Paleoecology of *Hipparion* sp. (Equidae-Hipparionini) from latest Miocene of Padhri, northern Pakistan

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**ABSTRACT**

The broad geo-chronologic ranges with dietary and habitat preferences of *Hipparion* sp. (in hipparion remains) can provide significant biostratigraphic and paleoecological information. Paleoeology of *Hipparion* sp. (Equidae-Hipparionini), an extinct Hipparionine horse from Padhri deposits, has been investigated applying biometric method. The hypsodonty index for *Hipparion* sp. is 3.43 that categorizes it within the dietary spectrums of mixed feeders to hypsodont grazers. The ecomorphic information of *Hipparion* sp. depicts the change from closed to semi-closed vegetation followed by open one, humid to warm and seasonal paleoclimatic regimes leading to reconstruction of paleoecological mosaics ranging from closed woodlands to wooded-grassy savannas and grasslands.

**Key words:** Siwaliks, hypsodonty, late Miocene, *Hipparion*, biostratigraphy, paleoecology.

**INTRODUCTION**

The broad geo-chronologic ranges with diverse dietary and habitat preferences of *Hipparion* remains can provide significant biostratigraphic and paleoecological information. The studied material attributed to the genus *Hipparion* was collected from Padhri, a locality near village Padhri, district Jhelum (Fig. 1). The *Hipparion* chronologically ranges from late Miocene to early Pliocene. The Padhri village is located (32° 52′ 009 N; 73° 18′ 297 E) at 57 km south west of the Jhelum city in Potwar Siwaliks of Pakistan (Bhatti et al., 2012). Topography of the locality displays water channels, paleosols, levees, ponds and swamps with different frequency of occurrence (Barry et al., 2002). The mammalian remains have been recovered from the locality situated at the southeast of the Padhri village (Fig. 1). The Padhri outcrops are part of Hasnot composite belonging to upper part of Dhok Pathan Formation (late Miocene to early Pliocene) of the Middle Siwaliks. This chronology is consistent with Late Turolian age (ca. MN 13) of Europe, ranging from 7 to 5 Ma (Barry et al., 2002; Bhatti et al., 2012). The Dhok Pathan Formation is comprised of sand stones alternating with clay with minor layers of conglomerates in lower while more thick layer of conglomerates along with red brown clay and sandstone in upper part (Badgley et al., 2005). The lithologic setting is comprised of well-cemented, light gray sandstone, orange red clay stone and section of small conglomerates in the upper horizon. The fluvial system of fossiliferous deposits probably led to the

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genesis of a complex landscape displaying water bodies (ponds, lakes, streams), marshes, herb-lands, shrub-lands, forests and wood lands (Barry et al., 2002).

Fig., 1: Map of the Potwar Siwaliks of Pakistan with stratigraphic dates of the Siwalik formations; the rectangle marks the studied locality of Padhri which is shaded by its biochronostratigraphic context in boundary dates (data from Johnson et al., 1982; Barry et al., 2002; Cohen & Gibbard, 2008).

During the last few decades, the Padhri outcrops have been the focus of investigation by several national and international workers due to documenting an extensive mammalian fossil record of late Miocene in it (Colbert, 1935; Pilgrim, 1937; Bhatti et al., 2012). The Padhri deposits have also yielded excellently preserved Hipparionine material and its paleoecology needs to be worked out. This paper addresses the exploration of dietary based paleoecology of Hipparion sp. via hypsodonty analysis. Hypsodonty is recognized as an ecological proxy to interpret habitat and feeding preferences in herbivorous mammals for unraveling their ecological reconstructions (Janis et al., 2002; Jernvall & Fortelius, 2002; Fortelius et al., 2003). The dietary inferences in ungulate remains can provide paleoecological information of individual species and of mammalian paleocommunities in terrestrial ecosystem (Kaiser et al., 2000).

Abbreviations

GCUPC= Govt. College University, Lahore Paleontological Collection; ca.= Circa; H= crown height; L= crown length; W= crown width; l= left; r= right; m=lower molar; Ma= mega annum/million years; MN= Mein Zones; HI= Hypsodonty Index.
MATERIALS AND METHODS

Mammalian remains were collected from Padhri deposits as a result of extensive field work. Four taxonomically resolved specimens of *Hipparion* sp. were selected from the collected material, for investigation. Metrics of specimens such as dental crown height (H), length (L) and width (W) were calculated (in mm) with the help of vernier callipers. Ecomorphic (diet and habitat etc.) characterization of *Hipparion* sp. was done on the basis of degrees of Hypsodonty. The HI was calculated by considering metrics of unworn m2s. We followed HI scheme of Janis (1988), Damuth & Janis (2011) where HI m2 tooth crown height/m2 tooth crown width. Hypsodonty based dietary niche characterization was considered as baseline for exploration of paleoecology of *Hipparion* sp. The HI for *Hipparion* sp. and its extant analogues versus body weight are represented in bivariate plot (Fig. 2). Catalogue numbers along with tooth occlusal height and width measurements are listed in the Table 1.

RESULTS AND DISCUSSION

Hypsodonty index shows that *Hipparion* sp. is hypsodont. The Hypsodonty Index (HI) for *Hipparion* sp. calculated here is 3.10 (n=4). The purpose of hypsodonty analysis is to evaluate the metrical data by comparing with extant analogues for drawing ecomorphic information. Considering Janis (1988), Damuth & Janis (2011) hypsodonty interpretations, *Hipparion* sp. may also be categorized within the dietary spectrums ranging from both types of mixed feeders (MFC, MFO) to grazers. Ecomorphology of studied taxon may be comparable to a living Boselaphine; *Boselaphus tragocamelus* which is mixed feeder in closed habitat (MFC). *Hipparion* sp. also shows affinities with a living mixed feeder in open habitat (MFO); *Budorcas taxicorol* (Bovidae-Rupicapridi).

Table 1: Metrics (in mm) of *Hipparion* sp. recovered from Padhri

<table>
<thead>
<tr>
<th>Catalogue #</th>
<th>Description</th>
<th>H</th>
<th>W</th>
<th>L</th>
<th>H/W Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCUPC 1125/09</td>
<td>rm2</td>
<td>55.11</td>
<td>15.56</td>
<td>31.24</td>
<td>3.54</td>
</tr>
<tr>
<td>GCUPC 1117/09</td>
<td>Im2</td>
<td>53.35</td>
<td>16.09</td>
<td>29.02</td>
<td>3.31</td>
</tr>
<tr>
<td>GCUPC 1104/09</td>
<td>Im2</td>
<td>55.22</td>
<td>15.99</td>
<td>28.90</td>
<td>3.45</td>
</tr>
<tr>
<td>GCUPC 1114/09</td>
<td>Im2</td>
<td>48.84</td>
<td>14.20</td>
<td>25.19</td>
<td>3.43</td>
</tr>
</tbody>
</table>

Mean Hypsodonty Index: 3.43
Furthermore, the HI of *Hipparion* sp. is similar to a dry grass grazer (GG) *Hippotragus niger* (Bovidae-Hippotragini) (see Fig. 2). Mixed feeders in closed habitats (MFC) are indicators of forest or woodland and bushland habitats whereas mixed feeders in open habitat (MFO) and dry grass grazers (GG) are found in savannas or prairies (Janis, 1988; Damuth & Janis, 2011). Although some Hipparionine and *Equus* remains of Siwaliks show ecological affinities with living equines, yet the studied taxon exhibit diverse ecological preferences as compared to present day equines (Fig. 2).

In the Siwaliks, *Hipparion* first migrated from North America and had been documented in the lithologic confines of the Nagri Formation at about 10.3 Ma and demised around 3.7 Ma (Pilbeam et al., 1997; Barry et al., 2002). *Hipparion* sp. is abundantly found in the Middle Siwaliks and is considered to be biostratigraphic indicator of late Miocene to early Pliocene deposits of Pakistan (Barry et al., 2002; Badgley et al., 2005; Naseem et al., 2009). The coexistence of Siwalik *Hipparion* with mammalian faunal elements of late Miocene are found to have diverse spectrum of habitats ranging from pronounced woodlands to extreme steppes. *Hipparion* thus exhibits broad habitat adaptations as compared to the earlier equines and is a hypsodont genus of browsers, mixed feeders and grazers (Badgley et al., 2005; Khan et al., 2011). The limb metapodials of *Hipparion* reflect typical anatomical changes compatible with the transitional life.
mainly from forest to steppe (Khan et al., 2011). *Hipparion* preferred more open and drier mosaics of the vegetation as revealed by the most enriched carbon and oxygen isotopic values of its specimens at latest Miocene (Badgley et al., 2005; Nelson, 2005).

**Conclusions**

The *Hipparion* sp. is biostratigraphic indicator of late Miocene to early Pliocene (10.3-3.7 Ma). The ecomorphic information (diet, habitat etc.) of the studied taxon depicts the change from closed vegetation to semi-closed vegetation followed by open one, humid to warm and seasonal paleoclimatic regimes leading to evolution of paleoecological mosaics ranging from closed woodlands to wooded-grassy savannas and grasslands. Its diverse dietary and habitat adaptations reveal varying ecological preferences as compared to of present day equines.

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**REFERENCES**


