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### Amphibia and Reptilia from the Campanian of New Mexico

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#### ABSTRACT

A washing and screening process has resulted in recovery of more than 7,000 vertebrate fossils from four sites in the late Cretaceous Fruitland Formation, northwestern New Mexico. At least 48 genera are represented (see Armstrong-Ziegler, 1978, for complete vertebrate faunal listing). Only the Amphibia and Reptilia are described in this report.

On the basis of total taxonomic content, the Fruitland Formation fauna is closest to, but slightly younger than, that from the Campanian Judith River Formation of Montana. An Upper Campanian age is therefore assigned to the Fruitland Formation. Faunal comparisons also indicate that the Fruitland Formation fauna is slightly older than the Maestrichtian Lance and Hell Creek Formations of Wyoming and Montana. The four sites studied in the Fruitland represent three aquatic subenvironments of deposition: upland river, upland stream, and lowland river. Both freshwater and terrestrial forms appear in varying proportions in all three of these subenvironments. In addition, brackish water forms appear in the lowland river subenvironment.

#### INTRODUCTION

The Fruitland Formation, first described by Bauer (1916), was named after the town of Fruitland, N.M., on the San Juan River, where outcrops of the formation are particularly well exposed. The unit at Bauer's type locality, N29N R15W, is 73.5 m. thick. Other extensive

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exposures of the Fruitland Formation occur on the northwestern, western, and southern borders of the San Juan Basin, which extend from northwestern New Mexico into southwestern Colorado. In New Mexico and Colorado, north of the San Juan River, the formation is consistently thicker, ranging up to 161.5 m. as seen on the La Plata River near the New Mexico-Colorado boundary. South of the San Juan River, the formation ranges between 76 and 107 m. in thickness. In Bauer's section of "Cottonwood Arroyo" (T26N R16W), the Fruitland Formation is 100 m. thick; this section is near the three localities (A, B, and C) included in this study.

The Upper Cretaceous sequence of stratigraphic units in the area of this study consists, from bottom to top, of the Lewis Shale, the Pictured Cliffs Sandstone, the Fruitland Formation, and the Kirtland Shale. The beds of the Fruitland Formation, deposited under both freshwater and brackish water conditions, include mudstones, siltstones, crossbedded sandstones, and coal. Individual beds are highly lenticular and of limited lateral extent.

The Upper Cretaceous rock units of the San Juan Basin represent extensive transgressive-regressive cycles of deposition. These rock units were deposited in and near a late Cretaceous epicontinental sea that extended from the Gulf of Mexico to the Arctic Ocean. Lying on the west margin of this sea, the basin was intermittently above and below sea level as the sea advanced and retreated during late Cretaceous times. As this sea regressed for the last time, the Fruitland Formation was formed through swamp, fluvial, floodplain, and lacustrine deposition that occurred shoreward on top of the Pictured Cliffs Sandstone. Fassett & Hinds (1971) have contributed a detailed consideration of the Fruitland's areal and stratigraphic extent, of its lithology, and of its mode of deposition.

Fossils are numerous and varied in the Fruitland. The fauna contains terrestrial, freshwater, and brackish water forms, including vertebrates and invertebrates. The flora consists of a variety of both angiosperms and gymnosperms.

Since 1962, Dr. W. A. Clemens, Department of Paleontology, University of California, Berkeley, has made collections of fossil vertebrates from Hunter's Wash (Fruitland and Kirtland Formations) in the southwestern part of the basin. He published a preliminary paper on the mammals (Clemens, 1973) and intends to do further studies here and also on the mammals collected by myself and associates.

In the summer of 1975, Dr. E. Lindsay of the University of Arizona investigated the magnetic stratigraphy of the San Juan Basin in New

Mexico. During this time, he collected some microvertebrate material from the Fruitland at locality UALP 75137, which is in SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , Sec. 34, T24N, R13W, Alamo Mesa West, 7 $\frac{1}{2}$ ' Quadrangle. The stratigraphic position of this locality is 30.5 m. above the University of Kansas locality number 43 (Clemens and Eaton field trip, 1962). Both mammal and lower vertebrate fossils were obtained from this locality, and a number of identifiable specimens were sent to me. Dr. Clemens is conducting a study of the mammal specimens of this collection, and the present paper includes descriptions of the amphibian and reptilian specimens.

From June 12-24, 1974, Mr. W. J. Breed and Dr. L. G. Marshall and associates from the Department of Geology, Museum of Northern Arizona, conducted and reported on an initial survey of the paleontological resources on Navajo Tribal Lands leased by Western Gasification Company for a coal company, Utah International, near Burnham, San Juan County, New Mexico. Two microvertebrate localities were found by Mr. D. Lawler of this party and were given field numbers 88 and 93 (Marshall Field Notes, M.N.A. 1974). A third locality, HW#24 (= UCMP V-72090), discovered by Mr. H. Wagner, University of California, Berkeley, in April and May, 1972, was re-located and given the number 16 (Marshall Field Notes M.N.A., 1974).

In this paper, these localities are referred to by the MNA locality numbers as follows: #16=A, #88=B, and #93=C. Each locality is in T26N, R16W, and their exact positions follow:

Locality A: 108° 29' 10" W longitude

36° 31' 18" N latitude

Locality B: 108° 30' 49" W longitude

36° 29' 10" N latitude

Locality C: 108° 32' 6" W longitude

36° 29' 18" N latitude

During the summer of 1974, while employed as an assistant preparator for the Geology Department, Museum of Northern Arizona, I became involved in the field and laboratory work for the preliminary paleontological survey of this area. With the aid of MNA personnel, I collected seven burlap bags of matrix and seven and one-half bags of anthill concentrate on August 14-15, 1974, from microvertebrate Locality A.

The following summer, I again returned to the Museum of Northern Arizona. Locality B was visited the weekend of June 25-27, 1975, at which time material was collected and stratigraphic notes were taken. From June 28 to August 22, 1975, screen washing was carried on, and a

preliminary report of my progress was given at the Four Corners Geological Symposium at MNA. A final field trip, the weekend of August 22-24, was made with the aid of Mr. D. Gnidovec, Mr. M. Zavada, and Ms. T. Kreklau, and collections of matrix were made from Locality C. Zavada, a graduate student at Arizona State University, made a collection of plant megafossils at this time; he later informed me that eight species, heretofore unknown from the Fruitland, were acquired from this site.

The present report describes only the amphibian and reptilian portions of the total lower vertebrate assemblage. The fish component of the fauna and certain invertebrates, important as environmental indicators, will be described in a separate paper. A preliminary paper describing a new species of snake and a complete material listing for the vertebrates of the Fruitland has been submitted to the *Journal of Paleontology*. In subsequent sections of this report, the total assemblage from the Fruitland is compared with the following major studies: Lance Formation of Wyoming (Estes, 1964; Clemens, 1964); Hell Creek and Judith River Formations of Montana (Sloan & Van Valen, 1965; Estes et al., 1969; Sahni, 1972); Milk River Formation of Alberta, Canada (Russell, 1935); Fruitland and Kirtland Formations of New Mexico (Clemens, 1973; Reeside, 1924; Stanton, 1916; Gilmore, 1916; Knowlton, 1916).

Comparison of the total assemblage from the three sites and Lindsay's site with other faunas has provided evidence for assigning a more definitive age than "Late Cretaceous" to the Fruitland Formation. Zoogeographical interpretations, leading from comparisons among these assemblages, have provided a more complete picture of the biota that existed along an epicontinental seaway that ranged from Mexico to Canada during late Cretaceous times. In addition, study of the fauna and comparisons with other fossil and recent faunas have led to a better understanding of the paleoenvironment of deposition and of paleoclimatic conditions. Some conclusions are drawn about the paleoecology of this thanatocoenotic assemblage of land and aquatic fossil forms by comparing them with analogous extant ecological communities.

#### LOCALITIES

Localities A, B, and C apparently lie within the upper 15.2 m. of the Fruitland Formation. This stratigraphic position was determined through field comparisons of the strata with descriptions of lithology and maps of the Fruitland Formation in the area of the localities provided by Bauer (1916) and Fassett & Hinds (1971). Figure 1 shows the

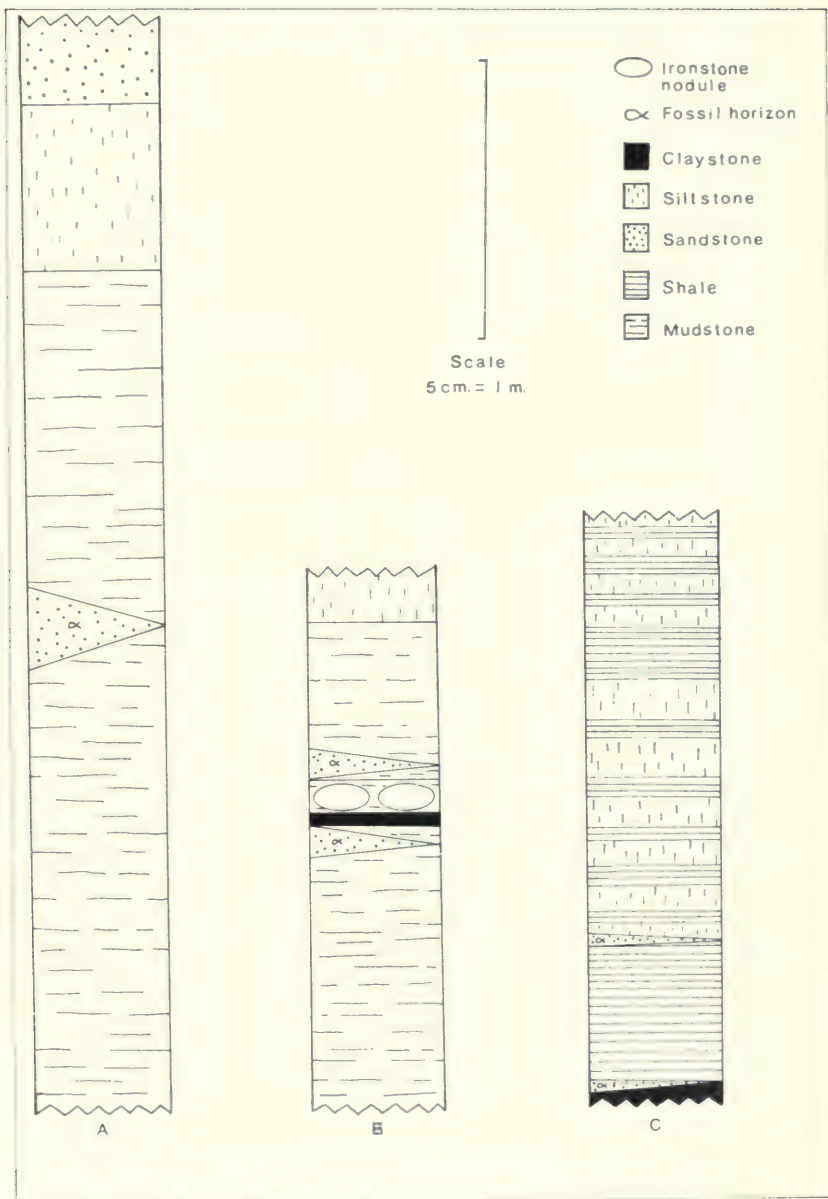


FIG. 1. Sections of the Fruitland Formation from Sites A, B, and C, New Mexico.

positions of the fossil horizons in generalized stratigraphic columns of the sections exposed at the three localities.

Locality A contains one productive horizon consisting of two calcareous fossiliferous lenses outcropping about 3 m. apart (fig. 2). Ten burlap feed bags of matrix were collected from this locality. In addition to the excavated matrix, five and a half bags of anthill material were collected from four separate anthills, located 137 m. north and northwest of locality A. These recent fossiliferous anthills were formed by the small red ant, *Pogonomyrmex*, the same genus that formed the fossiliferous Bug Creek Anthills of the Hell Creek Formation in Montana. Some anthills formed by a larger black ant species were sampled but yielded no fossil material; the rock particles transported by these ants are considerably smaller than the sand grains and fossil fragments transported by *Pogonomyrmex*.

Locality B contains two fossil horizons, each of which has a lateral extent of about 4.5 m. (fig. 2). Six burlap feed bags of excavated matrix were collected at this locality, together with specimens picked from the surface.

Locality C contains two fossil horizons whose exposures encircle a small hillock approximately 4.5 m. in diameter. The lower fossil horizon on the hillock has a second outcropping 3 m. due north of it at ground level (fig. 2). The beds exhibit a general 4° dip to the east. The shale bed shown for Locality C in Figure 3 contains an abundance of plant mega-fossils, including angiosperms and gymnosperms. Six burlap feed bags of matrix were collected from Locality C.

These three localities are strikingly similar in lithology and appearance. Differential weathering has given them a vuggy look, with "toadstools" capped by resistant siltstones (fig. 2) and sandstones resting on pinnacles of the more easily weathered shales and mudstones.

Lindsay (written comm., 1976) describes the lithologic character of Locality UALP 75137: "fossiliferous siltstone, light tan, poorly sorted, with a few lignite fragments. The locality is the surface of a round knob, underlain by a white concretionary sandstone, about 4.5 m. thick that overlies a thick (about 3-3.5 m.) black carbonaceous, relatively continuous siltstone." Locality UALP 75137 is about 30.5 m. above the Kansas University Locality 43. On the Alamo Mesa West Quadrangle (seven and one-half series) topographic map, Locality UALP 75137 is in SE¼, SE¼, sec. 34, T24N, R13W (Lindsay, written comm., 1976). Lindsay's crew collected ten sacks of matrix at this locality.

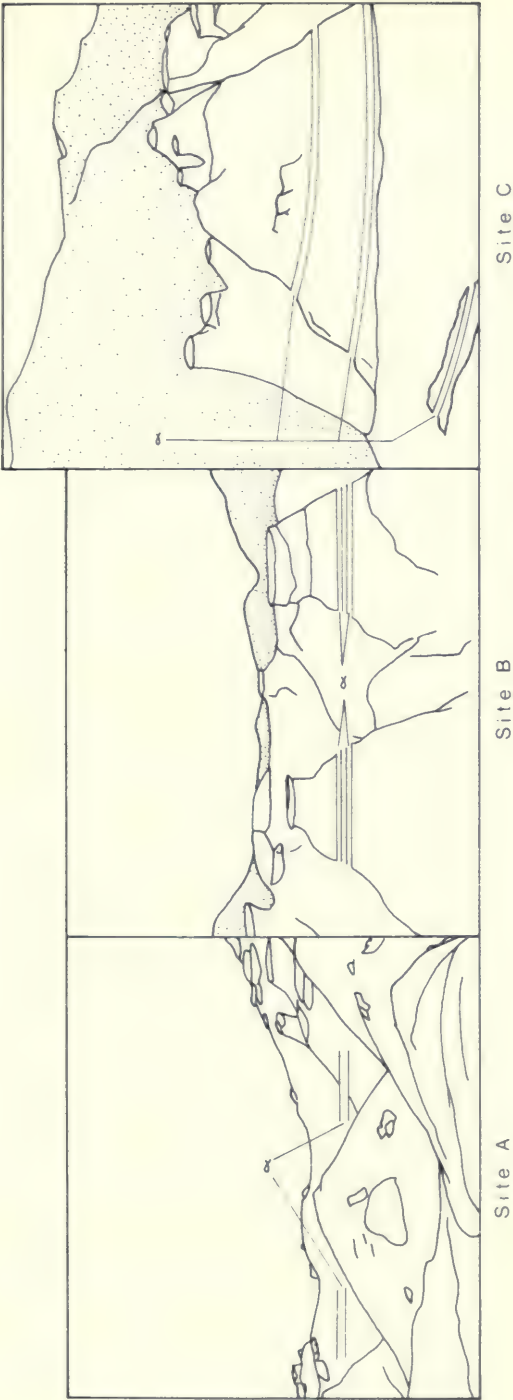
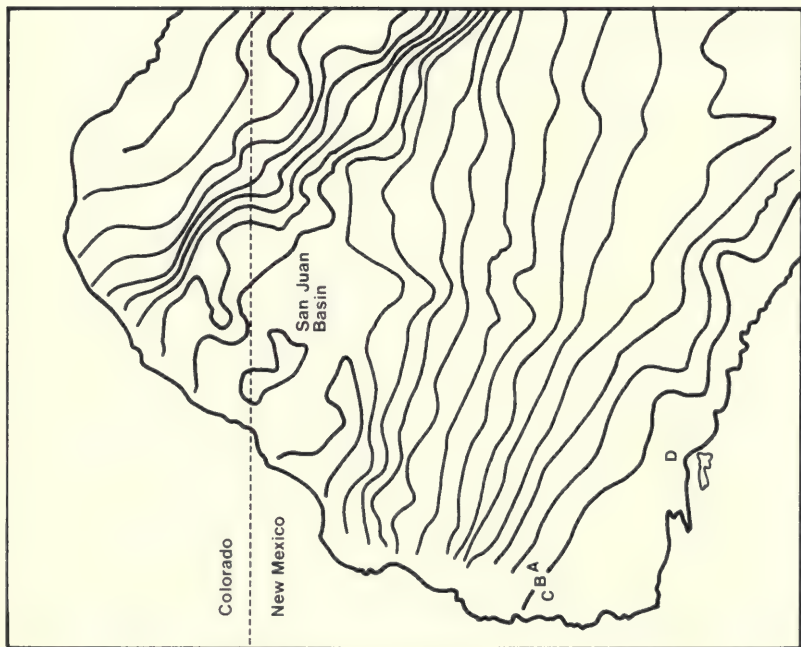
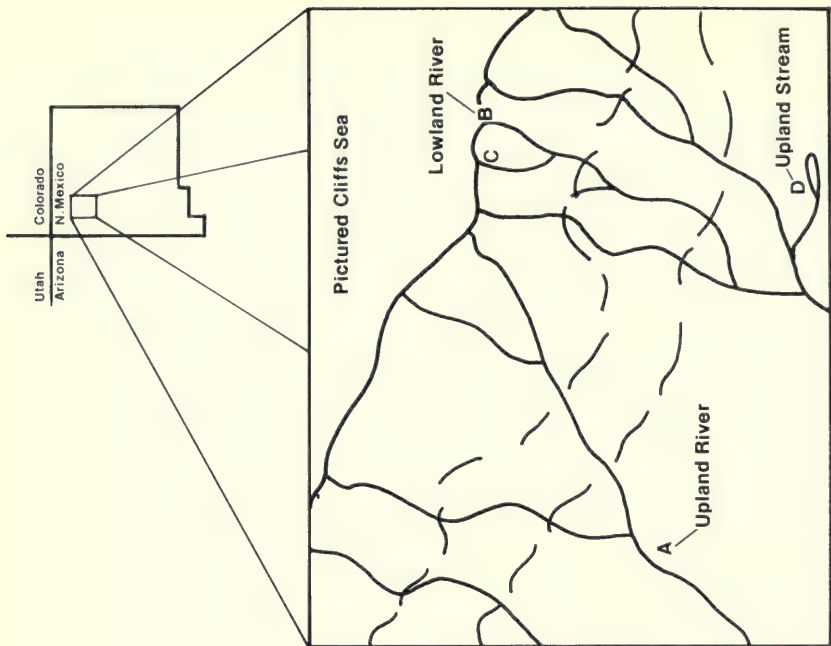


FIG. 2. Fossil horizons ( $\alpha$ ) at sites A, B, and C.



## MATERIALS AND METHODS

The bone concentrations occur in calcareous sandstone lenses and consist mainly of disassociated and fragmentary elements. Much of the material was eroded by transportation before burial. Approximately 6,092 identifiable specimens were collected from Locality A; 1,544 from Locality B; and 426 from Locality C. About 33% of the specimens from Locality A, 40% from Locality B, and 36% from Locality C are gar-pike scales. Obviously, these high percentages of gar scales do not reflect the actual abundance of the gar-pike, *Lepisosteus*, because a gar-pike contains many hundreds of scales.

The washing and screening process as developed by Hibbard (1949), Clemens (1973), and McKenna (1962) was employed to concentrate and reduce the matrix for hand sorting. The screen boxes were constructed according to McKenna (1962). For his Locality UALP 75137, Lindsay used tandem screen boxes, the inner box with one-sixteenth-inch mesh size and the outer box with a one-twenty-fifth-inch mesh size, to process 10 bags of matrix two or three times in water without the use of chemicals. The smallest identifiable specimen sent to me by Lindsay is a fragmentary lizard osteoscuta approximately 1.0 mm. in width.

Due to the calcareous nature of the matrix from Locality A, diluted formic acid, as recommended by Sahni (1972), was used to disaggregate the matrix before it was washed. The other localities (B and C) produced matrix containing more clay and other particles of small size that made disaggregation by washing difficult to accomplish because of the clinging properties of these particles. A chemical separation using Amine 220 and Methyl Amyl Alcohol as recommended by Lund (1970) was tried on the matrix from these localities, but it was discovered that the same results could be obtained just as effectively and with less expense by dry screening the matrix after the initial wet screening. It is possible that valuable information concerning the environment of deposition could be obtained by doing a grain size and mineral analysis on the matrix; however, such a sedimentological treatment is beyond the scope of the present research.

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*Opposite:*

FIG. 3. (Left) Diagrammatic paleogeographic map showing the subenvironments of deposition for sites A, B, C, and D. (Right) Past Pictured Cliffs Sea's shorelines showing sites A, B, C, and D in relation to them. After Fasset & Hinds (1971, p. 14, fig. 7, p. 37).

## INVERTEBRATES

A tubular pelecypod, *Teredina neomexicana* (Family Pholadidae) is found at Localities A, B, and C. Distinctive fossil molds of insect burrows and crab claws occur at Locality C.

## VERTEBRATES

## Order Salientia

## Family Discoglossidae

**Scotiophryne pustulosa** Estes, 1969b. Plate 1a,b.

*Referred specimen.*—MNA P1. 1625 fragmentary posterior portion of left maxilla.

*Locality.*—MNA A.

*Description.*—Specimen P1. 1625 is a fragment of the posterior portion of a left maxilla that exhibits prominent pustulate sculpturing on its lateral surface. On the medial surface there is a distinct pterygoid process and, dorsally, an expansion and notch for the squamosal. The teeth are small and closely spaced (*i.e.*, five/mm.) Specimen P1. 1625 corresponds closely with the holotype (MCZ 3626) from the Lance Formation described by Estes (1969b, p. 4, fig. 2c).

*Discussion.*—Recovery of specimen P1. 1625 from the Fruitland Formation expands the geographic range for *Scotiophryne pustulosa* from Montana to New Mexico during Late Cretaceous times. The stratigraphic range of this species now extends from the Campanian Fruitland Formation into the Middle Paleocene as established by its occurrence in the Tongue River Formation of Montana (Estes, 1969b). In addition to the Fruitland and Tongue River Formation, *S. pustulosa* has also been recorded from the Lance Formation of Wyoming and Hell Creek Formation of Montana (Estes, 1969b).

## Family Pelobatidae

?**Eopelobates** sp. Plate 1c,d.

*Referred specimen.*—UALP No. 75137-A, fragmentary posterior portion of a left maxilla.

*Locality.*—UALP 75137.

*Description.*—Both ends of this right maxilla are broken, but the distinctive slope of the dorsal border for the orbit is evident, supporting the assumption that it is from the posterior portion of the maxilla. The lateral surface has prominent sculpturing, consisting of shallow depressions bounded by ridges extending from halfway down the outer

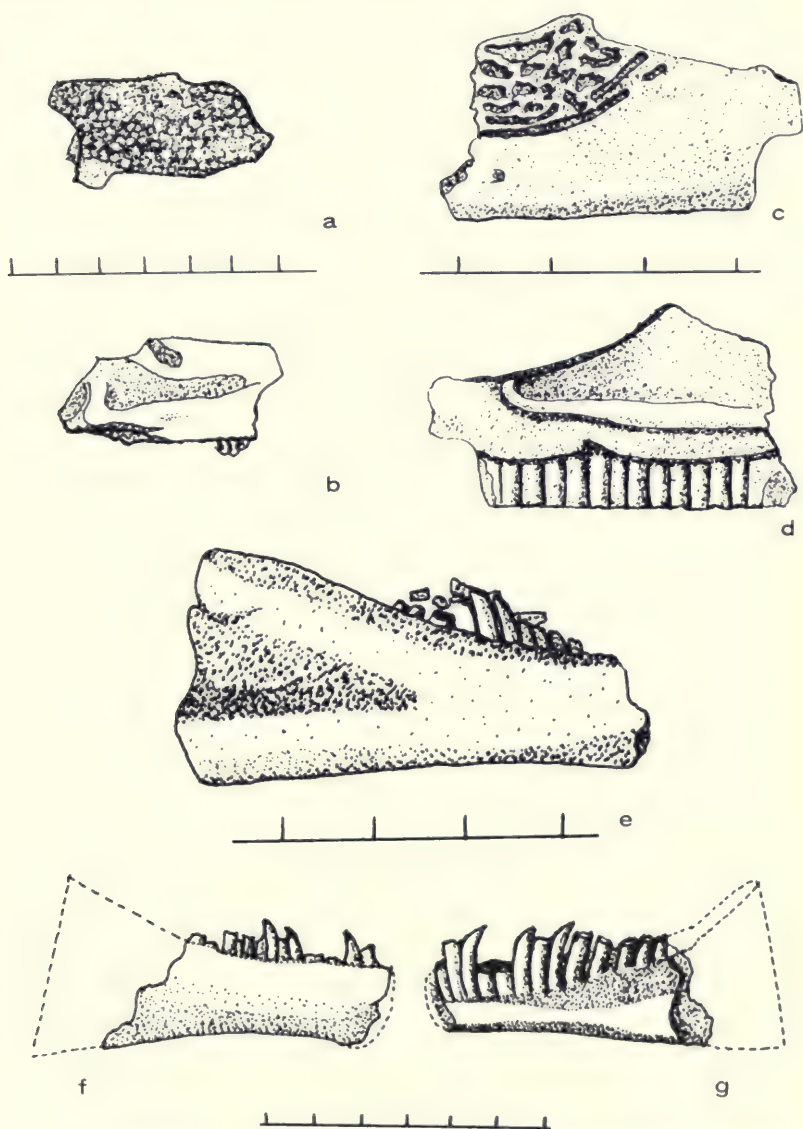


PLATE 1. Each scale is in millimeters, a, b, *Scotiophryne pustulosa* Estes, 1969c, MNA Pl. 1625, maxilla: a, labial view, b, lingual view; c, d, *?Eopelobates* sp., UALP 754137-A, left maxilla: c, labial view; d, lingual view; e, *Opisthotriton kayi* Auffenberg, 1961, UALP 75137-0, right dentary, labial view; f, g, *Cuttysarkus mcnallyi* Estes, 1964, UALP 75137-C, right dentary: f, labial view, g, lingual view.

surface of the maxilla. This sculpturing is confined to the posterior portion of the fragment, leaving both the ventral one half and anterior regions of the maxilla smooth. The posteroventral smooth surface is separated from the sculpture above by a long furrow. The medial surface has a strong dental gutter and attachment spaces for 12 teeth in a distance of 3.0 mm.

*Discussion.*—This specimen is questionably referred to the genus *Eopelobates*. The sculpture present on the maxilla is similar to the sculpture on the squamosal of UCMP 55707 (Estes, 1964, p. 59, fig. 31b) from the Lance Formation, Wyoming, defined at that time as "near Hylidae" but later redefined (Estes, 1970) as being possible *?Eopelobates* sp. or "a related pelobatid perhaps nearer to the discoglossids." Estes mentions that a fragment of maxilla, AMNH 8133, is now known from the Lance with sculpture similar to the squamosal, UCMP 55707, but it has not been described or figured. Estes' (1970) account of the different species of *Eopelobates* notes a similar sculpture pattern seen on UALP 75137-A, but he does not specifically state whether the sculpturing covered the entire maxilla or only parts of it. Drawings of *E. anthracinus* and *E. guthriei* (Estes, 1970, figs. 8, 14) suggest a narrow smooth surface of bone immediately dorsal to the teeth. Since only the dorsal half of the posterior portion of the maxilla recovered from the Fruitland is covered with sculpturing, its reference to *Eopelobates* can only be provisional. The Fruitland specimen may prove more closely related to *Miopelobates robustus* (Bolkay, 1913) from the Lower Pliocene of Poland and Hungary, which exhibits sculpturing only on the posterior portion of its maxilla and, in addition, has a "bifurcated furrow" possibly homologous with the furrow seen along the ventromedial border of the sculpture on UALP 75137-A. Bolkay does not indicate if the ventral half of the posterior portion of the maxilla of *Miopelobates* is free of sculpture.

Sahni (1972, p. 347, figs. 7L, M) described a discoglossid maxilla (designated specimen C) from the Campanian Judith River Formation, Montana, which possesses sculpture pattern and size similar to UALP 75137-A and also exhibits a ventral border free of sculpture. In comparing sculpture pattern and relative size between the maxilla (C) from the Judith River, the squamosal, UCMP 55707, from the Lance, and the specimens of *Eopelobates* (Estes, 1970), similarities are clear and, therefore, it seems certain Sahni's maxilla (C) is referable to the pelobatids instead of the discoglossids. Without more material, it is impossible at this point to assign the fragmentary maxilla from the Fruitland to *Eopelobates* or any other pelobatid genus with certainty. However, UALP 75137-A is, beyond doubt, a Late Cretaceous

pelobatid with close taxonomic affinity (sculpture pattern and ventral border free of sculpturing) to the maxilla (C) from the Campanian Judith River Formation of Montana.

#### Family Prosirenidae

##### **Prodesmodon ?copei** Estes, 1964

*Referred specimens.*—UALP 75137-Y, right premaxilla; 75137-Z, fragmentary premaxilla; 75137-aa, dorsal vertebra; 75137-bb, fragmentary dorsal vertebra; 75137-cc, fragmentary left dentary; 75137-dd, fragmentary right dentary; 75137-ee, fragmentary left dentary; 75137-ff, fragmentary maxilla. MNA Pl. 1644, fragmentary ?cervical vertebra.

*Localities.*—UALP 75137 and MNA A.

*Description.*—The referred specimens of these various skeletal elements from the Fruitland Formation are identical through all of their features to their counterparts in the hypodigm from the Lance Formation described by Estes (1964, p. 88-92). Diagnostic characteristics for the elements cited above include: vertebrae with completely hemispherical ball-and-socket condyles and cotyles; nasal process on internal surface of premaxilla excavated by deep pit set off by two distinct septae, one in medial position by midline and the other lateral to it; broad supradental shelf internal and dorsal to tooth row on maxilla; external surface of maxilla pitted; dentaries joined by strong symphysial union marked by prominently interdigitating lobes; dentary, maxillary, and premaxillary teeth nonpedicellate and with compressed, faintly spatulate crowns.

*Discussion.*—Specimen MNA Pl. 1644 is questionably a fragmentary cervical vertebra of *Prodesmodon copei*. Although the completely hemispherical condyle and the small size of the specimen are indicative of this genus (Estes, 1964, p. 88), it has basapophyses that extend anteriorly beyond the midpoint of the centrum. This latter character was formerly believed to be definitive of another small Late Cretaceous salamander species, *Opisthotriton kayi*, and was one of the characters used to distinguish *O. kayi* from *P. copei*. Estes (1969c, p. 88), however, has recently concluded that basapophyses are highly variable structures; therefore, I feel that the hemispherical condyle and small size are probably sufficient to allot this specimen and similar vertebrae to *P. copei* rather than *O. kayi*. If Pl. 1644 is from *P. copei*, it is likely a cervical vertebra, because cervical vertebrae of *O. kayi* exhibit similarly elongate basapophyses. Estes (1964, p. 88), considering *P. copei*, notes that the basapophyseal keels on cervical vertebrae in his

hypodigm do not extend as far as the midpoint of the centrum; this may constitute a specific distinction of the Lance Formation form from the Fruitland Formation form. Acquisition of additional vertebral material, derived from other portions of the vertebral column, is needed to verify the conspecificity of the *Prodesmodon* from New Mexico with *P. copei* from Wyoming. Maestrichtian occurrences of *P. copei* include the Hell Creek Formation of Montana (Estes et al., 1969) and the Lance Formation of Wyoming (Estes, 1964). Campanian occurrences include the Judith River Formation of Montana (Sahni, 1972) as well as the Fruitland Formation of New Mexico (this study).

#### Family Batrachosauroididae

**Opisthotriton kayi** Auffenberg, 1961. Plate 1e.

*Referred specimen.*—UALP Nos.: 75137-O, fragment of right dentary; 75137-P, fragmentary cervical vertebra; 75137-Q, fragment of vertebra; 75137-R, fragment of vertebra; 75137-S, fragment of vertebra; 75137-T, fragment of vertebra.

*Locality.*—UALP 75137.

*Description.*—Specimen 75137-P, the fragmentary cervical vertebra of *Opisthotriton kayi* has a circular cotyle that appears to be completely hollow, with no ossification in its deepest part. It has prominent ventroposterior basapophyses and a distinct median keel. The neural arch is low and dorsally flattened and carries the broken base of the neural spine. The zygapophyses are slightly oblique to the horizontal.

The fragmentary right dentary, 75137-O, exhibits a smooth external bone surface and contains nine badly broken and medially crushed teeth. The labial surface is strongly concave in the lateroposterior area, and on the lateroventral surface there is a prominent ridge for the attachment of the intermandibularis muscle.

All of these scattered characters of the fragmentary vertebrae and right dentary agree in detail with Estes' (1964, 1969a) accounts of *O. kayi*.

*Discussion.*—Estes (1969a, p. 230) placed *O. kayi* in a new family, Batrachosauroididae, along with genus *Batrachosauroides*. Following Estes, the fragmentary cervical vertebra is referable to *Opisthotriton* rather than *Batrachosauroides* because it shows the greater flattening of the neural arch and the stronger development and more posterior position of the basapophyses.

*Opisthotriton kayi* has been reported from the Maestrichtian Hell Creek and Lance Formation of Montana (Estes et al., 1969), and

Wyoming (Estes, 1964, 1969b; Auffenberg, 1961). Elsewhere, material representative of the genus is known from the Late Paleocene Polecat Bench Formation (Silver Coulee beds), Park County, Wyoming (Jepsen, 1940; Gilmore, 1942, p. 166).

## Order Urodela

### Family incertae sedis

**Cuttysarkus mcnallyi** Estes, 1964. Plate 1f,g.

*Referred specimens*.—UALP Nos.: 75137-C, right dentary; 75137-J, right dentary; 75137-B fragment of dentary; 75137-hh, fragment of dentary; 75137-gg, fragment of dentary.

*Locality*.—UALP 75137.

*Description*.—The dentaries recovered from the Fruitland agree in detail with Estes' (1964, pp. 139, 140) descriptions of this peculiar form. Diagnostic characters of the dentaries used by Estes include: short, subtriangular overall shape; meckelian fossa triangular, closed anteriorly and broadly open posteriorly; external surface smooth without foramina; teeth pleurodont and recurved posteriorly. The most complete specimen on hand, 75137-C, exhibits 13 teeth, three of which are complete to the tips.

*Discussion*.—*Cuttysarkus mcnallyi* was placed tentatively in the Order Sauria by Estes (1964, p. 140) on the basis of two reptilian characteristics: deep pleurodont tooth attachment and lack of a dental gutter. He also noted that two features, the smooth, imperforate external surface of the jaw and the broad, triangular, posteriorly expanded meckelian fossa were reminiscent of some of the urodeles. Estes et al. (1969, p. 22), in a second account of *C. mcnallyi*, suggested that the absence of maxillae for the species was indicative of a larval salamander condition.

In addition to the Urodelian characters cited above, the fact that deeply pleurodont teeth are not necessarily confined to the Reptilia [many salamanders (see table 1), including two late Cretaceous genera *Opisthotriton* and *Prodesmodon*, exhibit this condition] serves to further support the conclusion that the dentaries of *C. mcnallyi* belong to a larval salamander rather than a lizard.

On the basis of the above observations, I reassign *Cuttysarkus* to the Order Urodela. Dr. Richard Estes, San Diego State University, and Mr. Bruce Naylor, University of Alberta, are separately working on *Cuttysarkus*' relationship to different Urodelan families.

Order Testudinata  
Family Dermatemydidae

**Adocus** sp.

*Referred specimen.*—MNA Pl. 1646, isolated carapace and plastron fragments.

*Localities.*—MNA Localities A and C.

*Description.*—The ornamentation on these specimens consists of regular rows of shallow pits that have three rows of pits in a 5-mm. line or six or seven per centimeter. The thickness of these fragments is 0.5 cm. (=5 mm.).

*Discussion.*—*Adocus vigoratus* from the Paleocene Ojo Alamo Sandstone in New Mexico was erected by Hay (1910) on the basis of carapace and plastron characters alone. The material at hand corresponds with Hay's description of the sculpture pattern on these specimens, but I feel that sculpture pattern similarities alone do not provide sufficient basis for definite assignment of this material to *A. vigoratus*.

Another species, *Adocus ?lineolatus* [*sic*] nominated by Cope (1875) for material from Colorado was tentatively defined on the basis of more finely pitted sculpture (four to five rows of pits in a 5-mm. line) than typical of *A. vigoratus*. Later, Gilmore (1916) reported *A. ?lineolatus* from the Fruitland Formation. The sculpture pattern variations seen between *A. vigoratus* and *A. ?lineolatus* could well signify individual or ontogenic differences rather than a species separation. Until cranial remains are recovered in association with these carapace and plastron elements, a proper assessment of the validity of these described species will be difficult to make.

*Adocus* sp. also occurs in the Maestrichtian Hell Creek Formation of Montana (Estes et al., 1969).

**Compsemys** sp. Leidy

*Referred specimen.*—MNA Pl. 1648, carapace fragment.

*Locality.*—MNA Locality A.

*Description.*—The present specimen exhibits the closely set, flat-topped pustulae typical of carapace sculpture for this genus.

*Discussion.*—Gilmore (1916) reported carapace fragments of *Compsemys* sp. from the Paleocene Ojo Alamo Sandstone of New Mexico. Late Cretaceous occurrences of the genus include *C. victa* (Estes et al., 1969) from the Maestrichtian Lance and Hell Creek Formations of Wyoming and Montana and *Compsemys* sp. (Russell, 1935) from the Campanian Milk River Formation of Alberta. Since many described

species of *Compsemys* have similar sculpture patterns, this character alone is insufficient for species identification.

### ?*Basilemys* sp.

*Referred specimens.*—MNA Pl. 1647, shell fragments.

*Locality.*—MNA Locality A.

*Description.*—These shell fragments are 1 cm. in thickness and have a very coarse, exaggerated sculpture pattern consisting of pits 1 cm. in diameter spaced approximately 1 cm. apart.

*Discussion.*—The fragments are questionably referred to *Basilemys* on the basis of large relative size. *Basilemys* sp. (Estes et al., 1969, pp. 17, 18) from the Maestrichtian Lance and Hell Creek Formations also exhibits pitted sculpture, but here, the pattern is on a finer scale; the pits, although circular, are both smaller in diameter and more closely spaced, with three to four occupying each square centimeter.

Other specimens ascribed to this genus resemble the form from the Lance and Hell Creek Formations rather than the present material from the Fruitland Formation in the above noted distinction in sculpture pattern. These include *B. nobilis* (Gilmore, 1916) from the Paleocene Ojo Alamo Sandstone of New Mexico, *Basilemys* sp. (Gilmore, 1916; Sahni, 1972) from the Campanian Judith River Formation of Montana, and *Basilemys* sp. (Russell, 1935) from the Campanian Mile River Formation of Alberta. Perhaps the present material represents a new genus and species of the family, but more diagnostic material is needed before it is identified further.

### Family Trionychidae

#### *Trionyx* sp.

*Referred specimen.*—MNA Pl. 1629, plastron and carapace fragments.

*Locality.*—MNA Locality A.

*Description.*—These specimens have a honeycomb pattern of sculpture in which small irregular pits give the appearance of being uniformly punched into the bone. Interlocking ridges surround each pit.

*Discussion.*—Webb (1962) states that the presence or absence of a preuchal bone does not constitute sufficient grounds for a separation of *Aspideretes* from *Trionyx*. Therefore, the present material and similar material from the Fruitland Formation found by Gilmore (1916) and described by him as *Aspideretes austerus* are now allocated to *Trionyx* (Cope, 1875). It is not generally conceded that the sculpture pattern in

trionychids is of dubious taxonomic significance at the species level (Estes, 1964, p. 98). In the absence of other more definitive skeletal material, the *Trionyx* remains from the Fruitland Formation cannot be allocated to a species.

Order Sauria

Family Teiidae

**Leptochamops** Estes, 1964

**Leptochamops denticulatus** (Gilmore, 1928). Plate 2d.

*Chamops denticulatus* Gilmore, 1928, p. 26.

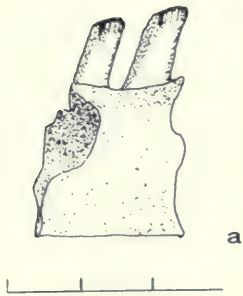
*Leptochamops denticulatus* Estes, 1964, p. 110.

*Referred specimens.*—UALP Nos.: 75137-E, fragments of left dentary; 75137-K, fragment of right dentary; 75137-D, fragment of dentary; 75137-L, fragment of ?dentary; 75137-M, maxillary fragment; 75137-N, maxillary fragment.

*Locality.*—UALP 75137.

*Description.*—Estes (1964, p. 110) erected a new genus *Leptochamops*, for *Chamops denticulatus* Gilmore (1928), removing this species from the genus *Chamops*, the type species of which is *Chamops segnis* (Marsh, 1892). The principal criteria for this action were the following features of *L. denticulatus*: greater restriction of the anterior portion of the meckelian fossa; concave lateral border of the dentary; enlargement of the dentary for the coronoid articulation; more numerous teeth; cusp form; and heterodonty through the tooth row on some specimens. Estes (1964, p. 113) points out that, among recent teiids, each of these characters is subject to variation but, taken together, they represent a degree of morphologic divergence from Marsh's species that necessitates separation at the generic level.

The most complete and diagnostic dentary in the collection at hand is specimen No. UALP 75137-K, which comprises much of the anterior portion of a right ramus and which clearly shows the restriction of the meckelian groove in this region. The lateral border of the dentary is slightly concave. All the teeth are tricuspid and subpleurodont, closely matching those on the dentary illustrated by Estes (1964, fig. 50). Many of the tooth crowns have a black shaft capped by a sharply contrasting light brown occlusal surface. The teeth project about one-half of their height above the parapet of the jaw. A heterodont condition (variability in height and diameter of individual teeth on one specimen) can be seen on the dentary fragment, UALP 75137-D, Plate 2d. As Estes (1964, p. 112) surmises, heterodonty in the genus appears to be a function of size



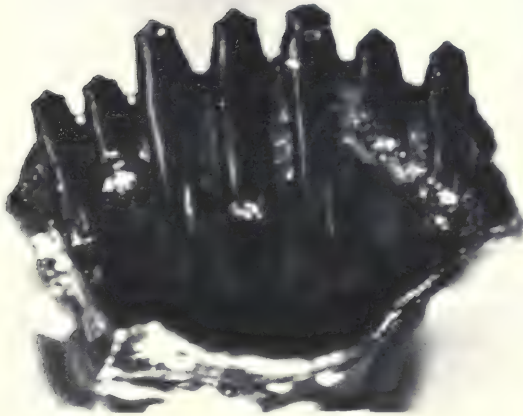
a



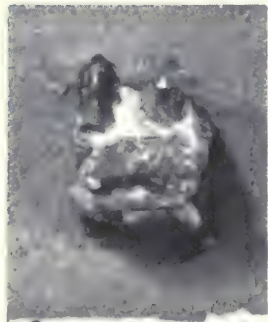
c



b



d



e

PLATE 2. Each scale is in millimeters. a, b, cf. *Gerrhonotus* sp., UALP 75137-F, fragmentary left dentary: a, labial view, b, lingual view; c, anguid osteoscuta; d, *Lep-tochamops denticulatus* (Gilmore, 1928), UALP 75137-D, dentary, fragment lingual view, x30; e, *Chamops segnis* Marsh, 1892a, MNA Pl. 1613, dentary fragment, lingual view.

and also of region of the dentary or maxilla preserved, so it is not surprising to find that only one of six fragmentary specimens in the present collection displays this condition.

The maxilla of *L. denticulatus* is distinguished from the dentary by an elongated flange that represents a portion of the deep dorsoventral border of the bone. The two fragmentary specimens, Nos. UALP 75137-M and 75137-N, share tricuspid, subpleurodont, bicolored teeth that extend about one-half their height over the parapet of the deep dorsoventral border of the bone. Homotaxy with these is thus assured.

*Discussion.*—The presence of *Leptochamops* in the Fruitland Formation of New Mexico represents the southernmost known occurrence of this genus. Elsewhere, it has been reported from the Lance Formation, Wyoming, Estes (1964); Hell Creek Formation, Montana, Estes et al. (1969); and Judith River Formation, Montana, Sahni (1972). The Hell Creek and Lance Formations are both Maestrichtian in age, and the Judith River Formation is slightly older, being Campanian. Two other teiid genera, *Meniscognathus* and *Haptosphenus*, described by Estes (1964) from the Lance Formation have not yet been identified from the Fruitland Formation. These two genera are also found in the Hell Creek Formation (Estes et al., 1969) but are conspicuously absent in the fauna from the older Judith River Formation.

**Chamops segnis** Marsh, 1892a. Plate 2e.

*Iguanavus teres* Marsh (1892a, p. 451).

*Lanceosaurus hatcheri* Gilmore (1928, p. 160).

*Lanceosaurus compressus* Gilmore (1928, p. 161).

*Alethesaurus quadratus* Gilmore (1928, p. 162).

*Referred specimen.*—MNA Pl. 1613, fragment of dentary.

*Locality.*—MNA Locality A.

*Description.*—Estes (1964, pp. 102, 103) has provided an excellent description of the dentary of *Chamops segnis*. Some of Estes' diagnostic characters used to identify the above fragmentary specimen include: tooth crowns wrinkled, tricuspid lingually and grooved labially; subpleurodont teeth projecting two-thirds of their height over the parapet of the jaw; medial curvature of the jaw; expanded splenial; and medial curvature of dorsal and ventral borders of dentary.

*Discussion.*—*Chamops segnis* and *Leptochamops denticulatus* represent the first two teiid genera to be reported from the Campanian Fruitland Formation. Other Campanian occurrences of *C. segnis* include the Judith River Formation of Montana (Sahni, 1972) and the Wapiti Formation of Canada (Sternberg, 1951). Maestrichtian occur-

rences include the Lance Formation of Wyoming (Estes, 1964) and the Hell Creek Formation of Montana (Estes et al., 1969).

### Family Anguidae

Genus and species indet. Plate 2c.

*Referred specimens.*—UALP 75137-h, four complete lateral body osteoscutes and 50 fragmentary osteoscutes.

*Locality.*—UALP 75137.

*Description.*—All of the complete lateral body osteoscutes are rectangular in shape. Each is sculptured over one-half of its external surface with irregular pits and ridges, and a flat gliding surface occupies the other half. There is no evidence of lateral suturing or of a keel on any of the osteoscutes. The length of a complete osteoscuta is ca. 3.5 mm., and the width is ca. 2 mm. The dentaries of both *Gerrhonotus* and *Pancelosaurus* occur in the Lance Formation; Meszoely (1970, p. 105) assigned the above defined osteoscutes to *Pancelosaurus* instead of *Gerrhonotus* on the basis of the greater abundance of skull remains of *Pancelosaurus* relative to *Gerrhonotus*. This criterion of relative abundance used by Meszoely does not seem sufficient reason to assign these osteoscutes to either *Pancelosaurus* or *Gerrhonotus*. Further, it cannot be applied to the osteoscutes from the Fruitland (identical to those illustrated by Meszoely) because *Gerrhonotus* dentary fragments occur in the Fruitland, but no *Pancelosaurus* cranial remains have been recorded to date. Until more extensive material has been recovered from the Fruitland or elsewhere, the generic identification of these osteoscutes will remain uncertain.

### Subfamily Gerrhonotinae

cf. *Gerrhonotus* sp. Plate 2a, b.

*Referred specimens.*—UALP Nos.: 75137-F, fragment of left dentary; 75137-G, fragment of left dentary.

*Locality.*—UALP 75137.

*Description.*—The teeth are pleurodont and slightly recurved posteriorly, projecting one-half of their height over the parapet of the jaw. Specimen 75137-F shows the characters of the tooth crown unique to *Gerrhonotus* as established by Estes (1964, p. 124). These characters include tooth crown striated to varying degrees lingually and labially and lingual and labial vertical grooves that separate the crown of the tooth into two separate cusps, of which the posterior is larger. The grooves dividing the crown are not present on the teeth of the smaller

specimen, 75137-G; following the comparative work of Estes (p. 124), this specimen, thereby, probably derives from the anterior portion of the dentary of an adult specimen or from any portion of the dentary of a juvenile.

*Discussion.*—Occurrence of *Gerrhonotus* in the Campanian Fruitland Formation constitutes the second late Cretaceous record of this still extant genus; the first is the Maestrichtian Lance Formation of Wyoming (Estes, 1964). *Gerrhonotus* is absent in the Maestrichtian Hell Creek and Campanian Judith River Formations of Montana, two faunas generally similar to that of the Fruitland in overall composition. Prior to these late Cretaceous records for *Gerrhonotus*, fossil remains were limited to the ?Eocene Four Mile local fauna, northwest Colorado (McKenna, 1960, p. 10), and the Miocene Niobrara River local fauna, Nebraska (Estes, 1964, p. 123). The recent species of *Gerrhonotus* are widely distributed over North and Central America.

Order Serpentes

Family Aniliidae

Genus *Coniophis* Marsh, 1892

*Coniophis cosgriffii* n. sp. (Armstrong-Ziegler, March, 1978, J. Paleontol.)

Order Crocodylia

Family Crocodylidae

Subfamily Crocodylinae

*Leidyosuchus* sp. Lambe, 1907

*Referred specimens.*—MNA No. Pl. 1428, several isolated teeth.

*Localities.*—MNA sites A and C.

*Description.*—These Fruitland Formation teeth are stout and conical, and their anterior and posterior blade-like ridges do not lie in the same longitudinal plane but, rather, are offset somewhat medially. The inner surfaces of all of the teeth are less convex than the outer surfaces, but both surfaces are completely smooth, lacking striations.

*Discussion.*—These teeth resemble the teeth of the genus *Leidyosuchus*, a form characterized by small teeth in the following literature: by Lambe (1907) and Sahní (1972) for *Leidyosuchus canadensis* from the Campanian Oldman and Judith River Formations of Alberta and Montana; by Leidy (1856) for synonym of *L. canadensis*, *Crocodylus humilis*, from the Judith River Formation of Montana;

by Gilmore (1910) and Estes (1964) for *L. sternbergi* from the Maestrichtian Lance and Hell Creek Formations of Wyoming and Montana; and by Russell (1935) for *L. sternbergi* from the Campanian Milk River Formation of Alberta.

Previously, crocodylian teeth from the Kirtland Shale and Fruitland Formation were identified as *Crocodylus* sp. by Reeside (1924). As Lambe (1907) has demonstrated, all Cretaceous *Crocodylus* should be placed in synonymy with *Leidyosuchus*. Therefore, the Fruitland Formation form is now identified as *Leidyosuchus* sp.

?*Thoracosaurus* sp. Cope, 1875

*Referred specimens*.—MNA Pl. 1628, isolated teeth.

*Locality*.—MNA Locality A.

*Description*.—Teeth from the front of the mouth are strongly recurved and conical, bearing longitudinal striations on the crowns. Teeth from the posterior part of the mouth have crowns that are robust and rounded, with fewer, more widely spaced striations. All the teeth have ridges separating their lateral from their medial surfaces.

*Discussion*.—The first record of this genus was reported by Cope in 1875 from the Cretaceous of New Jersey, at which time he placed the species *Thoracosaurus neocesariensis* in the subfamily Alligatorinae on the basis of well-preserved and complete cranial elements. Recently, DeKay (in Estes, 1970) placed this species in the subfamily Crocodylinae, and Estes (1970) further notes its presence in the Hell Creek Formation of Montana.

Subfamily Alligatorinae

*Brachychampsa* sp. Gilmore, 1911

*Referred specimens*.—MNA Pl. 1445, isolated teeth.

*Localities*.—MNA Localities A, B, and C.

*Description*.—The referred teeth are slightly recurved, with short, rounded, wrinkled crowns that have slight ridges on both their anterior and posterior edges.

*Discussion*.—*Brachychampsa* sp. teeth were recorded from the Kirtland Shale in New Mexico by Gilmore (1916), who based his identification on the similarities of his specimens with teeth of *Brachychampsa montana* from the Hell Creek Formation of Montana (Gilmore, 1911). Other Cretaceous records for the genus include: *Brachychampsa* sp. (Estes, 1964), Lance Formation of Wyoming; *B. perrugosa* (Cope, 1874), Arapahoe Formation of Colorado; *B. per-*

*rugosa* (Lambe, 1902), Oldman Formation of Alberta; *B. montana* (Sahni, 1972), Judith River Formation of Montana.

Order Saurischia

Suborder Theropoda

Infraorder Coelurosauria

Family Coeluridae

**Paronychodon lacustris** Cope, 1876. Plate 3d.

*Tripriodon caperatus* Marsh (1889, pl. 3, figs. 18–33).

*Zapsalis abradens* Cope (1876, p. 345).

*Referred specimens*.—MNA Pl. 1627, several isolated teeth.

*Locality*.—MNA Locality A.

*Description*.—Each of these recurved, laterally compressed teeth bears two to four longitudinal striations on its internal surface and is smooth or striated (two to four ridges) on its external surface. According to Estes et al. (1969, p. 25), the teeth with flattened external surfaces may be from the anterior part of the tooth row, and those without this condition may have had a posterior position.

*Discussion*.—*Paronychodon lacustris* teeth have been recovered from the Maestrichtian Hell Creek and Lance Formations of Montana (Estes et al., 1969) and Wyoming (Estes, 1964). Campanian occurrences other than the Fruitland Formation include the Judith River Formation of Montana (Sahni, 1972) and the Milk River Formation of Alberta (Russell, 1935).

Family ?Coeluridae. Plate 3a.

*Specimens*.—MNA Pl. 1624, several isolated teeth.

*Locality*.—MNA Locality A.

*Description*.—These possibly coelurosaurid teeth are recurved, with smooth anterior edges and serrate posterior edges.

*Discussion*.—Unfortunately, these teeth do not possess features allowing generic determination. Estes (1964) and Estes et al. (1969) described similar teeth from Lance and Hell Creek Formations and noted that they resembled those of *Velociraptor mongoliensis* (Osborn, 1924, p. 1, fig. 1) from the Djadochta Formation, Central Mongolia. However, in shape and size, they also resemble teeth of such other coelurid genera as *Chirostenotes* from the Campanian Oldman Formation and *Coelophys* from the upper Triassic at Ghost Ranch, New Mexico (Estes et al., 1969, p. 25).

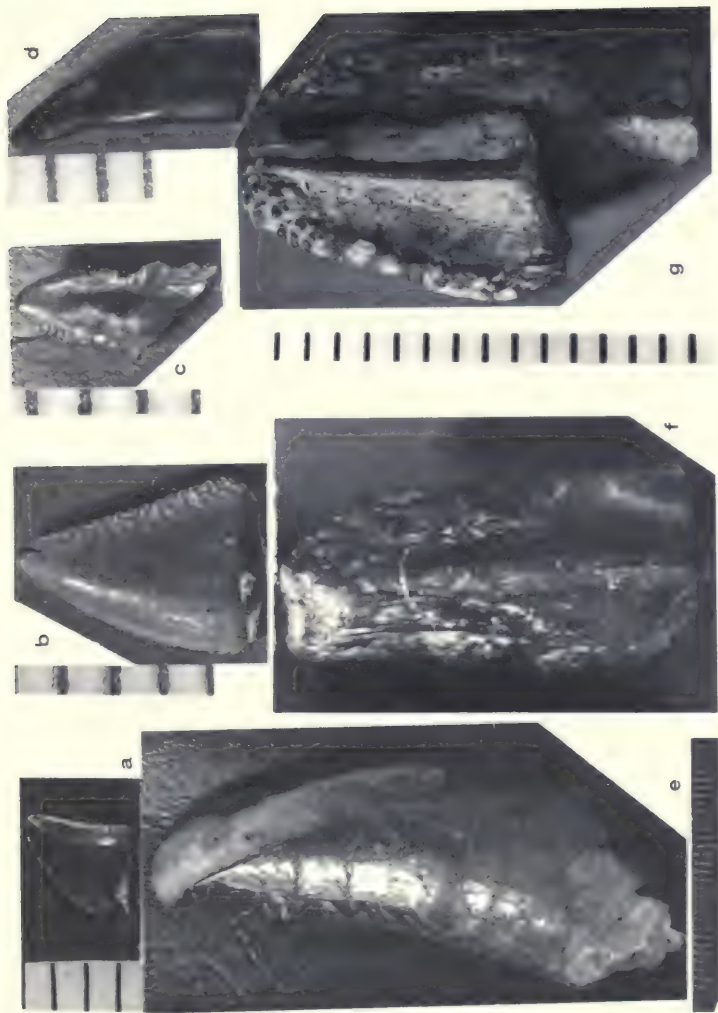


PLATE 3. Each scale is in millimeters. **a**, ?Coeluridae, MNA Pl. 1624, isolated tooth; **b**, ?Dromaeosauridae, MNA Pl. 1645, isolated tooth; **c**, ?Pachycephalosauridae, MNA Pl. 1642, isolated tooth; **d**, *Paronychodon lacustris* Cope, 1876, MNA Pl. 1627, external surface of anterior tooth; **e**, *Deinodon horridus* Leidy, 1856, MNA Pl. 1623, isolated tooth; **f-g**, *Kritosaurus navajovius* Brown, 1910, MNA Pl. 1626: **f**, maxillary tooth, **g**, mandibular tooth.

## Infraorder ?Deinonychosauria

## Family ?Dromaeosauridae. Plate 3b.

*Specimens*.—MNA Pl. 1645, several isolated teeth.

*Locality*.—MNA Locality A.

*Description*.—These short-crowned, compressed teeth are serrated on both anterior and posterior edges with the sets of serrations lying on the same longitudinal plane. There are 30 to 40 serrations per 5 mm. on the anterior edge and 20 to 30 on the posterior edge. Recurvature among these teeth ranges from slight to pronounced.

*Discussion*.—The specimens at hand closely resemble a number of specimens from other late Cretaceous deposits. These, listed by unit and by their various taxonomic allocations are: the Maestrichtian Hell Creek Formation of Montana, *Dromaeosauridae?* (Estes et al., 1969, pl. 1, C); the Maestrichtian Lance Formation of Wyoming, cf. *Dryptosaurus* sp. (Estes, 1964, p. 144); the Campanian Judith River Formation of Montana, *Dromaeosaurus albertensis* (Sahni, 1972, p. 359); the Campanian Milk River Formation of Alberta, cf. *Dromaeosaurus* sp. (Russell, 1935, fig. 7); and the Judith River Formation of Montana, *Laelaps* (Cope, 1876). *Laelaps* tooth types have often been included in *Dryptosaurus* (e.g., Estes, 1964). However, Colbert and Russell (1969), in a revision of the family, surmised that *Laelaps* might, with better reasons, be included with the dromaeosaurs.

The teeth from the Fruitland Formation do not fall into any of the ranges of tooth serration number cited from the various taxa of the group by Colbert and Russell (1969, p. 39, 40). Further, the teeth of the Fruitland Formation form differ from the premaxillary and maxillary teeth of *Dromaeosaurus albertensis* in two seemingly significant respects. First, the serrations on the anterior and posterior edges of the latter are equally developed, with approximately 16 serrations per 5 mm. Second, the anterior serrated edge on a tooth of *D. albertensis* is offset somewhat medially relative to the posterior edge rather than lying in the same longitudinal plane as in the Fruitland form. These differences serve to exclude the present material from *Dromaeosaurus* (*Laelaps*) but do not provide sufficient basis for the nomination of a new genus to include them. Therefore, in the absence of more definitive criteria, they can only be included with question in the family Dromaeosauridae.

## Family Deinodontidae

**Deinodon horridus** Leidy, 1856. Plate 3e.

*Aublysodon misandus* Leidy, 1868, p. 198.

*A. lateralis* Cope, 1876, p. 248.

*Laelaps incrassatus* Cope, 1876, p. 248, 341.

*L. hazenianus* Cope, 1876, p. 343.

*Ornithomimus grandis* Marsh, 1890, p. 85.

*Dryptosaurus kenabekides* Hay, 1899, p. 348.

*Gorgosaurus libratus* Lambe, 1914, 13.

*Referred specimens.*—MNA Pl. 1623, three isolated teeth.

*Locality.*—MNA Locality A.

*Description.*—The largest and most complete specimen has a length of 64 mm., a width at the base of 25 mm., and is compressed linguolabially, with a wear facet on one surface. Both anterior and posterior edges are serrated.

*Discussion.*—*Deinodon horridus* has been recorded from the Maestrichtian Hell Creek Formation of Montana (Estes et al., 1969). In addition to the present material, Campanian occurrences include the Judith River Formation of Montana (Sahni, 1972) and the Oldman Formation of Alberta (Lambe, 1914).

#### Order Ornithischia

#### Suborder Ornithopoda

#### Family ?Pachycephalosauridae. Plate 3c.

*Specimen.*—MNA Pl. 1642, isolated tooth.

*Locality.*—MNA Locality B.

*Description.*—This slightly compressed tooth crown has serrations on both anterior and posterior borders, with a distinct constriction at its junction with the root. Although much of the root is broken off, enough remains to show that it ventrally continues the triangular outline initiated by the crown.

*Discussion.*—This specimen resembles teeth from the Lance, Hell Creek, and Judith River Formations in the characters of the crown. However, all of these possess a cylindrical root in contrast to the triangular root of the present form. Therefore, it is with reservation that I assign the Fruitland tooth to the family Pachycephalosauridae on the basis of tooth crown similarities to all previously described teeth of forms assigned to this family.

Estes (1964) and Estes et al. (1969) designated the Lance form as cf. *Pachycephalosaurus* sp. and referred the Hell Creek form with question to the family Pachycephalosauridae. Sahni (1972) assigns his Judith River form with question to the pachycephalosaur, *Stegoceras validus*, founded for material from the Oldman Formation by Lambe (1902).

## Family Hadrosauridae

**Kritosaurus navajovius** Brown, 1910. Plate 3f, g.

*Referred specimens.*—MNA Pl. 1626, several isolated teeth.

*Locality.*—MNA Locality B.

*Description and discussion.*—*Kritosaurus navajovius* is represented in the collection from Locality B by both maxillary teeth with smooth borders and mandibular teeth with papillate borders. This species was originally described for material from the Kirtland Shale and Fruitland Formation of New Mexico by Brown (1910). Other occurrences of the genus *Kritosaurus* are in the Campanian Judith River Formation of Montana (Sahni, 1972) and Campanian Oldman and Milk River Formations of Alberta (Russell, 1935).

## PALEOECOLOGY AND PALEOGEOGRAPHY

The Fruitland Formation is a continental sequence deposited on top of the marine Pictured Cliffs Sandstone when the epicontinental seaway that formed the latter retreated from the area. The sediments composing the Fruitland were derived from eroding highlands to the southwest and were transported by rivers and streams flowing in a northeasterly direction toward the Pictured Cliffs Sea. Deposition occurred under environmental conditions typical for late Cretaceous deposits in western North America; the climatic regime was moist and subtropical, and the detrital material accumulated in a lowland floodplain setting. The same general regime is represented by such units as the Lance, Hell Creek, and Judith River Formations; and the gulf coastal plain of the southeastern United States constitutes a modern analogue. Interpretations of the faunas at four localities in the Fruitland Formation together with their geographic locations in relation to the ancient shorelines as established by Fassett and Hinds (1971, p. 14, fig. 3) has led to the distinction of three subenvironments: lowland river, upland river, and upland stream.

The subenvironment at Localities B and C, as interpreted both from the assemblages that they have produced and from their position on Fassett and Hind's paleogeographic map (1971, p. 14, fig. 3), represents two variants of the general lowland river subenvironment. Total faunal content at Locality B favors an estuarine regime. Included in the assemblage are 11 taxa of fish, three taxa of dinosaurs, and one abundant pelecypod. Six of the fish are elasmobranchs. Two of these, *Myledaphus* sp. and *Ischyrhiza* sp., belong to genera whose living representatives prefer brackish or estuarine conditions but have been

identified in freshwater fossil deposits. Although the two species of *Squatirhina* and the one species of *Lonchidion* have no recent record of nonmarine habitation, they also have been identified in freshwater fossil assemblages. Only the mackerel shark, *Isurus (Oxyrhina)*, is limited to marine waters in the modern fauna and to marine fossil assemblages. The osteichthyan component at Locality B is comprised of forms whose living representatives are found in large, slow Mississippi-like rivers and also in brackish-marine bays. Included in this group are *Acipenser*, *Paleopsephurus*, *Amia*, *Lepisosteus*, and *Paralbula*.

*Teredina neomexicana*, a tubular pelecypod, is abundant at Locality B. In morphology, this species resembles the living shipworm, *Teredo*, a pelecypod found burrowing into wood debris along the Atlantic coastal regions of the United States.

The dinosaurs consist of the small terrestrial saurischian, *Paronychodon*, and two ornithischians, a pachycephalosaurid and a duck-billed semiaquatic form *Kritosaurus*.

The presence of the estuarine marine, *Hybodus*, at Locality B suggests a deposit very proximal to the Pictured Cliffs Sea. The absence of amphibians and small semiaquatic reptiles further strengthens the interpretation of the locality as a large river mouth on the shore of the Pictured Cliffs Sea because the somewhat saline water of this type of locale would have excluded them. Most of the fish included in the assemblage were forms adapted to and living at the locality. The dinosaur teeth present in the assemblage represent forms that were adapted to and living at the locality. The dinosaur teeth present in the assemblage were massive enough to have survived transport from more inland areas, whereas the delicate skeletal elements of anurans, urodeles, and squamates would have been destroyed in transit. Moreover, it is possible that some of the dinosaurs lived at or near the locality. This is particularly likely for the duckbill, *Kritosaurus*.

Locality C lies somewhat inland from Locality B, as evidenced by the slightly different composition of its produced faunal assemblage. The overall correspondence, however, is great enough to include it with Locality B in the general lowland river subenvironment. The euryhaline fish, *Squatirhina*, *Myledaphus*, *Amia*, *Lepisosteus*, and *Paralbula*, occur at this site together with the crocodylians, *Leidyosuchus* and *Brachychampsa*. Although this association is ambiguous for purposes of interpreting the living environment, the abundance of the tubular pelecypod, *Teredina*, serves to confirm a near-coastal position for Locality C. As noted in the discussion of Locality B, *Teredina* was found in association with a marine shark, *Isurus*. This

occurrence reflects the preference of this fossil pelecypod for saline or estuarine conditions.

What appear to be insect burrows in the form of tubes arranged in a semi-symmetrical fashion and crab claws were also collected at Locality C. These provide only limited evidence relevant to environmental interpretations because neither can be identified as to genus or species. They suggest shallow water at the point of deposition, perhaps a sand bar or muddy bank at the mouth of a large river. The abundance of large fish such as the alligator gar and bowfin at Locality C support the conclusion that the general area of deposition was a large river.

Essentially, then, the faunal community of the lowland river sub-environment represented by Localities B and C is characterized by a mixture of euryhaline and marine vertebrates and by the presence of some fish of considerable size.

Locality A represents an upland river subenvironment. In addition to fish that show no preference between fresh and brackish water, the assemblage from this locality includes exclusively freshwater fish together with amphibians and turtles. No exclusively marine vertebrates are present. As in the case of the assemblages from Localities B and C, the presence of large fish suggests a broad, deep river. In addition to the general character of the suite of lower vertebrates, the abundance of marsupials and multituberculates in the assemblage from Locality A suggests a more upland locality of deposition. Two partial shell fragments of *Teredina* were recovered from this locality so that one may infer that *Teredina* was adapted to both freshwater or marine environments but prefers the latter habitat.

Locality D (=UALP 75137) is the farthest removed from the shoreline of the Pictured Cliffs Sea and represents a small body of water, either a stream or pond, in the more upland regions to the southwest. The recovered assemblage includes only freshwater and terrestrial vertebrates. There are two small fish—the hybodont, *Lonchidion*, and a form related to the recent freshwater drum, *Platacodon*. Aquatic or semiaquatic amphibians are abundant and include: an amphiumid, *C. mcnellyi*; two salamanders, *P. copei* and *O. kayi*; and a frog, *?Eopelobates* sp. The reptiles include three lizards and one crocodilian. One of the lizards, the teiid, *Leptochamops*, may have been semiaquatic. The two anguils are cf. *Gerrhonotus* and a generically and specifically indeterminate form represented by *Pancelosaurus*-like osteoscutes. The crocodilian is known only from osteoscutes of uncertain allocation. They may pertain to either *Leidysuchus*, *Thoracosaurus*, or *Brachychampsia*. As might be ex-

pected, no evidence of the tubular pelecypod, *Teredina*, was recorded from this site (Lindsay, written comm., 1976).

Using electric log data to correlate the isopachal intervals between the radioactively dated Huerfano Bentonite Bed of the Lewis Shale to the top of the Pictured Cliffs Sandstone, Fassett and Hinds (1971) inferred the approximate successive shorelines of the Pictured Cliffs Sea. Figure 3 shows these shorelines in relationship to the geographical positions of the vertebrate localities. Localities B and C were indeed closest to the shoreline. Locality A lies somewhat inland, and Locality D was the most distal from the Pictured Cliffs Sea. This type of correlation has exciting implications for further paleoenvironmental work in the San Juan Basin. Theoretically, if one were to collect microvertebrates along one of these "past shorelines," time-equivalent samples from similar ecologic niches would be obtained. The probable environments of deposition for Localities A, B, C, and D are shown in Figure 3, a revised version of the diagrammatic paleogeographic map compiled by Fassett and Hinds (1971, p. 37).

The vertebrate localities probably vary somewhat in age, with Locality A the youngest, Localities B and C intermediate in age, and Locality D the oldest; the intervals separating them, however, are probably not extensive. The differences in composition among the assemblages collected from them, therefore, are sure to reflect differences among contemporary living environments rather than evolutionary changes caused by the lapse of time.

In the following section, the four localities in the Fruitland will be considered together and separately in making comparisons with other faunas to the north.

#### BIOSTRATIGRAPHY

Cobban (1973) computed a potassium-argon date for the lower part of the Fruitland Formation as  $75 \pm 2$  million years. By synthesizing this date with the Western Interior Ammonite Zones, he was able to estimate that both the Kirtland Shale and Fruitland Formation were deposited in the Upper Campanian between 72 and 73 million years ago (Cobban, 1973, p. 151). On the basis of his palynological work on samples from the Fruitland Formation, Tschudy in Fassett and Hinds (1971) also assigns a Late Campanian age to this unit. Zavada (written comm., 1976) disagrees with Tschudy's determination and, on the basis of samples from Locality C and other localities in the Fruitland, assigns an Early Maestrichtian rather than Late Campanian age to the deposits.

The diversity contained in the vertebrate fauna of the Fruitland Formation of New Mexico is comparable to that from the Campanian Judith River Formation; both contain some 48 genera of vertebrates. The recovered vertebrate assemblages from the Maestrichtian Lance and Hell Creek Formations of Wyoming and Montana are notably larger, containing 75 and 78 genera, respectively. This greater diversity, no doubt, reflects the more intensive and prolonged collecting that has been accomplished at localities in these units. Table 1 is a listing of all lower vertebrate genera occurring in the principal Late Cretaceous vertebrate-bearing units of the western parts of the United States and Canada. Table 2 is a summary of this data, showing the percentage of taxonomic resemblance between the faunas of the Fruitland, Judith River, Lance, and Hell Creek Formations. An inspection of this reveals that there is close taxonomic correspondence between the Lance and Hell Creek faunas, but that the Fruitland and Judith River faunas are divergent in part from the Lance-Hell Creek complex. A portion of this divergence is identical for Fruitland and Judith River faunas, but it should be noted that these units diverge from each other in the areas of several important taxonomic groups. There is, in total, greater correspondence of the Fruitland fauna with the Judith River fauna than with the Lance or Hell Creek faunas. There is, however, less correspondence between the Fruitland and Judith River faunas

TABLE 1. Extant salamanders which exhibit deeply pleurodont teeth.

<i>Amphiuma means</i>	<i>Cryptobranchus alleghanensis</i>
<i>Necturus maculosus</i>	<i>Desmognathus fuscus</i>
<i>Salamandra maculosa</i>	<i>Gyrinophilus porphyriticus</i>
<i>Megalobatrachus japonicus</i>	<i>Ambystoma maculatum</i>

TABLE 2. Percentage of correlations\* based on taxonomic resemblances between four major late Cretaceous Faunas.

Faunas	No. of common genera	Percentage
Lance and Hell Creek	47	71%
Judith River and Fruitland	33	50%
Judith River and Lance	33	50%
Judith River and Hell Creek	33	50%
Fruitland and Lance	30	45%
Fruitland and Hell Creek	31	48%

\*Either the two formations both have a given genera (positive correlation) or both do not (negative correlation).

than between the Lance and Hell Creek faunas. This general taxonomic comparison, then, is in accord with the interpretation, derived from pollen analysis (Tschudy in Fassett and Hind, 1971) and from ammonite stratigraphy and radiometric dating (Cobban, 1973), that the Fruitland Formation was deposited in Late Campanian time.

A portion of the taxonomic divergence between the Fruitland and Judith River assemblages is certain to reflect differences in the environments of deposition represented in the two units. Within this category, some of the marine and euryhaline fish present in the collections from Localities B and C, *Lonchidion*, *Squatirhina*, and *Ischyrrhiza*, are particularly notable. All three of these also occur in the Lance and Hell Creek faunas but are conspicuously absent from the Judith River collections. This strongly suggests the absence of the littoral zone facies from the Judith River vertebrate-bearing deposits rather than a faunal distinction indicative of differing stratigraphic positions.

The following discussion is a commentary on the more important taxonomic similarities and differences among the assemblages from the four Late Cretaceous units that, in total, yield a Campanian stratigraphic position for the Fruitland Formation vertebrate fauna. As will be shown, many of the faunal differences between the Campanian Judith River and Fruitland faunas on the one hand and the Maestrichtian Lance and Hell Creek faunas on the other are indicative of evolutionary changes that occurred in the composition of the terrestrial and freshwater vertebrate fauna during Late Cretaceous time. In this consideration, it is recognized that an indeterminate portion of the differences between the faunas is due to less intensive collection in the Campanian units. However, within a number of the important groups of vertebrates represented in all of the faunas, it seems fairly certain that the observed differences in assemblage composition reflect genuine and stratigraphically important differences that existed in the living faunas.

The Judith River fauna appears to reflect solely an upland river setting because it contains only freshwater and terrestrial vertebrate remains. As expected, the fish component of this fauna is most comparable with the fish component from Locality A (also an upland river assemblage). Both contain *Myledaphus*, *Amia* (*Kindleia*), *Lepisosteus*, and *?Paralbula*. The Fruitland fauna at Locality A contains *Acipenser*, absent from the Judith River fauna, but lacks *Belonostomus*, present in the latter. This difference may well constitute a change in faunal composition, perhaps even an incident of ecologic replacement, that occurred through the passage of time. The fish assemblages from Lo-

calities B, C, and D are very different from the Judith River complex because they include the various elasmobranch species adapted to marine and brackish water conditions. On the other hand, the fish assemblages of Locality B, C, and D closely resemble those from the Lance and Hell Creek Formations but are conspicuously absent from the older Judith River and Milk River Formations as well as from the Fruitland Formation.

Among the Anura, the Fruitland has a pelobatid, *?Eopelobates*, in common with the Judith River assemblage. This was initially described from the Judith River Formations as "Discoglossid type C" (Sahni, 1972). In addition to *?Eopelobates*, the Fruitland fauna shares *Scotiophyrne pustulosa* with both the Lance and Hell Creek faunas. However, the Lance and Hell Creek faunas contain cf. *Barbourula*, a form absent from the Judith River and Fruitland faunas. Among the *Urodela*, the Fruitland assemblage shares two genera (*Prodesmodon*, *Opisthotriton*) in common with the Judith River assemblage and three genera (*Prodesmodon*, *Opisthotriton*, and *Cuttysarkus*) in common with the Hell Creek and Lance assemblages. The Judith River, Lance, and Hell Creek faunas also contain three genera (*Habrosaurus*, *Scapherpeton*, and *Lisserpeton*) not in the Fruitland fauna, which could reflect less intensive collecting in the latter or, perhaps, a regional rather than stratigraphic variation.

Of the four turtle genera from the Fruitland, two (*Basilemys* and *Trionyx*) are found in the Judith River fauna, three (*Compsemys*, *Basilemys*, and *Trionyx*) are found in the Lance fauna, and three (*Adocus*, *Compsemys*, and *Trionyx*) are found in the Hell Creek fauna. In addition to these, one additional chelonian genus, *Eubaena*, is common to the Lance and Hell Creek faunas but is missing from all of the earlier faunas. Because *Adocus* and *Basilemys* are easily confused, perhaps a closer review of the turtle fragments collected from the Milk River and Judith River faunas, using Estes' criteria for distinguishing these two genera, might show that these earlier Campanian units shared *Adocus* as well as *Basilemys* with the Fruitland Formation.

An Eosuchian, *Champsosaurus* sp., is present in the Maestrichtian Lance and Hell Creek Formations (Estes et al., 1969) and the Campanian Edmonton and Judith River Formations (Sahni, 1972) but, thus far, no remains of this form have been discovered in the Fruitland Formation. There are three crocodylians (*Leidyosuchus*, *Thoracosaurus*, and *Brachychampsia*) present in the Fruitland fauna, and all of these are found in the Hell Creek fauna as well (Estes et al., 1969). Two of them (*Leidyosuchus* and *Brachychampsia*) are found in

the Judith River (Sahni, 1972) and Lance faunas (Estes, 1964) as well. The New aniliid snake, *Coniophis cosgriffi*, from the Fruitland Formation (Armstrong-Ziegler, 1978) is probably also represented in the Hell Creek fauna by an unidentified fragmentary vertebra (see Estes et al., 1969, p. 23, fig. 4). Another snake, *Coniophis*, is recorded from both the Lance and Hell Creek Formations (Estes et al., 1969). Thus far, no snake remains have been recovered from the Judith River Formation fauna (Sahni, 1972).

The Fruitland fauna shares two teiids, *Chamops segnis* and *Leptochamops denticulatus*, with the Judith River fauna (Sahni, 1972). In addition to these, the Hell Creek fauna also has *Haptosphenus placodon* and *Peneteius aquilonius*, with only the latter occurring in the Lance fauna (Estes et al., 1969). One and, perhaps, two different anguids are present in the Fruitland collections—*i.e.*, cf. *Gerrhonotus* and gen. et sp. indet. represented by *Pancelosaurus*-like osteoscutes. Both of these are described in accounts from the Lance fauna (Estes, 1964), but only the latter, in accounts of the Hell Creek fauna (Estes et al., 1969). The Judith River Formation (Sahni, 1972) entirely lacks anguids; therefore, the family may have been totally absent from North America during the earlier Campanian. Three additional lizards absent in the Fruitland Formation (*Parasaniwa*, *Paraderma*, and *Exostinus*) are common to the Lance, Hell Creek, and Judith River faunas; and two additional lizards (*Palaeosaniwa* and *Colpodontosaurus*) are common only to the Lance and Hell Creek faunas. One scincid, *Contogenys sloani*, is reported only from the Hell Creek fauna.

A comparison among the dinosaurian records for the Lance, Hell Creek, Judith River, and Fruitland Formations yields few items of possible stratigraphic significance because it portrays, for the most part, dissimilarities due to ecologic facies differences (*i.e.*, *Triceratops* vs. *Pentaceratops* distributions) and similarities due to long-ranging genera (*i.e.*, *Paronychodon*). However, one exception to this generality appears to be the presence of *Kritosaurus* in the Judith River (Sahni, 1972) and Fruitland faunas as well as other Campanian deposits such as those of the Oldman and Milk River Formations (Russell, 1935) and its conspicuous absence in the Maestrichtian Lance and Hell Creek Formations. This record constitutes yet another taxonomic datum in support of closer time correspondence of the Fruitland Formation with the older units of Montana and Alberta. Further support for this conclusion is derived from the presence of *Anatosaurus*, *Triceratops*, and *Tyrannosaurus* in the Lance and Hell Creek faunas (Estes, 1964; and Estes et al., 1969) and their absence in the older Judith River (Sahni, 1972) and Fruitland faunas.

Clemens (written comm., 1976) has identified the following mammalian material from my Fruitland localities, A, B, and C:

?*Mesodma* sp. Based on part of a P<sub>4</sub>. ?New multituberculate(s): The M<sub>2</sub> differs from *Mesodma* in the irregular development of cusps. The P<sub>4</sub> differs from *Mesodma* in that the slope of the anterior edge is not parallel with the roots, and there is a great distance between the first and second serrations. A.

?*Essonodon* sp. The configuration of cusps and basins on this molar are somewhat *Essonodon*-like. A.

*Cimolodon* sp., new species, with smaller bulbous cusps than found in *C. nitidus*. A.

Eucosmodontid, a new genus and new species. A, B.

*Alphadon* cf. *marshi*. Represented by an upper molar lacking only the parastyle. This tooth might be the M<sup>2</sup> or M<sup>3</sup> of *A. marshi*; however, its crown could be a bit too bulbous to be referable to that species. The differences are not great. C.

?*Peradectes* sp. The talonid of a molar shows *Peradectes*-like characters that include a small hypoconulid and its separation from the entoconid. A.

This material and Clemens' (1973) former work on Fruitland mammals still supports his original contention that the unique character of the Fruitland mammalian faunal complex reflects an intermediacy in age between Maestrichtian and Campanian assemblages (Clemens, 1973, p. 164).

From a consideration of the total fossil content of the Fruitland Formation, including vertebrate, invertebrate, and pollen taxa, it seems most reasonable to assume an Upper Campanian age for the unit because the evidence points toward a closer affinity with the Campanian Judith River Formation than with the Maestrichtian Lance and Hell Creek Formations. This affinity is evident despite obvious ecologic facies differences existing, in part, between the two units and the relatively small amounts of collecting (and, thus, incomplete sampling) that have been accomplished in the two. Certain taxa, as discussed above, signify an age for the Fruitland Formation that is only slightly younger than that of the typical Campanian units.

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