Chapter 25

Mimotricentes tedfordi, a New Arctocyonid from the Late Paleocene of California

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ABSTRACT

Mimotricentes tedfordi, new species, is a small arctocyonid mammal whose type specimen is from the Tiffanian (late Paleocene) Laudate local fauna, found at the base of informal member 4b of the Goler Formation, southwesternmost Great Basin, Kern County, California. The type specimen is a fragmentary maxilla with P4–M3. Smaller than morphologically similar taxa based on upper teeth, *M. tedfordi* is characterized by a large, projecting parastyle on M1 and M2, by a proliferation of mesostyle-like cusps on the molars, by lack of complete cingula around the lingual bases of the molar protocones, and by somewhat crenulated enamel surfaces on the posterior slope of P4 and possibly the molars when unworn. *M. tedfordi* is most similar to, but 20% smaller than, certain specimens formerly identified as *Chriacus* sp. from the earliest Tiffanian of Douglass Quarry, eastern Crazy Mountain Basin, Montana. Also, newly collected specimens from the Goler Formation of other mammalian taxa show strong Tiffanian affinities. As a whole, these data support a Tiffanian age for the Laudate local fauna, but require that an unnamed anisonchine periptychid similar to *Conacodon* be considered a Tiffanian relict.

INTRODUCTION

In 1948, Dr. Chester Stock of the California Institute of Technology published an address as retiring President of the Society of Vertebrate Paleontology. It was entitled ''Pushing back the history of land mammals in western North America.'' In his address, Stock (1948) pointed with some pride to his accomplishments, because he and his students were responsible for filling in large gaps in the Tertiary mammalian fossil record of the West Coast. Nonetheless, in 1948, fossil mammals older than Middle Eocene in continental deposits on North America's western shore remained unknown. Shortly thereafter, Stock interested two chemistry students at the University of California at Los Angeles, Robert L. Shultz, Jr., and Richard H. Tedford, in prospecting Goler Formation outcrops in the El Paso Mountains, near Inyokern, Kern County, California (fig. 25.1). Goler outcrops occur beneath and generally northeast of well-known late Tertiary badlands in and near Red Rock Canyon (Baker, 1912; Merriam, 1919; Whistler, 1987; Burbank and Loomis, 1988).

Stock was keenly interested in the Goler Formation because he had read early descriptions of the Goler deposits that noted the presence of redbeds and other sediments beneath the Miocene deposits of the area (Merriam, 1919, and contained references). Stock thought that exploration of these redbeds might lead to the recognition in California of strata similar in age to the early Eocene Wasatch Formation of Wyoming. Early in 1950, following Stock's lead, Tedford and Shultz were successful in finding a fossil ''turtle shell'' and a mammal tooth in the lower part of the Goler Formation. Like Stock before

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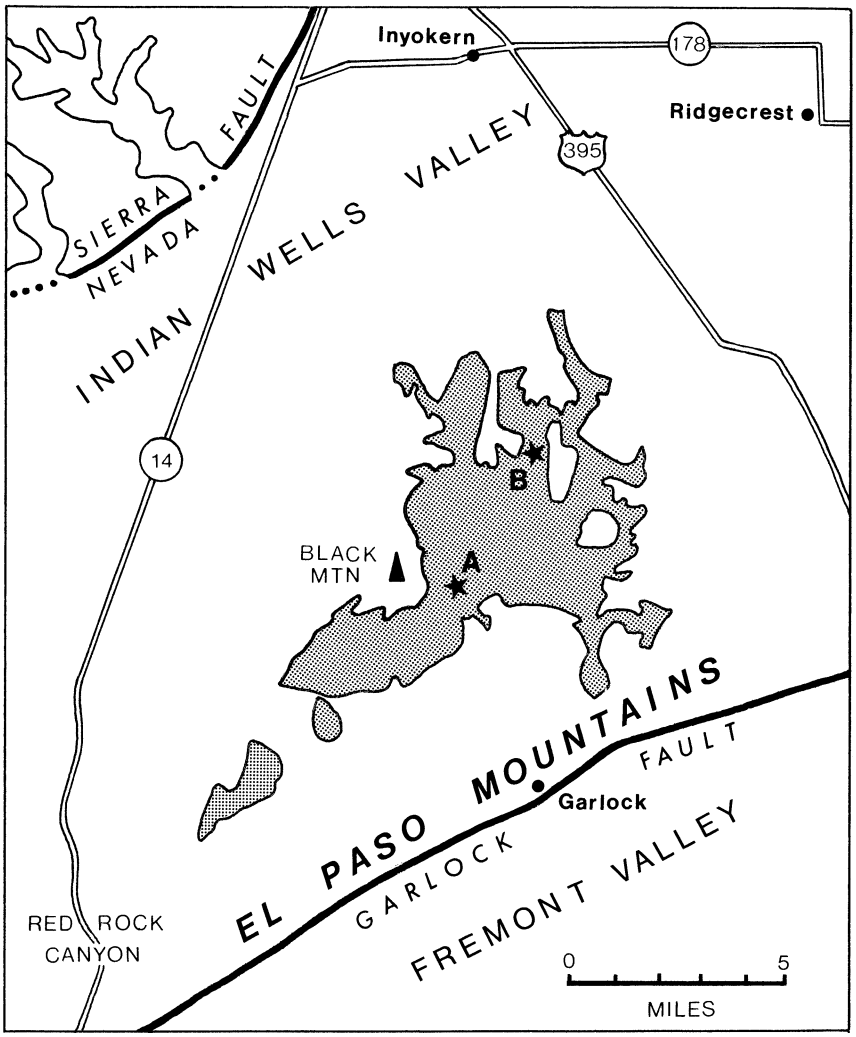

Fig. 25.1. Map of the El Paso Mountains, Kern County, California, showing (**A**) position of Tedford Discovery site for Paleocene vertebrates and (**B**) site of discovery of *Mimotricentes tedfordi*. Goler Formation shaded; triangle marking Black Mountain points to geographic north. Modified from Cox (1987: fig. 1).

them, they pushed back the history of western North American land mammals significantly. The specimens were taken to Stock for study but, unfortunately, Stock died before he could describe the material. The specimens were subsequently lost.

In 1952, Tedford and Malcolm C. McKenna renewed prospecting efforts in the Goler Formation and were successful in finding various other bone fragments and an alligator tooth, stratigraphically higher than the level that had produced the lost mammal tooth. Fossils at this higher stratigraphic level, which includes UCMP localities V5252 and V5870, are known as the Laudate local fauna (McKenna, 1955, 1960; McKenna et al., 1987). Soon thereafter, UCMP locality V5252 yielded a *Conacodon*-like mammal jaw (McKenna, 1955), indicating that at least part of the Goler Formation is Paleocene in age. In the Rocky Mountain states, records of *Conacodon* are limited to the early Paleocene Puercan NALMA (Archibald et al., 1987).

Although the Goler Formation did not prove to be very fossiliferous, subsequent collecting over many years produced a few more fossils, including two multituberculate (cf. *Neoliotomus* sp.) incisor fragments from UCMP locality V5870, that confirmed a Paleocene assignment for the Laudate local fauna. However, these fossils did not allow a more detailed positioning of the Laudate local fauna within the Paleocene. Its age was estimated to be Torrejonian or older, with continental sediments above the Laudate level perhaps demonstrable as early Tiffanian in age (McKenna, 1960; McKenna et al., 1987). A marine biota occurring stratigraphically above the Laudate local fauna was reported by Cox and Edwards (1984). The age of the marine fossils near the top of the Goler Formation is debated (McDougall, 1987; Squires et al., 1988), but is either latest Paleocene or early Eocene.

Recently, further surface collecting and screen washing at UCMP locality V5252 (= RAM locality V94014) has resulted in additional identifiable specimens (McKenna et al., 1987; Lofgren et al., 1999; unpublished data). These specimens are finally becoming decisive with regard to placing the Laudate local fauna within the biochronologic framework of Paleocene NALMAs. Surface collecting at UCMP locality V5870 (= RAM locality V94133) in November 1999 yielded the specimen described herein. In September, 2000, an m3 of *Plesiadapis* sp. from locality V5252/V94014 provided additional evidence for assignment of the Laudate local fauna to the Tiffanian NALMA (Lofgren and McKenna, unpublished data), which is late Paleocene in age (Archibald et al., 1987). Moreover, an upper molar of cf. *Phenacodus* sp. from a stratigraphically lower level in the Goler sequence leads to the conclusion that much of the upper part of the Goler Formation is either Tiffanian in age or younger (Lofgren and McKenna, in prep.).

This paper adds a new taxon to the Laudate local fauna of California. *Mimotricentes tedfordi*, new species, is a small arctocyonid that may also be represented by, or is at least very closely related to, an early Tiffanian arctocyonid known from Montana. Although the Tiffanian has been subdivided into six biochronological divisions in the Rocky Mountain states (Archibald et al., 1987), we refrain from extending them to California at this time, pending study of additional newly collected specimens from several localities.

Abbreviations

AMNH	American Museum of Natural History, New York
GPS	Global Positioning System
NAD 27	North American Map Datum, 1927, in use prior to 1984
NALMA	North American Land Mammal Age
RAM	Raymond M. Alf Museum of Paleontology, The Webb Schools, Claremont, California
UCMP	Museum of Paleontology, University of California, Berkeley
USGS	United States Geological Survey
WGS 84	World Geodetic System, in use since 1984
N	number of specimens in a sample
OR	observed range of measurement
s	standard deviation of the mean
M	mean
V	coefficient of variation

GEOLOGIC SETTING

The very thick Goler Formation and its sparse fossils have been described and discussed extensively by Dibblee (1952), McKenna (1955, 1960), West (1970), Cox (1982, 1987), Cox and Diggles (1986), McDougall (1987), McKenna et al. (1987), and Lofgren et al. (1999). Consequently, only a brief, updated summary is provided here.

Primarily during late Paleocene to early Eocene time, a thick accumulation of nonmarine and then marine sediments was deposited in a rapidly subsiding depression in what was later to become the southwesternmost corner of North America's Basin and Range Province (Southwestern Basin and Range microplate of Monastero et al., 2000). Almost 4 km of conglomerates, feldspathic sandstones, and drab or variegated mudstones were laid down as basin subsidence eventually outpaced basin filling. At first, a northern local source supplied the basal sediments of the Goler Formation. Later, sediments were supplied by a river originating in highlands generally to the east. Ultimately, the river valley was drowned by eastward advancing marine waters from the Pacific Ocean (McDougall,

1987; Squires et al., 1988). These events took place far to the east of the formerly accepted early Cenozoic Pacific shoreline. A long bay connecting the area of the Goler marine deposits with the San Joaquin Valley area is required but unproven. Marine sediments are unknown between the two areas. Post-Goler uplifting raised the entire Goler sequence at least 5 km and tilted the rocks to form a homocline dipping toward the north and northwest, toward Indian Wells Valley. Later, outcrops of the tilted Goler Formation were covered by fossiliferous Neogene continental sediments and volcanics. These too were tilted in turn, but generally in a more westerly direction (Baker, 1912; Burbank and Loomis, 1988).

The Goler Formation has been divided into informal members in four different schemes (Dibblee, 1952; Cox, 1982, 1987; Cox and Diggles, 1986). In terms of Cox's latest published views, the small arctocyonid described herein occurs near the base of informal member 4b (formerly Tgsu). This level lies about two-thirds of the way up-section from the base of the Goler Formation. Strata at this level bearing the Laudate local fauna have been reported to be either late Torrejonian or early Tiffanian in age (McKenna et al., 1987). However, the level now appears to be more definitely Tiffanian on the basis of *Plesiadapis* sp. at UCMP loc. V5252/RAM loc. V94014. Moreover, a recently collected upper molar probably referable to *Phenacodus* sp. has been found lower in the section, within informal member 4a (Lofgren, in prep.). Fossils of undoubted Tiffanian age occur nearby along the southern border of the Inyokern SE 7 1/2 minute Quadrangle, 1972 (35°30.023′N; 117°46.05′W. 11-S: 0430400E; 3928807N [GPS coordinates using WGS 84, not NAD 27]) at either the same level or slightly higher in informal member 4b (Lofgren et al., 1999). The restricted Laudate local fauna (McKenna et al., 1987: 32) is thus bracketed by fossils that indicate Tiffanian age for this part of the Goler Formation. The Laudate local fauna lies stratigraphically below sediments dated by marine fossils as either latest Paleocene or early Eocene in age (McDougall, 1987; Squires et al., 1988).

SYSTEMATIC PALEONTOLOGY

CLASS MAMMALIA LINNAEUS, 1758

GRANDORDER UNGULATA LINNAEUS, 1766

ORDER PROCREODI MATTHEW, 1915

FAMILY ARCTOCYONIDAE GIEBEL, 1855

Genus *Mimotricentes* Simpson, 1937

Mimotricentes tedfordi, new species

?*Chriacus*. sp., Douglass Quarry, Fort Union Group, earliest Tiffanian, eastern Crazy Mountain Basin, Montana (Krause and Gingerich (1983: 189).

HOLOTYPE: RAM 6908, heavily damaged right maxilla with slightly damaged P4–M3 (fig. 25.2).

LOCALITY AND HORIZON: RAM Locality V94133 (= UCMP Locality V5870), near the base of member 4b (Cox, 1982) or informal unit Tgsu (Cox and Diggles, 1986) of the Goler Formation of Dibblee (1952), at the same stratigraphic level as RAM Locality V94014 (= UCMP loc. V5252); mammalian fossils from localities V94133 and V94014 are referred to as the Laudate local fauna (McKenna, 1955, 1960; McKenna et al., 1987; Lofgren et al., 1999). These localities lie along the southern border of the USGS Inyokern SE 7 1/2 minute Quadrangle, Kern County, California, 1972 (NAD 27).

AGE: Tiffanian.

DIAGNOSIS: Size significantly smaller than the sample referred to *Mimotricentes subtrigonus* from Swain Quarry in the Torrejonian of southern Wyoming (see discussion below), *Mimotricentes elassus* from the Torrejonian of the Dragon local fauna, Utah (Gazin, 1941: 22–23), and all other described species of *Mimotricentes* and *Lambertocyon*. *M. tedfordi* apparently differs from the hypodigm of *M. elassus* in possessing a projecting and prominent parastyle on M1 and M2, and possessing strong mesostylar development on all the upper molars. Posterior and anterior cingula do not meet in a continuous cingulum around the base of the protocone on the molars.

ETYMOLOGY: *tedfordi* in honor of Richard H. Tedford, whose early prospecting efforts in the Goler Formation helped push back the history of land mammals in coastal western North America by about 15 m.y., and whose

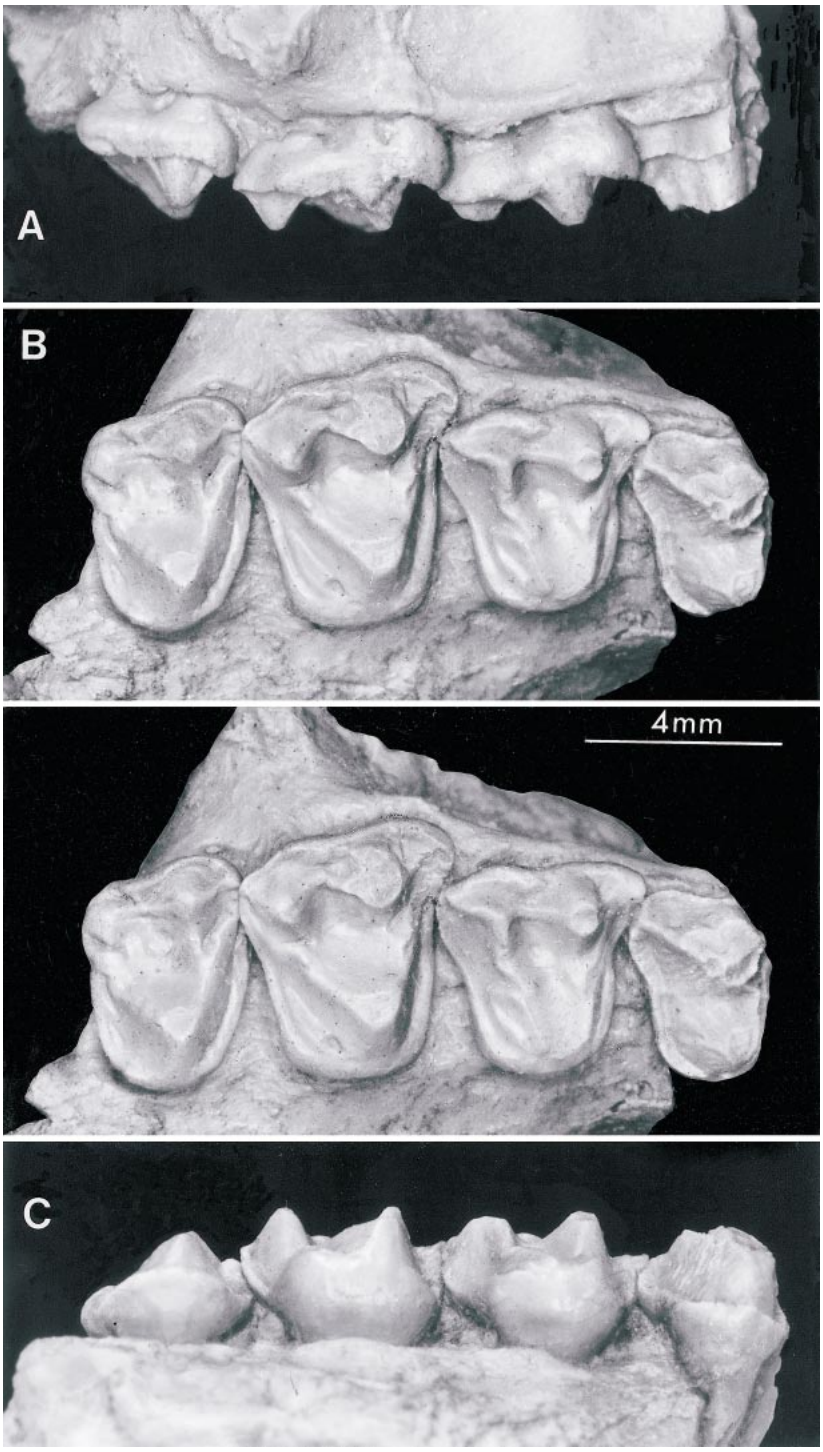

Fig. 25.2. *Mimotricentes tedfordi*, epoxy cast of RAM 6908, maxillary fragment with right P4–M3, holotype, Tiffanian, Goler Formation, Kern County, California. **A,** Labial view. **B,** Stereo occlusal view. **C,** Lingual view. Scale bar equals 4 mm.

discovery of the first Goler mammal tooth sparked 50 years of subsequent exploration that eventually led to discovery of the species named here in his honor.

DESCRIPTION OF THE TYPE SPECIMEN

We emphasize that the following description is of a single specimen drawn from what, by analogy with other samples, was probably a rather variable population. The cluster of species to which *M. tedfordi* belongs is much in need of revision, but this will have to await the collection of much new material. Especially important will be the collection of statistically adequate samples from single sites, as well as acquisition of associated upper and lower teeth. Some of these taxa are presently known from upper teeth, others by lowers, and nearly all by fragmentary material only.

Not much can be said about the maxilla itself, except that the anterior end of the zygomatic arch arises opposite M2. Part of the passage of the infraorbital canal can be seen, but its anterior opening can only be stated to lie anterior to the level of P4.

P4 is damaged anterolabially, and also on the apices of the incompletely separate paracone and metacone, but otherwise the tooth is intact. There are three roots. The extent of the missing parastylar area cannot be determined. P4 has a steep anterior side and a sloping posterior side, resulting in a tilted appearance. The enamel surface is corrugated, particularly on the labial side of the high protocone and on the posterolingual wall of the metacone. The high paracone and somewhat smaller metacone are conjoined for much of their height, with the paracone bulging farther labiad than the metacone. A crest was present on the anterior side of the paracone. The metacone is continuous with a sharp ridge that connects to the metastylar area at the juncture of the posterior and labial cingula. There is no hypocone, and no metaconule is present. A tiny paraconule may have existed at the anterolingual base of the paracone. A broad, flat, corrugated cingulum runs as a shelf nearly around the tooth from the metastylar area around the protocone (with a short interruption at the lingual base of the protocone), continuing along the anterior base of the paracone, until encountering breakage in the parastylar area, where its nature is unknown. Midway along the anterior side of the tooth, the anterior cingulum rises in the occlusal direction. On the labial side of P4 the cingular shelf is narrow around the base of the paracone, but it broadens labial to the metacone, forming a labial lip of a small basin. There is no mesostyle.

M1 is a smaller tooth than M2, is three-rooted, and has a strongly projecting parastyle. The paracone is a high cone, well in front of the metacone, bearing two crests: an anterior crest connects anterolabially to the posterolingual base of the parastyle as on M2, and a posterior crest takes a slightly sinuous course rearward, connecting to the metacone apex. The metacone itself is now a peculiar crestlike cusp whose present shape may be caused by wear. The remaining labial crest of the metacone lies anterolingual to the slightly damaged metastylar area and turns linguad at its junction with the crest coming from the paracone. From the junction, the lingual continuation of the crestlike, worn metacone continues until it meets the metaconule. The enamel of the posterior slopes of both the metacone and metaconule is heavily worn, but the shapes of the metacone and metaconule are nonetheless distinctive. If any corrugation of enamel surfaces was originally present, it is worn away. Both the anterior and posterior cingula are strong, but not so shelflike as on P4 and M2. The posterior cingulum is heavily worn. The anterior and posterior cingula do not connect across the broad, lingual base of the protocone. The protocone (when unworn) was evidently quite high, but before the animal's death it was substantially lowered by wear, which has resulted in a transverse wear trough that seems to divide the worn protocone into anterior and posterior parts. The paraconule is small, with a faint posterior connection to the base of the paracone and a stronger anterolabial ridge that runs along the anterior base of the paracone. On the posterolingual slope of the protocone a hypoconal shelf is present. The shelf is worn, but evidently was not so prominent as that of M2. A small, well-worn hypocone is present as a swelling of the posterior cingulum. It does not project lingual to the level of the protocone base. Posterior to

the large, crested parastyle is a small stylar cusp, but there is no labial cingulum around the labial base of the paracone. However, posterolabial to the base of the paracone, a massive stylar ridge begins at a high stylar cusp (mesostyle?) and continues in a curve, terminating in a small, slightly damaged metastyle.

M2 is decidedly less worn than M1, and, although larger and a bit more transverse, is similar in most respects. There are three roots. The nearly unworn labial cingulum has the same curved crest as M1, running posteriad from a large mesostyle-like cuspule, in front of which is another, smaller, mesostyle-like cuspule lying at the posterolabial corner of the base of the broken paracone. The metacone of M2 is normal in structure, suggesting that the condition observed on M1 is due to wear. Crests lead posterolabially and anterolabially from its apex. The crest from paracone to metacone is interrupted, with a third mesostyle-like cuspule present at the base of the crest leading anterolabiad from the metacone. At the anterolabial base of the paracone, yet another stylar cuspule lies just posterior to the curving posterior crest of the parastyle. From the middle of the parastyle, a posterolingually directed crest runs to the paracone base as well, creating a small stylar basin on its posterolabial side. The anterolingual end of the parastyle hooks around to the rear lingually, before dying out in a series of three steplike corrugations. The hypoconal shelf is strong and worn. Lingually, after swelling to a small hypoconal apex, the hypoconal shelf curves forward, enclosing a tiny basin, before joining the posterior base of the protocone. There is no cingulum across the lingual base of the protocone, and the hypoconal shelf does not project linguad of the level of the base of the protocone. The paraconule and metaconule of M2 are both rather worn, but each exhibits two labial wings. The anterior wing of the metaconule is weak, but the anterior wing of the paraconule forms a strong crest that runs along the anterior base of the paracone until it meets the stepped corrugations of the lingual crest from the parastyle. Lingually, the anterior cingulum is slightly broadened, suggesting an incipient pericone (protostyle) just anterior to the lingual base of the protocone.

TABLE 25.1
Tooth Measurements (mm) for RAM 6908, the Type Specimen of *Mimotricentes tedfordi*, New Species

	Length	Width
P4	3.3+	4.10
M1	4.40	4.58
M2	4.62	5.50
M3	3.44	4.89

The enamel of M2 is worn, but not completely enough to obscure traces of fluting on the labial slope of the protocone.

M3 is three-rooted and similar to M2, but is smaller and has a much smaller metacone. A faint hypoconal shelf is present, and a series of tiny cuspules decorate the anterior cingulum, terminating lingually in a tiny pericone-like cuspule like that adumbrated on M2. The anterior and posterior cingula do not connect as a continuous cingulum across the lingual base of the protocone. The stylar shelf possesses a row of three small mesostyle-like cuspules. Another pair of mesostyle-like cuspules lies at the juncture of the ridges joining the paracone and metacone to each other. The metaconule lacks an anterolabial wing, but the anterolabial wing of the paraconule is strong and similar to that of M2, and corrugated all the way to the parastyle.

Tooth measurements for RAM 6908, the type specimen of *Mimotricentes tedfordi*, new species, are given in table 25.1.

COMPARISONS

Tricentes, *Mimotricentes*, and *Lambertocyon* are closely related Paleocene arctocyonids occurring in the Torrejonian through Clarkforkian NALMAS. *Tricentes* Cope, 1884, was based on the type species, *T. crassicolidens* Cope, 1884, from New Mexico. Simpson (1935) named a related taxon *Metachriacus*, based upon *M. punitor* Simpson, 1935, a taxon from Montana said by Van Valen (1978) to be a junior synonym of *Chriacus orthogonius* Russell, 1929, from Alberta. Van Valen and Sloan (1965: 745) opined that *T. crassicolidens* is a synonym of *"Chriacus" truncatus* Cope, 1884, and that

Tricentes is also a ''senior synonym of *Epichriacus* [Scott, 1892], *Metachriacus*, and possibly *Prothryptacodon* [Simpson, 1935].'' ''Other species'' of *Tricentes* were placed by Van Valen and Sloan in *Mimotricentes* Simpson, 1937, whose type species is *Mimotricentes latidens* Gidley *in* Simpson, 1935, and to which genus *M. angustidens* Simpson, 1937, was later assigned by Simpson. By ''other species'' of *Tricentes*, Van Valen and Sloan presumably meant *Tricentes subtrigonus* Cope, 1881, *T. elassus* Gazin, 1941, and *T. fremontensis* Gazin, 1956. Williamson (1996: 65) synonymized *T. ellassus* with *M. subtrigonus*, but gave no reasons. McKenna and Bell (1997) included *Tricentes crassicolidens* in *Chriacus*, whose type species is *Lipodectes pelvidens* Cope, 1881.

Krishtalka et al. (1975) reported *Mimotricentes* sp. from the late Tiffanian of the Badwater Creek area, Wind River Basin, Wyoming, but the animal in question is too large to belong to *M. tedfordi*: M1 length 6.3 mm ($N = 2$), width 6.5–6.7; M2 length 6.9 mm, width 8.1 mm. Possibly this sample belongs to *Mimotricentes fremontensis*, or *Lambertocyon eximius* as Gingerich (1979) postulated, but additional specimens are necessary before a firm decision can be reached.

Van Valen (1978: 57) described *Mimotricentes mirielae*, n. sp., based upon AMNH 58219, a fragmentary lower jaw with one-half m2 and m3 from the Puercan of New Mexico. Although smaller than *M. subtrigonus*, the species cannot be compared adequately with *M. tedfordi*, the samples being inadequate and there being no comparable teeth.

Rose (1981a) reported cf. *Tricentes* sp. from the Clarkforkian of Wyoming, but the material on which the report was based may represent *Mimotricentes* or *Lambertocyon* instead. The Clarkforkian animal is larger (M1 or M2 length 5.65 mm, width 6.50 mm) than *M. tedfordi* and is otherwise similar to some specimens of the Swain Quarry Torrejonian sample referred to *Mimotricentes subtrigonus*. Rose (1981b) reported both *Mimotricentes* sp. and *Tricentes* cf. *T. punitor* from Rock Bench Quarry in the late Torrejonian and ?*Mimotricentes* sp. in the mid-Tiffanian Cedar Point Quarry from the Fort Union Group of northwestern Wyoming.

Gingerich (1978) named *Mimotricentes ischyrus* from the Clarkforkian of Plateau Valley, Colorado. The type specimen of the species was a lower jaw with p4 and m1, which is not directly comparable with the type maxilla of *M. tedfordi* but evidently was a larger animal, based on measurements of its lower teeth compared with lower teeth of animals also known from upper teeth. In 1979, Gingerich created the genus *Lambertocyon* for what appear to be advanced (read ''late'') species formerly placed in *Mimotricentes*. The type species of *Lambertocyon* is *L. eximius* Gingerich, 1979, from the late Tiffanian of Northwestern Wyoming and western Texas (Schiebout, 1974; Gingerich, 1979). Gingerich transferred *Mimotricentes ischyrus* to *Lambertocyon*. *M. tedfordi* is significantly smaller than either species of *Lambertocyon*.

Fox (1990) reported ?*Mimotricentes* sp. from Cochrane II, a Tiffanian locality in southwestern Alberta. Cochrane II occurs in the Porcupine Hills Formation, assigned in age to the early Tiffanian. The specimen upon which the report was based has not been described and cannot be assessed here.

Comparisons of the type specimen of *Mimotricentes tedfordi* with closely similar taxa are made difficult by the fact that only one statistically useful sample of a quarry population of *Mimotricentes* exists. This is the material referred to *M. subtrigonus* that occurs at Swain Quarry in the late Torrejonian of Carbon County, southern Wyoming (Rigby, 1976, 1980). Other related species are represented at present by few specimens at any particular site, whose variability cannot be assessed except by analogy with the Swain Quarry sample.

Prior to Rigby's (1976, 1980) description of specimens from Swain Quarry, which were referred by him to *Mimotricentes subtrigonus*, and the description of *Lambertocyon eximius* (Gingerich, 1979), upper teeth of *Mimotricentes*-like mammals were virtually unknown except for *Mimotricentes elassus* from the Dragon local fauna of Utah (Gazin, 1941) and two unnumbered upper teeth from the Fort Union Formation of Montana in the AMNH collection (now numbered AMNH 35433). These latter are from Locality 81 of Simpson (1937), which lies 91 m above the base of ''Fort Union No. 2'' (upper

Lebo Formation of Fort Union Group) in the Crazy Mountain Basin. Simpson (1937: 205) did not figure these teeth, left M2 and M3, but he did discuss them: ''Like the lower molars, they closely resemble those of *Tricentes*, the only clear difference, and this of doubtful value, being that the internal cingulum does not circle the protocone and that on M2 the external cingulum does not cross the paracone.''

Rigby (1980: 103) did not illustrate upper teeth from the large Swain Quarry sample, but his descriptions and measurements of them are worth repeating here:

''All dental elements from Swain Quarry are inseparable from *M. subtrigonus* from the Nacimiento Formation of the San Juan Basin. Because of the lack of associated material and because of their general similarity to a number of other taxa, no isolated P4's have been assigned to the taxon. M1–2 show variably developed cingula around the base of the protocone. M2's have a complete cingulum although a few show a continuous wrinkle. The cingulum of M1 has a suggestion of continuity but is generally incomplete. M2's also show a mesostyle in various forms of development on the external cingulum or in the centroloph if the external cingulum is reduced. Some M1's and M3's also show the phenomenon but substantial development is rare. The conules are variably developed although the metaconule is generally larger and all crests are variably inflated. The parastyle can be either strong, separate and inflated, or may be present only as a small cuspule at the confluence of anterior cingulum and preparacrista. M1 and M2, when represented only by isolated teeth, may be easily separated because of the more quadrate nature of the M1. M3's are exceptionably variable, particularly in width, which affects the metaconule, posterior cingulum, and confluence of the labial and posterior cingula.''

Rigby (1976, 1980) provided statistical calculations based on measurements of upper molars referred to *Mimotricentes subtrigonus* as part of his table 38. These are given in part in table 25.2.

We have omitted calculations concerning M3 width from Swain Quarry because of an error: the mean (6.27) given by Rigby (1976, 1980) falls outside the OR (3.45–5.95), an impossibility. M3 width is quite variable in any case, and indeed, the only measurement of *M. tedfordi* to fall within any observed range of a character of referred *M. subtrigonus* from Swain Quarry is M3 width.

TABLE 25.2
Measurements (mm) of Upper Molars Referred to *Mimotricentes subtrigonus*
Source: Rigby; 1980: table 38

	OR	s	M	V	*N*
M1 length	4.65–6.45	0.323	5.61	5.76	55
M1 width	5.25–7.20	0.370	6.05	6.12	55
M2 length	5.25–6.60	0.395	5.86	6.74	56
M2 width	6.60–8.85	0.514	7.55	6.81	56
M3 length	5.40–6.75	0.317	4.15	7.64	52

OR, observed range of measurement; s, standard deviation of the mean; M, mean; V, coefficient of variation.

Measurements provided by Rigby (1976, 1980) show that the type specimen of *Mimotricentes tedfordi* differs by the following amounts from the referred Swain Quarry *M. subtrigonus* specimens, measured in multiples of standard deviations, s, from the mean, M: length M1: ×3.75; width M1: ×3.97; length M2: ×3.14; width M2: ×3.99; length M3: ×2.24. These results affirm that *M. tedfordi* is statistically highly unlikely to be a small specimen of the same taxon as that recovered from Swain Quarry.

The type specimen of *M. tedfordi* is about 84% the size of the type specimen of *Mimotricentes elassus*, from the Torrejonian Dragon local fauna, Utah, but the length and width of M1 of that specimen, 5.1 and 5.6 mm, respectively, fall within the observed ranges exhibited by the Swain Quarry sample referred to *M. subtrigonus* by Rigby (1976, 1980). If the Swain Quarry sample is truly a single species, possibly *M. elassus* is synonymous with *M. subtrigonus*. We leave the matter open.

In his description of ''*Tricentes*.'' *fremontensis* from the Tiffanian Saddle and Ledge localities, Bison Basin, Wyoming, Gazin (1956) was able to assign lower teeth only. These are clearly too large to belong to an animal the size of *M. tedfordi*: m1 length 6.2 mm; m2 length 6.4 mm; m3 length 6.6 mm.

From the previous discussion it is evident that, based on size and on morphology (when

described), *Mimotricentes tedfordi* is distinct from all named taxa of arctocyonids investigated. However, Krause and Gingerich (1983) described and illustrated, but did not name, a species of small arctocyonid referred to by them as *Chriacus* sp., from Douglass Quarry in the early Tiffanian of Montana. Although about 25% larger than the type specimen of *M. tedfordi*, these teeth are quite similar to and may be members of a species of the genus *Mimotricentes* rather than *Chriacus*. They seem to be closely related to *M. tedfordi* based on morphology. A Tiffanian age of the Laudate local fauna is thus additionally supported.

Gradually, enough specimens have been recovered from the Goler Formation to establish that the age of the part that bears the Laudate local fauna is Tiffanian (late Paleocene) in age. This age determination is compatible with data from overlying early Eocene marine fossils found near the exposed top of the Goler Formation that are correlative with the marine Penutian Stage, planktic foraminiferal zone P8 (and P9?) and Nannofossil zones NP12 and/or NP13 (see McDougall, 1987, and references therein). The age determination for beds stratigraphically beneath the early Eocene marine fossils is based on first appearances of such taxa as cf. *Phenacodus*, cf. *Neoliotomus*, and *Plesiadapis*. However, this puts the *Conacodon*-like taxon from the Laudate local fauna (McKenna, 1955, 1960; McKenna et al., 1987) in a new light. It must be a Tiffanian relict taxon with Puercan relatives elsewhere.

CONCLUSIONS

Mimotricentes tedfordi is a small species of the genus *Mimotricentes* that occurs in the Laudate local fauna in the upper part of the mainly continental Paleocene Goler Formation of Kern County, California. The type locality is in the southwestern corner of the Great Basin, north of the Garlock Fault and southeast of the southernmost Sierra Nevada. The type specimen of *M. tedfordi* is similar to certain specimens from Douglass Quarry in the Tiffanian part of the Fort Union Group in the Crazy Mountains Basin of Montana. The type specimen of *M. tedfordi* is presently one of the best-known representatives of associated P4–M3 of the genus *Mimotricentes*. The occurrence of *M. tedfordi* in informal member 4b of the Goler formation is consistent with a Tiffanian age of the Laudate local fauna as indicated by specimens of other mammalian taxa occurring nearby in the same part of the Goler Formation. Previous age determinations for the Laudate local fauna were unduly influenced by the unrecognized relictual status of a primitive anisonchine periptychid.

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REFERENCES

Archibald, J.D., W.A. Clemens, P.D. Gingerich, D.W. Krause, E.H. Lindsay, and K.D. Rose. 1987. First North American land mammal ages of the Cenozoic Era. *In* M.O. Woodburne (editor), Cenozoic mammals of North America: geochronology and biostratigraphy: 24–76. Berkeley: University of California Press.

Axelrod, D.I. 1948. An Eocene flora from El Paso Mountains, Kern County, California [Abstract]: Geological Society of America Cordilleran Section Proceedings, April, 1947, Pasadena: 1 p.

Baker, C.L. 1912. Physiography and structure of the western El Paso Range and the southern Sierra Nevada. University of California Publi-

cations, Bulletin of the Department of Geology 7(6): 117–142.

Burbank, D.W., and D.P. Loomis. 1988. The stratigraphic evolution of the El Paso Basin, Southern California: implications for the Miocene development of the Garlock Fault and uplift of the Sierra Nevada. Geological Society of America Bulletin 100: 12–28.

Cope, E.D. 1882. On some Mammalia of the lowest Eocene beds of New Mexico. Proceedings of the American Philosophical Society 19: 484–495. [Issued also as Paleontological Bulletin No. 33]

Cope, E.D. 1884. Second addition to the knowledge of the Puerco epoch. Proceedings of the American Philosophical Society 21: 309–324. [Issued also as Paleontological Bulletin No. 37]

Cox, B.F. 1982. Stratigraphy, sedimentology, and structure of the Goler Formation (Paleocene), El Paso Mountains, California: implications for Paleogene tectonism on the Garlock Fault Zone. Unpublished Ph.D. dissertation, University of California, Riverside, 248 pp.

Cox, B.F. 1987. Stratigraphy, depositional environments, and paleotectonics of the Paleocene and Eocene Goler Formation, El Paso Mountains, California. Geologic summary and roadlog. *In* B.F. Cox (editor), Basin analysis and paleontology of the Paleocene and Eocene Goler Formation, El Paso Mountains, California: 1–29. Los Angeles: Society for Economic Paleontology and Mineralogy, Pacific Section.

Cox, B.F., and M.F. Diggles. 1986. Geologic map of the El Paso Mountains Wilderness Study Area, Kern County, California. USGS Miscellaneous Field Studies Map MF-1827. [Map and 13 pp.]

Cox, B.F., and L.E. Edwards. 1984. Possible marginal-marine deposits in the Goler Formation (Paleocene), El Paso Mountains, California [abstract]. EOS (American Geophysical Union Transactions) 65: 1084.

Dibblee, T.W. 1952. Geology of the Saltdale Quadrangle, California. California Division of Mines Bulletin 160: 7–43.

Fox, R.C. 1990. The succession of Paleocene mammals in western Canada. Geological Society of America Special Paper 243: 51–70.

Gazin, C.L. 1941. The mammalian faunas of the Paleocene of central Utah, with notes on the geology. Proceedings of the United States National Museum 91(3121): 1–53.

Gazin, C.L. 1956. Paleocene mammalian faunas of the Bison Basin in south-central Wyoming. Smithsonian Miscellaneous Collections 131(6): 1–57.

Giebel, C.G.A. 1855. Die Säugethiere in zoologischer, anatomischer, und palaeontologischer Beziehung um fassend dargestellt. Leipzig: Ambrosius Abel.

Gingerich, P.D. 1978. New Condylarthra (Mammalia) from the Paleocene and early Eocene of North America. Contributions from the Museum of Paleontology, University of Michigan 25(1): 1–9.

Gingerich, P.D. 1979. *Lambertocyon eximius*, a new arctocyonid (Mammalia, Condylarthra) from the late Paleocene of western North America. Journal of Paleontology 53(3): 524–529.

Krause, D.W., and P.D. Gingerich. 1983. Mammalian fauna from Douglass Quarry, earliest Tiffanian (Late Paleocene) of the eastern Crazy Mountain Basin, Montana. Contributions from the Museum of Paleontology, University of Michigan 26(9): 157–196.

Krishtalka, L., C.C. Black, and D.W. Riedel. 1975. Paleontology and geology of the Badwater Creek area, central Wyoming. Part 10. A late Paleocene mammal fauna from the Shotgun Member of the Fort Union Formation. Annals Carnegie Museum 45(9): 179–212.

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Vol. 1: Regnum Animale. Editio decima, reformata. Stockholm: Laurentii Salvii. ii + 824 pp.

Linnaeus, C. 1766. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Vol. 1: Regnum Animale. Editio decima, reformata. Stockholm: Laurentii Salvii. 532 pp. [12th ed.]

Lofgren, D.L., M.C. McKenna, and S.L. Walsh. 1999. New records of Torrejonian-Tiffanian mammals from the Paleocene-Eocene Goler Formation, California, Journal of Vertebrate Paleontology 19(3 supplement): 60A.

Matthew, W.D. 1915. Part I. Order Ferae (Carnivora). Suborder Creodonta. *In* W.D. Matthew and W. Granger, A revision of the lower Eocene Wasatch and Wind River faunas. Bulletin of the American Museum of Natural History 34(1): 1–103.

McDougall, K. 1987. Foraminiferal biostratigraphy and paleoecology of marine deposits, Goler Formation, California. *In* B.F. Cox (editor), Basin analysis and paleontology of the Paleocene and Eocene Goler Formation, El Paso Mountains, California: 43–67. Los Angeles: Society for Economic Paleontology and Mineralogy, Pacific Section.

McKenna, M.C. 1955. Paleocene mammal, Goler Formation, Mojave Desert, California. Bulletin

of the American Association of Petroleum Geologists 39(4): 512–515.
McKenna, M.C. 1960. A continental Paleocene vertebrate fauna from California. American Museum Novitates 2024: 1–20.
McKenna, M.C., and S.K. Bell. 1997. Classification of mammals above the species level. New York: Columbia University Press, xii + 631 pp.
McKenna, M.C., J.H. Hutchison, and J.T. Hartman. 1987. Paleocene vertebrates and nonmarine Mollusca from the Goler Formation, California. *In* B.F. Cox (editor), Basin analysis and paleontology of the Paleocene and Eocene Goler Formation, El Paso Mountains, California: 31–41. Los Angeles: Society for Economic Paleontology and Mineralogy, Pacific Section.
Merriam, J.C. 1919. Tertiary mammalian faunas of the Mohave Desert. University of California Publications, Bulletin of the Department of Geology 11(5): 437a–437e, 438–585.
Monastero, F.C., J.D. Walker, and A.F. Glasner. 2000. Microplates of the Pacific-North America boundary. Geological Society of America Abstracts with Programs 2000: A-156.
Rigby, J.K., Jr. 1976. Swain Quarry of the Fort Union Formation, middle Paleocene (Torrejonian), Carbon County, Wyoming: geologic setting and mammalian fauna. Unpublished Ph.D. thesis, Columbia University, New York, 294 pp.
Rigby, J.K. Jr. 1980. Swain Quarry of the Fort Union Formation, middle Paleocene (Torrejonian), Carbon County, Wyoming: geologic setting and mammalian fauna. Evolutionary Monographs 3: i-vi, 1–179.
Rose, K.D. 1981a. Clarkforkian land-mammal age and mammalian faunal composition across the Paleocene-Eocene boundary. University of Michigan Papers on Paleontology 26: 1–197.
Rose, K.D. 1981b. Composition and species diversity in Paleocene and Eocene mammal assemblages: an empirical study. Journal of Vertebrate Paleontology 1(3–4): 367–388.
Russell, L.S. 1929. Paleocene vertebrates from Alberta. American Journal of Science 17: 162–178.
Schiebout, J.A. 1974. Vertebrate paleontology and paleoecology of Paleocene Black Peaks Formation, Big Bend National Park, Texas. Texas Memorial Museum Bulletin 24:viii, 1–88.
Scott, W.B. 1892. A revision of the North American Creodonta with notes on some genera which have been referred to that group. Proceedings of the Academy of Natural Sciences of Philadelphia 1892: 291–323.
Simpson, G.G. 1935. New Paleocene mammals from the Fort Union of Montana. Proceedings of the United States National Museum 83: 221–244.
Simpson, G.G. 1937. The Fort Union of the Crazy Mountain Field, Montana, and its mammalian faunas. Smithsonian Institution, United States National Museum Bulletin 169: 1–287.
Squires, R.L., B.F. Cox, and C.L. Powell, II. 1988. Late Paleocene or early Eocene mollusks from the uppermost part of the Goler Formation, California. *In* M.V. Filewicz and R.L. Squires (editors), Paleogene stratigraphy, west coast of North America. Pacific Section, Society for Economic Paleontology and Mineralogy, West Coast Paleogene Symposium 58: 183–187.
Stock, C. 1948. Pushing back the history of land mammals in western North America. Bulletin of the Geological Society of America 59: 327–332.
Van Valen, L. 1978. The beginning of the age of mammals. Evolutionary Theory 4: 45–80.
Van Valen, L., and R.E. Sloan. 1965. The earliest primates. Science: 150(3697): 743–745.
West, R.M. 1970. *Tetraclaenodon puercensis*. (Mammalia: Phenacodontidae), Goler Formation, Paleocene of California, and distribution of the genus. Journal of Paleontology 44(5): 851–857.
Whistler, D.P. 1987. Field guide to the geology of Red Rock Canyon and the southern El Paso Mountains, Mojave Desert, California. National Association of Geology Teachers, Far Western Section, April Meeting: 1–16.
Williamson, T.E. 1996. The beginning of the age of mammals in the San Juan Basin, New Mexico: biostratigraphy and evolution of Paleocene mammals of the Nacimiento Formation. New Mexico Museum of Natural History and Science Bulletin 8: 1–141.