-studied for the fishes and invertebrates but our understandings about the fossils of primary consumers and secondary-tertiary consumers with special reference to cervids and carnivores reveal the better understanding about predator-prey relationship in the vertebrates. For this purpose, we treated the available fossil material of family Cervidae and order Carnivora from the Siwalik continental deposits. The collection of these fossils was made during the last four decades by different paleontological expeditions including the authors of this paper. Bakr (1986) wrote a first comprehensive report on the Siwalik carnivores. This report comprises the taxonomic details of fossil carnivores from the Siwaliks. Later on, Ghaffar (2005) worked on the fossils of family Cervidae and order Carnivora and made a significant collection with other paleontologists. This study is actually a result of those field works done during 1982-2003. It is of interest that some localities bear almost all types of fossils including a variety of vertebrates and invertebrates, as a result of unconfined flood flow contributed to the assemblage's final arrangement (Arribas and Palmqvist, 1998).

MATERIALS AND METHODS

In this study we used all the collected fossils displayed at AbuBakr Fossil Display and Research Centre, Department of Zoology, University of the Punjab, Lahore catalogued as PUPC (Punjab University Paleontological Collection). There are almost 40 fossil specimens of family cervidae an equal number of fossil carnivores. This collection includes five species of *Cervus* and nine species of order Carnivora. All these specimens are collected from Miocene–Pleistocene times (Lower to Upper Siwaliks). This material includes mandibular and maxillary fragments, antlers, and isolated premolars and molars of Cervidae, and well preserved maxillary and mandibular fragments with isolated incisors, canines, premolars and molars of Carnivora. It is important to note that the fossils of Cervidae and carnivores coexisted from late Miocene – Pleistocene time from the Siwalik continental deposits.

SYSTEMATIC PALEONTOLOGY: Taxonomic classification of family Cervidae and order Carnivora follows the Simpson's` (1945) classification.
Family Cervidae Gray, 1821
Genus *Cervus* Linnaeus, 1758

***C. simplisidense* Lydekker 1876, *C. triplidense* Lydekker 1876, *C. sivalesis* Lydekker 1884, *C. punjabiensis* Brown 1926, *C. rewati* Arif and Shah 1991**
Order Carnivora Bowdich 1821
Family Mustelidae Swainson 1835
Subfamily Mustelinae Gill 1872
Genus *Martes* Pinel 1792

***Martes lydekkeri* Colbert 1933**

Subfamily Lutrinae Baird 1857
Genus *Sivaonyx* Pilgrim 1932

***Sivaonyx bathygnathus* Lydekker 1884**

Family Ursidae Gray 1825
Subfamily Ursinae Swainson 1835
Genus *Indarctos* Pilgrim 1913

***Indarctos punjabiensis* Lydekker 1884**
Family Hyaenidae Gray 1821
Subfamily Hyaeninae Mivart 1882
Genus *Crocuta* Kaup 1828

***Crocuta sivalensis* Falconer 1868, *Crocuta carnifex* Pilgrim 1910, *Crocuta gigantea* Schlosser 1903**
Family Felidae Gray 1821
Subfamily Felinae Fischer 1817

Genus *Panthera* Oken 1816
Species *Panthera dhokpathanensis* Bakr 1986
Subfamily Felinae Fischer, 1817
Genus *Sivapanthera* Kretzoi1929

***Sivapanthera potens* Pilgrim, 1932, *Sivapanthera padhriensis* Ghaffar and Akhtar 2004.**

These taxonomic details show that Carnivora is diverse group with a variety of genera and species in fossils form, while family Cervidae is represented only by one genus having five species.

DISCUSSION

The biodiversity of family Cervidae and order Carnivora in the fossil form indicates that there is an additional controlling factor for fossilization of cervids as compare to carnivores. Trophic structure of present day mammalian communities can be used for reconstruction of past terrestrial mammalian dominated communities (Mendoza *et al.,* 2005). This additional preservation factor is predator-prey relationship. In turn this relationship provides a better chance of preservation to family Cervidae after predation in the form of migration to a better medium of preservation and this type of activity is not available for carnivores. Due to this the fossils of carnivores are rare in spite there are large number of species and genera of order Carnivora as compare to single genus *Cervus* with few species of family Cervidae. The red deer has been the subject of several studies with a phylogeographic background although often these studies only addressed single population restricted to a comparatively a small geographic region (Hmwe *et al*., 2006; Sommer *et al*., 2008). The red deer has been classified as a different subspecies, although the subspecies concept is partly arbitrary (Mayr, 1963). As a result of predator-prey relationship the smallest subspecies population of red deer i.e. *C.elaphus corcicanus* is one of the most threatened taxa of the world (Hajji *et al*., 2007).

Paleoenvironments of the Siwaliks indicate two major environmental turnover as the older one is Asian monsoonal precipitation system and the younger one is transition from C_3 floras to C_4 grasses (Molnar *et al.*, 1993). The timing of monsoonal inception is controversial. According to Molnar *et al*. (1993) it estimates at 7.0 to 8.0 Ma while according to Kroon *et al*., 1991 it estimates at 9.0 to 11.0 Ma. The transition from C_{3-} dominated to C_{4-} dominated vegetation is documented approximately 8.1 Ma and with fully C_4 floras at 7.4 Ma with last occurrence of C_3 floras at 7.0 Ma (Kroon *et al*., 1991). . This transition had a marked effect on mammalian feeding ecology. Different taxa described from Siwaliks indicate that the separation of European and South Asian biogeographic theaters occurred at middle Miocene (Barry *et al.*, 2002). The Lower to Upper Siwalik Group of the Potwar Plateau, Pakistan (Miocene-Pliocene, approximately 18 to 1.8 Ma) is a continuous fluvial sequence that preserves a dense fossil record of vertebrates. Miocene climates of Pakistan and northern India were probably monsoonal, as these are now a day (Barry and Flynn, 1989).

CONCLUSION: Order Carnivora is represented by the significant record of fossils of family Hyaenidae which are considered as hyper carnivores indicating that there is a biodiversity of large herbivores having large carnivores (predator-prey relationship). The members of family Cervidae had been easily attacked by these carnivores (Hynids, Saber-toothed felids, wild dogs, tigers, leopards, etc) during the time in question. Several species of wild ursids, felids and canids together constitute the predator fauna for family Cervidae. In addition to this the crocodiles also play a role as predators for cervid cubs during the time of drinking at natural water bodies. In other words we can interpret that the members of family Cervidae are preyed more easily by these carnivores as a single predator-prey relationship, as is going on now a days. It is apparent that hard body parts including bones, antlers and teeth are ultimately transported to a suitable medium for fossil preservation especially by hyaenas acting as hyper carnivores (Arribas and Palmqvist, 1998, Mazza *et al.,* 2004). The members of order Carnivora were devoid of this additional preservation factor. Perhaps this is the reason of fair fossil record of family Cervidae with only one genus as compare to order Carnivora with a great variety of genera and species. In the portion of Systematic paleontology the whole fossil record of order Carnivora listed, does not mean that all the members of this group are involved in predator-prey relationship. This list only shows the diversity of carnivores in paleoecological associations. Furthermore, this study can be compared with other mammalian groups to evaluate the best possible results.

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