

CHAPTER 6

DISCUSSION AND CONCLUSION

In the light of new researches in Vertebrate Palaeontology, the study of fossil vertebrates from the Manjra Valley has supplied a plethora of information for the interpretation of life history of the individual fauna in a given assemblage. An attempt has been made here to bridge together the gross morphological and microanatomical studies, to understand better the problem of phylogenetic affinities and adaptational responses of various animals in the Manjra Valley. Besides, the author has attempted to integrate the biological and geological aspects of fossil assemblages in relation to their palaeontological history in a limited area of field study.

The results of the present study can be summarised as follows :

A> LITHO - BIO, AND CHRONOSTRATIGRAPHY

The salient features of the Pleistocene formations in the Manjra Valley are that these formations are essentially of fluvial origin with a characteristic cut and fill type, and are confined to broad and shallow valleys. The two types of alluvial fills recognised in the area are :

i) Calcreted yellowish brown silt associated with sandy pebbly gravel.

ii) Brownish less calcareous clayey silt associated with sandy pebbly gravel.

The composite Litho - and - bio stratigraphy on the main channels of the Manjra can be summarised as follows :-

Litho-units	Stratigraphy	Age	C14 dates	Associated fauna
1. Non-calcareous dark brown silts and gravels	Younger Alluvium (Post Black soil Formation +8M)	Early to Mid Holocene	---	Semi mineralised bones of Bos sp. Cervus sp. and unidentifiable fragments
DISCONFORMITY				
2. Calcareous brownish silts and gravels	Older Alluvium (Upper Bhima Formation +15M)	late Pleistocene	34,470+ 2070 BP 26,820+ 750 BP	Equus namadicus, Bos namadicus, Bubalus palaeindicus, Antelope cervicapra Hippopotamus palaeindicus,
ANGULAR UNCONFORMITY				
3. Laterite	Laterite Formation	Late Tertiary to Early Pleistocene		Cervus duvauceli, Cervus unicolor, Axis axis, Stegodon insignis ganesa, Elephas hysudricus Elephas sp., crocodylus sp., Trionyx sp. and Unio sp.

**Stratigraphy on the main river of the Manjra in
Middle and Lower reaches**

(From top to bottom)

- | | |
|--|--|
| 1. Non - calcareous dark
brown sandy silt | Mesolithic artifacts |
| 2. Non - Kankary sandy silt | ---- |
| 3. Cross - bedded sandy pebbly
gravel occasionally cemented | Middle Palaeolithic tools
with stray surface finds
of highly abraded
vertebrate fragments |
| 4. Loose bouldery pebbly gravel | ---- |

The field observations in the Manjra Valley have revealed that the litho - stratigraphy exposed at the main river has remained fairly uniform in its content. In the lower reaches some Palaeolithic sites are located on small tributaries of the river Manjra. Older Alluvium in the lower reaches has not preserved any fossil record except Mugaon (18° 00' : 77° 27') which yielded a poor, fragmentary record of the bovids. Hitherto, in the absence of radiometric / palaeomagnetic dates, the dating of the Older Alluvium of the Manjra to late Pleistocene was relative and based on geomorphological as well as palaeontological observations (Joshi et al., 1981; Badam, 1984; Badam et al., 1984). Palaeontologically the presence of *Elephas maximus* (?), *Bubalus palaeindicus*, *Cervus unicolor*, *Cervus duyauceli*, *Equus namadicus* and *Bos namadicus* indicate late Pleistocene age for the Older Alluvium. However, Badam (1988) has suggested that

the earliest appearance of these animals may have had a higher antiquity. Taking into consideration the degree of oxidation and calcification of alluvial deposits and the faunal components, the deposits at Manjra have been found to be well comparable with the Upper group of Older Alluvium of the Central Narmada, major portion of the exposed Older Alluvium of the Upper Godavari, Upper Bhima and Upper Krishna (Joshi et al., 1981). The term Upper Bhima Formation (UBF) (Kajale et al., 1976) is used for Older Alluvium in all the Peninsular river valleys and has been dated to late Pleistocene (Rajaguru and Badam, 1988).

The application of fluorine method for relative dating of bones from archaeological sites, was taken up (1983; Joshi and Kshirsagar, 1986; Kshirsagar and Badam, 1989) to provide further authenticity to the existing geomorphological and palaeontological dating methods. The hypothesis that the fluorine content in buried bones increases in course of time, has been particularly helpful in assigning relative dates to the biological remains in their respective stratigraphical context. The theoretical maximum value is 8.92 which denotes a saturation point. Interestingly, the geologically younger ages assigned to the faunal assemblage in Peninsular India (Badam, 1979) correspond well with the ratios of fluorine / phosphate contents in the bones of the animals (Kshirsagar and Joshi, 1986).

Narmada Valley	-	3.2	to	8.1
Ghod and Godavari Valley	-	4.0	to	6.1
Kurnool Caves	-	2.8	to	3.6

Joshi and Kshirsagar (1986) carried out detailed fluorine / phosphate analysis of the fossils from Tadula, Wangdari, Ganjur and Dhenegaon, all in the upper reaches of the Manjra basin. The $\frac{100F}{25} / \frac{P}{O}$ ratio obtained from the bones is tabulated below :-

Upper Manjra Valley	% F	%P205	$\frac{100F}{25} / \frac{P}{O}$	% CaCO ₃	% N
Dhenegaon	0.307	6.00	5.11	74.69	0.022
Ganjur	0.400	8.29	4.825	65.96	0.026
Tadula	0.456	14.59	3.125	43.65	0.051
Wangdari	0.931	20.75	4.487	45.55	0.038

The $\frac{100F}{25} / \frac{P}{O}$ ratios obtained on the bones attest late Pleistocene age to the faunal assemblage, well established by two C^{14} dates now available from Tadula (34,470 ± 2070 Y.B.P) and Wangdari (26,820 ± 750 Y.B.P), both in upper reaches of the valley.

C^{14} dates on molluscan shells (*Unio* sp.) from Kankary sandy silt of Upper Bhima Formation. Samples (Tadula : B.S.I.P BS - 562 and Wangdari : B. S. I. P. BS - 561 (Half Life 5570 ± 30 years) The C^{14} dates for UBF and Younger Alluvium (PE¹¹)

Table 10

Carbon14 Dates of Alluvial Deposits in Western Maharashtra

(Modified after Rajaguru and Badam, 1988)

River valley	Geological formation	Material	C14 Date Year B. P.
Ghod	PBF	Wood	3175 ± 105 (TF -1330)
Godavari	PBF	Charcoal	3400 ± 115 (PRL - 77)
Krishna	PBF	Shells	3855 ± 710 (TF -1213)
Krishna	UBF(um)	Shells	10,035 ± 125 (TF - 1178)
Ghod	UBF(um)	Shells	11,700 ± 150 (BS - 146)
Godavari	UBF (um)	Shells	17,075 ± 660 (TF - 8911)
Manjra	UBF (lm)	Shells	26,820 ± 750 (BS - 561)
Manjra	UBF (lm)	Shells	34,470 ± 2070 (BS-562)
Godavari	UBF (lm)	Shells	26,635 ± 425 ()
Krishan	UBF (lm)	Shells	38,480 ± 8940 (TF -1004) 4125
Mula	UBF (lm)	Wood	>39,000 (TF - 217)

PBF --- Post Black Soil Formation
 UBF --- Upper Bhima Formation
 (um) --- Upper Member
 (lm) --- Lower Member

from some river valleys in Western Maharashtra are tabulated here (Table) to provide a definite chronological framework for the deposition of these sediments during the late Pleistocene times.

B) PALAEOLOGICAL DEDUCTIONS

From a total of thirteen animal species represented, 6 are extinct today. Some of the elements are holdovers of the Early Pleistocene and the rest are characteristic of late Pleistocene period. The faunal record includes the following species :-

- 1) *Stegodon insignis ganesa*
- 2) *Elephas blythianus*
- 3) *Equus namadicus*
- 4) *Hippopotamus palaendicus*
- 5) *Antelope cervicapra*
- 6) *Bos namadicus*
- 7) *Bubalus palaendicus*
- 8) *Cervus duvauceli*
- 9) *Cervus unicolor*
- 10) *Axis axis*
- 11) *Crocodylus* sp. (? *palaendicus*)
- 12) *Trionyx* sp.

Morphological study of the cranial and osteological parts of the animals mentioned above has been elaborated in the study. Cervidae is dealt with in a separate section. A comparative study of fossil cervids from Siwaliks of NW India,

Peninsular river valleys, as well as living cervids, was undertaken to comprehend the phylogenetic history of the group. However, the paucity of adequate dental and cranial material regarding metrical inferences has handicapped the work to a great extent. As a result, inferences are drawn from non - metrical observations and from published sources.

The non - metric observations on the dental and post - cranials support the contention of Colbert (1935) and Lydekker (1880), that *Ceryus siyalensis* of Pinjor Siwaliks seems to have given rise to *C. duyauceli*. The latter appears first in late Pleistocene (Badam, 1979, 1984) and is being represented today by three living subspecies viz., *Ceryus duyauceli duyauceli*, *Ceryus duyauceli ranjitsinhi*, and *Ceryus duyauceli branderi*.

Regarding the early history of *C. unicolor* very little is known. It has been suggested that ancestral affinity exists with *C. punjabiensis* of the Upper Siwaliks of NW India. Brown (1926) opined that the later is intermediate and transitional species between *Axis axis* and *Ceryus unicolor*. Some of his observations were considered diagnostic for *C. punjabiensis*, which include cranium with low and rounded auditory bullae; antlers round, smooth and widely expanded, lying in a plane parallel to facial angle; narrow nasals and muzzle not expanded; teeth hypsodont while enamel crescent shaped, enfolded and lacking accessory inner columns (Brown, 1926 : 1).

The origin of spotted deer (*Axis axis*) is not certain. It has been reported widely from Upper Pleistocene sediments at several sites in Peninsular India. According to Lydekker (1888), *Axis axis* is related to *Cervus simplicidens*. However, since the latter is a synonym of *C. punjabiensis* (Colbert, 1935), it can be presumed that *Axis axis* and *C. punjabiensis* are also related. At the present stage of our knowledge it cannot be ascertained whether spotted deer has originated from *Cervus punjabiensis*.

C) PALAEOECOLOGY

Faunastically, the late Pleistocene biota from Upper Manjra is predominantly composed of megamammals and a few reptiles. Hence, palaeoecological inferences attempted in the present study are based on the faunal material (extinct and extant) and their habitats in different environments.

It is worthwhile to note that the taphonomic attributes have a great bearing on ecological studies. The taphonomical approach helps in linking habitat preferences to preservation in a particular sedimentary environment. Further, incorporated with the data on morphology and modern analogues, it has made palaeoecological interpretation of fossil assemblages more meaningful (Behrensmeyer, 1975, 1982 & 1988; Behrensmeyer and Hill, 1980; Shipman, 1981; Badam et al., 1986)

Taphonomic attributes reveal that the vertebrates from Upper Manjra are derived from channel - lag assemblages, representing different habitats on the alluvial plains.

Generally, such assemblages supply the most homogeneous sample of diverse palaeocommunity which, in addition to being useful in determining faunal changes in a long geological time span, can also be exploited for a wide range of ecological inferences for the sampled assemblage (Behrensmeyer, 1988). It is interesting to note that only a few fossil yielding localities were recorded in the Upper Manjra basin within the vicinity of about 40 - 50 Km of the main river. Taking into consideration the taphonomic attributes, the fossil assemblage does not appear to have moved (by means of transportation) far away from the place of death. The region as a whole may have been the natural home of these vertebrates, in terms of habitat preferences. The bones of juvenile animals are generally vulnerable to natural and biological attritional forces, sometimes resulting in their total disappearance from an assemblage. However, the representation of different age groups of fossil bovids at Wangdari and Tadula has given better perspective of the mode of preservation of death assemblages.

The absence of palaeontologically potential deposits elsewhere in the upper reaches, does not necessarily indicate lack of good vegetational diversity. Further, it is natural to believe that the animal population occupying areas in and around the depositional basins are more frequently represented in the collection. In this context, the palaeoecology of individual animal needs a detailed study with comparable analogy, which may provide a coherent picture of the prevalent

ecological conditions during the deposition of the late Pleistocene sediments.

The palaeocommunity structure of mammalian fauna of the Manjra can be classified into two types, viz.,

- i> Stream and streambank community.
- ii> Megaterrestrial community.

i> Stream and streambank community

The sporadic but definite record of crocodiles, turtles and a large number of skeletal - dental remains belonging to *Hippopotamus palaeindicus* are the representative taxa of this community.

Hippopotamus is an amphibious animal which spends more time in marshy wet lands, apart from the time involved in foraging in nearby grasslands. Grass is easily available to the animal, thus reducing its long range foraging movements in a single region. It is one of the heaviest herbivores which may even reduce the tall grasslands of the seasonal swamps to short grass - pasture, facilitating smaller grazers like gazella and antelopes to pasture during dry seasons (Vesey - Fitzgerald, 1960, 1965). It may be noted that the seasonal swamps in the vicinity of the flood plains, with naturally grown extensive tall grass sheets, provide an ideal habitat for hippopotamus.

The discovery of hippo remains, specially at Tadula, in

the sandy pebbly gravel with lenticular bands of silts and clay, indicates the existence of stagnant water bodies of considerable depth in close proximity to the main channel. Evidence for such water bodies in an area of about 15 acres at Tadula (Badam et al., 1984) provides an ideal ground for geomorphological investigations.

ii) Megaterrestrial community

Herbivores are the sole survivors of this palaeocommunity, which probably exploited all possible nutritional opportunities in the area. They were of medium to large size and included proboscideans, equids, bovids and cervids. Majority of these were grazers with a few of mix feeders. Bovid with hypsodont high crowned teeth suggest the existence of vast sheets of open grasslands available to them, as they have a tendency of successfully exploiting open and / or habitats best suited for grazing.

While discussing the ecology of large herbivores such as elephants, many significant facts have been added to our knowledge. The studies reveal that the existence of elephant does not necessarily suggest a dense woodland forest, but should be identified with a habitat that provides forest cover and grassland in roughly equal proportions. The observations on elephant movements indicate that they spend more time at the forest and grassland interface (Mckay, 1973). This indicates two types of opportunistic feeding tendencies, such as :

- a) feeding on grass without venturing too far from the relative safety of a forested area;
- b) by moving and feeding in an ecotone area, they have access to a variety of potential food plants which are available during all given feeding periods. Feeding in separate zones, is unlikely to substantiate their demands in all seasons.

Elephants have a tendency of browsing in a mixed type of such secondary habitats where the components of their diet through natural selection, not only increase in abundance but also in diversity. The observed diet of living elephants is generally dominated by grass which is a staple food in terms of diet qualities, supplemented by woody plants which are scarce in a primary forest (Olivier, 1982). The habitats comprising of forested regions with grasses and grasslands are found naturally in riverine situations, a phenomenon particular of mosaic habitats on the alluvial flood plains of large seasonal rivers. Such riverine situations also provide important elephant foods other than grasses. Olivier (1982) noted that riverine situations contain the optional elephant habitat. This may be because of interdispersion of cover types where gallery forest and alluvial plains integrate, bringing such ecological conditions together. The seasonal movements of Asian elephants with response to fluctuations in food supply, suggest excessive exploitation of grasslands during

wet seasons (Baze, 1955; Mckay and Eisenberg, 1974), while the dry seasons drive them to the wetter forested areas (Sharatchandra and Gadgil, 1975). In the context of palaeoecological interpretation of proboscidean material, it is worthwhile to quote Olivier -- "The mere presence of an elephant in the ecosystem is an evidence of considerable floral diversity" (Olivier, 1982 : 297).

Fossil ungulates, which account for 60% of the total assemblage predominantly come from Tadula and Wangdari. Cervids were one of the significant groups of ungulates living in the area, being represented by three species *Ceryus duyauceli*, *Ceryus unicolor* and *Axis axis*. As discussed earlier these taxa appeared for the first time in the late Pleistocene and have continued to live even in the present. It will be pertinent to cite the details of ecology of living cervids, to shed light on their habit and habitats which do not appear to have changed much since the last 25,000 years or so.

Ceryus duyauceli once lived in a vast geographical range, but is now confined to a few natural habitats chiefly characterised by the swamp grasslands (Groves, 1982), interspersed with water bodies particularly in dry seasons. This prevents interspecific competition with other ungulates, such as *Axis axis*, *Boselaphas tragocamelus*, *Ceryus unicolor* etc. *C. duyauceli* is indigenous to India appearing for the first time during the late Pleistocene. It has been reported extensively from archaeological sites all over India and is found today in restricted areas.

Groves (1982) while discussing the discovery of a new subspecies of *Cervus duvauceli* viz., *C.d.ranjitsinhi* from eastern India concluded that *Cervus duvauceli* is by and large, a deer, originally adapted to the swampy grassland. In the course of time, environmental conditions had an impact on these subspecies and as a result two other subspecies viz., *C.d.duvauceli* and *C.d.branderi* became better adapted to moist deciduous, semi evergreen and wet evergreen forest types (Martin, 1977). It was further pointed out that there are three main factors which control the movements of swamp deer. e.g.,

- i> Scarcity of water
- ii> Abundance of grass cover
- iii> Climatic conditions (Martin, 1977).

The interdependence of these factors leads to a state of equilibrium that maintains ecobalance of these animals in a given area. *Cervus duvauceli* is characterised by grazing behaviour, though browsing has also been noticed occasionally. In his detailed study on the status and ecology of swamp deer in Kanha National Park in Central India, Martin (1977,1982) concludes that this animal is practically dependent upon grass diet throughout the season to such an extent that it must be rated a rare event if a swamp deer is observed to be feeding on resources other than grass. Holloway (1972) argued that climatic changes have an important bearing on the seasonal movements of swamp deer population which during drier conditions bring them close to the aquatic - swampy

grasslands. However, the advent of monsoon directs their movements to the fringes of the forests and better drained cultivated areas. Such climatic changes drive them from glades to the woods. These movements are essentially seasonal and related to changes in climatic conditions. An overview of habitational preferences of living swamp deer, supports the contention that the major ungulate yielding areas in the Manjra, might have supplied open grasslands with swamp and stagnant water sheets which to provided an optimal habitat for these creatures. Similar conditions are also met with other cervids, such as, *Cervus unicolor* and *Axis axis* which equally compete with their cousins in foraging in such potential food yielding areas (Martin, 1977).

Bovids are known for their adaptability to varied macroenvironments. The cattle and their cousins have a tendency of successfully exploiting open and / or dry habitats, foraging being the major factor that affects the geographical movement of these animals. However, high - crowned teeth indicate adaptation to a tough fibrous diet. This is markedly found in the teeth of *Bos namadicus* and *Bubalus palaeindicus* which suggests grazing to be an exclusive mode of feeding. This undoubtedly reveals the presence of extensive stretch of grasslands at and around the floodplains of Manjra, with intervals of several stagnant water bodies (Badam et al, 1984)

Wangdari also records a considerable number of fossils of

Equus namadicus and some belonging to *Equus* sp. Equids are similar to the bovids in feeding behaviour and hence their occurrence does not alter the palaeoecological interpretation. However, in all probability, *Equus namadicus* must have been a potential competitor to *Bos namadicus* and *Bubalus palaeindicus* for their staple diet, in terms of extensive sheets of grass cover. Buffalo (*Bubalus* sp.), though a bovid, exhibits behavioural aspects of a semi - aquatic animal. Water buffaloes inhabit openlands with tall grasses, essentially in close proximity to the swamps and permanent water bodies. However, aquatic resources either in the form of swamps or flowing rivers are the essential factors in maintaining the proportionate habitat for the water buffaloes (Fahimuddin, 1975). Smaller members of the bovids, like *Antelope cervicapra*, are commonly found in association with their cousins, grazing in open grasslands in close proximity to aquatic resources. Antelopes are known to have strong territorial instincts not seen in other members of bovids (Ranjitsinh, 1982).

Ecological approach to the faunal assemblage at Manjra suggests similarity between the past and the present environmental conditions. However, lack of studies on microfossils from the area prevents a definite record of minute changes brought about by climatic fluctuations. The larger mammals are highly mobile and may escape adverse conditions with least impact. In a broader perspective, the fossil bearing sites are characterised by riverine

environments with galleria forests along the banks and floodplains of the rivers. However, climatic conditions were not the sole factor controlling the biological environments in and around the river valley. Local ecological factors (e.g. noted above) must have maintained forest refuges with highly fertile alluvial soils, and rich in inorganic contents. The prevailing arid climatic conditions at the end of the Pleistocene (Rajaguru, 1983) might have led to the shrinking of these refuges into small pockets. Persistent harsh conditions confined the area to the banks and floodplains during the later part of the Pleistocene.

CONCLUSIONS

- 1) The geomorphological and palaeontological studies confirm that the Older Alluvial deposits (Upper Bhima Formation) can be dated to late Pleistocene period. This is further supported by two C^{14} dates, $26,820 \pm 750$ B.P. and $34,470 \pm 2,070$ B.P., obtained from the molluscan shells collected at Tadula and Wangdari, respectively.
- 2) The faunal assemblage from the Upper Manjra Valley is allochthonous, partly attributed to the hydrodynamic sorting. However, the study of surface features of bones, reveal long exposures before final burial and subsequent fossilisation.
- 3) The presence of elements, predominantly of Voorhies' Group

III at Ganjur, with less abraded, fresh looking edges, suggests short distance transportation of the assemblage. Such accumulation indicates hydraulic sorting. However, being lag elements, the skeletal associations of the species are generally considered to be palaeoecologically significant.

4) A review of published literature and cranial data on skulls of various fossil cervids from the Siwaliks of NW India, the Manjra Valley and on living species indicates that *Ceryus duyauceli* probably originated from *Ceryus siwalensis* of the Upper Siwaliks of NW India.

5) The Scanning Electron Microscopic study of dental enamel of large vertebrates indicates that

i> The prismatic structure - Pattern 3, is commonly documented in the enamel of *Deinotherium*, *Stegodon*, *Elephas bursarius*, and *E. maximus*, though with a marked degree of modification in the prism's size and its density.

ii> A gradual shift from key - hole pattern in *Deinotherium* (4.5 - 4.7 μm) to enlarged ginko - tree leaf pattern in *Elephas* (5.2 μm) via *Stegodon*, with a slight enlargement (5 μm) in individual prism, suggests a gradual shift in the diet, with respect to dental morphology. This biomechanical

adaptation corresponds with specialised dentition of lophodont to hypsodont crowns, best suited for horizontal shearing pattern.

iii> True zone formation is also recorded, typical of prism pattern - 3.

iv> A slight variation from the idealistic prism pattern - 2 of ungulates, is documented in the enamel of *Hippopotamus* sp. The primate-like pattern - 3, seen in the inner half of the middle enamel layer, is attributed to the amelogenesis and remains enigmatic.

v> The characteristic pattern - 2 prismatic arrangement is documented in the enamel of bovids and equids.

6) The palaeoecological analysis of the vertebrate fossils largely based on analogues (also taking into account the taphonomical attributes) suggest the existence of proportionate floral biomass in the area. This consisted of woody plants, shrubs and open grasslands, forming forest refuges with the intervals of perennial aquatic resources, in an area covering a radius of 50 - 60 Km. This probably provided characteristic habitats to these megavertebrates at the time of deposition of Upper Pleistocene sediments in the upper reaches of the valley.