SUMMARY AND CONCLUSIONS

The Šivalik Group constitutes a thick sequence of fossiliferous continental molassic sediments. The Upper Šivalik, youngest of the three Subgroups of the Šivalik Group, has been a focus of many palaeontological and geological investigations, since the early part of the nineteenth century. Despite these studies, primates, rodents, small carnivores, some suids, etc. have been meagerly recorded from the area under investigation. Present study reports a murid, a small carnivore, some rare and new suids, and many additional mammalian taxa. Furthermore, the problem
of Upper Sivalik palaeoenvironments and palaeoecology, which was either ignored or inadequately tackled in the earlier works, has been discussed at length in this study. Geological, taphonomical and biological aspects have been considered to reconstruct the past ecology and environments of Upper Sivalik sediments exposed in the northeast of Chandigarh.

No radiometric dates are available for Upper Sivalik deposits of India. However, equivalent rocks in northern Pakistan have been assigned an age of 5.5 Myr B.P. to 0.6 Myr B.P. by Opdyke et al. (1979), on the basis of magnetic polarity stratigraphic investigations. They further suggested that the transition between Tatrot and Pinjor occurs at about 2.47 Myr B.P. On the basis of faunal correlations with European land mammalian fauna, Berggren and Van Couvering (1974), and Delson (1975) equated the Tatrot, Pinjor and Boulder Conglomerate Formation with Ruscinian and Lower Villafranchian, Upper Villafranchian, and Biharian, respectively.

As a result of about six months of field-work, spread over four years, about 500 vertebrate fossils including fish, reptiles and mammals, were collected. Besides vertebrates, a large number of charophytes, ostracodes, gastropods, unionids, etc. were also recovered.

Pinjor deposits are best exposed in this area, and have yielded more fossils than Tatrot sediments. The basal Pinjors
and top Tatrots appear to be more fossiliferous. Apart from a few chips of bones and teeth, no identifiable fossil could be collected from the Boulder Conglomerate Formation, during the entire field-work.

Sixteen mammalian taxa are systematically described in this work. These include *Vishnuictis choprii* sp. nov., *Stegodon insignis*, *Archidiskodon planifrons*, *Elephas byszudricus*, *Equus sivalensis*, *Equus sivalensis minor* var. nov., *Rhinoceros sivalensis*, *Rhinoceros palaeindicus*, *Coelodonta platyrhinus*, *Potamochoerus theobaldi*, *Sus falconeri*, *Sus pinjorensis* sp. nov., *Hexaprotodon sivalensis*, *Rucervus simplicidens*, *Sivatherium giganteum* and *Leptobos falconeri*.

Among the microfossils, the charophytes, viz., *Sphaerochara* sp., *Hornichara maslovi*, *Chara surajpurica*, *Chara rantzieni*, *Chara* sp., and *Nitellopsis* (*Nitellopsis*), and the ostracodes, namely *Candona lactea*, *Ilyocypris gibba*, *Ilyocypris bradyi*, *Zonocypris costata*, *Potamocypris* sp. and *Hemicypris?* sp., have been extracted from the rock samples collected from the Upper Sivaliks of this area.

The genus *Sphaerochara* has been recorded for the first time from Pinjors. Earlier, it was restricted upto Dhokpathan Formation (Bhatia and Mathur, 1978). *Nitellopsis* (*Nitellopsis*) is another charophyte taxon which is recorded here for the first time from Upper Sivaliks.

A new species of a small viverrid, viz., *Vishnuictis choprii* is reported from the Pinjor Formation. It is much
smaller than the other Upper Sivalik viverrids, namely Viverra bakerii and Vishnuictis durandi.

A new variety of Equus, viz., Equus sivalensis minor has been recovered from Pinjor Formation exposed in the east of Chandigarh. This form is more slender and smaller in size than Equus sivalensis. It differs from E. sivalensis by its relatively thin enamel, short and broad protocone, and simple borders of fossettes.

Potamochoerus theobaldi which was earlier known from the Upper Sivaliks of Kangra district, is also recorded from the Pinjor Formation of this area.

The Pinjor sediments of the area investigated have yielded a new species of Sus, viz., Sus pinjorensis. It is an advanced Sus which is characterized by a very long M3 with a long and complex talonid. There is a reduction in the premolar and molar series (except M3). The combined length of P4, M1 and M2 is less than the mesio-distal diameter of M3, which approaches the combined length of P3, P4, and M1 and M2. In this respect, this form comes closer to the African wart hog, Phacochoerus, which also displays these characters, though to a much greater extent. The elongation and complexity of the M3 of Sus pinjorensis suggests adaptation to harsher vegetation or, in other words, a grazing habit.

Equus is limited to Pinjor Formation and does not occur in Tatrots. No Hipparion specimen was collected from Pinjors. Rhinoceros and Elephas hysudricus are apparently restricted to
the Pinjor Formation. *Hexaprotodon* and *Leptobos* are more abundant in Tatrots than Pinjors. The Pinjor deposits abound in proboscideans, equids and bovids. Among the bovids the tribe Bovini is best represented.

9 On the whole, the Pinjor sediments are coarser than Tatrots. The conglomeratic beds are more frequent in Pinjors than Tatrots. The red and brown colouration is more abundant in Tatrot deposits than Pinjors. The carbonate content of Tatrots is higher than Pinjors. The cross-bedding and mud balls are more common in Pinjors than Tatrots.

10 The fresh-water Upper Sivalik deposits of this area were laid down under fluviatile conditions by a well-developed meandering riverine system.

11 The Tatrots were deposited by a more mature and meandering riverine system with the dominance of flood-plain facies over the channel deposits. The sinuosity of the rivers was higher and the flood-plain was bigger. The evidences suggest a low energy environment for Tatrots. Shallow-water conditions are also indicated. There were many back swamps. Oxidizing conditions also prevailed in parts. The climatic conditions were more humid and relatively warm.

12 The Pinjors were laid down under relatively high energy and shallow-water conditions. During this time the sinuosity of the riverine system reduced. Channel, point bar and
flood-plain environments dominated during Pinjors. Small-scale lacustrine conditions, such as small ponds, ox-bow lakes, and abandoned channels, are indicated for parts of Pinjors. There was a reduction in the back swamps. Available evidences suggest that the climate became less humid and less warm.

The Boulder Conglomerate Formation was deposited as alluvial fans at the base of mountains. During this time, the sinuosity of the rivers greatly reduced and a more or less braided river system with constant channel shifting resulted. The climate during this span of time was arid to semi-arid and relatively cold.

Upper Sivalik fossil assemblage is of mixed type with organisms having varied habitat preferences. On the whole, the fossil assemblage is of fragmentary nature. Majority of the fossil material was exposed to various pre-burial weathering agencies. The fossils from flood-plain are often leached and cracked while those with channel provenance usually display signs of abrasion, indicating pre-burial transportation. The fossils occur evenly distributed in sediments, but occasional concentration in pockets is noticed.

The dentitions are the most abundant elements and account for about 60 per cent of the total fossils in the assemblage. Of this material, only the more complete and better preserved dental material has been described in the body of the thesis, while some of the more complete post-cranial remains have been
referred in the thesis. The bones such as radius, ulna, ribs, vertebrae, phalanges, etc., are very few. This could be related to the relative strength of the bones to withstand surface weathering conditions, type of transporting and depositing medium, and the dispersal potential of the skeletal elements. Among the post-cranial elements, the metapodia and podial bones are better represented than other skeletal parts. The bones from the flood-plain environment have a better representation of skeletal parts other than dental and cranial parts, metapodia, and podial bones, as compared to channel environment.

16 The reptiles are much more profuse in Tatrots than Pinjors. The chelonids are better represented than crocodilids.

17 Three communities, viz., pond, river and river bank, and grassland and savannah, are distinguishable in the Upper Sivalik thanatocoenose.

The river and river bank community is represented by chelonids, crocodilids and *Hexaprotodon sivalensis*.

The pond community is depicted by charophytes, i.e., *Sphaerochara, Hornichara, Chara* and *Nitellopsis*, ostracodes, viz., *Candona, Ilyocypris, Zonocypris, Potamocypris* and *Hemicypris?*, seluroid fish, gastropods and unionids.

The grassland and savannah community is comprised of grassland and savannah populations. The grassland population of this community was the ecological dominant and includes grazers such as *Equus, Leptobos, Bos*, alcelaphines, antelopes and reduncines.
The savannah population is depicted by Vishnuictis, Stegodon, Archidiskodon, Elephas, Rhinoceros, Coelodonta, Potamochoerus, Sus, Rucervus and Sivatherium.

The faunal evidences favour the occurrence of wooded savannah conditions, in general, during Tatrots. The Tatrot landscape was probably more wooded with relatively few open patches. The Pinjor fauna indicates the presence of savannahs and grasslands which were less wooded than Tatrots. The dominant vegetation during Pinjors was probably grasses. The open country conditions were better developed during Pinjors. Due to the virtual absence of identifiable faunal and floral remains in the Boulder Conglomerate Formation, it is difficult to reconstruct the ecological set-up of this Formation of the Upper Sivaliks.