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GEOLOGY AND PALEONTOLOGY OF THE LOVE BONE BED FROM THE LATE MIOCENE OF FLORIDA*

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ABSTRACT. The Love Bone Bed richly samples late Miocene vertebrates from estuarine, freshwater, and terrestrial habitats in north central Florida. Over 80 taxa are recognized of which about half are mammals. Further study of microvertebrate samples is expected to bring the fauna to at least 100 species.

The site consists of fluvial sediments of the Alachua Formation that fill stream channels cut into the Late Eocene Crystal River Formation. The fluvial sediments represent a single depositional cycle and fine upward from coarse phosphatic sands and gravels to orange clays and clayey sands. Taphonomic data suggest a flow from north to south.

The age of the Love Bone Bed Local Fauna is very late Clarendonian as indicated by the stage of evolution of several mammal species, by the presence of the Eurasion immigrant genus *Beckia*, and by the absence of early Hemphillian immigrants including ground sloths and bears.

About 40 percent of the vertebrate sample (by weight) consists of lentic turtles and garfishes, apparently transported from perennial marshes. An estuarine fauna is marginally represented by sharks, various bony fishes, and two species of marine mammals. Evidently late Clarendonian sealevel approached the elevation of the Love site (about 20 m). The diverse terrestrial fauna includes elements of a streambank community, an open-country community, and a deciduous forest community. The rich samples of sylvan and lentic vertebrates as well as the presence of estuarine vertebrates readily distinguish the Love Bone Bed from otherwise broadly comparable local faunas in the midcontinent. This fauna is also notable for some taxa of possible neotropical affinities, including certain Procyonidae, Cricetidae, and an early member of the Laminae.

INTRODUCTION

Vertebrate life of the Tertiary in eastern North America is poorly known. For this reason a few richly fossiliferous sites in peninsular Florida have attracted special attention. The two most notable local faunas, lauded for the productivity and diversity of their vertebrate fossils, have been Thomas Farm of Hemingfordian (middle Miocene) age and Mixson's Bone Bed of Hemphillian (latest Miocene) age. In this paper, we place on record a third local fauna of comparable magnitude, the Love Bone Bed of Clarendonian (late Miocene) age.

The Love Bone Bed produces an extraordinarily rich concentration of vertebrate bones and teeth from channel deposits near the mouth of a late Miocene stream. The fauna represents estuarine, freshwater, and terrestrial habitats including an important sample from forested settings. Many new or unusual taxa are represented. The purposes of this paper

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are to describe the occurrence of the site and to provide an overview of the Love Bone Bed local fauna preceding more detailed studies of individual taxa.

GEOGRAPHIC AND GEOLOGICAL SETTING

The Love Bone Bed was discovered in 1974 by Mr. Ron Love while tilling an okra crop on his land near Archer, Fla. A tibia of *Teleoceras* that he presented to the Florida State Museum warranted additional investigation. At the site other scraps of bone were visible at the surface including interesting concentrations of terrestrial and aquatic vertebrates. During July, 1974 auger cores 3 m deep were drilled using an 8 m grid system. In August the fossiliferous concentration was delimited by trenching with a backhoe. Since then, the site has been worked by Florida State Museum field crews, expending about 3000 person days and about 15 days of backhoe work over a 5-yr period.

The Love Bone Bed is situated in western Alachua County about 1.5 km north of the town of Archer at an elevation above 20 m (fig. 1). It lies just east of State Route 241 in the NW¼ SW¼ NW¼ sec. 9, T. 11 S., R. 18 E. as indicated on the U.S. Geol. Survey 7½′ quad Archer (1968). The fluvial sediments now lie exposed in an area with no surface drainage whatever. The karst plain in which they now occur extends some 20 km northeast before being covered by a continuous mantle of the Hawthorne Formation which there supports minor creeks. The contrast between the Recent karst and the late Miocene fluvial

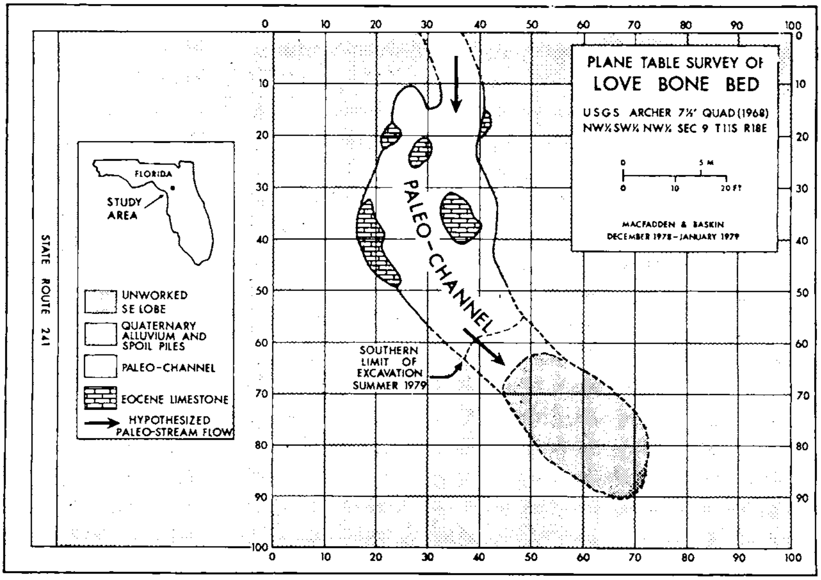

Fig. 1. Plane table survey and geographic location of the Love Bone Bed. Excavation grid lines are surveyed at 1½ m (5 ft) intervals east and south from a point 12 m south of the northwest property corner.

regime indicates the degree to which eustatic and erosional events have altered this region during the Pliocene and Pleistocene.

In north-central Florida two formation names, the Hawthorne and Alachua, are used for pre-Pleistocene clastic sediments that were deposited on the early Tertiary carbonate surface. Both these units are highly variable in lithologies and are often geographically restricted, or form isolated sink hole fills, and therefore it is difficult to distinguish between them in every instance.

The Hawthorne Formation was originally described by Dall and Harris (1892). Although never specifically designated, presumably the "type" section was from a phosphate pit near the town of Hawthorne in eastern Alachua County. More recently the Hawthorne Formation is associated with the "neotype" section from Devil's Millhopper in central Alachua County (Williams, Nicol, and Randazzo, 1977). Puri and Vernon (1964, p. 145) stated that the: "Hawthorne perhaps is the most misunderstood formational unit in the southeastern United States. It has been a dumping ground for alluvial, terrestrial, marine, deltaic, and pro-deltaic beds of diverse lithologic units in Florida and Georgia . . ." In some cases the Hawthorne Formation has been "recognized," by its "Miocene" vertebrate fauna.

Dall and Harris (1892) are credited with the original description of the Alachua Formation. Since that time, this unit has also commonly been referred to as the Alachua "Clays" (for example, Leidy and Lucas, 1896). The type locality of the Alachua Formation is at Mixson's Farm, a highly fossiliferous sinkhole fill about 3 km north of the town of Williston in Levy County (Webb, 1964). The Alachua Formation is generally considered to be a predominantly non-marine blue-gray and tan-brown clay with interbedded and poorly-indurated cross-bedded phosphatic sands. Some workers, not following accepted stratigraphic procedure, have "differentiated" the Alachua Formation by its "Pliocene" vertebrate fauna from the "Miocene" vertebrate fauna of the Hawthorne Formation. In western Alachua County the Hawthorne and Alachua Formations are not laterally continuous, but they can be distinguished on lithological criteria (Williams, Nicol, and Randazzo, 1977). In this region the Hawthorne Formation is predominantly marine, whereas the Alachua Formation is predominantly non-marine. At the Love site, the presence of brown clays and cross-bedded phosphatic sands is diagnostic of the Alachua Formation.

Stratigraphic section.—The stratigraphy at the Love site is complex, reflecting the marked spatial and temporal changes in environment of deposition associated with a meandering stream and its overbank deposits. The clastic deposits of the Alachua Formation at the Love Bone Bed form a lenticular body of variable thickness cut into the underlying Crystal River Formation. Figure 2 is a generalized section along survey line 30S which transects the thickest section (about 3 m). This section apparently crosses the center of the paleostream channel at the base of a plunge pool and gives some idea of the complexity of the site stratigraphy. Farther west, a pocket of interbedded clays and clayey sands contains fossils of mainly aquatic vertebrates and was apparently an area of quiet water deposition separated from the main channel by large limestone blocks. The main channel lies immediately east of a boulder bar, and farther east is a shallower channel.

In Alachua County the late Eocene Crystal River Formation underlies the Alachua Formation. This carbonate unit is the uppermost member of the Ocala Group, and it is a soft, granular, bioclastic limestone (Williams, Nicol, and Randazzo, 1977). The Crystal River Formation lies at, or very close to, the surface in much of western Alachua County, forming a karst plain about 20 to 25 m in elevation. In test holes drilled around the Love site, the Crystal River Formation was usually encountered within 2 m of the surface. Reworked marine invertebrates from this formation are occasionally found in the clastic deposits of the Love site. Large blocks of this limestone, some 2 m long, are also found within the clastic deposits, presumably the result of limestone bank collapse along flooded stream channels. The coarsest clastic particles of the Alachua Formation are contained in a channel bordered by limestone or limestone rubble. At the contact zone between the stream channel deposits and the Crystal River Formation, the limestone is diagenetically altered to a green or pink clay. The green clay varies from one to several centimeters in thickness and blankets the top of the limestone, wherever it has been excavated or exposed in test pits. Above it, the sediments of the Alachua Formation may be divided into three units.

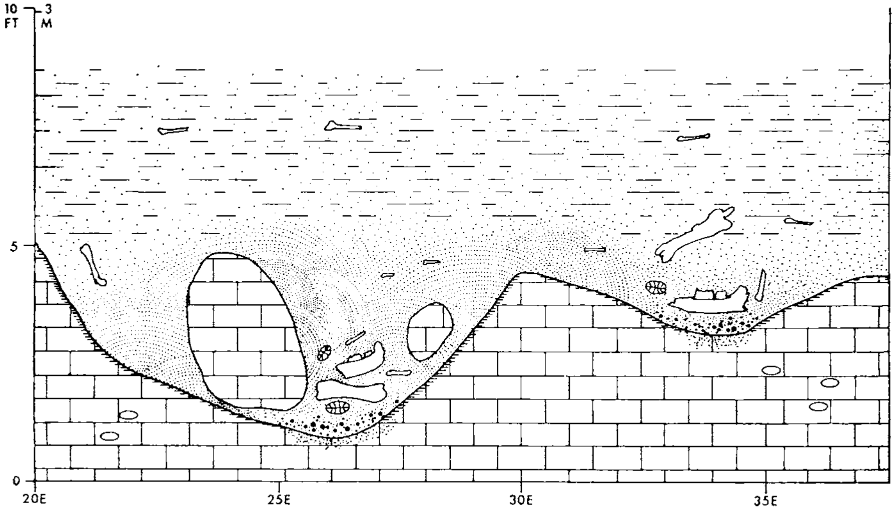

Fig. 2. Generalized east-west cross section of the Love Bone Bed showing late Eocene Crystal River Formation limestone bedrock, paleo-channel, limestone boulders, bones, crossbedded phosphatic sands, and clayey sands. As indicated dimensions are in feet with no vertical exaggeration.

The basal unit of the Alachua Formation at the Love Site is a massive bone breccia, consisting mainly of turtle and garfish material. There is also abundant mammalian material, including concentrations of larger skeletal and cranial elements of giant tortoise, elephant, and rhinoceros, which are often disarticulated or semi-disarticulated, broken, and crushed. Large limestone boulders are most common in this unit. A sediment sample, excluding large bone fragments, had a mean size of $-1.2\ \phi$. The inclusive standard deviation of $4.36\ \phi$ indicates that the sediment is extremely poorly sorted. The sediment distribution is bimodal. The primary mode is $-5.25\ \phi$. The coarsest fraction of the sediment sample is composed of bone fragments, mainly pieces of turtle shell. The secondary mode is $2.75\ \phi$. The finer fraction is composed of clean, fine-grained, quartz sand. Approx 5 percent of the sediment are silt and clay. A cumulative curve drawn for this sample shows a high percent of the traction population in these sediments.

This basal unit (unit 1) of the Alachua Formation is interpreted as a channel lag deposit, forming at the base of a plunge pool. It is 1 m thick at grid coordinate 30S × 30E and regularly attains half a meter elsewhere at the base of the main channel south of 20S. The bones in this unit are often worn and abraded, and the large bones, especially, are broken. Channel lag deposits represent residual concentrations of coarse material that accumulate as lenticular patches in the deeper part of the channel (Reineck and Singh, 1973). Bone is concentrated as coarse sediment in channel lag deposits.

At the base of the channel at coordinates 25S × 25E is a concentration of well rounded and darkly stained pebbles and cobbles, bone fragments, and some horse teeth. It is from this facies that unworn teeth of *Cacharodon megalodon,* an extinct relative of the great white shark, and a tooth and unworn skeletal elements of *Metaxytherium,* a seacow, have been recovered. Channel lag deposits occupy the lowest part of channel or point bar sequences.

The middle sedimentary unit (unit 2) is composed of less than 1 m of thin to very thin bedded, alternating, discontinuous, cross-bedded darker coarse phosphatic and lighter colored, finer grained sand. In places, this unit forms scour and fill troughs between larger limestone boulders. When this occurs, dips of the beds appear to be controlled by the shape and placement of the boulders. Along the southwest margin of the deposit, dips appear to be controlled by the limestone bank (that is, the beds dip to the southwest). Bones that occur in unit 2 seem to lie mainly on the bedding planes. This unit is highly fossiliferous (pl. 1) and produces most of the rich microvertebrate sample.

A sample taken from a darker layer of unit 2 had a graphic mean size of $-0.40\ \phi$. Rounded phosphatic pebbles plus some bone fragments form most of the pebble to coarse sand fraction. The fine and very fine sand fraction is mainly composed of quartz grains. Five percent of the sample is silt and clay. The sediment is poorly sorted ($\sigma_1 = 1.44\ \phi$), coarsely skewed ($SKi = -0.23$), and very leptokurtic ($Kg = 1.76$).

A sample taken from a lighter colored bed of unit 2 had a graphic mean diameter of 2.9 ϕ. The sediment is poorly sorted (σ_i = 1.62), symmetrical (SKi = 0.02), and very leptokurtic. Twenty percent of the sample consisted of silt and clay.

Unit 3 is a massive tan, grading to orange, clayey sand. Although not as fossiliferous as the underlying units, the material from this unit is often better preserved and shows much less evidence of abrasion. Several nearly complete turtle shells have come from this unit. A sample from unit 3 had a graphic mean size of 3.1 ϕ. The sediment is poorly sorted (σ = 1.57 ϕ), coarse skewed (SKi = –0.12), very leptokurtic (Kg = 2.49), and contains 18 percent silt and clay. Another sample has a graphic mean diameter of 1.5 ϕ, is very poorly sorted (σ = 2.83 ϕ), coarse skewed (SKi = 0.29), and consists of 19 percent silt and clay. The larger mean size is caused by bone fragments in the sample. This unit is continuous both horizontally and laterally with the underlying units. Laterally, the coarser crossbedded and lag deposits grade into this orange clayey sand. It can either lie unconformably on top of unit 2, producing an irregular contact surface or else horizontally truncate the crossbeds of the lower unit.

The clastic deposits of the Love site seem to represent a single cycle of deposition. Cut and fill structures are restricted to trough crossbedded unit 2. Sediments fine upward in every section. There has been no evidence of channeling cut into unit 3. Unit 3 probably represents the overbank deposits of the stream channel. As the stream migrated laterally this unit covered the lower lag and bar deposits. The unbroken trend toward successively finer sediments and the absence of rechanneling suggest that the Love Bone Bed accumulated in a single depositional cycle, which must represent a brief interval of geologic time.

Much of southwestern Alachua county, including the Love site, is mantled by a thin layer of sand. These sands generally have been interpreted as Pleistocene dune deposits. A sample of this surficial sand had a graphic mean diameter of 2.6 ϕ. The sample is moderately sorted (σ = 0.92 ϕ), fine skewed (SKi = 0.19), and mesokurtic (Kc = 1.05). The sorting is much poorer than that reported by Folk (1974) for Texas dune and beach sands and falls within the range for Texas river sediments. The cumulative curve is more similar to those of modern channel sands shown by Visher (1969).

Taphonomy.—The usefulness of bone orientation clues to current direction has been demonstrated by Voorhies (1969) and Hunt (1978). At the Love Bone Bed we recorded the plunge of 131 bones and plotted them on stereonets. Figure 3A shows orientations taken on bones north of grid line 35S; figure 3B shows those from south of that line. The long axis of the deposit bends markedly at about this coordinate. In figure 3A, despite much scatter of points representing strongly plunging bones, there are tendencies to cluster along the north-northeast and south-southwest axes, in general alignment with the long axis of the body of sediments. Other points are scattered from east to southeast and in the northwest quadrant. Figure 3B from the southern part of the site shows a strong tendency to cluster in the southeast quadrant, with much less scatter of steeply plunging bones than in the northern data set.

The orientation of long bones in the Love site indicates that the prevailing current flowed parallel to the long axis of the deposit. If the bones tended to dip upstream, the stream came from southeast, made a bend at about 35S, then flowed north. Extensive field data indicate, however, that the bones oriented themselves with the bedding planes of the crossbeds and thus give a measurement of crossbedding dip which tends to be downstream. In that case the stream flowed south and southeast. This accords with the geometry of the deposit (fig. 1).

Stream direction is further indicated by disarticulation trails of certain fossils in the Love Bone Bed. For example, a nearly complete upright shell of *Geochelone* in the basal gravels of unit 1 at 55S × 25E had sloughed most of the neural bones, but they were recovered adjacent to the carapace on the south and southwest sides. Similarly a palate of *Aepycamelus* cf. *major* from unit 2 at 50S × 20E had the right M^{2-3} rotated a few centimeters to the south from the rest of the palate, and a fragment of maxillary bone with right P^{3-4} was found in the same stratum 1 m to the southwest. These taphonomic data indicate that in the southwest corner of the site during deposition of the lowermost clastic sediments, bones were carried generally southward.

The preserved segment of the Love Bone Bed stream system appears to have flowed south and southeast. It is improbable that one short segment of a meandering stream would represent overall the average direction of that stream. The streams presently flowing from the "uplands" of north-central Florida into the Gulf of Mexico, such as the Steinhatchee, Suwannee, and Waccasassa Rivers, trend northeast to southwest. It is probable that late Miocene stream systems in the same area were shorter but followed similar courses. The stream of the Love Bone Bed probably joined other late Miocene fluvial sites in western

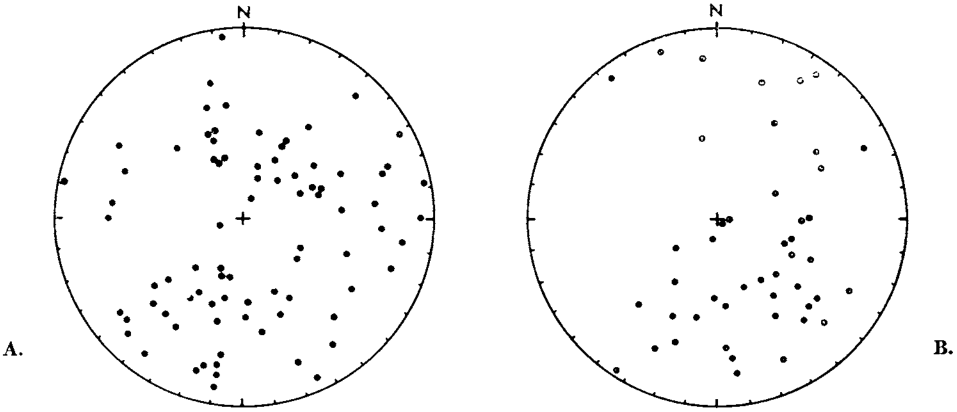

Fig. 3. Stereonet plot of long-bone plunges in the Love Bone Bed. (A) Bones north of 35 South; (B) bones south of 35 South.

TABLE 1

- CLASS CHONDRICHTHYES
  - *Carcharodon* sp.
  - *Carcharhinus leucas*
  - *Galeocerdo cuvieri*
  - *Negaprion brevirostris*
  - *Odontaspis taurus*
- CLASS OSTEICHTHYES
  - Family Lepisosteidae
    - *Atractosteus* cf. *spatula*
    - *Lepisosteus* sp.
  - Family Amiidae
    - *Amia* cf. *calva*
  - Family Elopidae
    - *Megalops* cf. *atlantica*
  - Family Ictaluridae
    - *Ictalurus* cf. *catus*
  - Family Centropomidae
    - *Centropomus* sp.
  - Family Lutjanidae
    - *Lutjanus* sp.
  - Family Sciaenidae
    - *Pogonias* cf. *cromis*
  - Family Diodontidae
    - *Chilomycterus* sp.
  - Family Labridae
  - Family Sparidae
    - *Lagodon* cf. *rhomboides*
- CLASS AMPHIBIA
  - Family Sirenidae
    - *Siren* sp.
  - Family Ranidae
- CLASS REPTILIA
- Order Chelonia
  - Family Trionychidae
    - *Trionyx* cf. *ferox*
  - Family Emydidae
    - *Chrysemys caelata*
    - *Deirochelys carri*
    - *Terrapene* n. sp.
  - Family Testudinidae
    - *Geochelone* small sp.
    - *Geochelone* large sp.
- Order Ophidia
  - Family Typhlopidae
    - *Typhlops* ?
  - Family Colubridae
    - Xenodontinae
      - cf. *Heterodon* sp. 1
      - cf. *Heterodon* sp. 2
      - sp. 3 (similar to *Dryinoides* Auffenberg)
      - sp. 4 (new)
    - Natricinae
      - cf. *Thamnophis*
      - cf. *Natrix*
    - Lampropeltinae
      - cf. *Lampropeltis getulus*
      - cf. *Elaphe*
  - Family Viperidae
    - Crotalinae
      - *Crotalus* or *Agkistrodon*
      - cf. *Sistrurus*
- Order Crocodilia
  - Family Alligatoridae
    - *Alligator mississipiensis*
  - Family Crocodylidae
    - *Gavialosuchus* cf. *americanus*
- CLASS AVES
- Order Podicipediformes
  - Family Podicipedidae
- Order Pelecaniformes
  - Family Phalacrocoracidae
  - Family Anhingidae
- Order Ardeiformes
  - Family Phoenicopteridae
  - Family Plataleidae
    - Subfamily Threskiornithinae
  - Family Ardeidae
  - Family Ciconiidae
- Order Anseriformes
  - Family Anatidae
    - Subfamily Anserinae
    - Subfamily Anatinae
- Order Accipitriformes
  - Family Vulturidae
  - Family Pandionidae
  - Family Accipitridae
- Order Galliformes
  - Family Phasianidae
    - Subfamily Meleagrinae
- Order Ralliformes
  - Family Rallidae
    - Subfamily Rallinae
    - Subfamily Fulicinae
  - Family Gruidae
  - Family Aramidae
- Order Charadriiformes
  - Suborder Charadrii
- Order Passeriformes
- CLASS MAMMALIA
- Order Insectivora
  - Soricidae gen. et sp. indet.
  - Talpidae gen. et sp. indet.
- Order Chiroptera
  - Microchiroptera, gen. et sp. indet.
- Order Lagomorpha
  - cf. *Hypolagus* sp.

Vertebrate faunal list

- Order Rodentia
  - *Mylagaulus* n. sp.
  - *Eucastor* cf. planus
  - Sciuridae gen. et sp. indet.
  - *Copemys* sp.
  - Cricetidae n. gen.
- Order Carnivora
  - Family Canidae
    - *Aelurodon* cf. *saevus*
    - *Aelurodon* cf. *haydeni*
    - *?Leptocyon*
    - *Proturocyon* cf. *macdonaldi*
  - Family Procyonidae
    - New genus A
    - New genus B
  - Family Mustelidae
    - *Leptarctus* n. sp.
    - *Sthenictis* cf. *lacota*
    - *Beckia* sp.
    - *?Plionictis* sp.
  - Family Nimravidae
    - *Barbourofelis* n. sp.
  - Family Felidae
    - *Nimravides* n. sp.
- Order Cetacea
- Order Sirenia
  - *Metaxytherium* sp.
- Order Proboscidea
  - *Amebelodon* cf. *barbourensis*
- Order Perissodactyla
  - Family Tapiridae
    - *Tapirus simpsoni*
  - Family Rhinocerotidae
    - *Teleoceras* cf. *fossiger*
    - *Aphelops malacorhinus*
  - Family Equidae
    - *Neohipparion* cf. *leptode*
    - cf. *Hipparion forcei*
    - *Nannippus* cf. *minor*
    - *Pseudhipparion* cf. *gratum*
    - *Calippus* cf. *regulus*
    - *Astrohippus martini*
    - cf. *Pliohippus* sp.
- Order Artiodactyla
  - Family Tayassuidae
    - *Prosthennops* cf. *serus*
  - Family Camelidae
    - *Aepycamelus major*
    - *Procamelus* cf. *grandis*
    - "*Hemiauchenia*" *minima*
  - Family Gelocidae
    - *Pseudoceras* sp.
  - Family Dromomerycidae
    - *Yumaceras* n. sp.
  - Family Antilocapridae
    - Antilocaprinae indet.

Alachua County and eastern Levy County such as McGehee, Mixson's Bone Bed, Haile V, and Haile VI (Webb and Tessman, 1968), to form an integrated drainage system broadly ancestral to the present Suwannee River system.

VERTEBRATE FAUNA

All potentially identifiable elements were collected from the Love Bone Bed. Exceptions were made for the ubiquitous turtles and garfishes of which only nuchal bones and unusually complete specimens were preserved. The position of each element within the site was recorded on a 1½ m (5 ft) grid system, measured from a point 12 m south of the northwest corner of the Love property. In this manner an estimated 300 cubic m of fossiliferous sediments have been removed in 5 yrs. Bulk samples of medium-grained clastic particles (unit 2) have been washed in the laboratory through 4, 10, and 25 mesh screen in order to concentrate microvertebrate remains. About 12 tons of productive matrix have been processed, although only about half of the material has been picked and sorted. In this manner a rich sample of the Love Bone Bed L. F. has been assembled.

A preliminary list of the vertebrates from the Love Bone Bed is presented in table 1. It represents some 84 species or higher taxa. To date we have studied the mammalian fauna most thoroughly. The ichthyofauna, herpetofauna, and avifauna have been studied in a preliminary manner. Further sorting and studying of the screen-washed microvertebrate samples will yield major additions to all vertebrate classes. The vertebrate fauna will surely exceed 100 species when it has been fully studied.

Jackson (1976 and 1977) has published studies of the two most abundant emydid turtles at the Love Bone Bed. One of these, *Deirochelys carri,* represents the oldest known member of the genus of living chicken turtles. The other, *Chrysemys caelata,* was previously described from Mixson's Bone Bed and probably is related to the recent *Chrysemys nelsoni.*

In the following pages we provide more detailed notes on the mammalian fauna only. This is justified not only because it is the most thoroughly studied part of the fauna, but also because it provides a reasonably secure biostratigraphic age for the whole vertebrate fauna.

With respect to the mammals, two insectivorans, at least one chiropteran, and a lagomorph, are as yet too incompletely known to provide generic determination. Presumably they will become better known when the concentrated matrix has been fully picked and studied.

Mylagaulus n. sp.—This new rodent from the Love site is slightly larger than, and appears to be ancestral to, *Mylagaulus kinseyi* from the early Hemphillian of Florida (Webb, 1966). It is known from about 20 isolated teeth. The Love site *Mylagaulus* demonstrates that *M. kinseyi* is not a Barstovian relict as previously supposed but is the end product of a dwarfing trend in *Mylagaulus* from the late Miocene of Florida (Baskin, in press a).

Eucastor cf. *planus.*—This beaver is represented at the Love site by a P_4, an upper molar, two lower molars, and incisor fragments. The P_4 has parastriid and mesostriid equal in length and possesses a small metafossettid. The two lower molars have an S-shaped occlusal pattern. One has a long mesostriid and a nearly complete hypostriid. The other has a very short mesostriid and hypostriid and is closed at the base. The upper molar has a short parastria and mesostria and a complete hypostria and metastria.

The species of *Eucastor* are badly in need of revision. The Love site *Eucastor* is an advanced species with usually open roots and long striae (ids). It is also comparable to *E. lecontei* but is smaller and possesses a metafossettid. *Eucastor lecontei* is known from the late Clarendonian Siesta Formation (type locality) and the Black Hawk Ranch L. F. of California and from the Truckee Formation of Nevada (Macdonald, 1956). Specimens similar to *E. lecontei* have been reported from the Hemphillian Smiths Valley L. F. (as *Dipoides* sp.) and from the Yerington L. F. *Eucastor planus* is known from the late Clarendonian Laverne L. F. of Oklahoma (type locality) and from the Wolf Creek L. F. of South Dakota.

Spermophilus sp.—A medium-sized squirrel is represented by three teeth: M^2, M^3, and a broken lower molar. The M^2 has a low but complete protoloph and metaloph. The metaconule is large. The mesostyle is very small. The M^3 is smaller than the M^2 and may belong to another taxon. *Spermophilus* has been recorded from only one other locality in Florida, the late Pleistocene Haile XIVA fauna (Martin, 1974).

Cricetidae.—At least three taxa of cricetid rodents are known from approx 200 isolated teeth. Not only are these the earliest known cricetids from Florida, but they constitute the only Tertiary record east of the Mississippi River. At present, they can all be referred to *Copemys (sensu lato)* because they all have nonalignment of protolophule II — anterior arm of hypocone and entolophulid — posterior arm of protoconid (Lindsay, 1972). These taxa are not as derived as Hemphillian cricetines known from the western United States. The reduction of accessory lophs (ids) and styles (ids) is at about a similar stage of evolution as that of late Clarendonian cricetines from Kansas and California. One of the taxa is of interest because it appears to be closely related to the oryzomyines and at the same time may demonstrate that the phyllotines were derived from this group. It has small accessory rootlets on the M1/1 and may be the earliest representative of the predominantly Neotropical Hesperomyini.

At least 11 taxa of carnivores are represented at the Love site. These carnivores are very interesting, because they are represented by large samples, and many of the taxa are new.

Barbourofelis n. sp.—This saber-cat-like carnivore is very well represented at the Love site. There is a fairly complete juvenile skull, numerous mandibles and mandible fragments, several basicranial regions, and various postcrania. The Love site *Barbourofelis* is intermediate in size between *B. morrisi,* best known from the late Clarendonian of Nebraska, and the early to medial Hemphillian *B. fricki.* Similar sized *Barbourofelis* apparently occur in the late Clarendonian Black Hawk Ranch L. F. of California (Macdonald, 1948) and the early Hemphillian Arnett L. F. of Oklahoma (Kitts, 1957; Baskin, in press, c).

Nimravides n. sp.—The Love site species differs from *N. thinobates* which is known from the late Clarendonian of California and Nebraska and the early Hemphillian of Oklahoma, Kansas, and Texas. The Florida species and *N. thinobates* probably share a common ancestor which was derived from a form similar to the medial Clarendonian *Pseudaelurus pedionomus.* There is a femur of a *Nimravides thinobates* sized cat from Mixson's Bone Bed in Florida (Baskin, in press, c.)

Aelurodon cf. *saevus.*—This hyena-like dog is one of the most common carnivores at the Love site. The premolars are not reduced relative to *Osteoborus.* There is much variation in the size and spacing of the premolars and in their degree of development of accessory cusps. This taxon is similar in size and morphology to *A. saevus* from the medial and late Clarendonian of Nebraska and South Dakota (McGrew, 1944). In the early Hemphillian, small species of *Aelurodon* are replaced by *Osteoborus* (Tedford and others, in press). *Osteoborus galushai* occurs in the Mixson's L. F. and McGehee Farm L. F. (Webb, 1969b).

Aelurodon cf. *haydeni.*—This large hyena-like dog is much rarer than *A.* cf. *saevus.* It is represented by one good mandible and a few jaw fragments and isolated teeth. This large species is not as advanced in the enlargement of the P_4 and reduction of $P_{1\text{-}3}$ as specimens from the early Hemphillian of Texas, Oklahoma, Nebraska, or Florida referred to *Aelurodon validus.*

Proturocyon cf. *macdonaldi.*—This fox is represented at the Love site by an M^1, P^3, and an edentulous mandible fragment. M^1 is slightly smaller than that in the late Clarendonian Black Hawk Ranch L. F. (Tedford and Taylor, in press) and has a more prominent metaconule, a more prominent anterior cingulum, and a less twisted hypocone.

An M^2 from the Love site appears to be too small to belong to this taxon and is tentatively referred to *?Leptocyon.*

Two new genera of Procyonidae are present in the Love L. F. The large new genus A is rare at the Love site but is known from Barstovian through Hemphillian age localities from western North America (Baskin, in press, b). This new genus is apparently closely related to the South American late Miocene through Pleistocene procyonids of the *Cyonasua* group. New genus B is much more common, being represented by mandibles as well as isolated teeth. It appears to be ancestral to the two Recent genera *Procyon* and *Nasua.*

Leptarctus n. sp.—*Leptarctus* is known from Hemingfordian through medial Hemphillian time. The Florida species is more primitive than undescribed Hemphillian material. A p_4 from the late Clarendonian Black Hawk Ranch L. F. described as a procyonine (Macdonald, 1948) and a lower jaw fragment with $M_{1\text{-}2}$ from the late Clarendonian Black Butte L. F. of Oregon described as *Pliotaxidea* sp. (Shotwell, 1963) may be conspecific with the Love site species.

Sthenictis cf. *lacota.*—The type of *Sthenictis lacota*, a lower jaw with P_2, P_3, and broken P_4 and M_1 from the Clarendonian Ash Hollow Formation of South Dakota was originally described as *Potamotherium lacota* (Matthew, 1904) and subsequently transferred to *Potamotherium, Paroligobunis* and finally *Brachsypalis.* It is here placed in *Sthenictis* because of its elongate mandible, narrow cheek teeth, and, as indicated by the alveoli, a narrow elongate M_1. The Love site material, which consists of two mandibles with P_4's, compares favorably with the holotype.

The two other mustelids are poorly represented. *Beckia* is known elsewhere from the late Clarendonian and early Hemphillian. *Plionictis* is known from Barstovian through Hemphillian deposits.

Amebelodon cf. *barbourensis.*—A large sample of proboscidean dentitions and some postcranial material represents a primitive shovel-tusked mastodon. As Tobien (1973) noted, most of the North American *Amebelodon* specimens belong to a large species like *Amebelodon fricki* and are Hemphillian in age. Smaller specimens resembling *"Serbelodon" barbourensis* from the late Clarendonian are relatively rare. The Love site adds an important additional sample of this smaller and older species group, close to *Amebelodon barbourensis* described by Frick (1933) from the upper part of the Ash Hollow Formation of Nebraska. The lower tusks are relatively short, the longest available being about 300 mm long. They do not extend to the back of the symphysis but lie about 175 mm anterior to the roots of the first cheek tooth in mature mandibles. The lower tusks are small, relatively deep in cross section, and have a convexity on the medial dorsal side. The largest tusk is 62.5 mm wide and 49 mm deep just behind the bevelled wear surface. The cheek teeth are small and simply constructed. The last lower molar has 4½ lophids. The Love sample of *Amebelodon* resembles that from the Christmas Quarry. It differs from more advanced species in which M_3 usually has double trefoils and 5½ lophids. Similarly, the tusks in more progressive species are at least 50 percent wider and lack the dorsal convexity. Refined comparisons of these shovel-tusked proboscideans may show a chronological progression from *A. barbourensis* to *A. hicksi* to *A. fricki*. The Love site seems to offer one of the largest samples of the earliest American shovel-tuskers.

Tapirus simpsoni.—Schultz, Martin, and Corner (1975) propose this species for specimens collected from the early Hemphillian Ft-40 locality (= "*Amebelodon fricki* Quarry") in western Nebraska.[1] *T. simpsoni* from the Love site and Nebraska is significantly (about 50 percent) larger than *Tapiravus polkensis* from the Bone Valley region of Florida (Olsen, 1960) and approaches in size *T. veroensis* from the Pleistocene of Florida (Sellards, 1918; Simpson, 1945). Shultz, Martin, and Corner (1975) state that *T. simpsoni* differs from *T. veroensis* because: (1) the premolars are more square in *T. veroensis*, and (2) the P^1 is more molarized in *T. simpsoni*. Based on our examination of the relevant figures in Schultz, Martin, and Corner (1975), the Love sample, and the holotype of *T. veroensis*, the relative squareness of the cheek teeth does not appear to be a valid character for separating *T. simpsoni* from *T. veroensis*. However, it does appear that the advanced molarization of the P^1 in *T. simpsoni* can distinguish that species from *T. veroensis*.

Teleoceras cf. *fossiger.*—One of the most abundant larger mammals at the Love site is *Teleoceras* cf. *fossiger*. This rhinoceros is characterized by very short and stout limbs, high-crowned teeth, reduced premolar series, and skull with a nasal horn (inferred by a bony thickening) in males. It should be noted that the species *T. fossiger* has been a dumping-ground for many forms from numerous late Tertitary localities in North America. In addition, Skinner, Skinner, and Gooris (1968) discuss some interesting problems in the nomenclature of *T. fossiger* and *T. major*.

To date at least 45 individuals of *Teleoceras* have been recovered from the Love site, including several skulls and mandibles, rami, hundreds of isolated teeth, and hundreds of postcranial elements. We

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[1] The biochron "Kimballian", typified at FT 40, has engendered much controversy. We follow Tedford and others (in press) in regarding the "Kimballian" as a local equivalent of early Hemphillian.

are presently engaged in a study of dental ontogeny and population dynamics of this large sample of *Teleoceras.*

Aphelops malacorhinus.—This species is represented at the Love site by about a third of the number of individuals of *Teleoceras.* This ratio is the reverse of that for many sites in the midcontinent. *Aphelops* has different skull proportions, no horns, relatively less hypsodont teeth, a longer tooth row (resulting from unreduced premolars), prominent external cingula, and relatively long limbs. The two rhinocerotid species at the Love site are closely comparable to the two species described by Leidy and Lucas (1896) from Mixson's Bone Bed.

At least 7 species of horses are represented from the Love site. This sample includes hundreds of isolated teeth, numerous partial dentitions, and hundreds of postcranial elements. As Skinner and MacFadden (1977) have recently shown, it is very difficult to characterize adequately by certain equid taxa, particularly hipparions, without reference to facial morphology.

Neohipparion cf. *leptode.*—This species is the most abundant horse at the Love site. MacFadden (in preparation) notes that *N.* cf. *leptode* from the Love site has numerous characters that demonstrate a close relationship with *N. leptode* from the early Hemphillian Thousand Creek L. F. of Nevada; for example, elongate, angular, and laterally compressed protocones in the upper cheek teeth and very shallow ectoflexids in the lower premolars. In many of these dental characters the *N. leptode* samples from Florida and Nevada demonstrate a close (that is, ancestral-descendent) relationship with the *N. eurystyle* "group" that is cosmopolitan in North America during the late Hemphillian. One skull from the Love site demonstrates that *N.* cf. *leptode* has a smooth preorbital region lacking any facial fossae. The absence of poorly developed facial fossa is characteristic of *Neohipparion (senus stricto)* and the closely related genus *Nannippus* (see, for example, Skinner and MacFadden, 1977, fig. 3B; MacFadden and Waldrop, 1980).

?Hipparion forcei.—There is another species of larger hipparion at the Love site that is tentatively assigned to *?H. forcei, faute de mieux.* The dentitions of this species can be distinguished from the similar-sized dentitions of *N.* cf. *leptode* by their relatively simple enamel plications, oval protocones in the upper cheek teeth, and relatively deep ectoflexids in the lower premolars and molars.

Nannippus cf. *minor.*—This very small hipparion is relatively rare at the Love site. It is less hypsodont than *N. minor* from the upper Bone Valley Formation and other Hemphillian sites in Florida but is referred to this species based on its small size, isolated oval protocones, and simple dental pattern.

Pseudhipparion cf. *gratum.*—Another small and rare horse at the Love site is *P.* cf. *gratum.* This assignment is based on the presence of protocones that tend to become connected to the protolophs (often with a constricted border), weak hypoconal grooves, and, in contrast to *Calippus,* some plications on the fossette borders.

Calippus cf. *regulus.*—The third small and rare horse at the Love site is *C.* cf. *regulus. Calippus* is characterized by very simple fossette borders and protocones that are more broadly connected to the protolophs than in similar wear stages in *Pseudhipparion.* In the original description of *C. regulus* from the Clarendon area of the Texas Panhandle, Johnston (1937) gave no characters that differentiate this species from *C. placidus,* which was described earlier from the Niobrara River area (Leidy, 1858). Webb (1969a) noted that these two species might be differentiated by size differences, where *C. regulus* is about one-fifth smaller than *C. placidus.* The Love sample does appear to be relatively small; however, pending a detailed statistical comparison, it can only be tentatively referred to *C.* cf. *regulus.*

Pliohippini.—A small pliohippine horse is identified as *Astrohippus martini* based on dentitions. This species is characterized by its small size, strongly curved cheek teeth, protocone connected to the protoloph, simple fossette borders, and weak hypoconal groove. This species is relatively rare at the Love site. Another pliohippine horse is tentatively identified as cf. *Pliohippus* sp. This taxon has the pliohippine characters also seen in *Astrohippus martini* but is larger. In addition, without cranial material it is difficult to distinguish *Pliohippus* from *Dinohippus,* although such dental features as the weak hypoconal groove are apparently diagnostic of *Pliohippus.*

Prosthennops cf. *serus.*—The Love site provides an excellent sample of dental and postcranial elements of a peccary. In addition to considerable variation in the sizes of canine teeth, presumably due to sexual dimorphism, there is at least a hint that the sample includes a similar but smaller species of peccary as well. The jaws are very long and slender compared to modern *Tayassu.* The upper and lower premolars are three in number, and are submolariform, or, in the case of the last premolar, fully molariform. The slender proportions of the jaws and teeth are comparable to those of *Prosthennops serus* described by Gidley (1924) from the Little White River collections of South Dakota.

Three camelid taxa are represented in the Love sample. They include a large, a medium, and a small-sized camelid. It is probably no coincidence that Leidy (1886) had recognized the same three size classes in the collections from "Mixson's Planation" nearly a century ago. He named his three taxa *major, minor*[2], and *minimus,* and it seems that these names are applicable to the Love camelids, also. These three species are not all referable to *Procamelus* as has been the practice (for example, Gregory, 1942). We remove two of them to distinct genera as indicated below.

Aepycamelus major.—The largest camelid at the Love Bone Bed is the giraffe camel, *Aspycamelus major.* A complete metacarpal from the Love Bone Bed measures 87.3 cm long and 7.0 cm wide at the proxi-

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[2] Some confusion exists as to the use of *minor.* In much of the later literature, the middle-sized camelid from Mixson's is called *medius,* but this error began 10 yrs later with Leidy and Lucas (1896).

mal end. As Matthew (1901) noted for *Aepycamelus giraffinus* the metapodials are actually the shortest limb segments in these giraffe camels. This animal probably exceeded 4 m in shoulder height. Webb (1969a) was surely incorrect in referring this species (based on Leidy's sample from Mixson's Bone Bed) to *Megatylopus* rather than to *Aepycamelus.*

Procamelus cf. *grandis.*—The medium-sized camelid at the Love Bone Bed has long narrow premolars and bladelike caniniform teeth as in *P. occidentalis* and *P. grandis.* P^3 has an incomplete lingual cingulum in keeping with the narrowness of the corresponding lower premolars. The diastema is moderately long as in *P. grandis* and in contrast with the short jaw of *P. robustus.* The Love site *Procamelus* is larger than *P. occidentalis* and near the lower end of the size range of *P. grandis.*

Procamelus is the most abundant camelid at the Love Bone Bed, and *Aepycamelus* is rare. This contrasts strikingly with the Mixson's site where *Aepycamelus* is quite common, and *Procamelus* is rare.

"Hemiauchenia" cf. *minima.*—Of the three taxa at the Love Bone Bed this is the only one that is distinctly llama-like in a number of features. Leidy (1886) originally referred this taxon to *"Auchenia,"* a synonym of the living genus *Lama.* Possibly a new generic term will be required for this distinctive early lamine.

Pseudoceras sp.—A small hornless ruminant is represented by a few teeth and limb elements. It can be identified as *Pseudoceras* by its long secant premolars, by the primitive construction of its molars, and by its delicate fused metapodials. Better representation is needed for a species determination.

Yumaceras n. sp.—A large horned ruminant from the Love Bone Bed appears referable to the genus *Yumaceras.* It is well represented by cranial, dental, and postcranial material. The large horns include paired orbitals and unpaired occipitals. The material compares most closely with the genotypic sample from the Wray local fauna in Yuma Co., Colo. (Frick, 1937) but differs in its smaller size and more open lower premolars.

Antilocaprinae.—A very limited sample of teeth and limb elements represent a pronghorn antilocaprid. The teeth are too hypsodont and too large to belong to any merycodontine. They compare closely with such primitive antilocaprine genera as *Sphenophalos, Plioceros,* and *Texoceros.*

MAMMALIAN BIOCHRONOLOGY

The age of the Love Bone Bed is here considered very late Calendonian. In the present report we recognize a three-fold subdivision of the Clarendonian, that is, early, medial, and late. These subdivisions are represented by the highly fossiliferous Miocene biostratigraphic succession exposed in north-central Nebraska. In that region the early Clarendonian is represented by the Burge mammalian fauna from the Burge member in the uppermost part of the Valentine Formation. (This interval would also be referred to as late "Valentinian" by some authors,

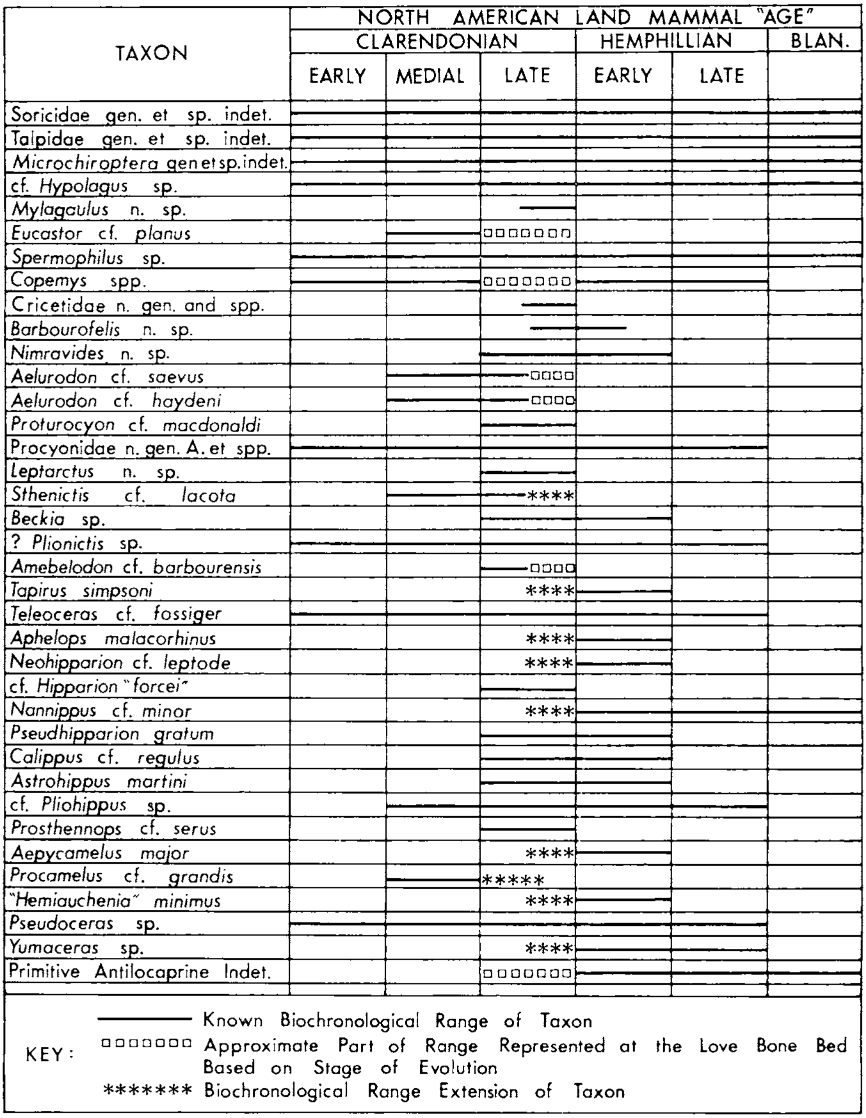

Fig. 4. Concurrent range zonation of Love Bone Bed land mammals.

although this term is not universally accepted.) The medial Clarendonian is represented by the Minnechaduza mammalian fauna from the Caprock member in the lower part of the Ash Hollow Formation. The late Clarendonian is represented by the mammalian fauna from the sediments above the Caprock member in the Ash Hollow Formation. This youngest group of Clarendonian deposits in north-central Nebraska has also been referred to as the "Xmas and Kat Quarries" zone. We realize that in other areas (for example, the Texas Panhandle) this threefold division of the Clarendonian is less easily recognized. However, for the purpose of the biochronological comparisons that are presented below, we find it convenient to use the three subdivisions of the Clarendonian.

The age of the Love Bone Bed is based on the concurrent range zones of the land mammals presented in figure 4. Four distinct biostratigraphic categories are as follows: (1) immigrant taxa, (2) rapidly evolving North American taxa ("stage of evolution"), (3) taxa whose absence is significant, and (4) unique, long-ranging, or poorly-known taxa. Each category is considered below.

1. *Immigrant taxa.*—One of the principal ways to define the base of certain North American Land Mammal "Ages" is by the appearance ("datum planes") of immigrant taxa (Repenning, 1967). *Beckia* from Eurasia first appears in North America during the late Clarendonian and ranges through the early Hemphillian (Tedford and others, in press).

2. *Rapidly evolving North American taxa.*—The new species of *Mylagaulus* from the Love site is relatively advanced but not as much so as *Mylagaulus kinseyi* from the early Hemphillian McGehee Farm L. F. of Florida (Webb, 1966; Hirschfeld and Webb, 1968; Baskin, in press, a).

The beaver *Eucastor* cf. *planus* is an advanced species of this genus that indicates a late Clarendonian age. *Eucastor* is "replaced" by *Dipoides* at the end of the Calendonian (Wood and others, 1941; Tedford and others, in press).

The cricetid rodents are long-ranging, but the Love sample compares favorably in stage of evolution with the late Clarendonian cricetids from the WaKeeney L. F. of Trego County, Kansas (Wilson, 1968). It is unfortunate that there are no well-studied early Hemphillian cricetid assemblages for further comparison. The Love cricetids are clearly more primitive than late Hemphillian rodent assemblages such as the White Cone L. F. (Baskin, 1977, 1979) and the Redington L. F. (Jacobs, 1977) from Arizona.

The new species of saber-toothed "cat" *Barbourofelis* from the Love site is morphologically intermediate between *B. morrisi* from the medial Clarendonian Ash Hollow Formation of north-central Nebraska and *B. fricki* from the early Hemphillian ("Kimballian," *sensu* Tedford and others, in press) Kimball L. F. of western Nebraska (Schultz, Schultz, and Martin, 1970). The Love *Barbourofelis* n. sp. also occurs at the late Clarendonian Black Hawk Ranch L. F. of California and earliest Hemphillian Arnett L. F. of Oklahoma (Baskin, in press, c).

The two species of dogs, *Aelurodon* cf. *saevus* and *Aelurodon* cf. *haydeni,* are at a comparable stage of evolution with these same taxa represented from the late Clarendonian upper Ash Hollow Formation (above the Caprock member) of north-central Nebraska. The Love species are more primitive than *A. validus* from early Hemphillian localities such as the Arnett L. F. of Oklahoma, Higgins L. F. of Oklahoma, and Mixson's L. F. of Florida.

The procyonids from the Love site represent new taxa, but one of these (new gen. A sp.) compares favorably with undescribed material in the Frick Collection from the upper Ash Hollow Formation (Baskin, in press, b).

The new species of *Leptarctus* from the Love site is probably conspecific with the late Clarendonian specimens described from the Black Hawk Ranch L. F. of California (Macdonald, 1948) and Black Butte L. F. of Oregon (Shotwell, 1963). *Proturocyon macdonaldi* was also described from the Black Hawk Ranch L. F. *Sthenictis* cf. *lacota* is known elsewhere from the late Clarendonian (Ash Hollow Formation) of South Dakota.

The gomphotheriid proboscidian at the Love site is closely comparable to *Amebelodon barbourensis,* known elsewhere from the late Clarendonian (upper part of the Ash Hollow Formation) of north-central Nebraska. *Amebelodon barbourensis* is more primitive (particularly in the less flattened tusks) than *A. fricki* from the early Hemphil-Kimball L. F. of western Nebraska (Schultz, Martin, and Corner, 1975) and *A. hicksi* from the early Hemphillian Higgins L. F. of western Oklahoma (Tobien, 1973).

Tapirus simpsoni is known elsewhere from the early Hemphillian Kimball L. F. of western Nebraska (Shultz, Martin, and Corner, 1975). The presence of *T. simpsoni* at the Love site is interpreted as a downward biochronological range extension (fig. 4).

The rhinocerotids from the Love site are represented by two taxa, *Teleoceras* cf. *fossiger* and *Aphelops malacorhinus.* The systematics of late Tertiary rhinoceroses is in need of revision. The biochronologic ranges of the two Love rhino taxa are poorly known in the literature. Based on unpublished studies of the Frick rhino collection, *Teleoceras fossiger (sensu lato)* ranges from early Barstovian to late Hemphillian. *Aphelops malacorhinus (sensu lato)* ranges throughout the Hemphillian. The presence of a morphologically primitive *A. malacorhinus* at the Love site represents a biochronological range extension (Manning, personal commun., 1979).

Five of the seven taxa of horses represented at the Love site are well-enough known to be biochronologically useful. *Neohipparion* cf. *leptode* has been previously described from the early Hemphillian Thousand Creek locality in Nevada (Stock, 1951). The large sample of *N.* cf. *leptode* is a biochronological range extension as is the presence of *Nannippus* cf. *minor* at the Love site, which had previously been restricted to the Hemphillian (Stirton, 1940; Waldrop, ms) and possibly early Blancan (Akersten, 1972). The three other biostratigraphically useful taxa of horses include *Pseudhipparion gratum, Calippus* cf. *regulus,* and *Astrohippus martini.* These horses are characteristic of the late Clarendonian in North America (Webb, 1969a; Tedford and others, in press).

The peccary *Prosthennops* cf. *serus* from the Love site is similar to material from such later Clarendonian mid-continental localities as the Little White River of South Dakota (Gidley, 1904).

Among the Camelidae, *Procamelus grandis* indicates a late Clarendonian age similar to, but slightly younger than, the Minnechaduza L. F. of Nebraska (Webb, 1969a) and the Big Springs L. F. of South Dakota (Greogory, 1942). *Aepycamelus* cf. *major* from the Love site compares favorably with *A. major* from the early Hemphillian Mixson's Bone Bed. The llama *"Hemiauchenia" minima* is only known from the Love site and the Mixson's L. F. These three camelid taxa from the Love site are interpreted as biochronological range extensions (see fig. 4).

The dromomerycid genus *Yumaceras* is represented at the Love site by a probable new species. Elsewhere in North America this genus is known from early Hemphillian sites including the Wray L. F. of Colorado and the Kimball L. F. in Nebraska. It apparently gives way in the late Hemphillian to *Pediomeryx.*

Although the antilocaprine at the Love site cannot be given a generic or specific designation, the presence of this subfamily is biochronologically useful. The earliest occurrence of antilocaprines is from the late Clarendonian (above the Caprock member of the Ash Hollow Formation) of Nebraska (Barbour and Schultz, 1934), and this subfamily ranges through to the Recent. The primitive stage of evolution of the Love site antilocaprine indicates an age near the early part of this range.

3. *Absent taxa.*—In extremely diverse and well-sampled localities such as the Love site, the absence of certain taxa can be used in a biochronological context. It is particularly striking that there are no megalonychid or mylodontid sloths of Neotropical origin nor any Hemphillian Eurasian carnivore immigrants such as bears and machairodonts. Such taxa, especially the sloths, are well represented at early and late Hemphillian sites in Florida and elsewhere, for example, Mixson's, McGehee, Withlacoochee 4A, and Bone Valley (Webb, 1978; Marshall and others, 1979). The absence of these taxa from the Love site apparently indicates a pre-Hemphillian age.

4. *Unique, long-ranging, or poorly-known taxa.*—The new genus and species "B" of procyonid is unique to the Love site (Baskin, in press, c) and therefore is not biochronologically useful (it is not indicated in fig. 4). The new species of *Nimravides* is unique to the Love site, and only the generic biochronological range is useful at present.

There are numerous long-ranging or poorly known taxa represented at the Love site, including most of the micromammals, the mustelid, *?Plionictis* sp., and the deer-like artiodactyl *Pseudoceras* sp. The cat genus *Nimravides* ranges from the beginning of the late Clarendonian to the end of the early Hemphillian (Tedford and others, in press) and a similar time interval is suggested for the Love site based on the presence of this genus. The two horses, cf. *Hipparion forcei* and cf. *Pliohippus*, are not biostratigraphically useful at present because: (1) they are rare at the Love site, and (2) their taxonomy is presently in a state of flux. The pseudoceratine *Pseudoceras* sp. is represented by a few specimens. It is anticipated that further collecting and study, particularly for the micromammals, will increase the biochronological utility of some taxa placed in this category.

Many mammalian taxa represented at the Love site are members of the Clarendonian chronofauna which extended into early Hemphillian time (Webb, 1977; Tedford and others, in press). More important, several rapidly evolving taxa such as *Eucastor* cf. *planus*, *Aelurodon* cf. *saevus*, and *Amebelodon* cf. *barbourensis* more precisely indicate a latest Clarendonian age. This view is supported by the presence of the immigrant *Beckia* and the absence of sloths and certain Eurasian carnivores such as bears and machairodont cats.

PALEOECOLOGY

The vertebrates from the Love Bone Bed indicate three aquatic and three terrestrial environments. In the following discussion we attempt to define each of the 6 environments on the basis of its vertebrate indicators. Our purpose in this section is to envision how these 6 environments came to be represented in a single site of deposition and to indicate the relative significance of each.

A preliminary paleoecological analysis was based on a census of the vertebrate fossils in two different samples of fluviatile sediments. A quarter cubic meter of silty clay was collected from stratigraphic unit 3 at 35′ E × 35′ S in the upper part of the Alachua Formation at the Love site. The sample was treated with amine 220 and methlyamyl alcohol to facilitate sieving and was then wet-sieved through a 10 mesh screen. Finer fractions yielded a negligible sample of identifiable specimens and, therefore, were disregarded in this census. A second quarter cubic meter sample was taken at 35′ E × 30′ S in this case from the coarse phosphatic sands of unit 1 near the base of the Alachua Formation. It was washed through a 10 mesh screen but did not require chemical treatment.

The bone from each sample was weighed and identified, as indicated in table 2. The phosphatic sand of unit 1 yielded three times as much fossil material as the silty clay of unit 3. Furthermore, the proportions of different vertebrate taxa differed considerably between the coarse sediments of unit 1 and the fine sediments of unit 3. In the silty clay, bony fishes accounted for 15 percent of the weight of all fossil vertebrates, while mammals made up only 9.9 percent. In the phosphatic sand on the other hand, bony fishes represented 9.4 percent by weight, and mammals 29.1 percent. Land tortoises comprised only 0.75 percent of the bones in the clay sample but 2.4 percent of the bones in the sand sample. Thus, the proportion of land vertebrates (compared to fishes) was much higher in the coarse sediments than in the fine sediments.

TABLE 2

A. Phosphatic sand samples

Class and Family	Bone wt (g)	Percent Bone wt
Class Chondrichthyes		
a. Genus *Carcharhinus acronotus* (Black-Nose)	0.26	0.001
b. Genus *Carcharhinus leucas* (Bull Shark)	1.61	0.004
c. Genus *Galeocerdo cuvieri* (Tiger Shark)	0.35	0.001
d. Genus *Negaprion brevirostris* (Lemon Shark)	0.93	0.002
e. Genus *Odontaspis taurus (*Sand Shark)	0.35	0.001
Total For Class	3.5	0.009
Class Osteichthyes		
Family Lepisosteidae (Garfish)	3645.	9.219
Family Amiidae (Bowfish)	50.	.126
Family Diodontidae (Pufferfish)	15.	.038
Total For Class	3710.	9.383
Class Amphibia		
Family Sirenidae (Sirens)	0.38	0.001
Class Reptilia		
Family Trionychidae (Softed-Shelled Turtles)	2400.	6.070
Genus *Trionyx*		
Family Emydidae (Pond Turtles)	8975.	22.699
a. Genus *Chrysemys* (Cooters)	1380.	3.490
b. Genus *Deirochelys* (Chicken Turtles)	405.	1.024
c. Unidentified Turtles	7520.	19.018
Family Testudinidae (Tortoises)	950.	2.402
Family Alligatoridae (Alligators)	345.	.872
Total For Class	13,000.	32.879
Class Aves	20.	0.051
Class Mammalia (Mammals)		
Family Mylagaulidae (Horned Rodents)	0.40	0.001
Family Leporidae (Rabbits)		
Family Canidae (Dogs)	110.	0.278
Family Felidae (Cats)	260.	0.657
Family Dugongidae (Dugongs)	230.	0.581
Family Gomphotheridae (Mastodonts)	1740.	4.401
Family Equidae (Horses)	930.	2.352
Family Tapiridae (Tapirs)	170.	0.430
Family Rhinocerotidae (Rhinoceros)	3100.	7.840
Family Tayassuidae (Peccaries)		
Family Camelidae (Camel)	430.	1.087
Family Palaeomerycidae (Giraffoids)	50.	0.126
Misc. Mammal Bones	4470.	11.305
Total For Class	11,490.4	29.061
Unidentifiable Bone Material	11,314.	28.615
Total	39,538.28	99.880

Bone weights and percentages of vertebrate fossils

B. Silty clay sample

Class and Family	Bone wt (g)	Percent Bone wt
Class Osteichthyes		
Family Amiidae	15.	0.113
Family Lepisosteidae	1930.	14.539
Unidentifiable Bony Fish	55.	0.414
Total For Class	2000.	15.060
Class Amphibia		
Family Sirenidae	2.	0.015
Class Reptilia		
Family Trionychidae	1165.	8.776
Family Emydidae	2790.	21.018
a. Genus *Chrysemys*	625.	4.708
b. Genus *Deirochelys*	215.	1.619
Unidentified Turtles	2110.	15.895
Family Testudinidae (Tortoises)	100.	0.753
Family Alligatoridae	80.	0.602
Total For Class	4295.	32.356
Class Aves	15.	0.113
Class Mammalia		
Family Leporidae	10.	0.011
Family Canidae	61.	0.659
Family Gomphotheridae	160.	1.205
Family Eqquidae	120.	0.904
Family Tapiridae	30.	0.226
Family Rhinocerotidae	265.	1.996
Family Tayassuidae	10.	0.075
Family Camelidae	70.	0.527
Family Palaeomerycidae	100.	0.753
Unidentified Mammalia	480.	3.616
Total For Class	1306.	9.838
Unidentifiable Bone Material	5656.5	42.613
Total	13,274.5	100.

The three aquatic settings that seem to be represented at the Love Bone Bed are estuarine, fast water (lotic), and slow water (lentic) environments. The rarest vertebrates are the estuarine taxa. They are largely restricted to the coarse clastic units and are especially noticeable in unit 1 near the north end of the site (see discussion under stratigraphy). The most conspicuous estuarine fossils are shark teeth and dugong (sea cow) ribs. A number of estuarine bony fishes including Diodontidae (Pufferfish), Sparidae such as *Lagodon* (pinfish), and Elopidae (drums) are also represented. *Gavialosuchus* and a small odontocete whale are other rare taxa diagnostic of a salt-water habitat.

Some of these salt-water vertebrate samples might have been reworked from older marine sediments. Many have clear signs of stream abrasion, but then so do most taxa in the coarse clastic units. The chances that many of these specimens are reworked from the underlying Eocene limestones or the once-present Miocene marine formations (stripped away prior to cutting of the Love stream channel) seem remote for two reasons. First, the nature of preservation of the shark teeth and other estuarine vertebrates closely resembles that of other Love specimens, and some, including small delicate teeth and a few cartilagionous vertebrae, are delicately preserved. Secondly, none of these is characteristic Eocene taxa, such as the common Eocene shark *Otodus.* Thus, most of the estuarine and marine vertebrates at the Love Bone Bed were probably contemporary with the terrestrial and freshwater taxa residing near the mouth of the stream.

Many of the vertebrates noted here as "estuarine" are euryhaline species. Notable examples are mullet, tarpon, pinfish, juvenile herrings, and bull sharks. Furthermore, freshwater systems in central Florida are noted for their high ionic concentrations, as a consequence of karst dissolution of limestone and other salts. The present fish fauna of the St. Johns River, for example, includes an extraordinary number of marine species that penetrate well into freshwater (McLane, ms). Marine taxa may be assumed to have made similar headway up the low-gradient stream that passed through the Love site. Nevertheless, the Love Bone Bed also preserves a few marine vertebrates that are notably stenohaline, for example *Chilomycterus* (the pufferfish), *Galeocerdo,* (the tiger shark), and the odontocete whale. These more clearly suggest that the site's elevation lay within a few meters of sealevel. Thus, during the late Clarendonian the sea reached about 20 m above its present level.

Freshwater aquatic vertebrates are far more abundant if not more diverse than estuarine vertebrates in the Love Bone Bed. By far the commonest elements are three species of freshwater turtles which account for nearly a third of the vertebrate material (by weight) in this site (table 2). Garfish are another of the major contributors of fossil material in these deposits. In the finer sediments on several occasions we have observed fully articulated series of garfish vertebrae and adjacent scale "pavement." Likewise groups of whole *Chrysemys* shells occur frequently in the orange silty clays, as at 20′ E × 50′ S in the upper part of the section.

These four abundant freshwater taxa mainly represent lentic habitats. *Chrysemys caelata* is similar to Recent *C. nelsoni* in morphology and presumably in habits (Jackson, 1976). If so, it is usually a lentic turtle, nestling in mucky bottoms and "gator holes." *Deirochelys carri,* an extinct species typified by the Love sample, shares with living *D. reticularia* such adaptive features as a narrow shell, a long neck, and ribs delicately arched over large cervical extensor muscles. *Deirochelys* is reliably lentic and feeds on aquatic invertebrates (Jackson, 1978). In Florida today *Trionyx ferox* is also usually a slow-water turtle, unlike *Trionyx* species in many other parts of North America. Carr and Goin (1959) regard it as "perhaps most abundant in the Everglades canals and in swamp-shore lakes." Although gars are notably abundant in marshy areas, they thrive in most freshwater situations in Florida. In addition to these four very abundant species, some other common taxa, such as

Amia calva (bowfins) and *Siren* (sirens), also have strong preferences for lentic habitats.

An excellent sample of birds variously represents stream, stream-bank, pond, marsh and wet prairie habitats. Of 284 preliminarily identified avian specimens from the Love Bone Bed nearly two-thirds belong to the following aquatic groups: ducks (97 specimens), flamingos (25), shorebirds (17), geese (13), grebes (10), coots (8), storks (7), ospreys (7), rails (7), anhingas (5), cormorants, (4), herons (4), and limpkins (1). The habitats most abundantly represented by these fossil birds are probably lentic sites as is the case for the lower vertebrate fauna.

There are few strictly lotic species in the Love Bone Bed. The sharks required continuously flowing, adequately oxygenated water. The emydid, *Chrysemys williamsi*, was probably lotic, judging from its nearest living relative *C. scripta*, but it is quite rare compared with the other turtle taxa. The conclusion that lentic taxa far outweigh lotic taxa in the Love Bone Bed seems paradoxical, since the site itself is a high-energy stream channel, filled predominantly with coarse clastic sediments. However, the coarse clastic sample is far from being a biocenosis (life assembly). The fossil contents of this site were drawn from adjacent source areas. The concentration of fossils in the Love Bone Bed probably represents a small sample of life from the narrow channel augmented greatly by samples transported from surrounding floodplains. One may envision, adjacent to the main stream, broad floodplains that were perennially wet and rich with aquatic vertebrates. Such wet prairies and back swamps are abundant in Florida today and are characteristically endowed with very high vertebrate biomass.

The predominance of gars and freshwater turtles is characteristic of late Cenozoic fluviatile deposits in Florida and contrasts markedly with most such deposits in the High Plains. In the High Plains, the overbank areas returned to dry prairie after a flood; in Florida they remained as wet prairie. Perhaps this explains why Florida stream channel deposits are regularly "swamped" with lentic vertebrates.

Terrestrial vertebrates account for only about a third of the bones and teeth (by weight) from unit 1. In unit 3, terrestrial material accounts for only about a tenth of the weight of fossils (table 2). Virtually all the mammals may be counted as non-aquatic, but of the reptiles only the tortoises weigh much on the terrestrial side.

The three terrestrial habitats represented by vertebrate fossils from the Love site are stream-bank, forest, and open country. It is more difficult to assign an extinct terrestrial species to one of these terrestrial habitats than it is to assign an extinct aquatic species to one of its environments. The reason for this difficulty is that the terrestrial vertebrate fauna from the late Miocene does not closely resemble that living in Florida today. While no major revolution upset the freshwater community structure during the Cenozoic, few of the late Miocene terrestrial vertebrates have living congeners, much less living communities of closely related species. For these reasons the following comments provide only a crude guess at the terrestrial ecology near the Love Bone Bed.

The amphibious and stream-bank tetrapods are diverse. Many amphibians, reptiles, and birds mentioned above in the aquatic fauna could, with equally good reason, be counted as stream-bank inhabitants. Among mammals, the abundant specimens of *Teleoceras*, with its massive body mounted on stubby limbs and its very high-crowned cheek teeth, are best interpreted as amphibious grazers, broadly comparable to living *Hippopotamus*. The long flattened tusks of *Amebelodon*, with enamel shearing faces along their edges, may be adapted, as suggested by Osborn (1936), to masticate lush aquatic vegetation in ponds and marshy areas.

TABLE 3

Minimum numbers of individuals of selected terrestrial species from Love Bone Bed

CLASS REPTILIA	MNI
Order Chelonia	
Terrapene n. sp.	1
Geochelone spp.	65
CLASS AVES	
Order Podicipediformes	
Family Podicipedidae	1
Order Pelecaniformes	
Family Phalacrocoracidae	2
Family Anhingidae	1
Order Ardeiformes	
Family Phoenicopteridae	2
Family Plataleidae	
Subfamily Threskiornithinae	1
Family Ardeidae	3
Family Ciconiidae	1
Order Anseriformes	
Family Anatidae	
Subfamily Anserinae	3
Subfamily Anatinae	5
Order Accipitriformes	
Family Vulturidae	1
Family Pandionidae	1
Family Accipitridae	1
Order Galliformes	
Family Phasianidae	
Subfamily Meleagrinae	1
Order Ralliformes	
Family Rallidae	
Subfamily Rallinae	2
Subfamily Fulicinae	1
Family Gruidae	2
Family Aramidae	1
Order Charadriiformes	
Suborder Charadrii	7
Order Passeriformes	2
CLASS MAMMALIA	
Order Carnivora	
Family Canidae	
Aelurodon cf. *saevus*	20
Aelurdodon cf. *haydeni*	3
Leptocyon	1
Proturocyon cf. *macdonaldi*	1
Family Procyonidae	
New genus A	4
New genus B	2
Family Mustelidae	
Leptarctus n. sp.	6
Sthenictis cf. *lacota*	3
Beckia sp.	2
?Plionictis sp.	1
Family Nimravidae	
Barbourofelis n. sp.	23
Family Felidae	
Nimravides n. sp.	9
Order Proboscidea	
Amebelodon cf. *barbourensis*	13
Order Perissodactyla	
Family Tapiridae	
Tapirus simpsoni	20
Family Rhinocerotidae	
Teleoceras cf. *fossiger*	40
Aphelops malacorhinus	18
Family Equidae	
Neohipparion cf. *leptode*	30
cf. *Hipparion forcei*	8
Nannippus cf. *minor*	1
Pseudhipparion gratum	1
Calippus cf. *regulus*	1
Astrohippus martini	17
cf. *Pliohippus* sp.	22
Order Artiodactyla	
Family Tayassuidae	
Prosthennops cf. *serus*	11
Family Camelidae	
Aepycamelus major	2
Procamelus cf. *grandis*	24
"Hemiauchenia" minima	31
Family Gelocidae	
Pseudoceras sp.	2
Family Dromomerycidae	
Yumaceras n. sp.	12
Family Antilocapridae	
Antilocaprinae indet.	1

A number of vertebrate taxa suggests the presence of deciduous forests along the higher banks of the Love Bone Bed stream system. Avian groups at the Love site which usually require trees for roosting and nesting are vultures, turkeys, hawks, and ibises. Among mammals probable forest and forest-border inhabitants include *Tapirus* (tapirs), *Prosthennops* (peccaries), *Pseudoceras* (hornless little ruminants), *Yumaceras* (giraffe-horned large ruminants), and *Aepycamelus* (the giraffe-camel). The extinct procyonids, especially new genus A, may have been forest and forest-edge omnivores. And finally the short legs of *Barbourofelis* and its hypercarnivorous dentition suggest that it probably ambushed its prey (various large ungulates) from deep cover.

Several of these probable forest-dwelling species are unusually abundant at the Love Bone Bed as compared with the many rich late Miocene fluviatile sites in the High Plains (table 3). For example *Barbourofelis*, a probable forest-dweller, is more than three times as abundant as *Nimravides*, a probable open-country cat, in the Love site; whereas the opposite seems true in the midcontinent. Among ungulates, the high frequency of *Tapirus* (20) and the moderately large numbers of *Prosthennops* (11) and *Yumaceras* (12) are notable. Evidently the expanse of forested land adjoining the Love Bone Bed was much more extensive than along contemporaneous streams in the High Plains.

Open-country dwellers are represented in the Love Bone Bed by about as many vertebrate species as the forest-dwellers, but they are generally more abundant than the latter (table 3). An abundance (41 specimens) of gruids (cranes) may be attributed to grassland or open savanna habitats. Among carnivorans, *Aelurodon* (hyaenoid canids) and *Nimravides* (long-legged felids), are abundant predators and possibly scavengers in the open terrain. The largest and most diverse family of grazing herbivores at this site (as elsewhere in the late Miocene of North America) are the Equidae. Of seven hypsodont genera the pliohippines, notably cf. *Pliohippus* (22), and most hipparionines, notably *Neohipparion* (30), may be predominantly grazers. However, as suggested by Shotwell's studies (1961), *Hipparion* itself may have been a mixed-feeder of the forest edge. *Aphelops*, the long legged rhinocerotid may be a grazer. *Procamelus* (24) and the small llama-like camelid (31) were predominantly grazers. The abundant *Geochelone* (large tortoise) was very abundant (65) and may have ranged both in prairies and in open forests. *Ophisaurus* (the glass lizard) represents well-drained soils and open savanna or grasslands habitats. The largest rodent is *Mylagaulus*, an hypsodont fossorial sciuromorph which fed on grass stems and roots and lived in well-drained sandy terrain (Fagan, 1960).

Both Leporidae (hares) and antilocapridae (pronghorns) were surely open-country herbivores. Both are astonishingly rare at the Love Bone Bed, presumably because their preferred habitats lay in drier upland areas at a considerable distance from the Love Bone Bed stream. The rarity of the antilocapridae in this site (and generally in Florida Miocene sites) contrasts markedly with their abundance in most contemporaneous sites from the High Plains.

Of the vertebrate fossils representing these 6 habitats, 3 seem to give the Love Bone Bed local fauna its distinctive composition. For aquatic vertebrates both the small estuarine sample and the large lentic or marshy sample are of special interest. The latter habitat is probably the source of the unusually large sample of freshwater birds. Of terrestrial samples the forest vertebrates are most distinctive, as this component seems rare or absent from contemporaneous midcontinental vertebrate sites.

BIOGEOGRAPHY

The Love Bone Bed provides the first picture of late Miocene vertebrate community organization east of the Mississippi River detailed enough to allow comparison with the contemporaneous fauna of the High Plains. Three classes of taxonomic distinctions between the Love L. F. and contemporaneous midcontinental faunas can be recognized: (1) taxa unique to Florida, (2) earlier records of taxa than those of closely related forms in the midcontinent, and (3) later records of taxa already extinct in the midcontinent. Each of these distinctions reflects differences in geography, ecology, or both.

Unique taxa and early records at the Love site provide evidence for a Florida or Gulf Coast endemic fauna and may provide clues to the make-up of the poorly known late Miocene faunas of Central America. The possibility exists that these taxa were missed or not picked up until later in the faunas of the Plains because of sampling error, but this seems unlikely, especially for large vertebrates, in the well sampled western faunas.

All the perrissodactyl genera at the Love site are found in the High Plains. *Cormohipparion,* common in the Plains, is apparently absent at the Love site. Of the seven species of horses at the Love site, two are Gulf Coast endemics: *Neohipparion* cf. *leptode* is known from the late Miocene of Florida, the Great Plains, and Nevada (MacFadden, in preparation); *Nannippus minor* occurs in Florida, Texas, and Mexico. Among the carnivores, unique taxa include the small new genus of procyonid and the new species of *Nimravides.* The small carnivores are too poorly known from anywhere for comparisons to be made even on a generic level.

Certain elements of the fauna appear to have special Neotropical affinities. Of the two new procyonid genera, the smaller species related to *Nasua* and *Procyon,* appears to have evolved in the Gulf Coast province, although a specimen apparently referrable to this genus is known from the early Hemphillian of Kansas. The larger genus, related to the South American *Cyonasua* group, is more widespread both temporally and geographically but is best known from the Gulf Coastal faunas. One of the Cricetidae, which are all probably Florida endemics at least on the specific level, is closely related to the Neotropical Hesperomyines and may document the origin of the oryzomyines. The early lamine *"Hemiauchenia" minima* is another Florida endemic closely related to South American taxa.

The ungulates of the Love site, as discussed in the paleoecology section, have a high relative abundance of many taxa, especially browsers, that are rare in contemporaneous midcontinent faunas. This probably indicates more extensive mesic forests in the Gulf Coast Savanna region (Graham, 1975) in contrast to the Plains. This region may have provided a haven for browsing artiodactyls, three-toed horses, and arboreal carnivores. The early and abundant record of the browsing *Yumaceras* at the Love site may suggest that it originated in the Gulf Coastal region.

Tedford and others (in press) have stated that the Gulf Coast seems to have been a separate biotic province during most of the Miocene, broad faunal continuity with the midcontinent having been established by Hemphillian time. During the Clarendonian, the Texas Panhandle evidently became incorporated into the Clarendonian (Great Plains) chronofauna range (Webb, 1969a), but it was unclear whether Florida and the Gulf Coast remained a haven for a distinctive mammalian assemblage. The Love L. F. sheds some light on this picture. While it does show some evidence of endemism, including special affinity with the Middle American fauna, such distinctions are minor. The major differences from midcontinental faunas are ecological rather than zoogeographic. In the latest Clarendonian, Florida had become part of the Clarendonian chronofauna showing a major overall similarity to the faunas of the midcontinent.

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