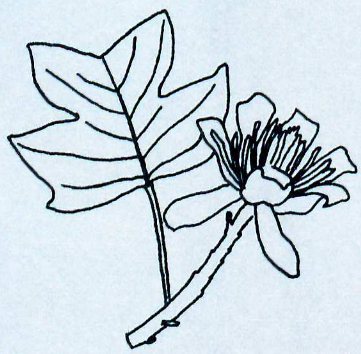
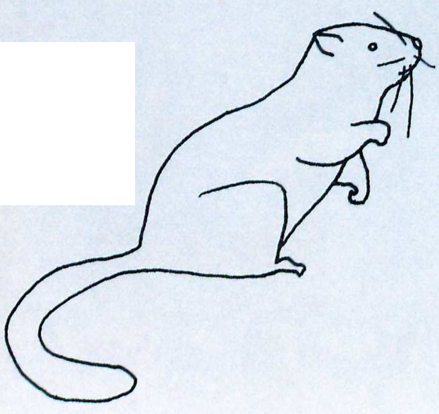
SWAIN QUARRY OF THE FORT UNION FORMATION, MIDDLE PALEOCENE (TORREJONIAN), CARBON COUNTY, WYOMING: GEOLOGIC SETTING AND MAMMALIAN FAUNA

J. Keith Rigby Jr.





EVOLUTIONARY MONOGRAPHS

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ABSTRACT

Swain Quarry has produced 28,000 fossil mammalian specimens. Based upon comparison and similarity to faunas from the San Juan Basin, New Mexico, and the Crazy Mountain Field, Montana, the Swain Quarry fauna is middle Paleocene (Torrejonian) in age.

Named new taxa include 3 multituberculates, 2 adapisoricids, 3 palaeoryctids, 1 primate, 1 miacid, 2 arctocyonids, and 1 anisonchine.

The purpose of this study is to document dental morphological variability from a single Paleocene locality. Populational variability, deme diversity, and their relationship to biostratigraphy are discussed. Metric properties of dental elements are of primary interest. The large sample size permits the comparison of statistical data derived from samples containing at least 10 specimens of a single dental element. Multituberculate dentitions are found to be exceptionally variable with coefficients of variation of many metric properties exceeding 4-6.

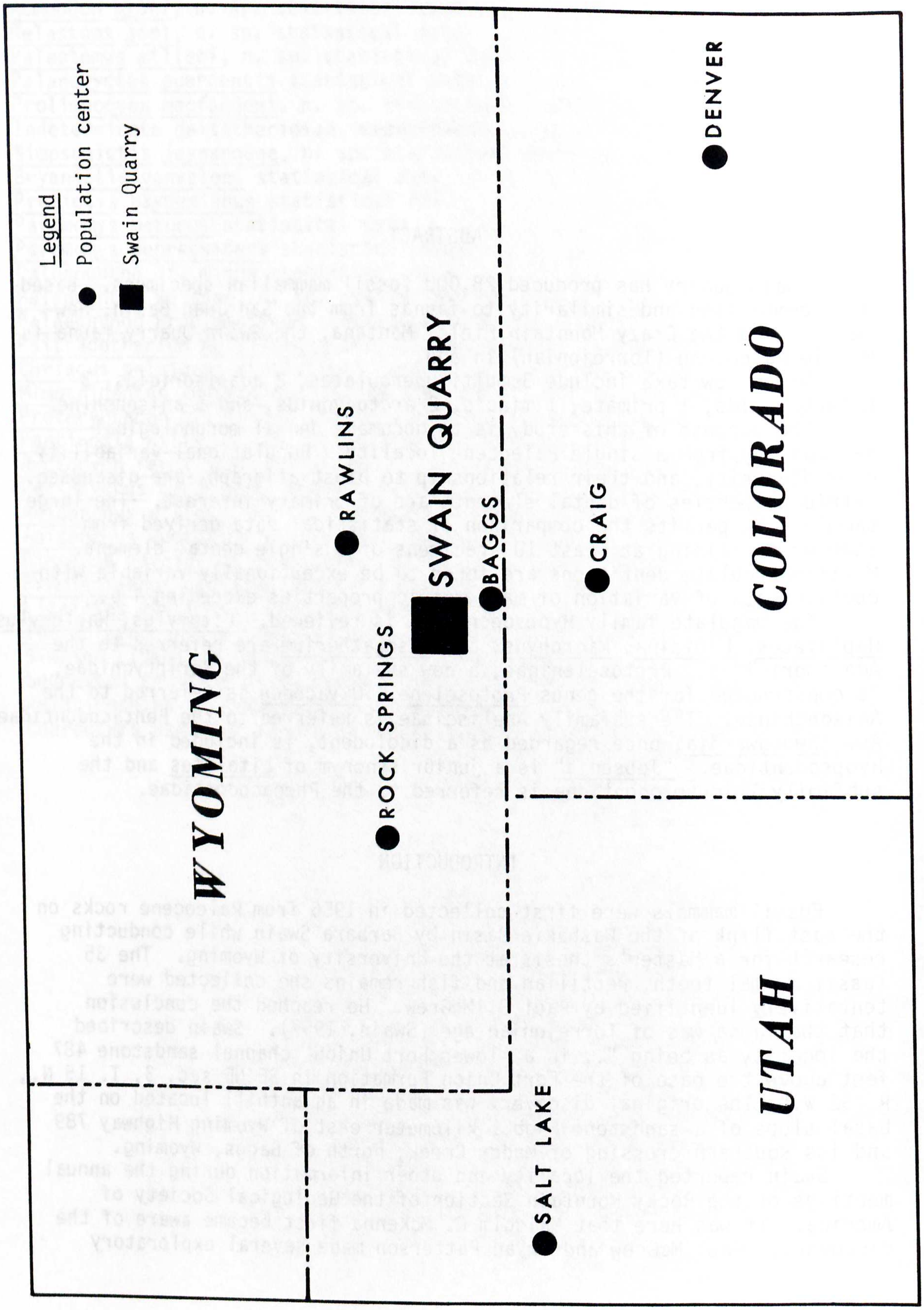
The ungulate family Hyopsodontidae is reviewed. Litomylus, Haplomylus, Haplaletes, Louisina, Microhyus, and Paschatherium are referred to the Adapisoricidae. Protoseleninae, a new subfamily of the Periptychidae, is constructed for the genus Protoselene. Oxyacodon is referred to the Anisonchinae. The subfamily Apheliscinae is referred to the Pentacodontidae. Asmithwoodwardia, once regarded as a didolodont, is included in the Hyopsodontidae. "Jepsenia" is a junior synonym of Litaletes and the subfamily Tricuspiodontidae is referred to the Phenacodontidae.

INTRODUCTION

Fossil mammals were first collected in 1956 from Paleocene rocks on the east flank of the Washakie Basin by Barbara Swain while conducting research for a Master's thesis at the University of Wyoming. The 35 fossil mammal teeth, reptilian and fish remains she collected were tentatively identified by Paul O. McGrew. He reached the conclusion that the fauna was of Torrejonian age (Swain, 1957). Swain described the locality as being "...in a 'lower Fort Union' channel sandstone 487 feet above the base of the Fort Union Formation in SE NE sec. 3, T. 15 N., R. 92 W." The original discovery was made in an anthill located on the basal slope of a sandstone knob 1 kilometer east of Wyoming Highway 789 and its southern crossing of Muddy Creek, north of Baggs, Wyoming.

Swain reported the locality and other information during the annual meetings of the Rocky Mountain Section of the Geological Society of America. It was here that Malcolm C. McKenna first became aware of the discovery. Paul McGrew and Bryan Patterson made several exploratory

Text-Figure 1



trips to the site to determine if a concentration of fossil material existed in the area that could be further exploited. Visits made by students under McGrew's supervision concentrated exploration efforts in the sandstone body upon which the original discovery had been made and the claystones immediately below. They failed to find any significant concentration of fossil material. The original discovery anthill was then collected and additional material taken to the Geological Museum of the University of Wyoming at Laramie. This apparently discouraged further investigation and the site was not revisited again for several years.

Because of research in the Four Mile Creek area south of Baggs, Wyoming, McKenna had maintained an interest in the Swain site. He asked and received permission from McGrew to conduct some further investigations there and did so for two years. The first year was primarily an exploratory visit during which several trenches were dug to determine exactly where fossil material was concentrated. The trenches revealed that there were several clayball conglomerates containing bone fragments in the base of the sandstone.

McKenna's experience at Four Mile Creek had indicated to him the site could produce identifiable material but screening techniques would need to be used and overburden would have to be removed in order to obtain sufficient quantities of matrix. The upper portions of the sandstone were indurated and had to be drilled and dynamited. A bulldozer was then used to remove the loosened overburden and to expose the producing horizon. Two more intersecting trenches were dug and the most promising portions of the productive level were identified.

In 1964, under the direction of Fredrick Szalay, screening operations began in earnest. Approximately 75 tons of material were removed from the quarry and a portion was screened in the small summer livestock tank near the quarry. Screening here proved to be undesirable and the operation was moved to the camp on Willow Creek 12.9 kilometers south of the Little Snake River Valley. It was here that the bulk of the screening and concentrate sorting was done. The collections were then removed to the American Museum of Natural History where Fredrick Szalay commenced study of them. Other problems attracted his interest and the collection remained essentially unstudied. Szalay did, however, describe and illustrate tooth replacement in multituberculates, and illustrated some multituberculate material (Szalay, 1965), Picrodus and some Paromomys (Szalay, 1968), Jepsenella (Szalay, 1968), and Mixodectes (Szalay, 1969). Robert Sloan has briefly reviewed the multituberculate remains from the quarry and has helped with identifications. Richard Estes and Eugene Gaffney have studied some of the nonmammalian remains not included in the present study.

Malcolm McKenna introduced the writer to the collection in the spring of 1972 in connection with a biostatistics problem involving the undescribed AMNH collection of Promioclaenus aquilonius from Gidley Quarry, Crazy Mountain Field. The collection from Swain Quarry of Promioclaenus obviously deserved further investigation and it was decided that George Engelman, Bruce MacFadden, Earl Manning and the writer would revisit the locality to see if more material could be gathered to complement the material on hand. The field season of 1972 was spent excavating matrix in the quarry, hauling it to the Willow Creek camp and screening 45 tons of matrix. Sorting fossil material from concentrate was postponed until the following field season.

The collections of concentrate made during the 1972 field season were made by hand. Eighty teeth per ton of matrix screened were recovered, yielding approximately 3,600 fossil mammal specimens, most of which were isolated teeth.

Because of the previous excavation, locations of producing horizons were known. It was concluded that 200 tons of matrix could be mass excavated and brought to the Willow Creek camp site for about the same cost as making the necessary trips to and from the quarry with 1 1/2 - 2 ton loads. Depreciation of the field vehicle and the 12 man hours per day travel time needed for hand quarry operations would be saved. It was decided to take a certain amount of risk in the quality and quantity of recoverable specimens by excavation with a caterpillar loader and dump truck. Approximately 12,200 mammalian specimens were recovered by this technique at about 1/3 to 1/2 the cost of hand quarry operations. The collection now contains 28,000 fossil mammalian specimens.

Aside from Szalay's papers (1965, 1968a, b, 1969) the fauna is previously unstudied. Geologic interest in the area has been great but little information is available in addition to Swain's (1957) unpublished master's thesis. The U. S. Geological Survey has begun detailed mapping of the coal deposits of the Fort Union and Lance Formations. Two quadrangle maps are available for the vicinity of Creston Junction but none is available as yet for the region near Swain Quarry. A geologic map has been constructed to show the major faults and relative location of known fossil localities (Text Figure 2).

Acknowledgments

The writer acknowledges with gratitude the assistance of Dr. Malcolm C. McKenna, who suggested and directed the current research, Dr. J. Keith Rigby Sr. for valued assistance in the field, and Dr. William Tidwell who encouraged careful inspection of exposures for fossil plant material. Mr. John Roth, Jr. has completed a study of the Tidwell Quarry flora and has given permission for some of his findings to be included in the present study.

Discussions with Drs. Eugene Gaffney, Giles MacIntyre, Donald Savage, Bobb Schaeffer, Larry Martin, Lehi Hintze, and Kenneth Hamblin on the practice of biostratigraphic and systematic thought were most helpful. Dr. Niles Eldredge willingly aided in a substantial introduction to basic statistical analysis. Drs. George Englemann, Bruce MacFadden, Mr. Earl Manning, Drs. Michael Novacek, Leonard Krishtalka, Craig Wood, and Kenneth Rose have helped the author see new relationships and encouraged him in his efforts.

The collecting and cataloguing were accomplished with the aid of volunteers. Significant contributions were made by: Brice Adair, Philip Aronow, Eric Christensen, Katie Culbertson, Jeffrey Eaton, George Englemann, Sylvia Graham, Orrin Hill, Eugene Hyon, Bruce MacFadden, Alan and Carol Martinez, Earl Manning, Jon Peterson, Jaynanne and Ruth Rigby, James Salisbury, Fredrick Szalay, Costas Tsentas, John Wahlert, William Weaver, Amy Weiss, and Robert Wolfson.

Many local residents of Baggs and Dixon, Wyoming, have been helpful, especially the Grieve and Criswell families of Dixon, Wyoming, and the Miller and Willey families of Baggs, Wyoming.

Dr. Donald Savage of the University of California at Berkeley, Dr. Larry Martin of the University of Kansas, Dr. Robert Emry of the United States National Museum of Natural History, and Dr. Donald Baird of Princeton University have generously lent specimens under their care to aid this research.

Accessibility

The area under investigation lies immediately east of Wyoming State Highway 789, 43.5 kilometers south of Creston Junction and 37 kilometers north of Baggs, Wyoming. All of the study area is only slightly removed from easy access from Highway 789, which is an all-weather road and major thoroughfare between Craig, Colorado and Interstate 80. The J. O. Ranch road has been improved and maintained by oil companies who have interests in a small oil field 8 kilometers east of the highway. Several other unimproved roads provide easy access to all portions of the study area.

Local relief is such that the Fort Union exposures may be approached from almost any point along Highway 789 between the two bridges over Muddy Creek. The two valleys north of the Dead Bull Run fault contain trails within them but immediate access is not visible from the highway and approaches must be made over the low vegetation on the gentle topographic slope between the highway and exposures to the east.

Geologic Setting

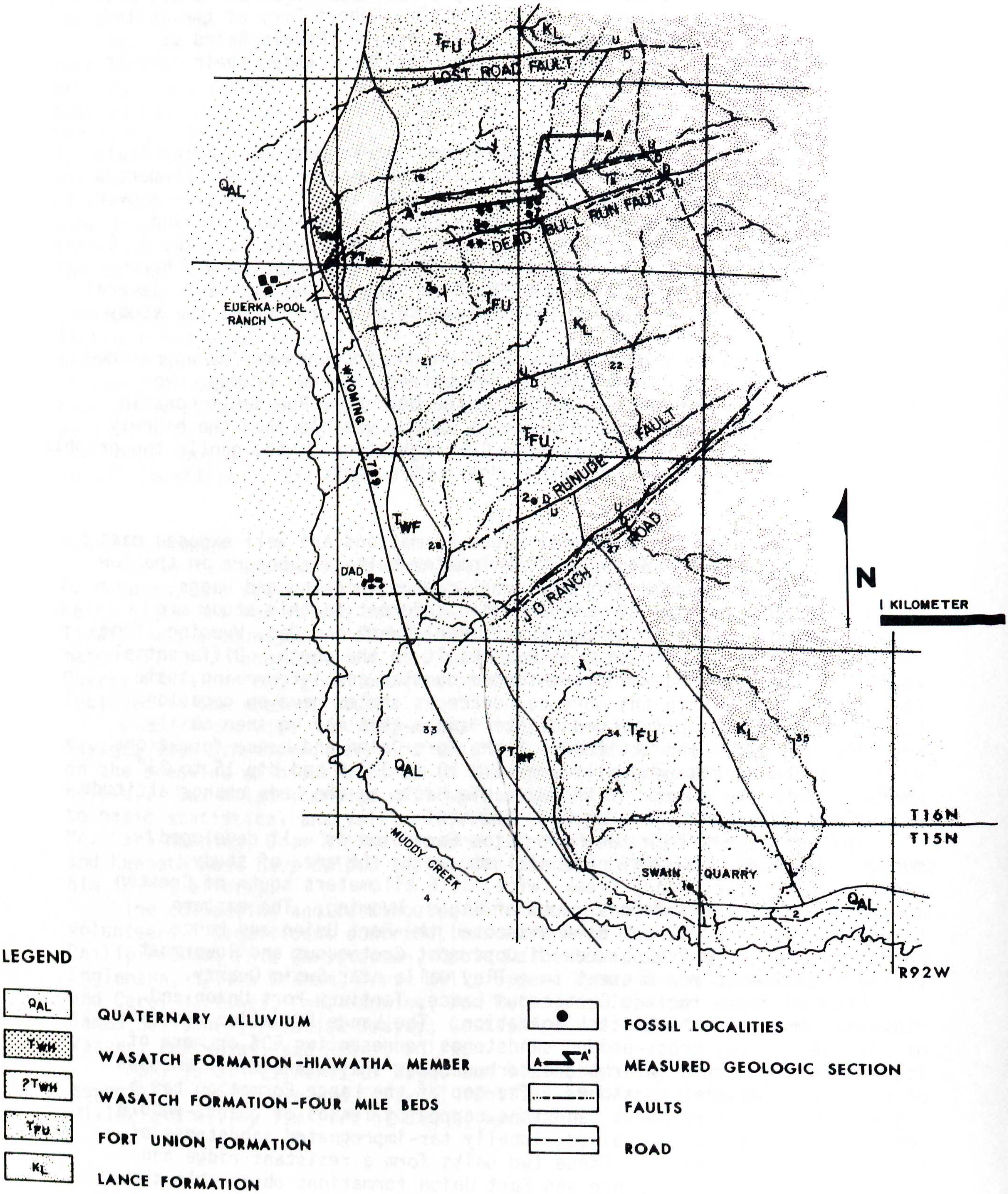
The Fort Union and uppermost Lance Formations are well exposed east of Wyoming Highway 789 along an 80-kilometer belt of exposure in the low juniper and sage-covered hills between Creston Junction and Baggs, Wyoming. The exposures of more specific interest to this study are located immediately east of the Eureka Pool Ranch and Dad, Wyoming, from Muddy Creek in the south to Lost Road Fault in the north. Differential weathering has exposed sandstone-topped cuestas and intervening shale valleys. Coals within the more carbonaceous shales have on occasion burned and produced bright red clinker zones that may be seen easily from the highway. The attitudes of the Fort Union and Lance formations vary, but the strata generally strike N 10 to 37° W and dip 16 to 23° westward into the center of the Washakie Basin as the beds change attitude around the structural nose at Dad, Wyoming.

The drainage within the Fort Union Formation is well developed. Muddy Creek forms the only perennial stream in the area of study. Highway 789 crosses Muddy Creek twice, 30.6 kilometers south of Creston Junction and 35.4 kilometers north of Baggs, Wyoming. The eastern tributaries to Muddy Creek have dissected the Fort Union and Lance Formations; excellent exposures of uppermost Cretaceous and lowermost Tertiary sediments are present in valley walls near Swain Quarry.

Exposed rocks include Cretaceous Lance, Tertiary Fort Union and Hiawatha Member of the Wasatch Formation. The Lance Formation consists of massive, thick, cross-bedded sandstones representing 50% or more of its thickness, within interbedded carbonaceous shales and minor amounts of nonorganic massive mudstones. The top of the Lance Formation has a major, laterally continuous sandstone capped by lenses of quartz-pebble conglomerate and coarse-grained, locally tar-impregnated sandstones of the Fort Union Formation. These two units form a resistant ridge and mappable contact of the Lance and Fort Union formations observable the full length of the study area. Fossil-plant evidence obtained from

Text-Figure 2

GEOLOGIC MAP



locality 9 (Fig. 2) in the uppermost sandstone of the Lance Formation north of Dead Bull Run fault dates this sandstone body as latest Cretaceous or earliest Tertiary (Tidwell, pers. comm., 1975). The Lance/Fort Union contact is drawn between the sandstone body and the quartz-pebble conglomerates.

The sandstones of the Lance Formation are fine- to coarse-grained, quartzose, and cemented with a variety of cements including limonite, calcium carbonate, and clay. The sandstone bodies generally have large clay cobbles as rip-up clasts included in their bases. These sandstone are slightly lenticular and may vary 20% in thickness in 8 kilometers. They are much more homogeneous and laterally continuous than any of the sandstones of the overlying Fort Union Formation.

The Fort Union Formation consists of interbedded sandstones, laterally equivalent siltstones and ironstone concretions and interbedded fluvial lacustrine sequences of carbonaceous shales, coals, massive mudstones and siltstones. The best-developed coals have been naturally burned and have produced clinker zones involving rocks immediately above and below. Because most of the coals are laterally discontinuous, clinker development is also laterally limited and appears in limited exposures or pods.

The sandstones of the Fort Union Formation are exceptionally variable. They vary along strike between thick massive, cross-bedded, medium-grained clay- and calcium-carbonate-cemented cliffs and mounds to thin siderite-and-silica-cemented, fine-grained, carbonaceous, brittle siltstones and ironstones. Most sandstone bodies are lenticular and symmetrical along strike. Throughout the succession major channel-fill sandstones and coals alternate as bricks in a wall.

Barbara Swain (1957) called for the use of "upper" and "lower" Fort Union Formation for units of rock stratigraphically above and separated from rocks referred to the Lance Formation by a continuous conglomeratic coarse-grained sandstone at its base and unconformably overlain by the variegated red and white siltstones of the Hiawatha Member of the Wasatch Formation. Present investigations agree with the placement of the Fort Union-Lance contact. This is a clear lithologic boundary that can be suitably mapped and provides a convenient reference point for the separation of rock bodies. It is not to be confused to also define a time-stratigraphic (Mesozoic-Tertiary) boundary as well, although a flora of "Mesozoic aspect" (Tidwell, pers. comm., 1975), was collected in the base of this uppermost Lance sandstone, and floras and faunas of "Paleocene aspect" were collected higher in the section.

Swain states:

> The contact between the "lower Fort Union" formation and the "upper Fort Union" formations were...chosen on the basis of change in gross lithology. The "lower Fort Union" formation contains many thin bedded carbonaceous sandstones interbedded with shales, coals and lignites, whereas the "upper Fort Union" formation contains much massive non-carbonaceous sandstone and claystone. The contact is characterized by change in topographic expression, color, and the presence of a marker zone. The persistance of the marker zone at approximately the same stratigraphic level indicates that this boundary is a time line. (Swain, 1957, p. 60-61)

Although she states she is defining rock bodies, the boundary is given equivalence with a time-stratigraphic boundary. The ironstone, taken as being a "time-line" by Swain (1957), is in fact a facies of several thin sandstone bodies. In at least two instances this supposed single ironstone can be demonstrated to grade laterally into separate non-equivalent superposed massive sandstones. These two massive sandstones can be shown to be separated stratigraphically by 60 meters in the vicinity of Dead Bull Run fault, located between two of her measured geologic sections. The beds of the Fort Union Formation are so variable that color and lithology are not continuous laterally for more than 3.2 kilometers, which makes it difficult to make broad general statements about rock bodies unless they are accompanied with detailed correlations. There are massive sandstones in each of her two subdivisions of the Fort Union. Both portions contain carbonaceous shales and coals, variable development of which can be seen along strike. The topographic expression she refers to does in fact change from a broad flat cuesta, which here has been interpreted as a pediment surface, to an irregular slope broken by local drainage as relief drops down to Muddy Creek. She did not make reference to several faults in the area that have offset beds as much as 1 kilometer, yet the topographic break referred to remains continuous with other portions that would be analogous with Swain's ironstone "time line". This change in topographic expression should be thought of as the break in relief caused by the fluvial development of Muddy Creek along two lower Eocene unconformities.

Coals and lignites are not limited to Swain's "lower Fort Union" formation. Shale sequences in several localities were sufficiently weathered as to disguise sediment variability and composition. Several trenches were dug to discover fresh exposures. A detailed geologic section was measured, including 3 minor siltstones and interbedded shales, through Tidwell Quarry on the southern exposures near the Dead Bull Run fault revealing that even though the clinker zones are not developed, coals still exist and their occurrence is predictable between siltstones. The sequence of sub-units within the lacustrine shales is so predictable and regular that it has been possible to spot check the sequence in scattered localities. Unit divisions recorded in the detailed measured section repeated themselves consistantly over 14 such samplings. Contrary to Swain's conclusion that the upper portion of the Fort Union Formation consists of more sandstones and less shales, the reverse seems to be true. Major coals and clinker zones are not developed in the uppermost parts of the sequences observed but coals are present and may be as much as 0.5 meters thick. Major thick, well-developed sandstones are present in the lower portion and in some sections are common. Lack of cementation may cause them to appear 2 to 2 1/2 meters thick but several have been measured at thicknesses of 50 meters.

With these observations in mind, it is impossible to recognize two distinct rock bodies within the Fort Union Formation. There is an obvious decrease in the proportion of coarse clastic sediment in the upper parts of the Fort Union Formation in any one measured section but detailed correlation between measured sections has shown that shales of some successions are equivalent to massive sandstones of others. The terms "upper Fort Union" and "lower Fort Union" Formation should no longer apply as rock-stratigraphic terms in this area, but may be used as an adjective to indicate stratigraphic position within the Fort Union Formation.

The name Fort Union Formation was first applied to rocks exposed around Fort Union, Montana, and in neighboring North Dakota (Meek and Hayden, 1861, p. 432-435). Continuity of the sediments in the study area cannot be demonstrated with those of the type section. Reference of these sediments to the Fort Union Formation has been done on the basis of gross lithology and faunal similarity to the type section. However, further investigations will undoubtedly conclude that the Paleocene sediments on the west flank of the Sierra Madre Mountains do belong to a separate rock body and should therefore receive a different formational name. Adequate exposures are at hand to give an excellent idea of lithology, fauna, and flora but the uppermost portions of the Fort Union Formation, covered by Eocene sediments in the study area, offer the best opportunity for presentation of a more complete succession. For reasons of conservatism and because the northern exposures have not been studied, the Paleocene rocks in question will continue to be referred to as Fort Union Formation even though stratigraphic problems exist.

Similar definition problems exist elsewhere. Jepsen (1940) summarized such problems in Park County, Wyoming, and these are substantially those encountered in the area of study. A similar situation also exists with the Lance Formation. Uppermost Cretaceous strata will similary be referred to the Lance Formation even though there are known stratigraphic problems.

Eocene sediments pose several unique problems. Excellent exposures of the Hiawatha Member of the Wasatch Formation are located west of Highway 789. They consist of variegated red and white siltstone bands with minor portions of purple sandstones, siltstones, and claystones. A basal conglomerate is observed and is best exposed truncating the Fort Union Formation in the drainage divide south and east of the southern bridge over Muddy Creek in section 3, T. 15 N., R. 92 W. Additional exposures are near the Eureka Pool Ranch east of the highway in Sec. 20, T. 16 N., R. 92 W. This basal conglomerate is taken to be the base of the Hiawatha Member. The problems that involve the definition of an upper mappable contact of the Fort Union Formation and determining the age of the remaining rocks exposed between rocks of definite Paleocene age (Torrejonian and Tiffanian) and those of definite Eocene age (Wasatchian).

McKenna (1960) conducted research on lowest Eocene rocks (earliest Wasatchian) exposed in the vicinity of Four Mile and Timberlake Creeks south of Baggs, Wyoming. The correlatives of these rocks are missing to the north unless the poor outcrops just east of Highway 789 and best exposed between the Muddy Creek bridge and the J. O. Ranch road are in fact equivalent to the Four Mile Creek section. These sediments are separated by unconformable relationships above with the Hiawatha Member and below with the Fort Union Formation. These white, grey-and-yellow-striped sandstones, siltstones and claystones are taken to be equivalent to the Four Mile Creek deposits to the south although continuity has not been demonstrated and fossil material has not been recovered to support this inference.

The general geologic structure is dominated by a broad gently plunging anticline. It can be easily recognized on aerial photographs of the study area, which extends from the junction of Muddy Creek and Wyoming Highway 789 in the southern extremity to north of the Eureka Pool Ranch. The N-S strike of Paleocene and uppermost Cretaceous strata can be seen changing attitude from N 37° W on the north to N 10° W farther south. Recorded dip angles are remarkably consistent, varying from 17° to 26°. The larger angles are generally in association with local fault deformation.

The stratigraphic succession is partially buried by two Eocene rock bodies which display angular unconformities at their bases. The stratigraphically lower of these two is here questionably equated with the Four Mile Creek deposits exposed south of Baggs, Wyoming. These sediments have been effected by sequential deformation of Paleocene and Cretaceous strata, and are also effected by faulting, which displaces portions of the Eocene strata. The upper of the two rock bodies consists of excellently exposed Hiawatha Member of the Wasatch Formation, which has basal quartz-pebble conglomerates accentuating a basal unconformity best observed south and east of the bridge of Highway 789 over Muddy Creek and immediately east of the Eureka Pool Ranch. These strata have not been effected by the faults observed in the Fort Union Formation.

Faulting displaces Lance and Fort Union Formations and questionable Four Mile Creek beds. Vertical displacement along the faults ranges from 1 1/2 to 230 meters. Only the major faults have been shown on the geologic map. These major faults provide a convenient method of dividing the study area into several blocks to facilitate description and discussion. Four blocks have been thus defined: (1) The Swain block, bounded on the south by Muddy Creek and on the north by the major Runude Fault, which borders the J. O. Ranch road valley 0.2 kilometers farther north; (2) The Runude block, bounded on the south by the major Runude Fault and on the north by the Dead Bull Run fault; (3) The south Dead Bull Run block, bounded on the south by the Dead Bull Run Fault and on the north by a minor fault developed in the center of the valley north of the fault; and (4) The North Dead Bull Run block, contains sediments exposed on the northern slope of the valley to a ridge crest and a major Lost Road Fault.

The Swain block is named for Swain Quarry, which has produced 28,000 fossil mammalian specimens and is located in the extreme south central part of the block near Muddy Creek, SE NE Sec. 3, T. 15 N., R. 92 W. The Fort Union Formation and upper Lance Formation are monoclinal, striking 20° to 30° to the west of north and dipping 17° to 21° to the southwest. They consist of a series of massive cross-bedded sandstones which thin and grade laterally into carbonaceous shales, mudstones and siltstones. Sandstones constitute 50% of the section on Muddy Creek but the observable amount decreases to the north. Clinker deposits are also developed immediately above the Swain Quarry sandstone and are not seen well developed elsewhere in the block. Exposures to the north are rare and make it difficult to accurately estimate sandstone proportions but it is assumed that they represent 30 to 40% of the succession just south of the J. O. Ranch road. All of the major and most of the minor sandstones thin to the north as their character undergoes some drastic changes. Efforts were made to trace the Swain Quarry sandstone and to physically correlate it with other localities to the north and place it accurately on measured geologic sections along the J. O. Ranch road and Dead Bull Run Valley. At the quarry the sandstone body is 6 meters thick, massively cross-bedded, with numerous sequentially terminated, basal, graded-bedded, clay-pebble conglomerates, sandstones, and desiccation-cracked mudstones. The upper portions are platy, formed by laminated minute cross-beds which are occasionally ripple-marked and organic rich.

The sandstone body 70 meters to the north, has changed character. It is 2 1/2 to 3 meters thick with cross-beds 25 to 30 centimeters thick and 3 to 4 meters long. The basal clay-pebble conglomerates have disappeared although an erosional contact was observed with the underlying carbonaceous shales. Slump folds were not observed in the quarry section but are developed to the north where the sandstone thins. The amount of organic matter in the section increased as evidenced by the number of limonite-ringed log remains, finely diffused carbon flecks and leaves in the upper portions of the sandstone. The log fragments are not as large, 5 to 5 1/2 centimeters in diameter, but more plentiful than the few 20 to 25-centimeter logs in the quarry section. The sandstone has lost the white, chalky, clay-cemented nature observed in the quarry section and has become brown and better cemented due to oxidation of the iron clays, which produces a limonite cement.

Farther north, the sandstone is covered by Quaternary pediment gravels and cannot be directly observed for 0.9 kilometers. Units above can be traced with ease. When again exposed it has changed character and is 0.7 meters thick, soft, argillaceous, fine-grained, ripple-marked and thinly cross-laminated. It appears to have lost its erosional base and has developed a typical levee sandstone nature, observed in well-developed fluvial systems.

This same sandstone body can be traced farther north where the lack of exposures and its thinning nature leave some doubt which of the three thin siltstones actually represents the lateral continuation of the Swain Quarry. The basal and upper splay siltstones are developed from levee sequences and appear to be above and below the major Swain Quarry sandstone. It contains identifiable leaf remains and is more continuous along strike than similar units above and below. The assumed Swain Quarry correlative, the middle siltstone, is 15 centimeters thick with 0.8 centimeter thick cross-beds that have 10 centimeter lateral extent. It is ripple-marked, graded bedded, shaly and carbonaceous in its upper portions. It has lost its clay cement and is now cemented by silica and siderite. It is very resistant and litters the surface with flakey chips from its uppper and lower portions and angular blocks from its middle portion.

The sandstone body can be traced farther to the north. Near the J. O. Ranch road it has thinned to 2 1/2 centimeters or less and is preserved as a thin ironstone concretion band developed in pods 3 to 6 1/2 meters apart. Its relationship with sediments above and below allow for its correlation with sediments across the fault. It is equated with an ironstone concretionary band within geologic sections measured along the exposures north of the Runude Fault.

Careful observations on other sandstone bodies within the Swain block reveal similar character changes as they are traced laterally. Each sandstone body represents some portion of the character gradation observed within the lateral continuity of the Swain sandstone. Most of these bodies are demonstrably symmetrical along strike. Structural complications south of Muddy Creek do not allow for observation of the sandstone body to the south except for a few exposures immediately south of Muddy Creek. Given the lenticular nature of the sediments the major sandstone bodies cannot be expected to have a lateral continuity greater than 6 kilometers. Furthermore, the sandstone body would be 1 1/2 meters thick or thinner on its lateral extremities for 5 of those 6 kilometers. This raises some question of the validity of physical correlation practices that have been used on this and similar geologic sections in the area, where massive sandstone bodies have been equated simply on the basis of their lithologic nature. This problem and other structural complications have duplicated and deleted portions of the formation in several geologic sections reported by Swain (1956), particularly the Cedars and Dad-Muddy Creek sections.

A pediment surface is better developed in the Swain block than on any other named block in the study area. The pediment gravels have limited exposure and are best exposed 0.2 kilometers northwest of Swain Quarry. They are variable pebble and cobble conglomerates unconformably resting on Fort Union Formation and Hiawatha and questionable Four Mile Creek equivalents. Individual clasts are fragments of diagnostic Eocene siliceous gastropod coquina, quartzite, Paleozoic chert, including some samples with crinoid stem fragments, and various igneous and metamorphic rocks including basalt, potassic granite, quartz monzonite, quartz pegmatite, serpentinized basalt, and rare slates and potassium feldspar gneiss. The clast size is sufficiently large to rule out a reworked source of quartz-pebble conglomerate of the basal Eocene and upper Lance formations in the immediate vicinity. Rocks of these types are found to the south near Baker Peak and Mount Welba and to the east in the Sierra Madre Range. Both areas would provide adequate sources. Much of the central portion of the Swain block is covered by sand dunes and lag deposits from these conglomerates on the pediment surface, limiting exposure of the lower portions of the Fort Union and most of the Lance Formation. The upper Fort Union sediments are well exposed along the western slope as relief drops down to the highway and Muddy Creek.

An unconformable relationship can be seen between the upper exposures of the Fort Union Formation and what are inferred to be the oldest preserved Eocene sediments in the study area, along the western border of the Swain block. The relationship can be most easily recognized by the difference in attitude and sediment character. The Fort Union Formation dips 15° to 20° to the west. The overlying Eocene strata dip 10° to 12° to the west. These Eocene strata are almost void of coarse clastic sediment and are primarily represented by nonorganic, massive bedded mudstones and siltstones with some thin, very fine sandstone stringers in basal portions. The questionable Eocene sediments are exposed 0.9 kilometers north of the bridge over Muddy Creek in the study area and form the light grey-and-yellow-streaked low hills immediately east of the highway between Muddy Creek and the J. O. Ranch road. The pediment surface is also developed on these sediments but it appears mostly as lag deposits which blanket the exposures between the "candy-striped" Hiawatha Member and upper part of the Fort Union Formation.

A second Eocene unconformity is represented in the Swain block by the base of Hiawatha Member of the Wasatch Formation, which rests on the probable Four Mile Creek equivalent. These units have abrupt attitude differences and different suites of sedimentary characters. The red, white and lesser purple sediments of the Hiawatha Member dip 5° to 8° to the west while the underlying Four Mile deposits dip 10° to 12° in the same general direction. There is a basal quartz-pebble conglomerate of the Hiawatha Member well developed in exposures immediately south of Muddy Creek and east of Highway 789. Swain included these in the upper portion of the "upper" Fort Union Formation. These conglomerates are demonstrably deposited upon a previously existing topography on the Fort Union sandstones and carbonaceous shales. Other questionably equivalent outcrops of this conglomerate occur farther north in the Runude block east of the Eureka Pool Ranch.

The lowest part of the Hiawatha Member does not contain the same proportion of red color as do the uppermost beds. The lowest Hiawatha Member is very similar to the beds along Four Mile Creek in color and sediment character. If it were not for the difference in attitude the two units would be difficult to distinguish as mappable units. The pebbles are quartz and chert pebbles with a few basalt and other igneous rock fragments. The quartz pebbles are very similar to those of the basal Fort Union Formation except that pale-green chert pebbles found in the Fort Union Formation are missing from the basal Eocene conglomerates, which contain more igneous rock fragments. There is a distinct possibility that the Eocene conglomerates are, in part, a reworked sample deriving much of their content from existing Fort Union conglomerates in the vicinity. They were certainly derived ultimately from the same source.

The contact between the Fort Union and Lance Formations in the Swain block is partially covered by sand dunes and pediment gravels but with care can be mapped. The contact is inferred as being immediately below the quartz-pebble conglomerate and above the medium-grained sandstone body which represents the upper Lance Formation. These two units are distinct, mappable, and continuous for the total length of the study area.

The Runude block is named for the Runude Fault. Locality 2 is located in the southwest portion of the fault block in the low lying hills 0.4 kilometers north of the J. O. Ranch road and 0.7 kilometers east of Highway 789. Localities 3 and 4 are located along the northern border of the block. In the southern portion of the block the strata strike N 25° W but in the north the strike changes to N 10° W. They have slightly shallower dips in the southern portions, averaging 16° to 19° to the west and 21° to 26° in the northern portion. There is a small fault located approximately in the middle of the block that may have as much as 30 meters of displacement.

The Fort Union strata are all homoclinal and the upper portions are well exposed along the western slope east of Highway 789. The lower portion of the formation is not well exposed and is covered for the most part by dune deposits and lag gravels. It is well exposed, however, along the northern edge of the block along the Dead Bull Run fault and is there represented by several 13-meter thick, massive, cross-bedded sandstones with interbedded carbonaceous shales. Sandstones represent 40 to 50% of the basal succession but this percentage decreases steadily upward until the upper portion has only 10% sandstone with some questionably included sandstones in the valley floor near the uppermost of the basal Eocene unconformities. There are several sandstone bodies within the block which have the same general lateral variation as observed in the Swain Quarry sandstone, preserving the characteristic symmetrical lenticular nature of the sandstone bodies. These are well exposed along the western slope and reveal that major sandstone bodies, reaching a greatest thickness of 10 to 13 meters, do not maintain a thickness of 1 1/2 meters or greater for more than 1.6 kilometers along strike. One of these bodies was observed to thin from 9 to 2 meters in 100 meters along strike. The contact of the Fort Union and Lance Formations forms a drainage divide and is visible through the covered intervals, at times forming weathered outcrops with diagnostic quartz pebbles littering the surface. The conglomeratic zone forms a distinct key bed which can be easily traced on the ground as well as on aerial photographs.

The contact of the questionable Four Mile Creek equivalent and these northern Fort Union deposits is obscure, although several weathered outcrops of the basal Hiawatha pebble conglomerate do appear near the highway and in the tops of some weathered, massive, cross-bedded, medium-grained sandstones 180 meters westward from the uppermost reliable Fort

Union Deposits. The attitude difference, as described in the Swain block, is also present in the Runude block, although there is a greater difference in dip angle between that of questionable Four Mile Creek deposits and the Hiawatha Member of the Wasatch Formation. The Fort Union Formation dips 17° to 19° to the west, the Four Mile Creek equivalent dips 12° to 16°, and the Hiawatha Member remains 5° to 8°. This relationship tends to make the basal Eocene sediments appear to be a conformable continuation of the "upper Fort Union" Formation. Barbara Swain (1957) included the exposures in her geologic sections as "upper Fort Union Formation".

A geologic section (Appendix 1) was measured along the southern portion of the block near the J. O. Ranch road. A total of 275 meters was unquestionably referred to the Fort Union Formation.

The south Dead Bull Run block is a small wedge of Fort Union rock bounded on the south by the Dead Bull Run Fault and on the north by a minor fault. The beds display anomalous attitudes, N 56 W, 21° SW, interpreted as drag folds associated with the southern fault. It is interesting as far as paleontological observations are concerned because the block contains localities 5 through 8.

The rocks are well exposed along the southern ridge bordering the Dead Bull Run Fault. The contact of the Lance Formation with the Fort Union sediments is between a massive, cross-bedded sandstone and the overlying basal Fort Union lenticular deposits of sandstone and quartz-pebble conglomerate. The contact is exposed on either side of the major fault in Dead Bull Run valley and in a more southern outcrop located at the head of a small valley immediately south of Dead Bull Run valley. The contact is mappable on south through the Runude block.

North Dead Bull Run block, northeast of the Eureka Pool Ranch, has the best exposures on the Fort Union and Lance Formations in the study area. The beds of the Fort Union Formation are homoclinal and strike N 10° W and dip 24° to the west. The Fort Union and Lance Formations in the south fold to strike N 5° E and dip 26° to the west in the north portion of the block. The Lance and Fort Union formational contact is beautifully exposed 2.5 kilometers east of Highway 789 on the north side of the valley containing the Dead Bull Run fault. Tar-impregnated, coarse-grained sandstones are in close association with the quartz-pebble conglomerates 0.2 kilometer north of the valley center and continue exceptionally well exposed for some distance along strike. Several clinker deposits are developed in pods that are controlled by well-developed coal deposits, which have burned to clinker the siltstones and mudstones above and below.

Fossil plant material is occasionally abundant in clinkered zones but the best preserved material comes from thin siltstones and sandstones bordered by fluvial lacustrine sequences which dominate the upper portion of the Fort Union exposures. A large collection of such material was collected from locality 6, "Tidwell Quarry". Other such siltstones offer similar possibilities for large plant collections. Some of these siltstones can be traced along strike where they thicken to form massive channel sandstones, which also contain basal clay-pebble conglomerates, that on occasion produce fossil vertebrate material. This relationship provides an excellent opportunity for correlating faunal and floral elements within the Fort Union Formation.

Sandstones represent 30% of the total thickness. The middle and lower parts contain most of the coarse clastic sediment exposed near the Dead Bull Run fault and Lost Road fault to the north. However, between the two drainage systems, several major sandstone bodies are developed but thin along strike and become minor sandstones and siltstones exposed in the major fault-controlled valleys. Exposures between faults are richest in coarse clastic rocks. The basal Eocene conglomerates and preserved Eocene sediments are best exposed near fault zones and may be controlled by substantial local relief developed on Paleocene sediment. It is probable that the drainage responsible for the deposition of the basal Eocene conglomerates was, at least in part, controlled by late Paleocene faulting. Such fault zones would tend to control development of fluvial systems, deposition of coarse clastic sediment and may explain the limited occurrence of basal Eocene conglomerates.

Clinker deposits observed in the Swain, Runude, North Dead Bull Run and Lost Road blocks show that coals and carbonaceous shales are best developed immediately above the thickest portions of the sandstone bodies.

Exposures continue northward undisturbed for some distance with much the same sediment type and development as observed to the south. The unconformable relationships of the Fort Union Formation, questionable Four Mile Creek equivalent, and Hiawatha Member lose their distinctness to the north. This suggests that the large, faulted, plunging anticline probably went through an early Paleocene and two early Eocene orogenic events.

Localities

Fossil plant materials are plentiful in the fluvial sections of the Fort Union Formation. All the siliceous siltstones, when traced along strike, yield identifiable plant remains at some point along the traverse. It may even be possible to recover identifiable remains from the carbonaceous shales and brown siltstones, which are interpreted here to represent fluvial lacustrine facies of back-levee and oxbow lake deposits. Efforts were made to make such collections but were frustrated by the fragile nature of the sediment. Upon drying, preserved plant material was exfoliated by desiccation fractures. Seeds, leaves, stems, and (rare) insects were observed.

The most readily collected and best-preserved plant remains come from the siliceous siltstones. "Tidwell Quarry", locality 6, represents one locality found in SE SE sec. 16, T. 16 N., R. 92 W. During the 1973 field season the combined field parties of the American Museum of Natural History and Brigham Young University, under the supervision of William Tidwell, collected the site that had been discovered while prospecting for fossil vertebrates along Dead Bull Run Fault earlier in the season. It is estimated that 1,000 excellently preserved, complete leaf and seed remains are housed at Brigham Young University, where Roth (1975) investigated the samples. A floral list submitted by him is included as Table 1. The flora is thought to represent a warm temperate environment with limited local relief, 5-7 meters, in the vicinity of a well-developed, morphologically mature, fluvial system developed upon a piedmont terrain similar to that observed by Roth in southern Georgia. All specimens are considered to be of Paleocene age.

Additional important fossil plant material was obtained from locality 9 in SE NW sec. 15, T. 16 N., R. 92 W. The locality is at the base of the uppermost sandstone body of the Lance Formation, in a poorly bedded claystone within the basal portions of the main sandstone body. The

Text-Figure 3

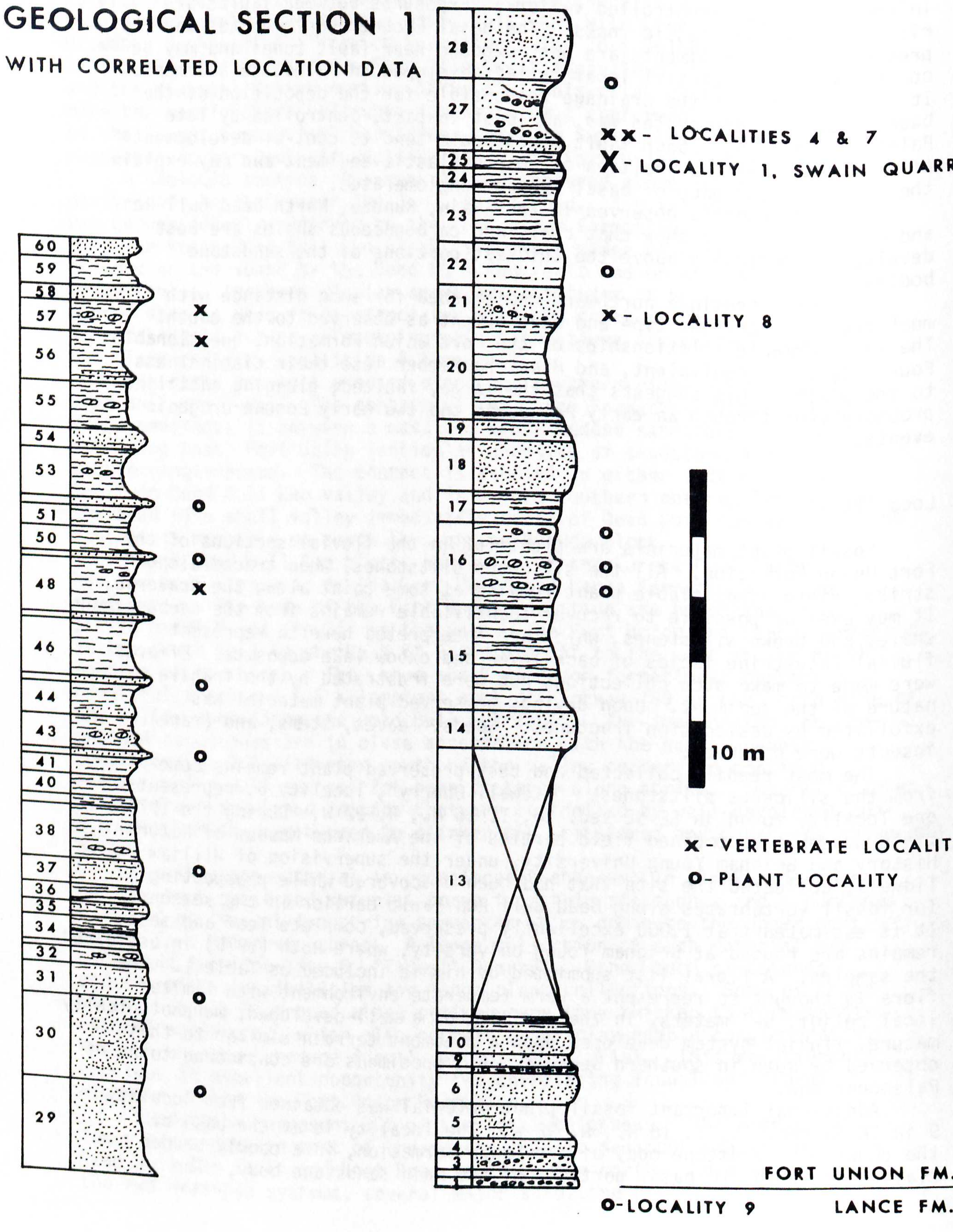


Table 1

Floral list and relative abundance of species from Tidwell Quarry, Carbon County, Wyoming

Species	Number Collected	Percentage
Carya antiguorum	168	30.8
Platanus nobilis	97	17.8
Cercidiphyllum arcticum	71	13.1
Platanus raynoldsi	65	11.9
Pterocarya glabra	26	4.7
Equisetum sp.	19	3.5
Cissus marginata	18	3.3
Viburnum antiguum	5	.9
Ficus artocarpoides	4	.7
Viburnum cupanoides	4	.7
Platanus affine	4	.7
Hamamelites inaequalis	3	.6
Cinnamomum sezannense	3	.6
Ampelopsis acerifolia	3	.6
Ficus subtruncata	3	.6
Hydromystria expansa	3	.6
Populus amplyrhyncha	2	.4
Persae brossiana	2	.4
Lindera obtusata	2	.4
Vitis olriki	1	.2
Trochodendroides arctica	1	.2
Phyllites demoresi	1	.2
Magnolia borealis	1	.2
Unidentified species	41	7.5
	544	100.0%

lenticular form of the sandstone bodies is demonstrated by discontinuous lenses of quartz-pebble conglomerate. The producing horizon can be traced 16 meters to the north on strike but massive, thick overlying sandstone limits collecting to the exposures on the promontory point of the south-facing slope. At this point the collecting horizon is in the uppermost 10 centimeters of a 35-centimeter silty, at times carbonaceous, poorly bedded mudstone. The best-preserved specimens came from the upper 2.5 centimeters of the productive horizon and were found in parallel brown silty bands within the light grey mudstone. The mudstones are capped by 1.3 to 2.6 meters of massive, cross-bedded, poorly sorted, fine- to coarse-grained, conglomeratic sandstone. In the basal portions of the overlying sandstone are 1.5 to 45-centimeter diameter clay cobbles and pebbles that appear to be of the same lithology, or at least very similar, as the productive zone of locality 9. Several specimens of Thuia, diagnostic of Mesozoic floras but not exclusively limited to them, were found here and may be used as evidence for placing the Mesozoic-Tertiary boundary in the vicinity of locality 9. The contact of the Lance and Fort Union formations is drawn at the top of the major sandstone immediately above the locality. Collections made in 1973 are housed at Brigham Young University and remain unstudied.

Fossil mammalian remains are known from eight separate localities, scattered throughout the Fort Union Formation. The oldest, based on superposition, is locality 8, located 120 meters above the base of the Fort Union Formation in NW SW Sec. 15, T. 16 N., R. 92 W. It was found during the early part of the 1973 field season and was significant at the time of its discovery because it confirmed the existence of other vertebrate remains that were not directly in association with those of Swain Quarry. It encouraged additional prospecting in the area, which resulted in the discovery of seven more localities during the 1973 field season.

Fossil turtle, crocodile bone scraps and a single unidentifiable mammalian premolar were found lying on the surface of the top of a small ridge descending into the Dead Bull Run Fault valley, 180 meters east of the summer retention tank and south of the large clinker pod in the center of the valley. The productive zone, Unit 21 of measured geological section 1, was determined to be in a lenticular clay-pebble conglomerate overlain by a fine- to medium-grained, thinly cross-bedded, on occasion ripple-marked, poorly sorted sandstone with platy, limonite-streaked upper and lower portions immediately above the fossil zone. The zone can be traced for 46 meters along strike before it disappears into the valley to the north and is truncated by the major fault to the south. The most productive portion is located at the break in slope as the ridge approaches the valley from the south. No additional fossil mammal material was recovered despite a careful search. Gar scales, turtle carapace fragments, fragmented limb elements and crocodile scutes were collected from weathered lag deposits on the ridge slope. Other such localities yield fossil mammal material when screened but locally a limonitic cement indurates the zone and makes screening impossible. An excavation should be made to determine if fresh exposures would yield suitable material for screening.

Two other localities, 7 and 4, are found within portions of the same lithologic unit, separated by the major fault on the southern face of the valley. They are 150 meters stratigraphically above the base of the Fort Union Formation and somewhat above locality 8 and do yield fossil mammal material in sufficient quantities to encourage further investigation. Locality 7 was recognized by fossil mammal remains in an anthill just south of the ridge crest forming the southern exposures of the valley along the Dead Bull Run Fault. Further investigation confirmed that the fossil material was coming from a series of clay-pebble conglomerates in the immediate vicinity, unit 27 of the geologic section. Prospect pits were dug and as many as ten, 15-cm lenticular deposits of clay-pebble conglomerate were found in 2 to 3 meters of stratigraphic section. The conglomerates occur as interbeds in the basal portion of a lenticular, poorly sorted, medium- to massively-cross-bedded, medium- to fine-grained, clay- and calcareous-cemented, quartzose sandstone which forms a semi-resistant unit on the ridge crest. The conglomerates are not indurated as they are in locality 8 and therefore offer some hope of collecting a sample of fossil mammal remains. Locality 4 was first recognized by numerous large portions of turtle carapace weathering in place on Dead Bull Run Fault. Closer investigation revealed that the material was derived from at least two lenticular clay-pebble conglomerates visible for 46 meters along strike in the basal portion of thick, cross-bedded, poorly sorted, fine- to medium-grained quartz and black chert sandstone. The best developed and best exposed of the two conglomeratic lenses contained fossil turtle and crocodile scute fragments.

The sediment had become secondarily indurated by the weathering production of limonitic cement. After minimal excavation, it was observed that complete induration did not extend more than a foot below the surface. Large fossil leaves were observed folded perpendicular to what must have been existing current directions when the clay pebbles and coarse sandstones were deposited. This appears to be conclusive evidence that the conglomeratic lens was deposited in one event and did not develop over an extended period of time. A total of 227 kilograms of matrix was obtained from a shallow excavation made in the middle portion of the best-developed conglomeratic lens and produced fossil mammal remains.

These three stratigraphically low localities are approximately equivalent to the horizon of Swain Quarry, locality 1, which is by far the most productive locality in the area.

Locality 2 is located in the westernmost exposures of the Fort Union Formation north of the J. O. Ranch road and east of Highway 789 in NE NE sec. 28, T. 16 N., R. 92 W. It is 260 meters above the base of the Fort Union Formation in the extreme southern portion of the Runude block. It is located at the southern end of a group of exposures that reveal clay-pebble conglomerates in the basal parts of several 1 to 1.3 meter thick, medium cross-bedded, fine- to medium-grained, occasionally ripple-marked, quartzitic, clay- and limonite-cemented sandstones. The sandstones in the southern extremity of the exposure obviously have been crumpled and folded by displacement along the Runude fault. Attitudes vary from N 67° W, near the fault trace to N 25° W immediately above the locality. Dips are locally variable but generally range between 16° to 26° westward into the center of the Washakie Basin.

Fossil mammal teeth were recovered from an anthill on the east-facing slope of the westernmost sandstone capped cuesta. Careful observations revealed that the area contained several other anthills that also contained fossil mammal teeth in the flat area immediately south and east of the original discovery anthill. Dry screening operations were conducted in an effort to gain more material. During the screening operation a loose unconsolidated brown carbonaceous zone was uncovered in close proximity to the most productive portion of the opening. It did not contain fossil vertebrates but approximately 40 freshwater gastropods were observed in it.

Locality 5 represents a unique preservational environment. It is located in SW SE sec. 16, T. 16 N., R. 92 W., 310 meters above the base of the Fort Union Formation at the top of a knoll on a ridge crest north of the Dead Bull Run fault. The productive horizon is marked by a lenticular bed of fresh-water algal concretions, 1.3 to 4 meters thick, which give the weathered surface a graveled appearance. The same horizon can be seen 0.2 kilometers to the southwest across the fault. The fossil materials are observed in close association with algal concretions, which occur in nonorganic, massive, light green mudstones with brown, carbonaceous shales above and thin siltstones and coals below. Recovered from surface materials were gar scales, postcranial vertebrate scraps and turtle carapace fragments, some of which showed tooth marks, and numerous crocodile scutes. The locality probably represents a single crocodile specimen in addition to small amounts of fossil mammal remains. Two different mesh sizes were used to facilitate the sorting of 136 kilograms of concentrate. Several mammal tooth fragments were recovered.

Locality 3 is in NE NW sec. 21, T. 16 N., R. 92 W., 314 meters above the base of the Fort Union Formation. Fossil vertebrate material was first discovered in an anthill and a shallow quarry has been developed in a series of partially indurated clay-pebble conglomerates interbedded with fine-to coarse-grained, poorly sorted, cross-laminated sandstones between two massive thick sandstones of the uppermost exposures of the Fort Union Formation. These rocks are exposed at the break in slope at the eastern fringe of the broad drainage slope east of Highway 789. The algal-ball bed of locality 5 can be seen 3.3 to 5 meters below the producing horizon of locality 3. It is therefore the youngest sample of fossil mammal material yet recovered from the Fort Union Formation in the study area. Efforts were made to recover a fossil sample sufficient to date the surrounding sediments paleontologically but efforts were frustrated in that the partially indurated producing zone did not lend itself easily to screening techniques. A careful search of the area recovered 2 mammal teeth. 227 kilograms of matrix were screened which produced several more specimens.

All specimens from localities other than Swain Quarry are at present unstudied.

SYSTEMATICS

Introduction

Until Simpson (1937) published his description of the Crazy Mountain Field, most Paleocene mammalian systematics, stratigraphy, and phylogeny were forced, simply by the nature and amount of material available, to be typologically oriented. Cope (1884), for example, had only one or at most a very few specimens for almost all of the taxa he published in "Tertiary Vertebrata". Additional material collected later allowed workers, including Matthew, Osborn, and Scott, to see some variability in existing taxa and more complete material allowed them to hypothesize new relationships. As soon as sufficiently large samples were available to obtain an adequate concept of variability, taxa represented by slightly different forms which could no longer be considered as separate and distinct were synonymized. Obviously Matthew (1937) was aware of dental populational variation because of statements relating to Paleocene mammals such as "...may be shown to be a small variety of Mioclaenus turgidus but is retained at present as a separate taxon."

Simpson (1937) was the first to introduce formally the concept of variability on a statistical basis in his monograph of the Crazy Mountain Field faunas, in which he attempted to quantify observed variability. It was possible for him to do so because he had the first large sample of Paleocene mammals. Jepson (1940) criticized Simpson's treatment of multituberculates and introduced the character of blade profile as taxonomically significant. Work has continued in the belief that refined character definitions will allow workers to subdivide the rock column almost indefinitely based on the assumption that observed differences have biostratigraphic importance. Many low-level taxa have been erected, in some cases on the most minute of differences. Only now, with several large collections from single quarries, have such questions as sexual dimorphism and geographic variation been raised in a context of contemporaneous variability.

Such questions force one to evaluate neontological investigations of living mammals. It is known that any given genetic code can have a variety of phenotypic expressions which produces a range of variability capable of being modulated by changes in environmental conditions. The gene pool of the population will therefore yield a substantial range of variability that will be distributed over the geographic range of the population. At any one time, a subset of the taxon's total phenotypic potential will be present and expressed in the taxon's geographic distribution. Any single deme sample of the distribution will display a range of variability in any one character. The diversity of the character will be governed by the strength of the selection pressures acting upon it. If samples are taken at different places and conditions within the geographic distribution different modes of character expression will be present.

Biostratigraphic correlation of terrestrial Paleocene mammalian faunas can no longer proceed on the assumption that inseparable dental morphology also indicates time equivalence. The degree of resolution of biostratigraphic data provided by mammalian faunas will be governed by contemporaneous variability of the compared taxa.

Until large collections are obtained, workers will have little opportunity to evaluate fossil populational samples in the context of morphologic variation to determine if recent and fossil deme samples do, in fact, represent similarly recognized taxa. Only after this is done will it be possible to begin solving a subsequent problem of how much variability is to be expected between contemporaneous samples.

Low-level fossil taxa or "morphospecies" may have some biological significance if it can be shown that the degree of variation among demes (living and fossil) is similar. By using samples taken across documented geographic ranges of recent taxa, observations can be made on how much variation is among contemporaneous demes. Numerous studies have been conducted but few contain the type of information needed on dental characters by paleomammalogists. Such observations on recent species would be a valuable tool for stratigraphic relationships of fossil taxa in hopes of reducing the confusion between variability factors of evolution,

Table 2

Mammalian Fauna of Swain Quarry

Order Multituberculata
  Family Eucosmodontidae
    Xyronomys swainae, n. gen. & sp.
  Family Neoplagiaulacidae
    Xanclomys mcgrewi, n. gen. & sp.
    Ectypodus c., n. sp. (not named)
    Ectypodus sylviae, n. sp.
    Neoplagiaulax cf. hunteri
  Family Ptilodontidae
    Ptilodus mediaevus

Order Marsupialia
  Family Didelphidae
    Peradectes, n. sp. (not named)

Order Insectivora
  Family Leptictidae
    Prodiacodon cf. puercensis
    Diacodon concordiarcensis
    Diacodon sp.
    Myrmecoboides montanensis
  Family Pantleostidae
    Propalaeosinopa diluculi
    pantolestine sp.
  Family Apatemyidae
    Jepsenella praepropera
  Family Mitodectidae
    Mixodectes malaris
    Mixodectes sp.
  Family Adapisoricedae
    Mckennatherium martinezi, n. sp.
    Mckennatherium fredricki, n. sp.
    Leptacodon cf. tener
    Litomylus dissentaneus
    Haplaletes disceptatrix

Order Deltatheridia
  Family Palaeoryctidae
    Acmeodon hyoni, n. sp.
    Gelastops joni, n. sp.
    Paleotomus milleri, n. sp.
    Palaeoryctes puercensis
  Family Hyaenodontidae
    Prolimnocyon macfaddeni, n. sp.
    deltatheridian indet.

Order Carnivora
- Family Miacidae
  - *Protictis haydenianus*
  - *Bryanictis vanvaleni*
  - *Simpsonictis jaynanneae*, n. sp.

Order Primates
- Family Paromomyidae
  - *Paromomys maturus*
  - *Paromomys depressidens*
- Family Picrodontidae
  - *Picrodus silberlingi*

Order Primates, incertae sedis
- Family Microsyopidae
  - *Palenochtha* cf. *minor*
  - *Palenochtha weissae*, n. sp.
  - *Palaechthon problematicus*

Order Taeniodonta
- Family Stylinodontidae
  - *Psittacotherium multifragum*

Order Arctocyonia
- Family Arctocyonidae
  - *Chriacus pelvidens*
  - *Mimotricentes subtrigonus*
  - *Prothryptacodon* cf. *furens*
  - *Prothryptacodon hilli*, n. sp.
  - *Protogonodon criswelli*, n. sp.
  - *Arctocyon ferox*
  - *Goniacodon levisanus*
- Family Periptychidae
  - *Periptychus carinidens*
  - *Anisonchus willeyi*, n. sp.
  - *Anisonchus sectorius*
  - *Haploconus* sp.

Order Acreodi
- Family Mesonychidae
  - *Dissacus navajovius*

Order Condylarthra
- Family Hyopsodontidae
  - *Promioclaenus acolytus*
  - *Litaletes mantiensis*
- Family Phenacodontidae
  - *Tetraclaenodon puercensis*

Table 3

Comparison of the Swain Quarry fauna

Swain Quarry Fauna	1	2	3	4
Xyronomys swainae, n. gen. & sp.	X			Torr. R+
Xanclomys mcgrewi, n. gen. & sp.	X			Torr. ?G+
Ectypodus c.		X		Torr. S=
Ectypodus sylviae, n. sp.	X			Torr. S+
Neoplagiaulax cf. hunteri			?	Torr. G-
Ptilodus mediaevus		X		Torr. S=
Peradectes n. sp.	X			P. S+
Prodiacodon cf. puercensis		X		Torr. S-
Diacodon concordiarcensis			X	Torr. G+
Diacodon sp.	X			?
Myrmecoboides montanensis			X	Torr. G-
Propalaeosinopa diluculi			X	Torr. G=
pantolestine sp.	X			Torr. G?
Jepsenella praepropera			X	Torr. G=
Mixodectes malaris		X		Torr. S+
Mixodectes sp.		X		Torr. S=
Mckennatherium martinezi, n. sp.	X			Torr. G+
Mckennatherium fredricki, n. sp.	X			Torr. G+
Leptacodon cf. tener			?	Torr. G?
Litomylus dissentaneus			X	Torr. G+
Haplaletes disceptatrix			X	Torr. G?+
Acmeodon hyoni, n. sp.	X			Torr. S+
Gelastops joni, n. sp.	X			Torr. G+
Paleotomus milleri, n. sp.	X			Tiff. Sc-
Palaeoryctes puercensis		X		Torr. S=
Prolimnocyon macfaddeni, n. sp.	X			Tiff. -
deltatheridian indet.	X			?
Protictis haydenianus		X	X	Torr. S, G=
Bryanictis vanvaleni		X		Torr. S-
Simpsonictis jaynanneae, n. sp.	X			Torr. G+
Paromomys maturus			X	Torr. G=
Paromomys depressidens			X	Torr. G=
Picrodus silberlingi			X	Torr. G=
Palenochtha cf. minor			?	Torr. G+
Palenochtha weissae, n. sp.	X			Torr. G-
Palaechthon problematicus		X	?	Torr. R=
Psittacotherium multifragum		X	?	Torr. S=
Chriacus pelvidens		X		Torr. S+
Mimotricentes subtrigonus		X		Torr. S+
Prothryptacodon cf. furens		X		Torr. G+
Prothryptacodon hilli, n. sp.	X			Torr. G+
Protogonodon criswelli, n. sp.	X			P. S-
Arctocyon ferox		X		Torr. S-
Goniacodon levisanus		X		Torr. S=
Periptychus carinidens		X		Torr. S=
Anisonchus willeyi, n. sp.	X			Torr. D+
Anisonchus sectorius		X	X	Torr. S, G=

Swain Quarry Fauna	1	2	3	4
Haploconus sp.	X			Torr. D+
Dissacus navajovius		X	X	Torr. S=
Promioclaenus acolytus		X	X	Torr. S-
Litaletes mantiensis			?	Torr. D=
Tetraclaenodon puercensis		X	?	Torr. S=

Legend

1. Elements restricted to the Swain Quarry fauna.
2. Elements in common with Torrejonian faunas of the Nacimiento Formation, San Juan Basin, New Mexico.
3. Elements in common with the Gidley Quarry fauna, Crazy Mountain Field, Montana.
4. Correlation of the Swain Quarry fauna. Data are presented in three parts: 1) Puercan, P.; Torrejonian, Torr.; Tiffanian, Tiff,; 2) The locality of the nearest related form, D, Dragon local fauna; G, Gidley Quarry; R, Rock Bench; S, San Juan Basin; Sc, Scarritt Quarry; 3) Indication of the Swain Quarry form being more derived (+), inseparable from (=), or more primitive (-) than its closest morphologic relative.
   A "?" indicates some question regarding that or the immediately following information.

Table 4

Characters used for morphologic comparisons of multituberculates

	Lower Dentition
1	cuvature
	length
	basal cross-section
	root length
	alveolus size and shape
	diastema length
P_L	position relative to M_b
	height
	crown enamel
	cusps
M_b*	height above enamel base
	width
	length
	serration count
	distance to first serration
	number of descending ridges
	serration curvature
	serration continuity with ridges
	serration shape
	angle of post. margin and root
	profile
	exodaenodont lobe size and shape
	lingual sculpture
	labial sculpture
	post. labial platform
	post. labial cuspules
M_{1-2}	shape
	length
	width
	cusp count
	cusp description, shape
	buttresses
	angle with base of jaw
	angle with ant. face of M_b

	Upper Dentition
1	cusps
	curvature
	length
	basal cross-section
	root extension
	alveolus size and shape
	diastema to 1^2
1^2	cusps
	curvature
	length
	basal cross-section
	root extension
	alvaeolus size and shape
P^{2-4}	shape
	length
	width
	cusp count
	distribution of cusps
	shape of cusps
M^b *	shape
	length
	width
	cusp counts
	row geometry
	cusp description
	buttresses
M^{1-2}	shape
	length
	width
	cusp count
	row geometry
	cusp description
	buttresses

*P_4^4 of authors

sample ecology, and geographic distribution.

The study of the Swain Quarry mammals is an attempt to define populational variability from a single site and to relate it to geographic and time distribution of certain fossil mammals. Populational evaluation will have an effect upon the systematics of the groups involved. It is the aim to make systematic schemes reflect phylogeny. Although there must be some interaction between time and morphologic change it is here considered wrong to assume that related forms in sequentially deposited rocks necessarily represent in-situ evolution. This would ignore possibilities of changes in animal distribution.

The problem of relating the Swain Quarry fauna to other described samples is essentially two-fold: 1) recognizing taxa with suitably defined characters to allow for the determination of phylogenetic relationships and 2) determining the degree of contemporaneous variability.

The most parsimonious solution to these problems has a common first step in similarity recognizing phena or fossil deme samples. Once this has been done, two separate thought processes are used to relate samples either phylogenetically or biostratigraphically. The basic requirement for both evaluations is that a sufficient sample of the taxon to be compared is at hand so that a confident definition of its variability can be obtained. Samples known from one or two specimens are of essentially no value for detailed biostratigraphic comparisons because the geographic and time intervals that could include them within a 95% confidence limit are so great. For this reason little valid biostratigraphic comparison for short intervals has been done among Paleocene localities because of collecting techniques which inadequately sample populations and typological concepts which have assumed any minor difference to be of stratigraphic and phylogenetic significance.

Nonmarine Paleocene strata in North America are divided into Puercan, Torrejonian, and Tiffanian ages based on faunal content. I ignore poorly known Paleocene localities from biostratigraphic discussion. Of the remaining Torrejonian samples, Gidley and Silberling Quarries of the Crazy Mountain Field, Shotgun member local fauna, and Rock Bench locality from Polecat Bench are adequately known but only those of the Crazy Mountain Field are sufficiently described and studied to be of value for comparison. The many localities of the Torrejonian part of the Nacimiento Formation from the San Juan Basin are either unstudied, yield few individual specimens, or possess so little stratigraphic data as to render them useless for comparison.

A faunal list of known forms from Swain Quarry is found in Table 2. Table 3 attempts to relate the Swain Quarry sample to well-known samples collected elsewhere in the Paleocene, particularly Gidley Quarry, and those of the Nacimiento Formation of the San Juan Basin. There should be no doubt that Swain Quarry represents a Torrejonian fauna (McGrew in Swain, 1957). However, if the practice of determining stratigraphic age of isolated samples on the basis of the primitive or derived nature of its nearest relative is valid then the Swain Quarry sample is quite probably younger than the sample from Gidley Quarry and is bracketed by samples from the San Juan Basin. This conclusion is theoretically weak in that even though samples have been compared in detail, it offers no guarantee that known primitive and derived forms could not be contemporaneous. The occurrence of Protogonodon in the fauna is disturbing in that the Puercan form, P. pentacus, is derived with respect to the form from Swain Quarry. Indeed, its presence offers the suggestion that if other

Torrejonian localities were as well known, other typically Puercan forms would also appear as rare elements of the fauna.

The dental nomenclature used is essentially that of Szalay (1969) with some additions; the protolophid is subdivided into inframetacristid and infraprotocristid portions, pre-and postmetacristids for crests anterior and posterior to the metaconid, and obliconid, defined as the cusp, or primitively the confluence, of the protolophid and cristid obliqua. Unless otherwise stated, all measurements are in millimeters.

Comments on Multituberculate Systematics

There are more than 12,000 known multituberculate teeth in the Swain Quarry collection, which is without question the largest sample of Paleocene multituberculates known. The curation of such a collection was difficult because most of the remains are isolated teeth, which display a significant degree of variability in what have been considered to be diagnostic characters. Table 4 details the number and variety of observations that have been made on the sample from Swain Quarry.

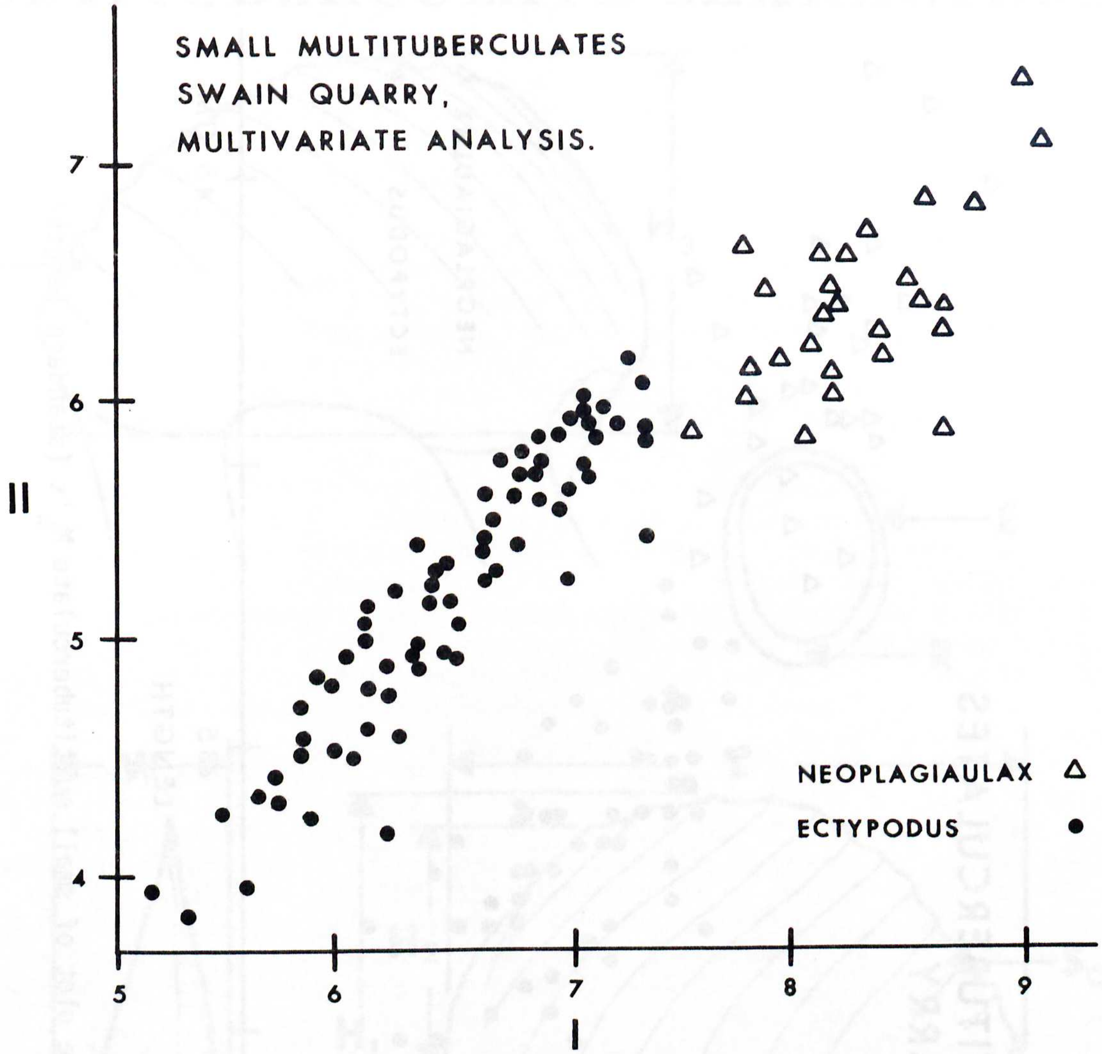
When attempts were made to divide the remains into phena (morphotypes), significant parts of the collection were found to be intermediate in a number of characters, particularly smaller specimens referable to Neoplagiaulax and Ectypodus. These samples were subjected to a bivariate cluster analysis (refer to Text figures 4 and 5) in an attempt to discover camouflaged morphologic groupings within samples of upper and lower blades and molars. Such analysis only slightly improved the degree of resolution of observed clusters provided by bivariate analysis.

The question was raised as to how much variation to expect in dental characters of multituberculates. If R. E. Sloan (per. comm., 1975) is correct in his analysis of the mastication apparatus of the multituberculates, which provides for a loosely articulated dentary, then it seems highly likely that multituberculate dentitions will not be subject to the same selection pressures as marsupial or eutherian mammals, where dental occlusal patterns are of much greater significance. Multituberculate upper premolars have no occlusal counterpart in the lower dentition and blades and molars are involved in separate power strokes at widely divergent angles. Based upon the difference in striation pattern of wear facets of multituberculate teeth, it is apparent that there are two significant strokes involved which must act independently of each other. The freedom of motion about the mandibular articulation has been compared to "a ball on a billiard table" (Sloan, pers. comm., 1975). An unfused symphysis allows further for independent mandible operation.

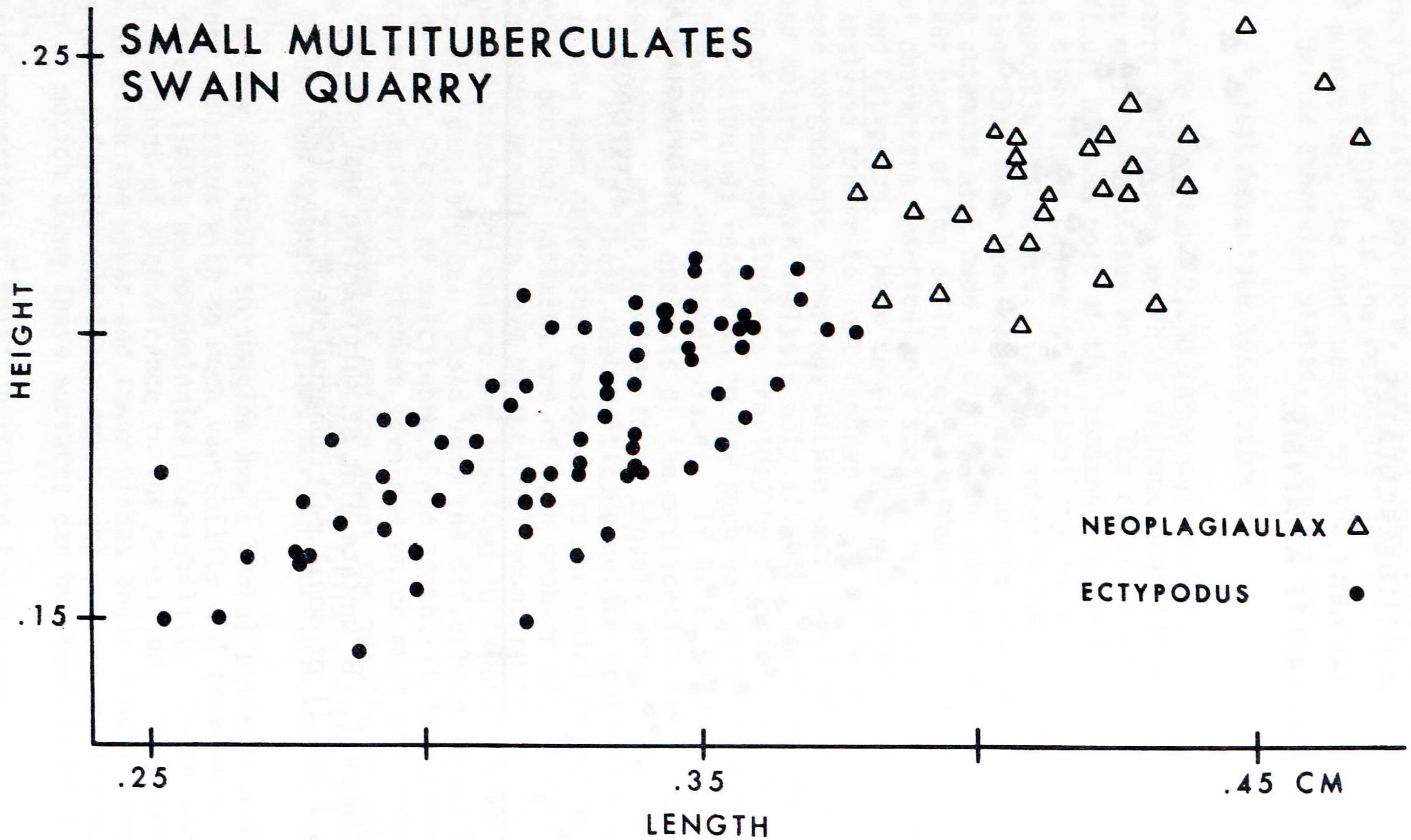
It is very difficult to imagine how a dental pattern propelled by a masticatory apparatus with so much variability and freedom of motion can dictate severe limits on morphological variability. There are in fact only two positions of significance in the dentition. They are the position at which the upper and lower blades begin functioning as a shearing pair and upper and lower molar cusp row and valley surfaces. Direction of motion along these surfaces can be shown to be distinctly different.

Metric properties of multituberculate teeth used in this study are illustrated in figure 6.

Something should be said, however, about the other characters from Table 4, used in the study, which are not so easily defined. One major

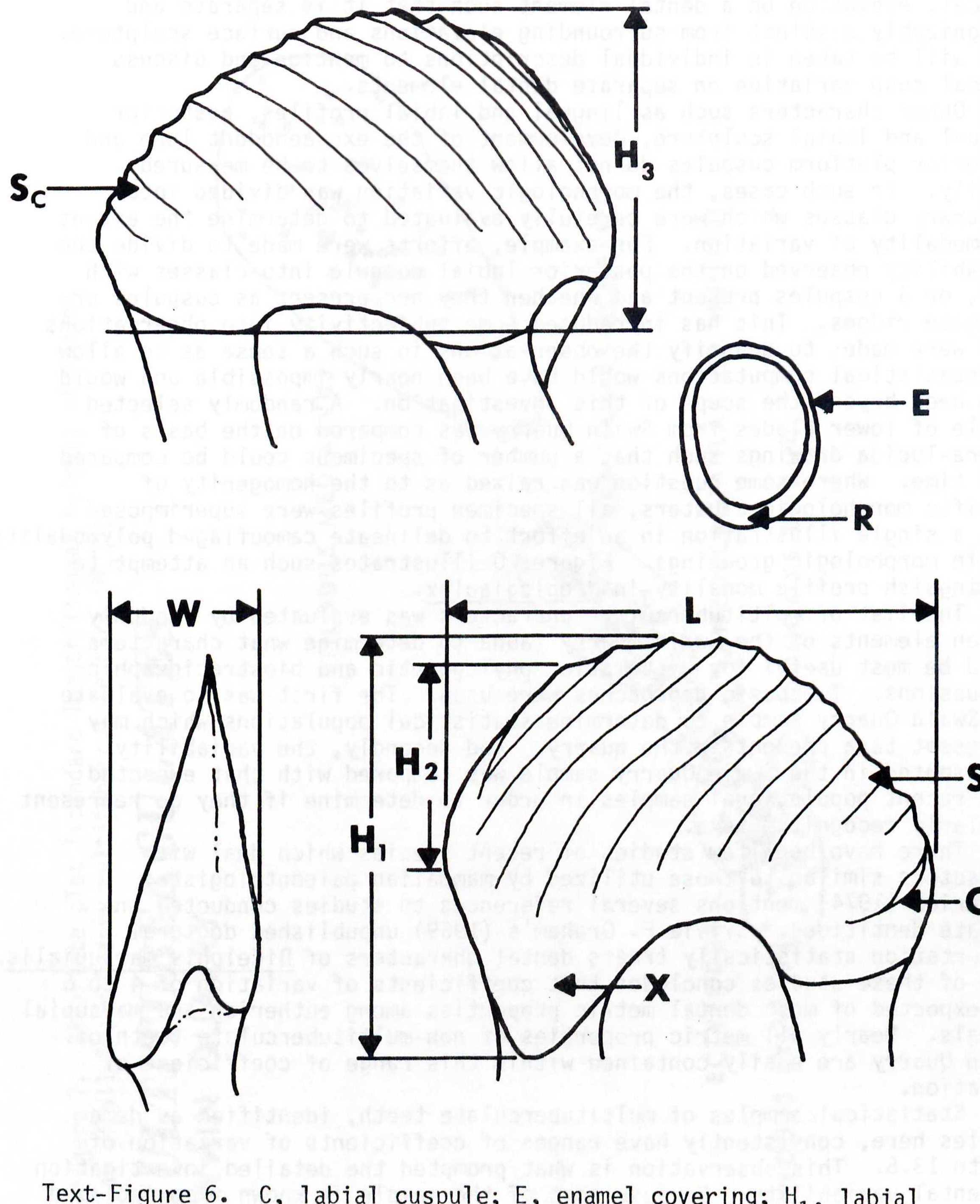


Text-Figure 4. Bivariate plot of multivariate analysis scores I and II of small multituberculate M_b's. (See Text)



Text-Figure 5. Bavariate plot of small multituberculate M_b's (standard length/lingual height).

MULTITUBERCULATE CHARACTERS



Text-Figure 6. C, labial cuspule; E, enamel covering; H_1, labial height; H_2, height of the first serration above the premdar excavation; H_3, lingual height; L, standard length; R, medial ridge S_c, lingual and labial sculpture; W, width; X, exodaenodont lobe profile.

problem has been to duplicate serration or cusp counts by different workers on dental elements. It is almost impossible to define what is meant by a "cusp" when the range of size, shape and position is so great. In this study "cusp" is defined as any symmetrical, generally conical, elevation on a dental element such that it is separate and recognizably distinct from surrounding elevations and surface sculpture. Care will be taken in individual descriptions to mention and discuss typical cusp variation on separate dental elements.

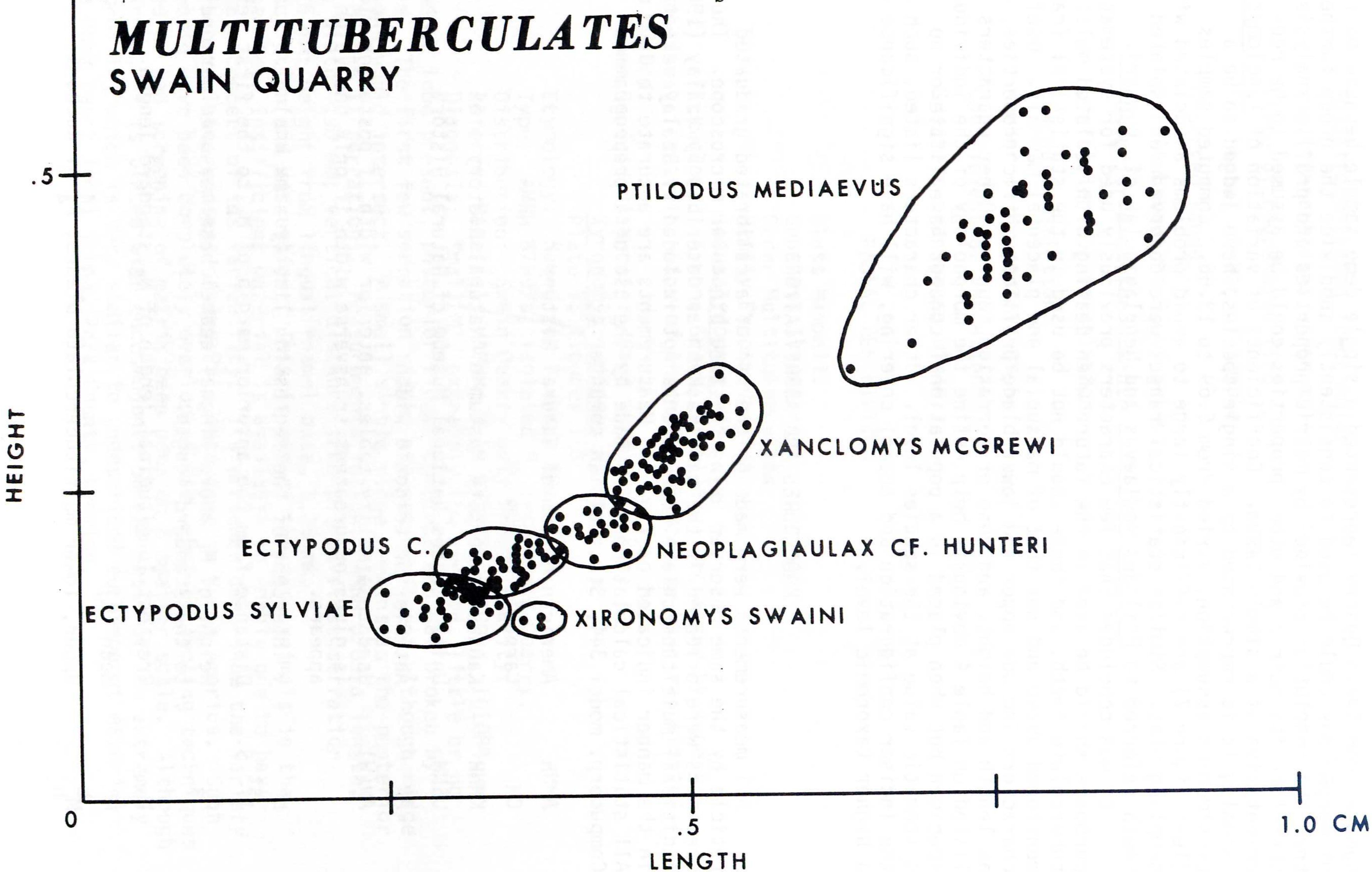
Other characters such as lingual and labial profiles, posterior lingual and labial sculpture, development of the exodaenodont lobe and posterior platform cuspules do not allow themselves to be measured readily. In such cases, the morphologic variation was divided into arbitrary classes which were carefully evaluated to determine the extent and modality of variation. For example, efforts were made to divide the variability observed on the posterior labial cuspule into classes with 1, 2, or 3 cuspules present and whether they are present as cuspules or elongate ridges. This has introduced some subjectivity into observations that were made; to quantify the observations in such a sense as to allow for statistical computations would have been nearly impossible and would have been beyond the scope of this investigation. A randomly selected sample of lower blades from Swain Quarry was compared on the basis of camera-lucida drawings such that a number of specimens could be compared at a time. Where some question was raised as to the homogenity of specific morphologic clusters, all specimen profiles were superimposed onto a single illustration in an effort to delineate camouflaged polymodality within morphologic groupings. Figure 10 illustrates such an attempt to distinguish profile modality in Neoplagiaulax.

The list of multituberculate characters was evaluated by randomly chosen elements of the Swain Quarry fauna to determine what characters could be most useful for systematic, phylogenetic and biostratigraphic discussions. Two basic approaches were used. The first was to evaluate the Swain Quarry sample to determine statistical populations which may represent taxa present in the quarry. And secondly, the variability represented in the Swain Quarry sample was compared with that expected from recent populational samples in order to determine if they do represent similarly recognized taxa.

There have been few studies of recent species which deal with characters similar to those utilized by mammalian paleontologists. Gingerich (1974) mentions several references to studies conducted on primate dentitions. Sylvia F. Graham's (1969) unpublished doctoral dissertation statistically treats dental characters of Didelphis marsupialis. Each of these studies concludes that coefficients of variation of 4 to 6 are expected of most dental metric properties among eutherian and marsupial mammals. Nearly all metric properties of non-multituberculate teeth of Swain Quarry are easily contained within this range of coefficient of variation.

Statistical samples of multituberculate teeth, identified as deme samples here, consistently have ranges of coefficients of variation of 4.5 to 13.5. This observation is what prompted the detailed investigation of dental variability. Because most of the sample is known from isolated teeth, it would have otherwise been difficult to obtain an adequate picture of variability were it not for the presence in the fauna of Xanclomys mcgrewi. Xanclomys is sufficiently diagnostic to eliminate confusion with other multituberculate forms. It was assumed that the

Text-Figure 7. Bivariate plot (standard length/lingual height) of random samples of all Swain Quarry multituberculate taxa (M_b's).



sample from Swain Quarry represented a single deme sample because no piece of morphology could be used to consistently subdivide the group further than the resolution provided by metric properties and profile analysis; therefore its metric and other properties could be assumed to be representative of a single taxon. Coefficients of variation of Xanclomys, assuming it is represented by a single species, here judged to be a parsimonius assumption, varied from 6.69 to 13.66. Computed samples (Text figure 7) are sufficiently large to avoid problems associated with sampling bias. Similar statistical ranges were observed for isolated teeth referred to Ptilodus mediaevus and Neoplagiaulax cf. hunteri.

It was concluded that few characters previously used for systematic purposes should be used in the future when dealing with isolated multituberculate teeth, and these should not be used in the statistical frame mentioned above and not that of marsupial and placental mammals. Useful characters include upper and lower blade profiles, metric properties, such as length and height, and cusp or serration counts. Other characters listed on Table 4 obviously help define the morphology of the individual specimen but when placed in a populational concept have little or no systematic value at the species level. Other characters listed, such as the incisor configuration and enamel covering, will have significance at a higher taxonomic level.

PROCEDURES AND ABBREVIATIONS

All measurements were made by the use of a calibrated graduated reticle by the same observer using the same binocular microscope. The specimens were oriented in the same fashion as described by Szalay (1969). Additional multituberculate measurements not included by Szalay were taken in the manner indicated on fig. 6. Measurements are accurate to 0.05 mm. All statistical calculations were made by the use of a preprogrammed Compucorp, model 344, Statistician computer.

AMNH	American Museum of Natural History
CM	Carnegie Museum
KMNH	Kansas University Museum of Natural History
USNM	United States National Museum of Natural History
AW	Anterior or trigonid width
AW(W)	Used to simplify tables; anterior width if posterior width is given or greatest transverse width if only one value appears.
b	y intercept of the regression line ($y = mx + b$)
1^{st} S.	Distance from the anterior margin of M_b to the first serration
H_3	Height of M_b above lingual enamel base measured perpendicular to the standard length.
L	Greatest longitudinal length of M_b standard length.
M	Mean ($\overline{X}$)
M^b_b	Upper, lower multituberculate blades, P^4_4 of authors.

M_L Nondifferentiated lower molar

M^U Nondifferentiated upper molar

m slope of regression line

N (n), total number of sample

OR Observed range

P_L Multituberculate P_3 of authors

PW Posterior or talonid width

r Coefficient of correlation

s Standard deviation

S.Δ Number of M_b serrations

V Coefficient of variation

W Greatest transverse width

FAUNAL DESCRIPTION

Class Mammalia
Subclass Allotheria
Order Multituberculata
Family Eucosmodontidae
Genus _Xyronomys_, n. gen.

Etymology: Xyron, Greek for blade. Suggested by Robert Sloan, who first identified many of the multituberculate taxa represented at Swain Quarry.

Generic diagnosis: Same as for species.

Xyronomys swainae, n. sp.
Plate 1, figures 1-3

Etymology: Named for Barbara Swain.

Type: AMNH 87897a, isolated M_b from Swain Quarry.

Distribution: Swain Quarry only known locality.

Referred Material: AMNH; M_b's 87897b, 101002d, 101084.

Diagnosis: Small M_b, extremely low crested, little or no exodaenodont lobe present, posterior ridges complete and not broken by sculpture. The first few serration ridges are not confluent although ridge projections would intersect. A small single ridge remains as the posterior shelf. M_b has 11 serrations. Measurements follow: AMNH 87897a length, 2.90 mm; width, .90 mm; vertical distance from pit to first serration (H_2), .75 mm; height from lingual enamel base, 1.25 mm.

Description and discussion: This is one of the rare animals in the quarry sample. Insifficient material is available to enable one to have an adequate concept of its variability. Its presence does show the variety of multituberculates present during Paleocene time in North America. Such a form would have been completely overlooked had other collecting techniques been used or had screening of matrix been done on a smaller scale. Although poorly known, it is placed with eucosmodonts on the basis of its extremely low M_b profile, which is very similar to undescribed eucosmodont material from the Rock Bench local fauna, Park County, Wyoming.

Family Neoplagiaulacidae

Genus Xanclomys, n. gen.

Etymology: Xanclos, Greek for sickle. Suggested by Robert Sloan.

Generic diagnosis: Same as for species.

Xanclomys mcgrewi, n. sp.

Plate 1, figures 4-11; Table 5

Etymology: Named for Paul McGrew.

Type: AMNH 87859, dentary fragment with P_1-M_b from Swain Quarry.

Paratypes: AMNH 87860, dentary fragment with P_1-M_b and alveoli for M_1. AMNH 101018j, isolated M^b and AMNH 101083d isolated M_b.

Distribution: Swain Quarry is the only known locality.

Referred Material: AMNH; M^b's, 87866a-n, 87888a-r, 101017a-r, 101018a-r, 101019a-r, 101020a-h; M^1's 101049f, 101056c, 101058k; M_b's 87857a-p, 101004a-b, 101014a-r, 101015a-r, 101016a-f, 101081a-r, 101082a-p, 101083a-o; M_b fragments, 87558; M_1's 101027g, 101028e, 101030j.

Diagnosis: M_b is sickle shaped with 1 to 3 serrations present high on the anterior face of the tooth with 9 to 13 serrations total. P_L is small, low, and with little enamel on the crown. M^b is subquadrate with a single major elevation comprised of 2 to 4 closely approximating cusps on the posterior portion of the buccal row with 1 to 4 anteriorly descending cusps. The labial row has a single major elevation of 1 to 2 cusps at its most laterally extended portion with cusps descending in magnitude anteriorly and posteriorly. Cusp counts vary 3-7; 4-6.

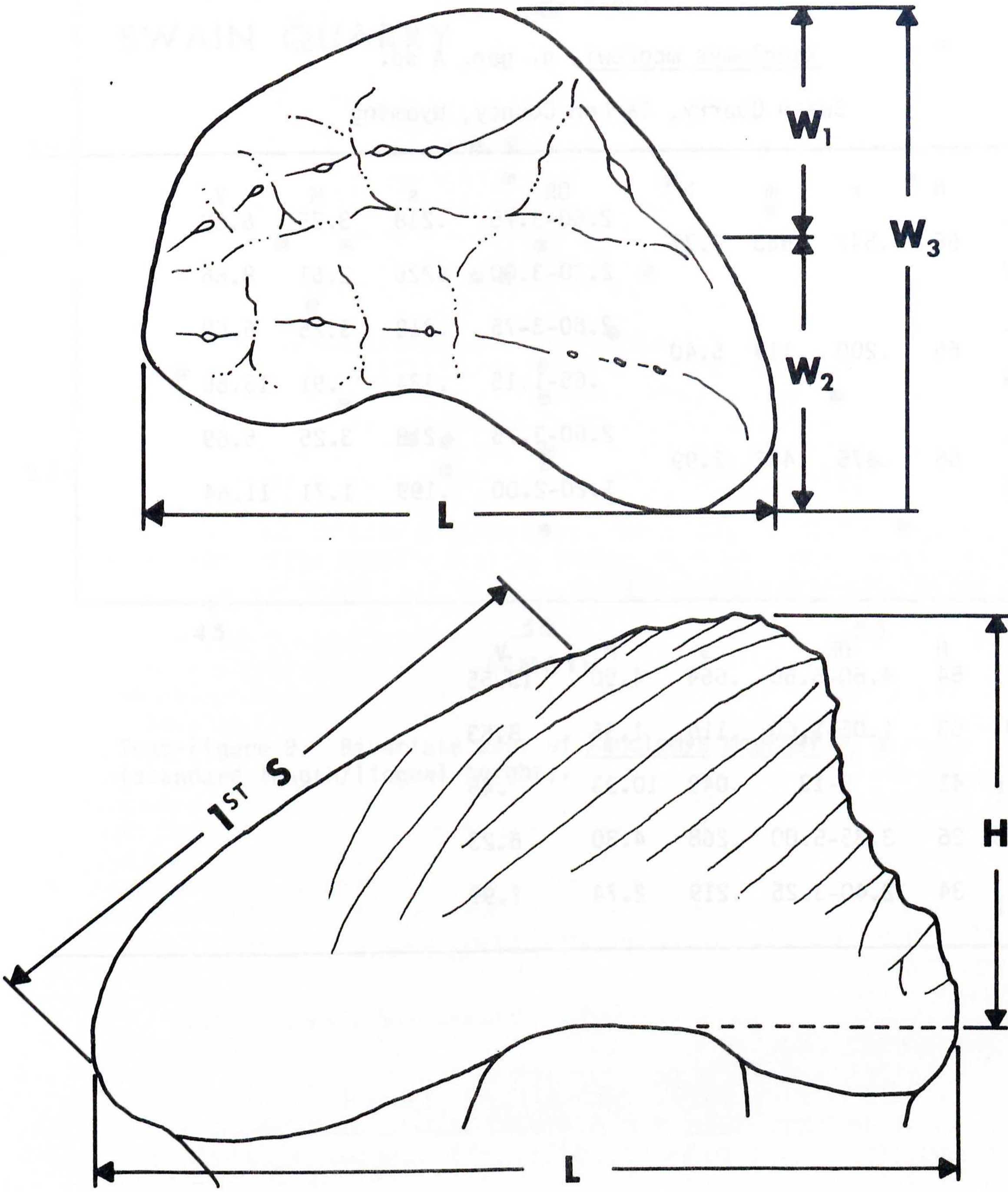
Description: Most molars are probably confused with elements referable to Neoplagiaulax; a small number of molars have been referred but with a query.

M^b is double rooted, the posterior root smaller by comparison. It has straight buccal row and externally arcuate labial row. The buccal row has three portions: an ascending portion comprised of 1 to 3 separate, increasingly higher cusps; an apical portion composed of 2 to 4 closely approximated cusps, forming a massive elongate cone which equals 1/3 the mass of the whole tooth; and a descending portion, which forms the basal buccal termination. The labial row similarly has three portions. The middle portion is the largest and highest, composed of 1 to 2 cusps. It is only 1/2 as high as the massive fused cone formed on the buccal row. The labial row has a posterior ascending portion of 1-2 cusps, which are generally longitudinally straight. Because of the irregular outline of the tooth, width measurements were made buccally and labially from the medial valley. Table 5 shows a buccal, labial and combined width for M^b.

P_L is small, low and almost engulfed by the enormous excavation or pit at the anterior end of M_b.

M_b has a very distinctive shape, with the anterior surface preserving serrations near the apex of the tooth. The first two of these serrations generally have no associated ridge descending from the crest but if some trace is present it is generally deformed, discontinuous and greatly abbreviated. The third or fourth serration maintains a continuous ridge to the base of the tooth. These and other continuous ridges may be interrupted to form a zig-zag pattern on either side or both sides of the tooth. Anterior to the first continuous serration and ridge may be as many as 6 ridges, all discontinuous; they may be primitively continuous, with serrations now obliterated by the rounded and swollen anterior face of the tooth. Two or three of these serrations are preserved as minute cuspules on exceptionally unworn teeth. The wear pattern makes it difficult to obtain serration

XANCLOMYS



Text-Figure 8. Xanclomys mcgrewi M_b^b measurements: 1^{st} S, distance to first serration; L, standard length; H, lingual height; W_1, labial width; W_2, lingual width; W_3, combined width.

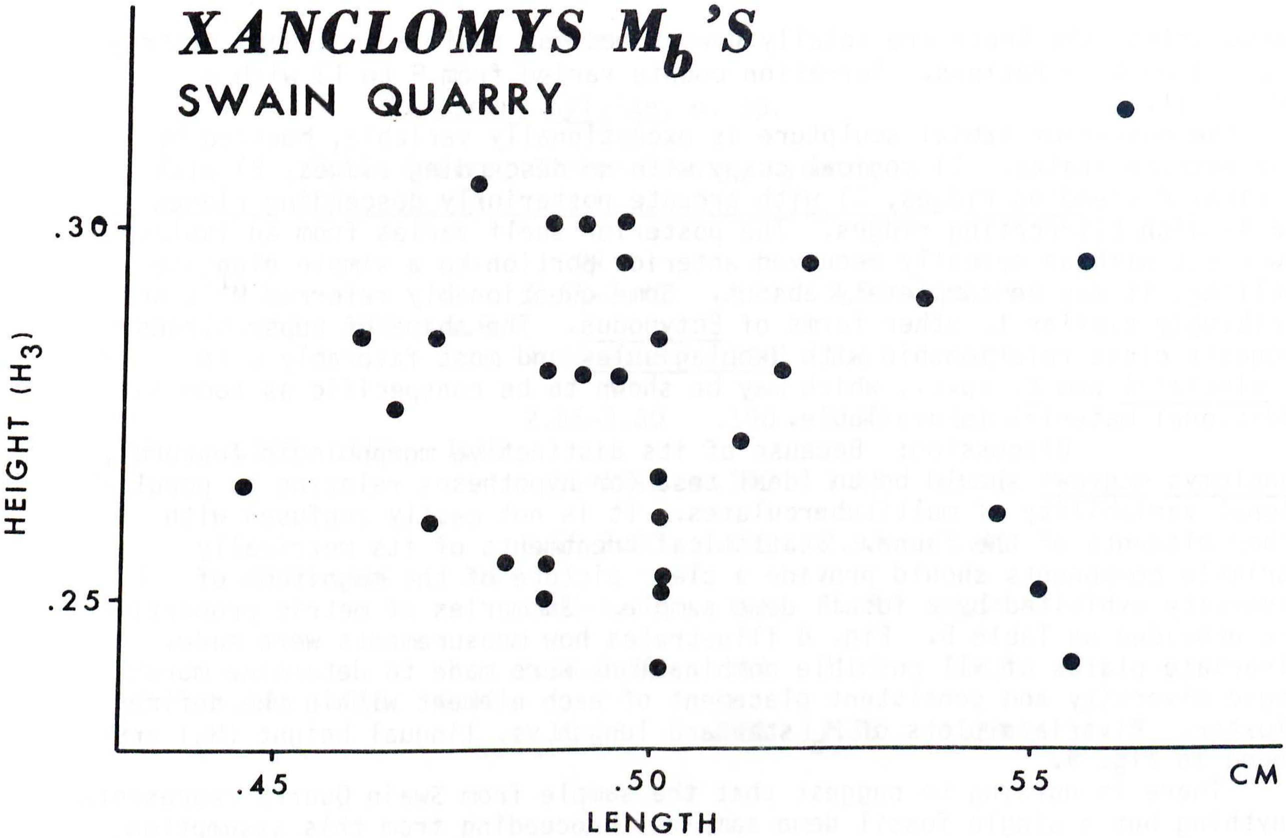
Table 5

Xanclomys *mcgrewi*, n. gen. & sp.

Swain Quarry, Carbon County, Wyoming

M^b	N	r	m	b	OR	s	M	V
L					2.60-3.75	.218	3.25	6.69
	66	.547	.563	7.77				
W					2.20-3.00	.226	2.61	8.66
L					2.60-3-75	.218	3.25	6.69
	66	.200	.113	5.40				
Ex.W					.65-1.15	.124	.91	13.66
L					2.60-3.75	.218	3.25	6.69
	66	.475	.432	2.99				
In.W					1.20-2.00	.199	1.71	11.64

M_b	N	OR	s	M	V
L	54	4.60-5.60	.664	4.90	13.55
W	53	1.05-1.60	.116	1.36	8.53
S.#	41	9-13	.049	10.93	.45
1st S.	26	3.85-5.00	.268	4.30	6.23
H_1	34	2.40-3.25	.219	2.74	7.99



Text-Figure 9. Bivariate plot of Xanclomys mcgrewi M_b's (standard length/lingual height).

counts unless the teeth are totally unworn because rapid apical wear destroys traces 3 or 4 serrations. Serration counts varied from 9 to 13 with a mode of 11.

The posterior labial sculpture is exceptionally variable, bounded by four extreme states: 1) conical cusps with no descending ridges, 2) with vertical descending ridges, 3) with arcuate posteriorly descending ridges and 4) with bifurcating ridges. The posterior shelf varies from an isolated low crest with an apically recurved anterior portion to a simple elongate swelling; it may be completely absent. Some questionably referred M^1's are strikingly similar to other forms of Ectypodus. The shape of upper blades suggests close relationship with Neoplagiaulax and most favorably with E. sinclairi and E. sp.c., which may be shown to be conspecific as soon as additional material is available.

Discussion: Because of its distinctive morphologic features, Xanclomys mcgrewi should be an ideal test for hypotheses relating to populational variability of multituberculates. It is not easily confused with other elements of the fauna. Statistical treatments of its metrically variable components should provide a clear picture of the magnitude of diversity exhibited by a fossil deme sample. Summaries of metric properties are provided on Table 5. Fig. 8 illustrates how measurements were made. Bivariate plates of all possible combinations were made to determine morphologic diversity and consistent placement of each element within the defined cluster. Bivariate plots of M_b standard length vs. lingual height (H_3) are found in fig. 9.

There is nothing to suggest that the sample from Swain Quarry represents anything but a single fossil deme sample. Proceeding from this assumption, one can evaluate morphologic characters exhibited by the taxon to determine if it represents comparable diversity to that exhibited by recent deme samples. Coefficients of variations are found in Table 5, and are substantially larger than present deme diversity observable in marsupial and placental mammals. Lower blade profile analysis is consistantly unimodal, as are all other observable characters taken from Table 5. I suggest that metric properties of multituberculates should not be considered in the context of variability observed for other groups of mammals. A greater degree of variation is expected in metric properties of multituberculates, with coefficients of variation of 4-5 exceeded, depending on the measurement made.

Genus Ectypodus Matthew and Granger, 1921

Matthew and Granger 1921, p. 1

Ectypodus sylviae, n. sp.

Plate 1, figures 12-17; Table 6

Etymology: Named for Sylvia R. Graham, who aided M. C. McKenna's early field work at Swain Quarry. The name was suggested by R. E. Sloan.

Type: AMNH 100939e, isolated M_b from Swain Quarry.

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH M^b's, 87895a-o; M^1's,101087b, g-h; 100490 dentary fragment with M_b; M_b's, 87864a-r, 100934a-r, 100936a-r, 100937a-r, 100938a-r, 100940a-d, f-r, 100941a-k, 100942a-h, 100943a-r, 100944a-r, 100945a-l, 100994a-e; M_1's, 101025c, f, 101028a-b; M_2's, 87884e, 101032a-b.

Diagnosis: M^b short, petultimate cusp highest; a steep straight posterior slope. There are 4 major cusps on the external row with 1-2 small questionable posterior swellings. M_b is small with an extremely

Table 6

Ectypodus sylviae, n. sp.

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
	L					2.55-3.30	.190	2.93	6.49
M_b		20	.352	.520	1.09				
	H_3					1.45-2.05	.280	1.63	7.17
	L					2.55-3.30	.190	2.93	6.49
		20	.205	.158	7.15				
	W					.85-1.40	.146	1.18	13.60
	L					2.55-3.30	.190	2.93	6.49
		20	.489	.416	.08				
1st	S.					1.00-1.65	.161	1.28	12.59
	L					2.55-3.30	.190	2.93	6.49
		20	-.106	-.016	6.16				
	S.#					10-12	.029	11.35	.28
	L					1.70-2.20		2.01	
M_1		4							
	W					.85- .90		.86	
	L					1.35-1.50		1.43	
M_2		3							
	W					1.10-1.30		1.20	
M^b	L	4				2.00-2.50		2.25	
	W					.85-.95		.89	
	L					2.65-2.40		2.77	
M^1		3							
	W					1.25-1.30		1.27	

high, even arcuate profile and a persistant posterior labial cuspular shelf. Cusp formulae follow: M^b 4-6:7-9, Mode 4:8, M^1-:11-12:9, mode -:11:9; M^2 1:4:2; M_b 10-12, Mode 11; M_1 8-10:5-6, mode 10:6; M_2 4:2.

Description: The species is diagnosed on upper and lower blade characteristics because the remainder of the dentition is so similar to a variety of other related forms. The M^b is diagnostic in its small size, steep posterior slope, slightly convex anterior slope and the presence of at least 4 well-defined conical cusps in the external row. Two specimens, AMNH 87895b and n, may not belong to E. sylviae because they show lesser height and a more gentle posterior slope. They may represent elements of Xyronomys. There is little of the antero-posterior bending or warp characteristic of related forms and all cusps remain simple and conical.

M_b has a diagnostic circular profile and modally has 11 serrations. The posterior labial cuspule is variable between two cuspiform swellings and a simple elongate crest confluent with the posterior portion of the major blade row. There may be a slight beveling on the posterior profile and for this reason the form is associated with Ectypodus rather than Neoplagiaulax. The exodaenodont lobe is highly variable, as is the posterior lingual and labial sculpture. A general trend can be seen in the retention of some portions of a primitive bifurcating ridge system as anterior and posterior ridges which fuse apically at individual serrations. E. sylviae selectively preserves most of the anterior set in parallel, as do most multituberculates. The posterior third of the tooth may show considerable portions of the posteriorly directed ridge set or may show neither set, in which case the cusps are simple, inflated, and conical.

Upper molars show a considerable degree of distortion in which lingual and labial portions are oppositely rotated about an axis parallel to the main central groove. The extreme internal row is exceptionally variable and cusps may be fused into a single crest or may be represented by as many as 5 questionable cusps. Because of its excessive variability, it has been eliminated from diagnostic cusp formulae. The medial row is comprised of elongate cusps with anterior and posterior buttress ridges. The external row has a similar arrangement, with elongate cusps being subdivided but only one per cusp. M^2's are indistinguishable in configuration from those of other species and isolated specimens are separated on metric properties alone.

M_1 and M_2 are so very similar to other Paleocene forms that description would be repetitive. They are referred to E. sylviae on the basis of metric properties and relative frequency of occurrence to that of upper and lower blades in the fauna.

Discussion: When compared with other forms, certain characters can be regarded as primitive, such as the retention of at least 4 cusps in the exterior row of M^b, a character shared with forms of Mesodma, E. laytoni, and possibly E. sloani. Such a character conversely eliminates it from lineages where the feature would necessarily be lost and regained at least once.

Lower blade profile can be shown to be diagnostic. Its importance should not be exaggerated and should not be used in the sense that any slight variation should represent a different taxon. The profile shows similarities with mentioned forms and with an undescribed form from the Shotgun member local fauna of central Wyoming. I believe that this group, (E. sylviae, E. laytoni, E. sloani) represents a monophyletic group separate and distinct from Neoplagiaulax and Ectypodus. It may at some point be formally recognized as generically separate, diagnosed by the high arcuate nature of the M_b, which is distinct and separate from the posterior straight bevel of Ectypodus sp. c. and from the even, arcuate low profile of Neoplagiaulax. Such designation is not made at this time, however, in deference to the work being conducted by Robert Sloan.

Ectypodus sp. c., n. sp. (not named)

Plate 1, figs. 18-20; 11, figs. 1-3; 111, figs. 1-3; Table 7

Distribution: Swain Quarry, and undescribed Torrejonian forms from the Nacimiento Formation, San Juan Basin, New Mexico, currently under study by Robert Sloan.

Referred Material: AMNH 87900, maxilla fragment with p^{1-3} showing fused roots; M^b's, 101064a-h, 101065a-o, 101071a-r, 101073a-r, 101074a-r, 101075a-c, 101076a-r; M^1's, 87890a-r, 87891a-f, 101048f-k, 101049a,j-n; 101050a-b, 101051a-f, 101052a-g, 101053c-e, 101054a-f, 101055c-g, i, 101056a-b, 101057a, c-f, 101058a-b, e-f, j, l-o, q-r,; M^2's, 87878a-c, 87883a-e, 101059c-d, 1; 87852, dentary fragment with M_1; 87853, dentary fragment with M_b; 87855, dentary fragment with ?P_1-M_1; 87856, dentary fragment with I-M_b; 87867, dentary fragment with M_1; 87898, dentary fragment with broken $M_b M_1$; 100489, dentary fragment with M_2; M_b's, 87854a-r, 87863a-r, 100964a-r, 100965a-h, 100966a-h, 100967a-r, 100968a-r, 100969a-r, 100970a-r, 100971a-r, 100972a-f, 100973a-r, 100974a-r, 100975a-r, 100976a-r, 100977a-r, 100978a-r, 100979a-r, 100980a-r, 100981a-r, 100982a-r, 100983a-r, 100984a-r, 100985a-n, 100986, 100987a-g, 100988a-r, 100989a-r, 100990a-f, 100991a-r, 100992a-r, 100993a-e, 101000a-r, 101001a-r, 101002a-n, p-q, 101003a-n; M_1's 87874c-n, 87879, 87880, 87881a-b, 101022b, 101023a-g, 101024a-e, 101025a-b, a, p, 101026a-c, 101027a-c, h, 101028c-d, 101029a-h, m, 101030b-e, k; M_2's, 87884a-d, f-g, 101033a-b, d, 101034a, e, g, i, j.

Description: M_b is similar to other neoplagiaulacids, with the ultimate or pentultimate cusp being highest. The anterior crest is slightly convex; the posterior slope is not steep and has a variably expanded base possessing 1 to 2 small cuspules. M_b is posteriorly beveled and has a truncated profile producing a straight posterior slope. Upper and lower molar teeth are not morphologically diagnostic. Metric properties do have limited systematic significance. Cusp formulae are as follows: M^b 1-4: 6-9, mode 2:7; M^1 -:7-10:10-13, mode -:9:11; M^2 -:5-6:2-3, mode -:5:2; M_b 10-13, mode 11-6; M_2 1:3-5:3-4, mode 1:3:4.

Most molars are remarkably similar to those of other small Paleocene multituberculates. They have been separated in the Swain Quarry collection on the basis of size and gross morphology. Groups so defined were related to other elements of the dentition on the basis of their relative frequency of occurrence in the collection when associated material was lacking.

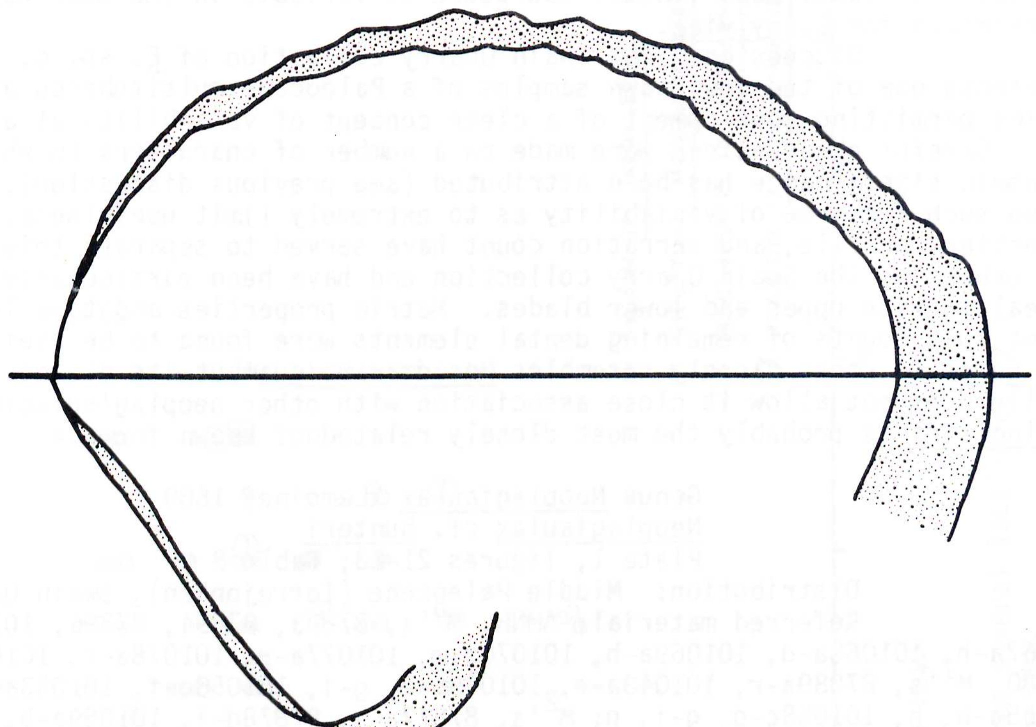
M^b is variable and the sample has been studied extensively to determine if some additional phenon's presence could be masked by inadequate associated material. No additional forms were found by using metric statistical treatments of various parameters, profile analysis and careful observation made on such characters as posterior lingual and labial sculpture, serration count, shape and nature of the posterior labial cuspule, ridge continuity, and serration shape. Although variable, the profile has the characteristic straight posterior edge, which may vary considerably in the angle it forms with the enamel base. This may cause small blades to be confused with E. sylviae. Care should be taken in the analysis of the profile because variation in serration count may produce an anterior serration that forms a strong vertical anterior edge. Some may consider this phenomenon as sufficient evidence to be diagnostic of a new taxon. The evidence from

Table 7

Ectypodus c. n. sp. (not named)

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M_b	L	53	.412	.513	1.18	3.05-3.80	.202	3.40	5.93
	H					1.60-2.10	.260	1.92	13.54
	L	52	.457	.332	.63	3.05-3.80	.199	3.39	5.88
	W					.95-1.40	.144	11.89	12.11
	L	54	.344	.319	2.94	3.05-3.80	.201	3.39	5.90
1st S.						.85-1.85	.186	13.77	13.51
	L	52	-.124	-.019	6.32	3.05-3.80	.199	3.39	5.88
S.#						10-13	.030	11.38	.26
M_1	L	43	.604	.301	2.99	2.25-2.95	.169	2.66	7.49
	W					.95-1.30	.084	1.10	7.64
M_2	L	8				1.75-1.85		1.78	
	W					1.25-1.50		1.43	
M^b	L	25	.358	.249	4.01	2.15-2.60	.119	2.44	4.88
	W					.80-1.15	.083	1.08	7.68
M^1	L	57	.464	.187	7.67	3.00-3.60	.173	3.28	5.27
	W					1.25-1.50	.070	1.38	5.07
M^2	L	11	.774	.706	3.21	1.35-1.70	.111	1.50	7.40
	W					1.20-1.55	.101	1.38	7.32



Text-Figure 10. Neoplagiaulax labial profile analysis of M_b. Neoplagiaulax M_b profiles were superposed; oriented by the anterior margin and standard length. Two extremes of the Swain Quarry sample are figured here with the stippled area representing other profiles. Profiles appear X30.

the Swain Quarry sample does not support such an assumption.

Other characters are also variable. The posterior labial cuspule may be present as a single elongate crest or as three small cuspules. The posterior labial and lingual sculpture is variable in the same ways as described for *E. sylviae*.

Discussion: The Swain Quarry collection of *E.* sp. c. represents one of the few known samples of a Paleocene multituberculate species permitting development of a clear concept of variability at a single site. Careful observations were made on a number of characters to which taxonomic significance has been attributed (see previous discussion). Most showed such a degree of variability as to extremely limit usefulness. Metric properties, profile, and serration count have served to separate this taxon from others on the Swain Quarry collection and have been particularly useful in dealing with upper and lower blades. Metric properties and to a lesser extent cusp counts of remaining dental elements were found to be useful.

E. sp. c. most closely resembles *Mesodma ambigua* but its diagnostic profile does not allow it close association with other neoplagiaulacids. *E. sinclairi* is probably the most closely related of known forms.

Genus *Neoplagiaulax* Lemoine, 1880

Neoplagiaulax cf. *hunteri*

Plate 1, figures 21-23; Table 8

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred material: AMNH, M^b's, 87893, 87894, 87896, 101066a-c, 101067a-h, 101068a-d, 101069a-h, 101070a-m, 101077a-r, 101078a-r, 101079a-r, 101080; M^1's, 87889a-r, 101048a-e, 101049b-e, g-i, 101050c-f, 101053a-b, f-g, 101055a-b, h, 101058c-d, g-i, p; M^2's, 87877a-j, 87878d-i, 101059a-b, e-k, m-o; 87861, dentary fragment with M_b, 100963, dentary fragment with M_b; M_b's 87862a-r, 100946a-c, 100947a-i, 100948a-m, 100949a-l, 100950a-r, 100951a-r, 100952a-r, 100953a-d, 100954a-r, 100955a-r, 100956a-r, 100957a-r, 100958a-r, 100959a-r, 100960a-q, 100961a-r, 100962a-l, 100995a-r, 100996a-r, 100997a-r, 100998a-r, 100999a-r, 101085; M_1's 87874a-e, 87882, 101022a, c, f, 101027d-f, i-k, 101028f-n, 101029i-l, n-r, 101030a, f-i, l-r, 101021; M_2's 101031, 101033c, 101034b-d, f, h.

Discussion: An obviously close relationship exists between *N. hunteri* of Tiffanian deposits and the Swain Quarry sample. The range of variability observed at Swain Quarry overlaps that found in Tiffanian localities of the Crazy Mountains, Montana. This overlap precludes subdividing a sequence of related deme samples from a variety of localities into different taxa, even though the Swain Quarry form is slightly smaller, modally possession one less lower blade serration and one less upper blade external row cusp.

Family Ptilodontidae

Genus *Ptilodus* Cope, 1881

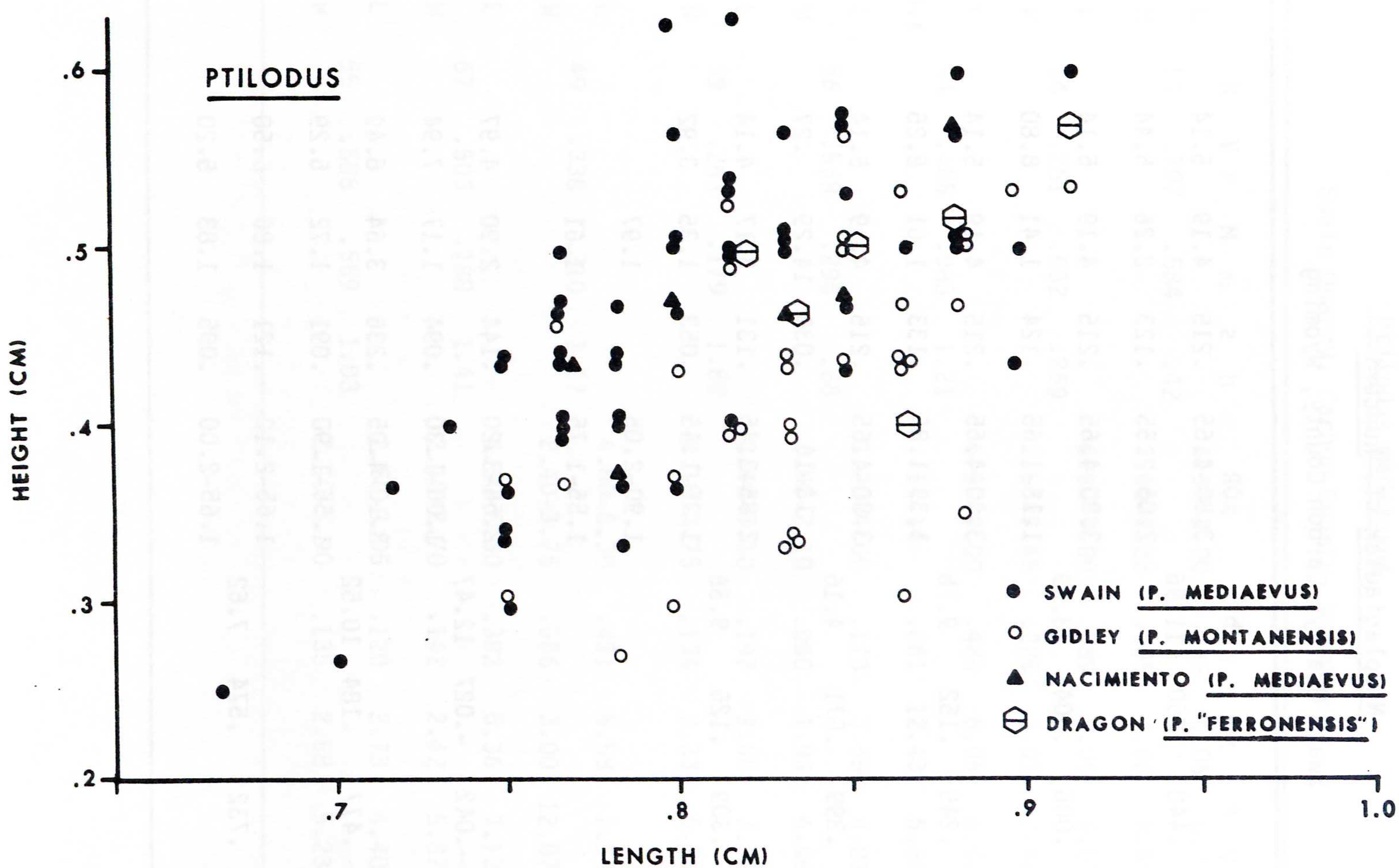
Ptilodus Cope, 1881a, p. 921
Chirox Cope, 1884, p. 321

Ptilodus mediaevus Cope, 1881

Plate 11, figs. 4-6; Table 9

Ptilodus mediaevus Cope, 1881a, p. 921
Chirox plicatus Cope, 1884, p. 321
Ptilodus plicatus (Cope): Gidley, 1909, p. 614
Ptilodus ferronesis Gazin, 1941, p. 10

Type: AMNH 3019, a lower M_b from the middle Paleocene (Torrejonian) of the San Juan Basin, New Mexico.



Text-Figure 11. Comparison of Ptilodus M_b's from several localities by a bivariate plot of standard length vs. lingual height.

Table 8

<u>Neoplagiaulax</u> cf. <u>hunteri</u>

Swain Quarry, Carbon County, Wyoming

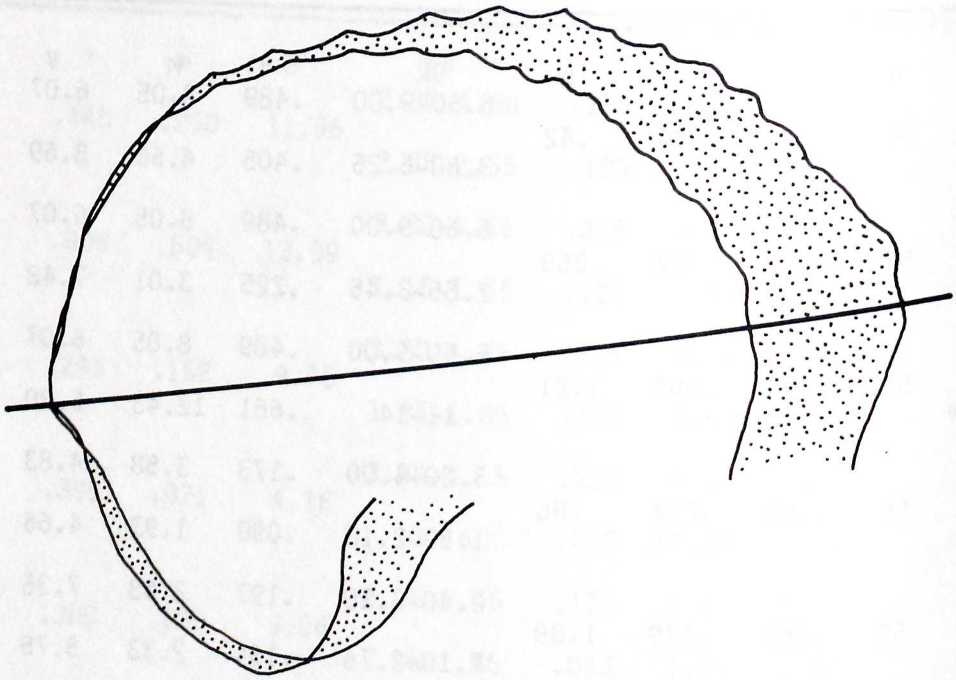
		N	r	m	b	OR	s	M	V
M_b	L	28	.440	.250	11.96	3.80-4.65	.215	4.19	5.14
	H					2.05-2.55	.123	2.26	5.44
	L	28	.006	.604	13.99	3.80-4.65	.215	4.19	5.14
	W					1.15-1.65	.124	1.41	8.80
	L	28	.245	.152	9.75	3.80-4.65	.215	4.19	5.14
	1st S.					1.35-1.85	.133	1.61	8.25
	L	28	.399	.071	4.16	3.80-4.65	.215	4.19	5.14
	S.#					13-16	.039	14.29	.27
M_1	L	40	.309	.125	9.56	2.85-3.45	.131	3.17	4.14
	W					1.25-1.45	.053	1.35	3.92
M_2	L	9				1.90-2.05		1.97	
	W					1.55-1.75		1.61	
M^b	L	23	-.042	-.027	12.47	2.65-3.20	.144	2.90	4.97
	W					1.00-1.30	.094	1.17	7.94
M^1	L	24	.477	.184	10.52	3.10-4.05	.236	3.64	6.49
	W					1.55-1.90	.091	1.72	5.29
M^2	L	27	.732	.574	7.62	1.65-2.10	.121	1.86	6.50
	W					1.65-2.00	.095	1.83	5.20

Table 9

Ptilodus mediaevus

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M_b	L	54	.707	.584	.42	6.60-9.00	.489	8.05	6.07
	H					3.60-5.25	.405	4.66	8.69
	L	54	.251	.052	.259	6.60-9.00	.489	8.05	6.07
	W					2.55-3.45	.225	3.01	7.48
	L	54	.405	.083	1.21	6.60-9.00	.489	8.05	6.07
	S.#					11-14	.661	12.43	5.30
M_1	L	56	.569	.296	.86	3.20-4.00	.173	3.58	4.83
	W					1.80-2.10	.090	1.93	4.66
M_2	L	59	.263	.179	1.89	2.40-3.10	.197	2.68	7.35
	W					2.10-2.75	.134	2.33	5.75
M^b	L	49	.338	.310	1.27	4.80-6.30	.421	5.58	7.54
	W					2.40-3.75	.386	3.00	12.87
M^1	L	67	.503	.188	1.41	4.50-6.30	.382	5.36	7.13
	W					2.10-2.70	.142	2.42	5.87
M^2	L	55	.505	.569	1.03	2.50-3.05	.120	2.73	4.40
	W					2.40-3.90	.135	2.58	5.23



Text-Figure 12. Ptilodus M_b labial profile analysis. Ptilodus M_b profiles were superposed; oriented by the anterior margin and standard length. Two extremes of the Swain Quarry sample are figured here with the stippled area representing other profiles. Profiles appear x12.

Distribution: Middle Paleocene (Torrejonian): Nacimiento Formation, San Juan Basin, New Mexico; Swain Quarry, Fort Union Formation, Washakie Basin, Wyoming; Dragon Local Fauna, Joe's Valley Member, North Horn Formation, Emery County, Utah; Black Peaks Formation, Big Bend National Park, Texas.

Referred material: AMNH 87829, maxilla fragment with P^{2-3}; 87832, maxilla fragment with P^{2-3}; 87833, maxilla fragment with P^{1-2}; 100495, maxilla fragment with P^{2-3}; 100499, maxilla fragment with P^{2-3}; P^1's, 87840, 45 isolated teeth, 87837, 169 isolated teeth; P^2's, 87841, 50 isolated teeth; P^3's, 87843, 24 isolated teeth, 87844, 135 isolated teeth; 87842, 324 unsorted upper premolars; M^b's, 87830, 87850, 87851, 100882, 100883, 100884a-b, 100885a-b, 100886a-r, 100887a-r, 100888a-c, 100889a-n, 100890a-n, 100891a-h, 100894a-c, 100895a-h, 100896a-n, 100897a-b, 100898a-h, 100899a-f, 100900a-d, 100901a-k, 100902a-l, 100903a-q, 100904a-p, 100905a-c, 100906a-n, 100907a-m; M^1's, 87839a-p, 100892a-r, 100893a-f, 100908a-i, 100909a-n, 100910a-l, 100911, 100912, 100913a-i, 100914a-n, 100915a-k, 100916a-n, 100918a-g, 100919a-g, 101062a-r, 101063a-i; M^2's, 87848a-r, 100920a-f, 100921, 100922, 100923a-k, 100924a-r, 100925a-m, 100926a-r, 100927a-r, 100928a-r, 100929a-r, 100930a-r, 100931a-r, 100932a-r, 100933a-e, 101011, 101012, 101013; 83001, dentary fragment with P_L-M_b; 83002, dentary fragment with D1, 1-M_b; 87831, dentary fragment with P_L; 87845, dentary fragment with M_b; 87846, dentary fragment with M_b; 87889, dentary fragment with P_L-M_b; 100496, dentary fragment with M_b; 100497, dentary fragment with P_L-M_b; 100498, dentary fragment with M^b; 100500, dentary fragment with M_b; 100501, dentary fragment with M_b; P_L, 87847; M_b's 87835a-l, 87836a-l, 87841a-l, 87842a-l, 87843a-l, 87844a-l, 100845a-d, 100846a-g, 100847a-l, 100848a-l, 100849a-l, 100850a-l, 100852a-l, 100853a-l, 100854a-l, 100855a-l, 100856a-l, 100857a-l, 100859a-l; 87834, 259 broken M_b's; 87849, broken M_b's; 101038, broken M_b's; M_1's, 87876, 100860, 100861, 100862, 100863a-r, 100864a-r, 100865a-r, 100866a-r, 100867a-r, 100868a-r, 100869a-r, 100870a-r, 100871a-r, 100872a-r, 100873a-b, 101006, 101007, 101008a-q, 101009a-q; M_2's, 87838a-h, 87865a-r, 87885a-f, 100874a-g, 100875a-j, 100876a-r, 100877a-r, 100878a-r, 100879a-r, 100880a-r, 100881a-e, 101010a-c.

Description: Until the Swain Quarry and Big Bend National Park collections were made, little additional material of P. mediaevus had been recovered outside of the San Juan Basin. Known specimens were reviewed by Matthew (1937). The twenty or so specimens were scattered among several localities, not one of which produced more than six specimens of the same dental element. The Swain Quarry collection contains more than 2,500 dental elements referred to P. mediaevus in addition to a large amount of broken, uncatalogued material. The amount of material allows one to make confident statements about its variability.

The upper premolars, although not treated statistically, agree closely with those of AMNH 3033, the type specimen of P. mediaevus. There are a number of anomalous premolars in the collection that remain unstudied.

The upper blade has a variable external row of cuspules which vary from two prominent, well-developed cusps with three accessory cuspules to two poorly developed cuspules. Such variability assuredly removes the character from specific significance. Cusp counts on the middle and external rows vary. Middle row counts vary from 2 to 8 with a mode of 5. The variability is concentrated in two separate locations at the anterior and posterior portions of the row. The anterior part may be truncated by premature confluence with the external row or it may be elongated to produce up to three additional cusps, although most specimens preserve only

1 cusp anterior to the first of two major cusps in the row. Posteriorly, the row may end abruptly or may continue the full length of the tooth with cuspules decreasing in size posteriorly. As many as five have been observed. The internal row is much more consistent in its cusp count, varying from 7 to 10 with a mode of 8. The variability has an anterior and posterior locus. The definition and separation of cusps and their respective buttresses ascending to the apex of the first and last cusps of the row are the major points of variability.

M^2 displays similar variation. The external row may be a simple ridge or may consist of up to six variably developed cuspules. The middle row generally has three cusps or, less frequently, four, controlled by the degree of separation of the anterior buttress. The internal row may be expressed by a simple ridge with several swellings or as many as 4 distinct cusps.

The large lower incisor is distinctive. There are nearly 3,000 isolated multituberculate incisors and many more fragments of anterior teeth that remain uncatalogued. Szalay (1965) referred AMNH 83003 to P. wyomingensis, which I believe to be an error. Large multituberculate incisors with perfectly elliptical cross-sections, referable to P. mediaevus and P. montanensis, and forms described by Jepsen (1940) as belonging to P. wyomingensis, having the diagnostic feature of the sharp internal angle bend or ridge, have been found in the Swain Quarry collection in addition to all intermediate forms. There is very little evidence to support the hypothesis that both P. mediaevus and P. wyomingensis are present in the fauna. Although the study is incomplete, there seems little validity in maintaining P. montanensis and P. wyomingensis as separate taxa and future collections may even reveal that these two forms are conspecific with P. mediaevus.

The P_1 is simple and has an enamel-covered crown but is indistinguishable from other forms of Ptilodus.

Most systematic attention has been given to the lower blades. The Swain Quarry sample poses a problem that will have to be investigated further. It is possible to make exact comparisons with each specific type specimen as presently contained within the genus Ptilodus sample from Swain Quarry. It seems highly improbable that all four species (P. mediaevus, P. wyomingensis, P. montanensis and P. ferronensis) are represented in the sample but more probable that the collection represents a sufficiently sampled population to include rare elements of its variation. It can now be shown that characters once thought to define discrete taxa (i.e. posterior blade sculpture, position and height of the first serration and slope of individual serrations and ridges) can no longer be taken as indicative of unique morphology limited to a single species.

For example, size of various dental elements, upper and lower blade profiles, cusp counts and various other bits of morphology have been used to define species. The Ptilodus sample from Swain Quarry was evaluated by the use of characters found on Table 4. It soon became evident that P. ferronensis should not be separated from P. mediaevus because the characters used by Gazin (1941), size, serration count, medial basal lobe expansion and profile, are totally within the range of variability of P. mediaevus even though selective collecting techniques may have produced a sample larger in size from the Dragon locality. "P. ferronensis" is synonomized with P. mediaevus. Although evidence strongly supports the synonym of P. wyomingensis with P. montanensis such action is not taken at this time pending further study.

M_b metric properties for several characters are summarized in Table 9.

Serration counts range from 10 to 14 for the total sample but the random sample from the collection, from which Table 9 is generated, records 11 to 14. The variability occurs in the definition of the first serration, whether a small ridge is present or absent, and in the definition of the last serration, which is a variably differentiated buttress continuous with the rudimentary external row. Blade profile can also be shown to vary between the limits shown in Text figure 12. From the analysis of lower blades, there is but a single species of Ptilodus present in the Swain Quarry fauna.

M_1 is of the typical shape and size with cusp counts varying 5-6:4-5. The separation of the anterior and posterior buttresses again accounts for the variation.

M_2 is similar to other Ptilodus samples with cusp counts varying 2:3-5. The definition of the posterior buttress causes the variation.

Subclass Theria
Order Marsupialia
Family Didelphidae
Genus Peradectes Matthew and Granger, 1921

Peradectes Matthew and Granger, 1921, p. 1

Peradectes, n. sp. (not named)
Table 10

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred material: AMNH M^1's, 100415a-b, 100417b, 100451a, 101087; M^2's, 100416a-c, 100417c; M^3, 100417a; M_1 101088; M_2 100411; M_3's, 100344a, 100412, 101088b; M_4's, 100344b, 100623, 101086.

Description: The Swain Quarry form is quite similar to P. pusillus from Puercan deposits of the San Juan Basin and in most characters is intermediate between that form and P. pusillus and the lower molars have similar but anteriorly expanded and wider trigonids. The mataconids and protoconids more nearly approach each other in size in the Swain Quarry form. The paraconids are more medially located and anteriorly protruding with a paralophid notch, the lowest part of the crest, more externally displaced. Upper molar morphology is similar to other known North American Paleocene marsupials, is very similar to both P. pusillus and P. elegans, and can be best described as being intermediate in most characters between the two forms.

Discussion: A new species is not named at this time because of the lack of associated material. It is sometimes difficult to distinguish isolated dental elements and relate them to a particular position in a dental row. Marsupial dentitions are particularly difficult in this regard, with the possible exception of M_1 and M_4 designation. Table 10 should therefore be considered with some reservation.

Subclass Eutheria
Order Insectivora
Family Leptictidae
Genus Prodiacodon Matthew, 1929

Diacodon: Matthew and Granger, 1918, p. 576

Prodiacodon Matthew, 1929, p. 171 (=Palaeolestes Matthew and Granger, 1918, preoccupied)

Palaeictops Van Valen, 1967, p. 232

Prodiacodon cf. puercensis
Table 11

Table 10

Peradectes, n. sp. (not named)

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
100451a	M^1	2.00	2.05	
100415b	M^1	2.05	2.05	
100417b	M^1	1.80	2.10	
101087	M^1	1.95	2.10	
100416b	M^2	2.00	2.05	
100416c	M^2	2.05	2.20	
100417c	M^2	1.70	2.40	
100417a	M^3	2.30	2.80	
101088a	M_1	2.15	1.25	1.25
100411	M_2	2.05	1.05	1.10
101088c	M_2	1.95	1.25	1.10
100344a	M_3	1.90	1.25	1.30
100412	M_3	2.15	1.25	1.25
101088b	M_3	2.15	1.30	1.25
100344b	M_4	1.95	1.20	
100623	M_4	2.00	1.10	
101086	M_4	2.05	1.10	

Table 11

<u>Prodiacodon</u> cf. <u>puercensis</u>

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	AW	PW
100315a	M_L*	3.20	2.55	2.05
100315b	M_L	3.10	2.30	2.00
100315c	M_L	3.00	2.65	1.80
100315d	M_L	3.20	2.30	2.00
100315e	M_L	3.20	2.25	2.25
100315f	M_L	2.95	2.40	1.95
100315g	M_L	3.15	2.50	2.00
100315h	M_L	3.20	2.50	2.00
100315i	M_L	2.95	2.35	2.10
100315j	M_L	3.30	2.40	2.25
100315k	M_L	2.75	2.20	1.85
100315l	M_L	3.00	2.40	1.95
100315m	M_L	3.15	2.70	2.05
100315n	M_L	3.00	2.50	1.90
100326	M_3	3.50	2.50	2.00
100336	M_3	3.45	2.40	1.80
100388a	M_3	3.50	2.20	1.70
100388b	M_3	3.40	2.20	1.60
100388c	M_3	3.30	2.10	1.50

*M_L denotes M_1 or M_2. Position in the tooth row is uncertain.

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred materials: AMNH $P^{?2}$, 100829; $P^{?3}$'s, 100830a-c; P^4, 100831; M^1's, 100823a-b; M^2's, 87708, 100833; M^3's, 100483, 100834a-b; M^U's, 100458a-o, 100791a-i; ?DP^3, 100828; ?DP^4, 100477; P_4's, 100320, 100321, 100324, 100677a-m; M_L's, 100315a-n, 100316a-b, 100317, 100318a-c, 100319, 100322a-b, 100323, 100328, 100329a-b, 100389a-g, 100654a-j; M_3's, 100325, 100326, 100327, 100336, 100388a-c, 100655, 100568, 100721; ?DP_4's, 100676a-g.

Description and discussion: The sample from Swain Quarry consists totally of isolated teeth that have been referred to *P. puercensis*. However, the sample from Swain Quarry has larger molar paraconids and more inflated robust teeth. Size differences exist between the Swain Quarry sample, being larger, and those of the San Juan Basin. M_1's and M_2's are difficult to separate (M_L of Table 11) and for this reason size differences are noted with less confidence than if associated material were available. Deciduous teeth are referred on the basis of similarity with those of *Leptictis* (Lillegraven, 1969) and on size of similar forms within the Swain Quarry collection. Few referable upper teeth are complete enough to provide accurate measurements. Isolated P_4's are also questionably referred.

Prodiacodon concordiarcensis Simpson, 1935

Prodiacodon concordiarcensis Simpson, 1935, p. 228

Diacodon concordiarcensis Gazin, 1956, Van Valen, 1967, p. 232

Diacodon pearcei Gazin, 1956, p. 16

Table 12

Type: USNM 9637, dentary fragment with P_2, P_4, and M_3 from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian), Gidley Quarry, upper Lebo Formation, Sweetgrass County, Montana; Swain Quarry, Fort Union Formation, east flank of the Washakie Basin, Carbon County, Wyoming.

Referred material: AMNH ?P^4,, 100414; M^U's, 100418, 101095a-b, 101097a-b; ?DP^4, 100420; 100348, dentary fragment with P_3-M_1; P_4, 100387; M_L's, 100398a-b, 100399a-i, k-l, n-r, 100400a-n, 100410, 100649a-b, 101094a-b; M_3. 100399m; ?DP_4, 100399j.

Discussion: Simpson (1937, p. 112) figures the type specimen (USNM 9637) but the drawing of the P_4 is misleading in that the paraconid is placed too low and projects more anteriorly than in the specimen. AMNH 35693, a dentary fragment from Gidley Quarry, also referred to *D. concordiarcensis*, is inseparable from the Swain Quarry sample.

Prodiacodon sp.

Table 13

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred material: AMNH M^U's, 100794a-d, 100795; ?DP^3, 100419; P_4's 100396b, 100651a-d, 100679a-c; M_L's, 100331, 100365, 100401a-h, 100408, 100656a-g; M_3's 100364, 100402a-b, 100407, 100657a-b; ?DP_3, 100659; ?DP_4's, 100675a-d.

Description and discussion: The sample is composed of isolated teeth. Were it not for size, the only observable difference, they would be inseparable from *D. concordiarcensis*. The conservative nature of their morphology makes it difficult to suggest further affinity. It is

Table 12

Diacodon concordiarcensis

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W/(AW)	PW
100399a	M_L *	1.80	1.05	.70
100399b	M_L	1.85	1.05	.90
100399c	M_L	2.10	1.15	.90
100399d	M_L	2.00	1.15	.90
100399e	M_L	2.00	1.30	.90
100399f	M_L	1.90	1.20	.90
100399g	M_L	1.85	1.15	.80
100399h	M_L	2.10	1.30	1.00
100399i	M_L	2.00	1.10	.90
100400a	M_L	1.60	1.10	.90
100400b	M_L	1.80	1.15	.90
100400c	M_L	1.90	1.35	.90
100400d	M_L	2.00	1.35	1.00
100400e	M_L	1.70	1.25	.90
100400f	M_L	2.00	1.20	.95
100400g	M_L	2.00	1.20	.90
100400h	M_L	1.95	1.10	.90
100400i	M_L	2.00	1.10	.95
100400j	M_L	2.00	1.15	.90
100400k	M_L	1.80	1.25	.85
100400l	M_L	1.85	1.30	.90
100400m	M_L	1.85	1.00	.90
100400n	M_L	1.90	1.30	.80

* M_L denotes M_1 or M_2. Position in tooth row is uncertain.

Table 13

Prodiacodon sp.

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	AW	PW
100331	M_L *	2.60	1.80	1.70
100401a	M_L	2.45	1.90	1.50
100401b	M_L	2.40	1.75	1.50
100401c	M_L	2.50	1.60	1.40
100401d	M_L	----	1.70	1.40
100401e	M_L	2.50	1.60	1.50
100401f	M_L	2.50	1.75	1.60
100401g	M_L	2.20	1.75	1.40
100401h	M_L	2.60	1.75	----
100402a	M_3	2.80	1.65	1.30
100402b	M_3	2.55	1.65	1.20
100407	M_3	2.90	1.70	1.30

* M_L denotes M_1 or M_2. Position in the tooth row is uncertain.

also questioned that all specimens here referred to Prodiacodon do not in fact represent the genus. Comparisons with Leptacodon are also favorable. Until associated material can be found, no reference to a formal taxon should be made.

Genus Myrmecoboides Gidley, 1915

Myrmecoboides Gidley, 1915, p. 395

Myrmecoboides montanensis Gidley, 1915

Myrmecoboides montanensis Gidley, 1915, p. 395

Table 14

Type: USNM 8037, dentary fragment with P_1-M_3 from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian), Swain Quarry, Gidley Quarry, upper Lebo Formation, Sweetgrass County, Montana.

Referred material: AMNH 100341, dentary fragment with P_4-M_1; M_1's, 100381g, i, 100646a-b; M_2's 100381c-f, j, 100646c-e; M_3's, 100381a-b, h, 100646f.

Discussion: The sample from Swain Quarry is inseparable from that of the type locality. There may be some subtle differences in size and length of the talonid. The Swain form does have the paraconid and metaconid more closely approximated. Both samples are small and are therefore inadequate to differentiate minor populational differences in morphology.

Family Pantolestidae

Genus Propalaeosinopa Simpson, 1927

Propalaeosinopa Simpson, 1927, p. 2

Bessoecetor Simpson, 1935, p. 230

Propalaeosinopa diluculi (Simpson), 1935

Plate V, figs. 6-8; Table 15

Bessoecetor diluculi Simpson, 1935, p. 230

Propalaeosinopa diluculi (Simpson): Van Valen, 1968, p. 227

Type: USNM 9810, dentary fragment with P_4-M_2 from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian), Swain Quarry, Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH M^1's, 100455a-b, 100478, 100480, 100482, and questionably referred 100486; M^2's 100479, 100487, 100489, 100800; M^3's, 100453a-d, 100456; 100366 dentary fragment with M^3; M_1's 100383, 100391a-j, 100394a-d, f-g, 100404, 100406, 100409b, 100645, 100653a, c, e, g-i, k, m; M_2's, 100392a-l, 100394e, 100395a-k, 100405, 100409c, 100653b, d, f, j, 1; M_3's, 100332, 100342, 100345, 100367, 100390a-c, 100393a-d, 100648.

Description: The sample from Swain Quarry is indistinguishable from that of Gidley Quarry even when such subtle differences as paraconid placement, inflation of cusps and crest development are considered.

Indeterminate genus and species of Pantolestine

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred material: AMNH 101096a-b, isolated lower molars.

Description: The referred specimens are primitive in most

Table 14

Myrmecoboides montanensis

Swain Quarry, Carbon County, Wyoming

		N	OR	M
M_1	L	4	2.55-2.75	2.64
	AW	4	1.35-1.60	1.45
	PW	4	1.40-1.55	1.46
M_2	L	6	2.50-2.80	2.70
	AW	6	1.55-1.65	1.58
	PW	6	1.45-1.55	1.50
M_3	L	4	2.70-3.05	2.85
	AW	4	1.60-1.95	1.75

Table 15

Propalaeosinopa diluculi

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M^1	L	4				2.55-2.70		2.64	
	W					3.40-3.80		3.63	
M^2	L	3				2.45-2.50		2.48	
	W					3.70-3.75		3.73	
M^3	L	4				1.30-1.65		1.49	
	W					2.09-3.55		3.31	
M_1	L	28	.723	.637	.11	2.40-2.70	.114	2.47	4.62
	AW					1.50-1.95	.100	1.68	5.95
	L	28	.702	.667	.04	2.40-2.70	.114	2.47	4.62
	PW					1.50-2.10	.108	1.68	6.42
	AW	28	.862	.887	.20	1.50-1.95	.100	1.68	5.95
	PW					1.50-2.10	.108	1.68	6.42
M_2	L	30	.639	.626	.26	2.35-2.75	.108	2.58	4.19
	AW					1.60-2.10	.106	1.87	5.67
	L	30	.670	.849	-.38	2.35-2.75	.108	2.58	4.19
	PW					1.50-2.10	.137	1.81	7.56
	AW	30	.863	1.120	-.28	1.60-2.10	.106	1.87	5.67
	PW					1.50-2.10	.137	1.81	7.56
M_3	L	10	.242	.093	1.66	2.55-2.95	.151	2.79	5.41
	W					1.85-2.00	.058	1.92	3.02

observable characters. The animal has a simple trigonid with the protoconid being 1/3 larger than the transversely opposed metaconid. The paraconid is only slightly anteriorly projecting from the base of an open trigonid. There are two well developed trigonid carnassial notches and a poorly developed inframetacristid, which gives the metaconid a trenchant appearance. The protoconid has a triangular base, a flat internal face and a moderately well developed trigonid slope to the lowest part of the trigonid, a valley near the base of the paraconid. The talonid is simple, without a mesoconid or entoconulid, and is posteriorly projecting, not internally displaced as in some leptictids and deltatheridians as defined by Van Valen (1966), which gives their teeth a bent appearance. The hypoconid and entoconid are equal in size, with the hypoconid being more anteriorly placed. There is a small, medially placed, slightly projecting hypoconulid, which is not connected to the other two main cusps by crest development. The talonid is as wide as the trigonid but is definitely longer. There is a large anterior cingulid best developed on the external face of the trigonid, where it must have served as a positioning device for the next anterior tooth. The small posterior cingulid is low and does not involve the hypoconulid. Measurements (in mm): L, 1.65-1.70: AW, 0.9; PW, 0.9.

Discussion: Preserved features do not allow for clear definition of the pantolestine's affinities. It may have miacid affinities but the talonid shape and cusp development are sufficiently different to discourage further discussion. The pantolestine superficially most nearly resembles Propalaeosinopa although the trigonid slope and talonid shape are different. The form is very small and nothing from the known Paleocene collections approaches it in morphologic similarity. This form is therefore placed questionably as a pantolestid, although it undoubtedly represents a new taxon of uncertain affinities.

Family Apatemyidae

Genus Jepsenella Simpson, 1940

Jepsenella Simpson 1940, p. 186

Jepsenella praepropera Simpson, 1940

Jepsenella praepropera Simpson, 1940, p. 186

Type: AMNH 35292, dentary fragment with M_1-M_3, from Middle Paleocene (Torrejonian), Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian), Swain Quarry, Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

An additional reference has been made to the genus on the basis of material from the Black Peaks Formation of the Big Bend National Park (Schiebout, 1974) to be a new and larger species and to remain unnamed until additional material was obtained.

Referred material: AMNH M^1, 89513; M^2, 89512; M^3m 89514; 89516, broken M^0; M_1, 89515; M_3, 87608.

Description: Little information can be added to that provided in Szalay (1968), where the material from Swain Quarry was figured and described.

Family Mixodectidae

Genus Mixodectes Cope, 1883

Mixodectes Cope, 1883a, p. 559

Indrodon Cope, 1883c, p. 318
Olbodotes Osborn, 1902, p. 205

Mixodectes malaris (Cope) Matthew, 1937
Table 16

Indrodon malaris Cope, 1883c, p. 318
Mixodectes malaris Matthew, 1937, p. 223

Type: AMNH 3080, badly broken palate and mandible, from the Deltatherium Zone of Osborn (1929), Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian), *Deltatherium* Zone Nacimiento Formation, San Juan Basin, New Mexico; Swain Quarry, Fort Union Formation, east flank of the Washakie Basin, Carbon County, Wyoming.

Referred material: AMNH M^1's, 100436a-c, 100439a-b, 100783a-c; M^2's, 100435a-e, 100438a-d; M^3's, 100434a-d, 100437, 100781a-b; M_1's, 100429b, 100430a-b, 100433a-d, 100625a, 100698c; M_2's, 100429a, 100432a-d, 100625b, 100698a-b, 100699a-b, d; M_3's 100343, 100428a-c, 100431a-i, 100696, 100698.

Description: Little can be added to the description of the form contained in Szalay's (1969) review of the Mixodectidae and Microsyopidae although the sample from Swain Quarry is somewhat larger in size than its southern counterpart.

Discussion: It should be noted that in Table 3 of Szalay (1969) elements of the Swain collection were included in the statistical treatment of *M. malaris*. Coefficients of variation recorded there are much higher than expected for eutherian deme samples. Statistics were recalculated for the Swain Quarry collection alone and can be found in Table 16, which much more closely approximates expected coefficients of variation of 4 to 6. There is little morphologic difference between members of the Swain Quarry sample and most specimens from the San Juan Basin. Metric and morphologic properties do substantially overlap when the two forms are compared, so a question of separate specific designation should not be raised. When additional collections are made from the Nacimiento Formation, it may be possible to show that two separate distinct species exist. The larger species is best represented in the Swain Quarry fauna, but an additional specimen, AMNH 100804, an isolated obviously mixodectid M_3, should represent the second species in the Swain Quarry fauna and will be discussed separately.

Mixodectes sp.

Referred material: AMNH 100804, an isolated M_3.

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Description: The specimen is obviously a dental element of *Mixodectes* but is retained as a separate entity because of its substantially smaller size, which is outside the expected range of previously described *Mixodectes malaris*. Measurements (in mm): L, 3.55; AW, 2.05; PW, 1.80.

Discussion: The smaller tooth is inseparable from smaller forms of *M. malaris* from the San Juan Basin. The presence of this smaller form lends some scant support to the suggestion that a second species similar to *M. malaris* may be present in Paleocene deposits.

Family Adapisoricidae
Subfamily Adapisoricinae

Table 16

Mixodectes malaris

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M^1	L	4				3.70-4.00	.138	3.84	3.59
	W	4				4.00-4.70	.302	4.43	6.82
M^2	L	7				3.35-3.90	.212	3.59	5.91
	W	7				4.15-5.15	.352	4.56	7.74
M^3	L	7				3.45-3.85	.147	3.72	3.95
	W	7				3.95-4.25	.167	4.16	4.01
M_1	L	8				3.35-3.75	.148	3.60	4.11
	AW	8				2.30-2.60	.115	2.45	4.69
	PW	7				2.50-3.05	.197	2.78	7.09
	L					3.55-3.95	.148	3.74	3.96
M_2		10	.448	.297	14.61				
	AW					2.50-2.75	.098	2.59	3.78
	L					3.55-3.95	.148	3.74	3.96
		10	.281	.255	19.64				
	PW					2.80-3.15	.134	2.92	4.59
	AW					2.50-2.75	.098	2.59	3.78
		10	.720	.983	3.90				
	PW					2.80-3.15	.134	2.92	4.59
	L					3.95-4.65	.198	4.30	4.60
M_3		11	.537	.340	10.89				
	AW					2.50-2.75	.121	2.55	4.75
	L					3.95-4.65	.198	4.30	4.60
		11	.818	.788	6.45				
	PW					2.60-3.05	.182	2.74	6.64
	AW					2.50-2.75	.121	2.55	4.75
		11	.834	1.26	-4.73				
	PW					2.60-3.05	.182	2.74	6.64

Genus *Mckennatherium* Van Valen, 1965

Leptacodon Matthew and Granger, 1921, p. 2

Mckennatherium Van Valen, 1965

Mckennatherium martinezi, n. sp.

Plate 111, figs. 4-6; Table 17

Etymology: Named for Alan and Carol Martinez, members of the 1973 field party.

Type: AMNH 100351, dentary fragment with P_4-M_1 from Swain Quarry, Middle Paleocene (Torrejonian).

Distribution: Type locality only.

Referred materials: M_1, 100360; M_3, 100361.

Diagnosis: Slightly smaller than *M. ladae* and with molar trigonids anteriorly expanded with a larger paraconid most noticable on M_1. P_4 is longer with the paraconid enlarged and more anteriorly projecting in addition to possibly a larger and more distinct metaconid.

Description: The molar morphology is very similar to *M. ladae* although the paraconid is slightly larger and the major cusps are more inflated than those of *M. ladae*. The expansion of the trigonid and slope of the trigonid basin have increased in addition to a slight internal shift of the entoconid.

Although not preserved in the present Swain Quarry collection, P_3 appears on the basis of alveolar placement to have been significantly elongated similar to P_4. There is also a diastema of significant dimensions preserved between ?P_2 and P_3. The canine is nondifferentiated, based on the size of its assumed alveolus.

Discussion: The Swain Quarry material represents a new species. There is no doubt that it represents a form of *Mckennatherium* based upon comparisons with *M. ladae*. It also shows remarkable similarities with the P_4 of *Litomylus* in the nature of paraconid and metaconid placement. *M. ladae* has molar morphology more closely resembling *Litomylus dissentaneus* than does *M. martinezi*. The molar trigonids are sufficiently diagnostic to suggest strong adapisoricid affinities of *Litomylus*, which makes retention of *Litomylus* in the Hyopsodontidae untenable.

Mckennatherium fredricki, n. sp.

Table 18

Etymology: Named for Dr. Fredrick Szalay.

Type: AMNH 100352, dentary fragment with P_4-M_1 from Swain Quarry, Middle Paleocene (Torrejonian), Fort Union Formation, east flank of the Washakie Basin, Carbon County, Wyoming.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry.

Referred material: AMNH M_1, 100625; M_2's 100354, 100358, 100359a-c; M_3, 100350.

Diagnosis: Similar to *M. ladae* but smaller, with a mandible depth 2/3 that of *M. ladae*. P_4 talonid notably less elongate; the paraconid nearer the protoconid and directed more buccally. The P_4 metaconid is present, well developed as a separate distinct cusp; the talonid possesses two equal posterior cusps. M_1 is similar to *M. ladae* but with the paraconid more anterior and with less anterior trigonid basin slope. M_2's of *M. fredericki* and *M. ladae* are inseparable. M_3 is unknown but a referred broken talonid of an M_3 shows little difference from that of *M. ladae*.

Description: *M. fredericki* is most easily recognized by its abbreviated length of P_4. Although the teeth of *M. ladae* and

Table 17

Mckennatherium martinezi, n. sp.

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
100351	P_4	1.35	.75	
	M_1	1.40	1.00	.95
100360	M_1	1.45	1.00	1.05
100361	M_3	1.45	1.10	

Table 18

Mckennatherium fredricki, n. sp.

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
100352	P_4	1.25	.70	
	M_1	1.40	1.00	1.00
100625	M_1	1.45	.95	1.00
100354	M_2	1.40	1.00	.95
100359a	M_2	1.40	1.15	1.05
100359b	M_2	1.40	1.10	1.00
100359c	M_2	1.50	1.10	1.00

Table 19

Leptacodon cf. tener

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
100353	P_4	1.30	.75	
	M_1	1.45	.95	.95

M. fredericki are nearly the same size, the mandibular depth of M. fredericki is strikingly less. Both preserved P_4's of M. fredericki show a strong anterior crest development on the edge of the protoconid, which is broken at the topographic low posterior to the paraconid. An anterior paralophid notch is developed but not a carnassial notch as in miacids. The metaconid is separate, large and slightly posterior to the protoconid. The talonid is simple with two conical, equal cusps symmetrically placed on the posterior margin of a poorly developed basin.

M_1's show moderately inflated, transversely opposed protoconid-metaconid and hypoconid-entoconid similar to those of M. ladae. The paraconid is somewhat smaller and the trigonid is slightly anteriorly expanded. M_2 of both forms are practically inseparable and assignment of this element on the basis of isolated teeth would be very difficult if mandible depth could not be determined. M_3 is known only from a questionably referred broken talonid which does not provide any significant difference from that of M. ladae.

Discussion: The very small size of this form will explain why it and small forms have not been collected other than by screening or detailed quarrying techniques. With the addition of the new form which appears in association with M. martinezi, a possible diversification of adapisoricid insectivores can be documented. The Swain Quarry collection has produced at least 2 forms of Mckennatherium.

Genus Leptacodon

Leptacodon Matthew and Granger, 1921, p. 2

Leptacodon cf. tener

Plate 111, figs. 7-9; Table 19

Distribution: Middle Paleocene (Torrejonian): Swain Quarry.

Referred material: AMNH 100353, dentary fragment with P_4-M_1.

Description and discussion: Represented by only a single specimen, it is sufficiently well preserved to document the presence of the genus Leptacodon in the Swain Quarry fauna. It is very similar to L. tener but is slightly larger and has a smaller and higher paraconid on the P_4.

Genus Litomylus Simpson, 1935

Litomylus Simpson, 1935, p. 243

Litomylus dissentaneus Simpson, 1935

Plate 111, figs. 13-15; IV, figs. 1-3; Table 20

Litomylus dissentaneus Simpson, 1935, p. 243

Litomylus scaphiscus Gazin, 1956, p. 38

Type: USNM 9425, left dentary fragment with P_3-M_3 from Middle Paleocene (Torrejonian), Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana. Upper Paleocene (Tiffanian), Ledge locality, Bison Basin, Fremont County, Wyoming.

Referred material: AMNH 87586, maxilla fragment with M^{1-2}; 100271, maxilla fragment with P^4; 100272, maxilla fragment with M^2; M^1's, 87735a-r, 100747h, 100748a-r, 100750a-l; M^2's, 100746a-p, 100747a-g, i,

Table 20

<u>Litomylus</u> <u>dissentaneus</u>

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
	L					3.05		3.05	
P^4		1							
	W					3.40		3.40	
	L					2.85-3.45	.138	3.14	4.39
M^1		35	.085	.136	3.62				
	W					3.75-4.50	.221	4.05	5.46
	L					2.90-3.70	.228	3.36	6.79
M^2		30	.695	.749	1.89				
	W					3.95-4.85	.246	4.40	5.59
	L					2.35-2.90	.199	2.58	7.71
M^3		33	.767	1.030	.99				
	W					3.00-4.15	.267	3.64	7.34
	L					3.20-3.70	.205	3.49	5.87
P_3		8	.876	.419	.09				
	W					1.35-1.65	.098	1.56	6.28
	L					3.30-4.15	.231	3.71	6.23
P_4		11	.122	.054	1.71				
	W					1.65-2.05	.102	1.91	5.34
	L					3.00-3.60	.109	3.28	3.32
M_1		47	.089	.124	1.98				
	AW					2.10-2.75	.152	2.38	6.39
	L					3.00-3.60	.108	3.28	3.29
		46	.228	.439	1.08				
	PW					2.20-2.85	.162	2.52	6.43
	AW					2.10-2.75	.154	2.38	6.47
		48	.707	.748	.72				
	PW					2.20-2.85	.163	2.50	6.52
	L					3.15-3.60	.116	3.44	3.37
M_2		52	.271	.372	1.51				
	AW					2.45-3.10	.159	2.79	5.70
	L					3.15-3.60	.115	3.44	3.34
		51	.248	.398	1.49				
	PW					2.50-3.10	.185	2.86	6.47

Table 20 cont.

Litomylus dissentaneus

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
	AW	53	.679	.755	.74	2.45-3.10	.155	2.79	5.56
	PW					2.50-3.10	.172	2.85	6.04
M_3	L	44	.450	.598	.30	3.20-3.65	.150	3.43	4.37
	W					1.90-2.80	.200	2.35	8.51

100749a-p; M^3's, 100751a-r, 100752a-r; 87527, dentary fragment with M_{1-2}; 87534, dentary fragment with P_4 and M_2; 87535, dentary fragment with M_{2-3}; 87536, dentary fragment with M_{1-2}^4; 87537, dentary fragment with M_{1-2}; 87539, dentary fragment with M_{2-3}; 87504, dentary fragment with M_{2-3}; 87541, dentary fragment with P_4^2-M_1; 87654, dentary fragment with M_{2-3}; 87544, dentary fragment with M_{2-3}; 87543, dentary fragment with P_4-M_3; 87620, dentary fragment with P_4^2 and M_2; 100217, dentary fragment with M_{2-3}; 100281, dentary fragment with P_{3-4}; 100472, dentary fragment with M_{2-3}; P_3's 100282, 100283, 100284, 100285, 100286, 100289, 100290; P_4's 87640, 100287, 100288, 100546a-c; M_1's, 87615, 100221, 100384, 100471, 100547, 100737i, q, 100738k-l, 100742a-q, 100744a-f, h-r; M_2's, 87533, 87617, 87652, 87681, 100264, 100279, 100476, 100737a-h, j-p, r; 100738a-j, m-r, 100742r, 100744g; M_3's, 87614, 87776a-r, 100474, 100509a-b, 100553, 100735a-o.

Description: The sample of _L. dissentaneus_ from Swain Quarry is only slightly larger in size than the sample from Gidley Quarry, Montana. P^4's of both forms are inseparable. The upper molars of the Swain Quarry form have a lesser degree of congular interruption by the conulecristas, and have more inflated cusps and less well defined crests. Parastyle and metastyle are present, small and very similar to those of the Montana form.

The paraconid on P_{3-4} is highly variable. It may be absent or small and distinct on P_3. Although always present on P_4, it may vary substantially in the degree of inflation and size. This may be related to the anterior variability where the part of the tooth holding the paraconid may be narrow, elongate and directed slightly lingually or blunted and longitudinally symmetric. The cusps of the Swain form are more inflated and less acute.

The lower molars are similar in construction to those of the Montana sample but the "paraconid" may exist as 1-3 cuspules. The associated crest never ascends the metaconid slope, but rather descends low around its base. Although the "paraconid", actually a remaining portion of the paralophid, is more medially placed on M_2, the same phenomenon is observed on M_1. The protolophid is present in the Montana sample but lost in the Swain Quarry sample, where the metaconid and protoconid are more inflated. The mesoconid swelling on the cristid obliqua is larger than in the Gidley Quarry form and the anterior cingulum is less developed in _L. dissentaneus_ from Swain Quarry.

Discussion: There can be little doubt that the Swain and Gidley Quarry collections contain samples of _L. dissentaneus_, although the Swain form is slightly more derived. When compared with _L. scaphiscus_, _L. scaphicus_, and _L. ishami_, the Swain Quarry sample contains elements inseparable from material described by Gazin (1956a, b). Nearly all of the morphologic distance which served to separate and distinguish the taxa from the Bison Basin no longer appears in such critical characters as size, degree of cusp inflation, paraconid development, size of premolars and molars and talonid basin cusp development. _L. scaphiscus_ is immediately recognized as synonymous with _L. dissentaneus_, particularly in light of the additional material from Swain Quarry. _L. scaphicus_, although inseparable from the largest forms from Swain Quarry, is questionably retained as a separate species. The validity of _L. scaphicus_ will depend on the nature of variation in Tiffanian samples even though there is substantial overlap with the observable variation of _L. dissentaneus_. It will undoubtedly prove to be a large element of a monophyletic morphocline of which *L. dissentaneus* is the name bearer. *L. ishami*, although poorly known and somewhat larger yet, may similarly represent a younger form. *L.* "*scaphicus*" is therefore regarded as synonymous with *L. dissentaneus*. *L. scaphicus* and *L. ishami* are questionably retained as separate species.

It can now be shown that a "medial paraconid" may be derived in a number of ways. *Litomylus* has anteroposteriorly compressed a low paralophid, the remaining part of which is the "medial paraconid", and reduced the paraconid to a small lingual cuspule. This is in direct contradiction to the high paraconid and low looping paralophid of most hyopsodonts. The P_4^4's are radically different from those of *Promioclaenus*, *Litaletes*, and *Hyopsodus*, yet remarkably similar to those of *Haplomylus* and *Propalaeosinopa*. Simpson (1937) compared *Litomylus* to *Oxyacodon*, which can be shown easily to be an anisonchine on the basis of its open, distinctive lower molar trigonids. The favorable comparison by Simpson was made on the basis of primitive characters exhibited in a wide variety of forms. *Litomylus* was therefore referred to the Hyopsodontidae on the basis of its stratigraphic occurence and size. The nature of its P_4^4's anteroposteriorly compressed molar trigonids, reduced paralophid complex, and inflated protoconid and metaconid have strong derived similarities with *Mckennatherium*. The new material of *Mckennatherium* from Swain Quarry suggests that the unique last premolar of *Litomylus* could easily be derived from a primitive state typified by *M. martinezi*. For these reasons *Litomylus* and its closely related form *Haplomylus* are referred to the Adapisoricidae.

The relationship of these forms and *Propalaeosinopa* is at present unclear. *Propalaeosinopa*, considered by Van Valen (1966) to be a pantoloestid, is morphologically similar to *Mckennatherium* and its related forms. It has not reduced the paralophid complex to the extent seen in *Mckennatherium*, inflated the protoconid and metaconid, or decreased the difference in trigonid to talonid height. The last premolar of *Propalaeosinopa* is only slightly exaggerated in a fashion similar to *Pantolestes* and its reference to the Pantolestidae may be questioned.

Genus *Haplaletes*, Simpson, 1935

Haplaletes Simpson, 1935, p. 243

Haplaletes disceptatrix Simpson, 1935

Plate IV, figs. 10-12; Table 21

Haplaletes disceptatrix Simpson, 1935, p. 243

Type: USNM 9500, a right dentary fragment with P_3-M_3, from Middle Paleocene (Torrejonian) Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH M^1's, 100786r, 100787a-q; M^2's, 100267, maxilla fragment with M^2, 100817, 100467a-b, 100786a-q; M^3's 100785a-i; 87517, dentary fragment with M_{2-3}; 87518, dentary fragment with M_{1-3}; 87519, dentary fragment with M_{1-2}; 87520, dentary fragment with M_2; 87522, dentary fragment with P_4-M_2; 87524, dentary fragment with P_4-M_1; 87538, dentary fragment with M_{2-3}; 87609, dentary fragment with P_4 and M_2; 100258, dentary fragment with M_{1-2}; M_1's 100265, 100551d, f, p-q, 100552a-b, 100771; M_2's 100280, 100385, 100551a-c, e, g-o, 100552c;

Table 21

<u>Haplaletes</u> <u>disceptatrix</u>

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M^2	L	1				3.10		3.10	
	W					3.80		3.80	
P_4	L	3				2.55-2.75		2.63	
	W					1.75-1.80		1.77	
M_1	L	13	.454	.627	.42	2.55-2.95	.123	2.69	4.57
	AW					1.85-2.25	.168	2.08	8.08
	L	13	.447	.656	.49	2.55-2.95	.123	2.69	4.57
	PW					2.05-2.65	.180	2.26	7.96
	AW	13	.819	.879	.43	1.85-2.25	.168	2.08	8.08
	PW					2.05-2.65	.180	2.26	7.96
M_2	L	23	.323	.317	1.54	2.65-3.35	.165	2.89	5.71
	AW					2.30-2.75	.162	2.45	6.61
	L	23	.370	.363	1.57	2.65-3.35	.165	2.89	5.71
	PW					2.40-3.00	.162	2.62	6.18
	AW	23	.880	.880	.46	2.30-2.75	.162	2.45	6.61
	PW					2.40-3.00	.162	2.62	6.18
M_3	L	22	.399	.535	.77	2.65-3.25	.149	3.05	4.88
	W					2.00-2.80	.200	2.40	8.33

M_3's, 87521, 87782a-n, 87523, 87741, 100256, 100263. DP^4, 100820, is questionably referred.

Description: Most upper teeth are isolated; because of their similarity to other taxa they are only questionably referred. They are not, with the exception of AMNH 100267, included in Table 21. If the isolated material has been correctly identified as to dental element, then the M^1's are more quadrate than and are nearly equal in size to M^2. They are larger than their respective elements from the type locality at Gidley Quarry. They also have reduced the external cingulum and have a smaller and more isolated hypocone. H. disceptatrix from Gidley Quarry has the appropriate conulecrista truncating the anterior and posterior cingulum to become confluent with the labial parts of the cingula. The degree of conulecrista interruption of the posterior and anterior cingula has also been reduced in the Swain Quarry form.

The sample of lower dental elements includes several associated P_4's, which are more inflated, have a smaller metaconid and paraconid, less developed cingulids and two variably inflated talonid cusps which are not so distinct as those of the Gidley Quarry sample. The M_1's and M_2's are larger but not separate from the range described by Simpson (1937) for H. disceptatrix. The external cingulid is variably developed but the expanded external portion of the teeth gives the same internally shifted or inclined appearance. Both teeth show a swelling on the anterior surface of the metaconid, which has been interpreted as a fusing paraconid best seen on M_2. It is in fact an inflated anterior metacristed homologous with those of primitive erinaceids. M_3 is similar to those of the Gidley Quarry sample but may be slightly wider in the same general state of reduction.

Discussion: A discussion of the relationships of Haplaletes is included in a discussion of hyopsodontid condylarths. The paraconid-metaconid relationship on lower teeth of the genus is indicative of adapisoricid relationship based on comparisons with Adapisorex and Mckennatherium. Prothryptocodon and Pantinomia are considered to be arctocyonid condylarths with a convergent inclination developed on lower teeth. Haplaletes does not share derived features with Promioclaenus or Litaletes and in fact was questionably referred to that group by Simpson (1937). Its exact relationships are unknown, but it certainly shares a derived feature in common with primitive adapisoricids. Arctocyonid affinities are unlikely because that would require a reversal in the premolarization of P_4. Pantinomia and Prothyrptacodon may at some future point be shown to be related to Haplaletes but are at present referred to the Oxyclaeninae.

Order Deltatheridia

Family Palaeoryctidae

Genus Acmeodon Matthew and Granger, 1921

Acmeodon Matthew and Granger, 1921, p. 3

Acmeodon hyoni, n. sp.

Plate IV, figs. 4-6; Table 22

Etymology: Named for Eugene Hyon, member of the 1973 field party.

Type: AMNH 100369e, isolated M_1 from Middle Paleocene (Torrejonian), Swain Quarry.

Distribution: Swain Quarry only known locality.

Table 22

<u>Aceodon</u> <u>hyoni</u>, n. sp.

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^4	L	3				3.55-3.65		3.45	
	W					4.05-4.60		4.40	
M^1	L	5				3.35-3.70		3.54	
	W					4.85-5.30		5.15	
M^2	L	7				3.80-4.30		4.00	
	W					5.20-5.75		5.54	
M^3	L	6				2.20-2.40		2.27	
	W					4.35-5.15		4.69	
M_1	L	29	-.057	-.040	24.80	3.75-4.30	.174	4.08	4.26
	AW					2.15-2.60	.123	2.32	5.30
	L	28	.482	.271	10.77	3.75-4.30	.174	4.08	4.22
	PW					2.00-2.35	.097	2.19	4.43
	AW	28	.344	.263	15.83	2.15-2.60	.114	2.31	4.94
	PW					2.00-2.35	.087	2.19	3.97
M_2	L	24	.190	.160	19.87	3.40-4.00	.148	3.78	3.92
	AW					2.40-2.75	.125	2.59	4.83
	L	23	.174	.125	16.67	3.40-4.00	.149	3.77	3.95
	PW					1.90-2.40	.106	2.14	4.95
	AW	23	.602	.493	8.56	2.40-2.75	.127	2.59	4.90
	PW					1.90-2.40	.104	2.14	4.86
M_3	L	15	.670	.269	13.64	3.35-3.95	.193	3.55	5.44
	W					2.20-2.45	.078	2.32	3.36

Referred material: AMNH P^4's, 100462, 100463, 100792; M^1's, 100461, 100464b-h, j-k, 100789a-g; M^2's, 100464i, 100465a-n; M^3's, 100441, 100611; M_1's, 100369a-d, f-h, 100370a-g, 100662b, 100644a-l, 100837b; M_2's, 100338a-b, 100373a-d, 100374a-c, 100375a-d, 100441a-d, 100447, 100628a-n, 100662a, 100663, 100720, 100837c, 100879; M_3's, 100371, 100372, 100376a, c, e, 100377c-e, 100379, 100442, 100443, 100444, 100665b, 100668, 100669.

Diagnosis: Very similar to A. secans but significantly larger with lower molars slightly anteroposteriorly compressed and wider. The molar paraconid is lowered and is reduced on M_1. Upper molars are larger and have the postmetacrista enlarged but not protruding over the posterior margin of upper molars.

Discussion: A. hyoni, although separate and distinct based on metric properties of known forms, represents a slightly advanced form of Acmeodon.

Genus Gelastops Simpson, 1935

Gelastops Simpson, 1935, p. 227

Gelastops joni, n. sp.

Plate IV, figs, 10-12; Table 23

Etymology: Named for Jon Peterson, member of the 1973 field party.

Type: AMNH 100378, isolated M_L from Middle Paleocene (Torrejonian), Swain Quarry.

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH M_1's, 100377a-b, 100665c, 100837a; M_2's, 100337, 100378, 100441e, 100665a; M_3's, 100376b, 100377d.

Diagnosis: Similar to Gelastops parcus but M_1 is distinctly wider and M_2 is longer.

Description: Very few differences can be maintained between the two species except for metric properties and proportions of the molar series. These differences are consistent and are recognizably distinct.

Discussion: One might be censured for naming the new species on the basis of isolated teeth where the association of other dental elements might be so easily confused with related forms. On the basis of relative abundance of elements and metric properties, Gelastops avunculus and Acmeodon can be readily separated. There can be little doubt that the referred specimens are closely related to Gelastops parcus from Gidley Quarry because of an overwhelming morphological similarity, but they have consistent size differences which maintain the Swain Quarry sample as separate and distinct. Although G. joni could possibly be considered synonymous with G. parcus, the two forms are considered separate and distinct on the basis of available material.

Genus Paleotomus Van Valen, 1967

Paleotomus Van Valen, 1967, p. 250

Paleotomus milleri, n. sp.

Plate IV, figs. 7-9; V, 1-5; Table 24

Etymology: Named for the Loren Miller family of Baggs, Wyoming.

Type: AMNH 100423, an isolated M_3 from Swain Quarry, Middle Paleocene (Torrejonian).

Table 23

Gelastops joni, n. sp.

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
100377a	M_1	3.15	2.65	2.20
100377b	M_1	3.35	2.60	2.25
100665c	M_1	3.50	2.60	2.20
100837a	M_1	3.25	2.50	1.80
100337	M_2	3.60	2.25	2.00
100378	M_2	3.40	2.30	1.90
100441e	M_2	3.50	2.40	2.10
100665a	M_2	3.40	2.40	2.10
100376b	M_3	3.15	2.25	
100376d	M_3	3.15	2.30	

Table 24

Paleotomus milleri, n. sp.

Swain Quarry, Carbon County, Wyoming

		N	OR	M
P^4	L	1	3.90	3.90
	W	1	5.30	5.30
M^2	L	3	3.95-4.00	3.98
	W	3	5.55-5.85	5.72
M^3	L	1	3.35	3.35
	W	1	5.00	5.00
M_1	L	8	3.70-4.05	3.88
	AW	8	2.10-2.65	2.36
	PW	8	2.05-2.35	2.19
M_2	L	7	3.70-4.05	3.84
	AW	7	2.45-3.00	2.67
	PW	7	2.20-2.50	2.31
M_3	L	2	4.25-4.60	4.43
	W	2	2.80-2.85	2.83

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH P^4, 100793; M^1, 100459; M^2's, 100454a-d; M^3, 100460; M_1's, 87929, 100425, 100426, 100327, 100445, 100644, 100667a-b, 100838; M_2's 100339, 100340a-b, 100422, 100626, 100652, 100827; M_3, 100424, and a questionably referred DP_4, 100651.

Diagnosis: M_3 similar to Paleotomus senior but smaller. The posterior carnassial notch is smaller, talonid cusp relief is considerably less and the protoconid is smaller in comparison with the metaconid. All molars have in varying degrees of development a mesoconid, entoconulid, and anterior and posterior trigonid carnassial notches. Upper molars have an enlarged postmetacrista that forms a large overhanging ledge continuous with and inseparable from the metastyle. A hypocene is present but only as an enlargement of the posterior cingulum.

Description: Although the sample consists totally of isolated teeth, the Swain Quarry form represents a species definitely allied with P. senior, known from a single tooth from Scarritt Quarry in the Crazy Mountain Field, Montana. Most upper dental elements are broken but their reference to the form is not questioned. They are similar to Didelphodus but the parastyle is much better developed, separate and anteriorly projecting. The paracone and metacone are essentially equal on M^{1-2} and the anterior and posterior cingula are preserved in three separate portions: internal, incomplete at the base of the protocone but maintaining anterior and posterior portions; anterior and posterior continuations of the appropriate conulecrista which are elevated and show complete interruption of internal cingula; the external cingulum formed anteriorly by a secondarily interrupted crest from the paracone slope to the apex of the parastyle and posteriorly by the dramatically enlarged fan-shaped postmetacrista. The external cingulum is variably complete but discontinuous posteriorly around the base of the poorly defined metastyle. Conules are present and well defined only as the confluence of conulecrista and protocrista and not as cusps. The protocone appears to be anteriorly shifted which is accomplished by enlarging the posterior base. M^1 is similarly formed but the post-metacrista is considerably less developed, much more quadrate than M^2 with a smaller hypocone and parastyle. M^3 is questionably referred.

M_1 and M_2 have two well defined trigonid carnassial notches, a moderately trenchant paraconid, mesoconid, and an entoconulid; and an externally expanded anterior cingulum is less noticable than on M_3. Molars do not display a posterior cingulum or any degree of external cingular development. Talonid cusps are generally separate and distinct, with the hypoconid and entotonid nearly equal. The hypoconid may be slightly larger and is transversely opposed. The hypoconulid is separated by notches from other cusps, and is medially located and only slightly larger and is transversely opposed. The hypoconulid is separated by notches from other cusps, and is medially located and only slightly posteriorly projecting. M_3 is very similar to P. senior. Some differences have been noted but the overall similarity suggests a close relationship.

Discussion: The form is definitely near Didelphodus but does not have the small talonid of D. absarokae with its elevated hypoconulid, entoconid and three trigonid notches. Postmetacrista development of the Swain form is strongly suggestive of a close relationship to Didelphodus and likewise rules out close relationships with Gelastops, Avunculus, and Acmeodon.

Genus Palaeoryctes Matthew, 1913

Palaeoryctes Matthew, 1913, p. 309

Palaeoryctes puercensis Matthew, 1913

Table 25

Palaeoryctes puercensis Matthew, 1913, p. 309

Type: AMNH 15923, skull with both upper and lower dentitions well preserved from the Middle Paleocene (Torrejonian), Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico. An additional occurrence has been reported from the Circle Local Fauna (Sloan, 1967) and is currently under investigation by Donald Wolberg.

Referred material: AMNH M^U's, 100481, 100484, 100452; M_L 100397.

Discussion: The material from Swain Quarry is inseparable from that of the San Juan Basin (Torrejonian), including the type specimen. Most of the material from Swain Quarry is broken and only the most complete teeth have been referred to P. puercensis. However, the collection also contains several other teeth which may represent P. puercensis but are fragmentary.

Table 25

Palaeoryctes puercensis

A.M.N.H. No.	Tooth	L	W(AW)	PW
100484	M^U	1.75	2.70	
100452	M^U	1.15	2.80	
100397	M_L	1.70	1.35	1.00

Family Hyaenodontidae

Genus Prolimnocyon Matthew, 1915

Prolimnocyon Matthew, 1915, p. 67

Prolimnocyon macfaddeni, n. sp.

Plate VI, figs. 14-19; Table 26

Etymology: Named for Bruce Macfadden, member of the 1972 field party.

Type: AMNH 100640a, isolated right M^2. Middle Paleocene (Torrejonian), Swain Quarry.

Distribution: Swain Quarry is only known locality.

Referred material: AMNH P^4's, 100641a-b; M^1, 100640b; M_1, 100649 and a questionably referred broken P^3.

Diagnosis: Similar in gross morphology to Prolimnocyon atavus and Arfia. It is much smaller than Arfia but larger than P. atavus. Upper molars have a proportionately larger stylar shelf than either P. atavus or Arfia with a variable number of cingular swellings which may be interpreted as stylar cusps. It has small and incomplete internal cingula and a "double" parastyle (parastyle and stylocone). The parastyle is developed from the confluence of external and anterior cingula and a smaller stylocone by the confluence of the external cingulum and a strong externally directed preparacrista similar to Prolimnocyon atavus. Both conules are more distinct, larger and better defined than in P. atavus. Lower molars have the protoconid and metaconid nearly equal in size and transversely opposed. There is no posterior metacristid. The trigonid is open, broad and anteriorly expanded with well-developed anterior and posterior carnassial notches.

Description: Although the sample is small and consists of isolated teeth, there can be little doubt that a new taxon is represented by AMNH 100640a. The configuration and exaggeration of the metastylar shearing blade on the M^2 is an unmistakable hyaenodont character. It also preserves a prominent well-developed carnassial notch. All three of the major cusps are nearly the same height. The conules are equally well developed though smaller than the major cusps. However, the paraconule is located higher on the slope of the protocone. Both anterior and posterior cingula are completely interrupted by the appropriate conulecrista. A small hypocone is developed internally and posterior to the protocone. The internal conulecristas are well developed and proceed to the basal portions of the paracone and metacone. Premetacrista and postparacrista are poorly developed, which gives their respective cusps a conical shape.

Other elements of the dentiton are questionably referred. It is quite possible that some of them represent parts of other forms but they are referred here until more complete material is obtained.

AMNH 100640b may be an M^1 of Prolimnocyon because of its more quadrate nature characteristic of that portion of the dentition. It is morphologically similar to the type specimen but the metastylar projection is reduced.

The lower molar, AMNH 100639, is referred with some degree of probability because of its comparison with Arfia and Prolimnocyon on the basis of similar anterior procumbence of the paraconid, the strong anterior slope of the trigonid basin, the open and expanded trigonid, nearly equal protoconid and metaconid (the metaconid being slightly taller), and the presence of a large massive hypoconid.

Discussion: The large sample of fossil material from Swain Quarry contains what is apparently a rare early hyaenodont; at least the animal is rare in habitats presently sampled in the Paleocene of North America. There can be little doubt that the nearest relatives of this form are to be found among the hyaenodonts. Most favorable comparisons were made with Arfia, Prolimnocyon, and Prototomus. Proviverra has a much reduced stylar shelf, no cingula on its upper molar, and has only a single parastyle. It can easily be eliminated from close relationship. Arfia, on the other hand, shares similar shelf development, small molar cingula, a double parastyle, more distinct and larger conules and a less anteriorly expanded M_1 trigonid. The favorable comparison with Arfia is due to a large number of shared primitive characters. The comparison, however, does show the derived nature of Proviverra.

The carnassial notch on the M^2 does appear to be smaller in P. macfaddeni but similar to that of Prolimnocyon. M_3 relative size, a distinctive character of Prolimnocyon, is not observable in the Swain Quarry sample and therefore, P. macfaddeni is only provisionally placed in the genus Prolimnocyon. The Swain Quarry form is about half the size of Arfia but larger than P. atavus.

Table 26

Prolimnocyon macfaddeni

A.M.N.H. No.	Tooth	L	W(AW)	PW
100641b	P^4	4.80	2.80	
100640a	M^2	5.03	6.50	
100640b	M^1	5.02	7.35	
100639	M_1	5.85	3.10	2.95

Order Deltatheridia indet.

Table 27

Referred material: AMNH M^2, 100824; 100349, dentary fragment with talonid of M_2 and complete M_3; M_2, 100334a-b; questionably referred P^4, 88077.

Description: The fragmentary dentary undoubtedly represents a new taxon. All three trigonid cusps of the referred M_1 are nearly equal in size but a moderate slope of the trigonid basin lowers the paraconid. The talonid is small with three simple cusps analogous to the major cusps of a primitive tooth but it is divided into two parts by an obliquely directed valley which separates the hypoconid and hypoconulid. All three cusps are approximately the same size with little crest development between them.

The M_2 talonid preserved in the dentary is sufficiently diagnostic to separate it from other similar teeth in the Swain Quarry collection. A single additional specimen, AMNH 100334, was found in the collection to agree with what remains of the M_2. It is complete, well preserved and possibly has sufficient character to be designated as the type specimen of a new taxon were additional material available. The protoconid is larger than the metaconid but with not nearly so much difference as observed in viverravine miacids. It preserves two carnassial notches and has a trigonid basin slope with the valley dividing the protoconid and metaconid descending anteriorly until it meets a transverse separation near the base of the paraconid. This valley then descends the lingual part of the crown in the viverravine miacid fashion rather than the deltatheridian fashion. The tooth is not characteristically enlarged when compared to the posterior tooth. The talonid, perhaps as a derived character, has reduced much of its cusp definition. Although excellently preserved, little cusp morphology remains. It preserves hypoconid and entoconid far posterior and transversely opposed. There is little or no crest development between talonid cusps; even the cristid obliqua is weak.

The ?M_3 preserved in the dentary is remarkably similar to Prolimnocyon in that its trigonid cusps are widely separate and are conical with little crest development between them.

Discussion: The form compares quite favorably with AMNH 22220 from the Tiffanian deposits of Bear Creek, Montana, described by Van Valen (1966, p. 84), but the paraconid is better developed although shaped and positioned similarly.

The questionably referred P^4 may be in fact, a viverravine miacid tooth but the very posteriorly directed paracone is strongly suggestive of deltatheridian affinities. It is very similar to those of Prolimnocyon macfaddeni but is substantially smaller.

Before a new taxon can be designated, more complete material is needed in order to define its characters properly.

Table 27

Indeterminate Deltatheridian

A.M.N.H. No.	Tooth	L	W(AW)	PW
88077	P^4	3.50	1.70	
100824	M^2	3.10	5.00	
100344a	M_2	3.45	2.40	1.75
100344b	M_2	3.60	-	1.75
100349	M_3	3.00	1.80	

Order Carnivora

Family Miacidae

Genus Simpsonictis Mac Intyre, 1962

Didymictis Simpson, 1937, p. 209 (in part)

Simpsonictis Mac Intyre, 1962, p. 1

Protictis (Simpsonictis) Mac Intyre, 1966, p. 168

Simpsonictis jaynanneae, n. sp.

Plate VI, figs. 5-13; Table 28

Etymology: Named for Jaynanne Rigby, member of the 1973 field party.

Type: AMNH 87932b, isolated P^4, Middle Paleocene (Torrejonian) Swain Quarry.

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH P^4's, 87788a-c, 87922a-c; M^1's, 87931a-c, 100798, 100449a-c; P_4's, 100630, 100632, 87932a-c; M_1's, 100333, 87908a, 100355, 100330; M_2's, 87908b.

Diagnosis: P^4 slightly larger than S. tenuis. Metastylar blade is bilobate with 2 elongate separate portions. Crests from the apex of the paracone are weak, inflated and poorly developed. Lower molar protolophid crests are much larger and blade-like than S. tenuis with distance from the posterior carnassial notch to the metaconid and protoconid apices reduced.

Description: Until the present collection was made, Simpsonictis upper molars were unknown. They have the characteristic shape and cusp development of other related miacids including the extremely exaggerated parastyle, weak conule development and anterointernal cingulum. They have a parastyle and stylocone, similar to hyaenodonts; its presence is probably a primitive feature lost in some related forms. One is developed from the confluence of the external cingulum with the antero-externally directed paracrista and the other form a swelling on the stylar portion of the anterior cingulum. The more posterior of the two cusps is the better developed and is connected to the base of the paracone by a simple well-defined crest which is continuous with the preparacrista. Carnassial notches are absent. The paracone and metacone are simple, conical and nearly equal. The postmetacrista is continuous with the external cingulum. Premetacrista and postparacrista are poorly developed. Several swellings are observed on the external cingulum and may be

Table 28

Simpsonictis jaynanneae, n. sp.

Swain Quarry, Carbon County, Wyoming

		N	OR	M
P^4	L	3	3.65-4.00	3.82
	W	3	2.05-2.35	2.22
M^1	L	2	2.55-2.85	2.70
	W	2	3.85-4.15	4.00
P_4	L	4	2.75-3.40	3.00
	W	4	1.15-1.35	1.26
M_1	L	3	2.90-3.30	3.07
	AW	3	1.80-2.05	1.90
	PW	3	1.60-1.80	1.70
M_2	L	1	2.50	2.50
	W	1	1.70	1.70

interpreted as being stylar cuspules or cusps. Both conules are weakly developed with the paraconule slightly higher on the preprotocrista. The protocone is generally the same size or slightly smaller than the paracone or metacone. The internal conulecristae are weakly developed and are at times absent altogether. The preparaconulecrista is continuous with the most anterior of the parastyles and interrupts the internal portion of the anterior cingulum. The postmetaconulecrista forms the middle of three successively interrupted parts of the posterior cingulum, the most external being the postmetacrista. No metastyle is present.

The P^4 has the characteristic miacine shape but is different in possessing a bilobate metastylar blade with a weak separation of two trenchant cusps. The major carnassial notch is well defined but crests descending from the apex of the paracone are less developed than those of S. tenuis. The postparacrista also shows signs of a bilobate nature. The carnassial notch is more open in profile view. The parastyle and protocone are separate and are equal in size, neither possessing a crest connecting to the paracone apex.

Lower dental elements are similar to those reported from Gidley Quarry from the Lebo Formation of Montana but are slightly larger and the crests of the Swain Form are distinctly more derived and blade-like. The difference in height from the posterior carnassial notch to the apexes of the protoconid and metaconid is distinctly less in the Swain Quarry form. The trigonids are more upright and with less basal, lateral displacement when compared with the vertical axis of the dentary. M_2's are inseparable from those of the Gidley Quarry sample.

Discussion: Only isolated teeth have been recovered from Swain Quarry. When compared with known miacid upper and lower dental associations, there can be little doubt that referred upper teeth belong to Simpsonictis. Size and morphologic similarity with cf. Simpsonictis from the Shotgun Local Fauna (Mac Intyre, 1966, p. 175) leave little doubt that the referred Swain Quarry teeth represent upper dental elements of Simpsonictis.

Mac Intyre (1962) considered "Protictis" tenuis to be generically distinct and created the genus Simpsonictis. He later (1966) reduced Simpsonictis to subgeneric rank. Mac Intyre (1966) believed that the observed variety among Protictis, without knowledge of additional species, could best be described on a subgeneric level even though P. vanvaleni was described by him. With the addition of S. jaynanneae it is no longer useful to maintain subgeneric rank for Simpsonictis and Bryanictis. Mac Intyre's (1966) diagnoses for the subgenera are adequate to define genera and are not repeated here.

Genus Bryanictis (Mac Intyre, 1966), new rank

Didymictis Simpson, 1937, p. 209 (in part)

Protictis (Bryanictis) vanvaleni Mac Intyre, 1966, p. 190

Type: AMNH 16031, dentary fragment with P_4 and broken M_1 from the Nacimiento Formation, east fork of Torrejon Arroyo, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, east fork of Torrejon Arroyo, San Juan Basin, New Mexico; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH P^3's, 87927a-b, 100629, 100631,

Table 29

<u>Bryanictis</u> <u>vanvaleni</u>

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^3	L	4				3.75-4.05		3.90	
	W					1.75-2.35		2.04	
P^4	L	3				5.85-6.20		6.03	
	W					3.35-3.55		3.42	
M^1	L	4				3.95-4.35		4.15	
	W					5.00-5.07		5.02	
M^2	L	4				2.15-2.75		2.56	
	W					3.85-4.45		4.16	
P_2	L	2				2.95		2.95	
	W					1.05		1.05	
P_3	L	16	.450	.208	.75	3.35-4.20	.259	3.77	6.87
	W					1.35-1.90	.120	3.53	7.83
P_4	L	24	.326	.225	.93	4.05-4.65	.135	4.29	3.15
	W					1.80-2.05	.093	1.89	4.91
M_1	L	16	.678	.400	1.04	4.30-4.65	.156	4.43	3.52
	AW					2.65-2.95	.092	2.82	3.27
	L	16	.392	.254	1.33	4.30-4.65	.156	4.43	3.52
	PW					2.30-2.55	.101	2.45	4.12
	AW	16	.681	.500	1.05	2.65-2.95	.092	2.82	3.27
	PW					2.30-2.55	.101	2.45	4.12
M_2	L	8				3.40-3.90		3.65	
	W					1.40-2.25		2.07	

87925; P^4's, 100825, 100697a-b, 88083a-e, 88078a-h; M^1's, 100609, 88082, 100440a-h, 100448a-d; M^2's, 100451, 100797a-b, 100784a-c, 100637a-e; P_2, 88081a-d; P_3's, 87926, 100593, 100635, 87921a-k, 100634, 100633a-b; P_4's, 100608, 100603a-b, 100633a-e, 87928a-j, 88076a-h; M_1's, 100602, 100594, 100610, 87930a-f, 88071a-j; M_2's, 100368, 100380a-g; ?DP_3, 88079; ?DP_4's, 88081c-d.

Description: Until the description of the present material upper dental elements were unknown. If the allocation of isolated teeth is correct, then the upper dentition is quite similar to that of _B. microlestes_. The M^1 of the Swain Quarry sample of _B. vanvaleni_ has a much better developed external stylar shelf with cuspules developed as distinct swellings on the external cungulum. It also has two distinct parastyles well developed in most specimens. The _B. microlestes_ P^4 sample from Gidley Quarry displays a more recurved carnassial notch and more blade-like crests. P^3's are quite similar but have better developed crests and are questionably larger.

P_3's of _B. vanvaleni_ were also unknown. They are quite similar to P_4's of _B. microlestes_ but may be distinguished by a much more anteriorly directed, protruding parastyle and a lesser developed external cingular margin. P_3's of _B. vanvaleni_ are easily distinguished from those of _B. microlestes_ by the much greater carnassial notch development on both anterior and posterior notches and by the greater lateral expansion of the talonid basin.

P_4's all resemble the P_4 of the type specimen but are substantially smaller. All possess a well defined metaconid which is sometimes present as a distinct cusp or may vary to present a smooth, non-differentiated, abrupt swelling on the internal portion of the tooth. All crests are much better developed into blade-like structures and all cusps are inflated. Both features combine to exaggerate the carnassial notches. M_1's are inseparable on the basis of isolated teeth. M_2's of _B. vanvaleni_ were also unknown from the San Juan Basin, but are again quite similar to _B. microlestes_ except that the paraconid has lost its cuspiform nature and appears as a simple blade-like structure. Size and relief of structures of the talonid are also less.

Genus _Protictis_ (Matthew), 1937

Didymictis Cope, 1882

Didymictis (_Protictis_) Matthew, 1937, p. 102

Didymictis Simpson, 1937, p. 209

Protictis (_Protictis_) Mac Intyre, 1966, p. 14G

Protictis haydenianus (Cope), 1882

Table 30

Didymictis haydenianus Cope, 1882, p. 464

Didymictis primus Cope, 1884, p. 464

Viverravus haydenianus Matthew, 1899, p. 29

Didymictis (_Protictis_) _haydenianus_ Matthew, 1937, p. 29

Type: AMNH 33688, left dentary with P_4-M_2, left maxilla with P^3-M^2, from the Middle Paleocene (Torrejonian) Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico; several localities from the upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana; Dragon Local Fauna, Joe's Valley Member, North Horn Formation, Emery County, Utah.

Table 30

Proticitis haydenianus

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W	AW	PW
100566	P^2	4.00	1.65		
100567	P^3	5.85	2.85		
87933	P^3	5.40	2.70		
88073	P^4	9.75	5.25		
88074a	M^1	7.50	8.55		
88074b	M^1	7.50	9.45		
88074c	M^1	5.85	8.25		
100638a	M^2	3.00	5.25		
100638b	M^2	2.40	4.50		
88072	M_1	7.65		4.80	3.60
100624	M_2	4.80	2.85		
87732	M_2	5.10	3.30		

Referred material: AMNH P^2, 100566; P^3_2's, 100567, 87933; P^4's, 88073, 87923; M^1's, 88074a-d, 100605, 100606; M^2's, 100638a-b; dentary with M_1, 88073; P_4's, 100591, 100568; M_1's, 100591, 88080a-b; M_2's, 87732, 100624.

Description: The sample from Swain Quarry is inseparable from samples of similar age from the upper and lower levels of Torrejonian deposits from scattered localities of the Nacimiento Formation of the San Juan Basin, Crazy Mountain Field localities in Montana and from the Dragon Local Fauna of the North Horn Formation, Emery County, Utah.

The talonid basins of the Swain Quarry sample are distinctly narrower than those specimens of the type region. Such a character might be taken as possible individual variation but all preserved elements from Swain Quarry preserve the same feature. All cusps of the M_2's show rounded and inflated cusps. P_4's are only slightly narrower than those from the San Juan Basin. These differences are readily observed but they are not considered sufficient to warrant the designation of a new taxon on the basis of comparative material at hand, particularly when taken in the context of demonstratable individual variation.

Comments: Mac Intyre (1966) provided a well documented account of the systematic history of Paleocene viverravine miacids. It is not necessary to duplicate his efforts here. It is sufficient to say that Simpson (1937) was aware of the great diversity that was then contained in the genus Didymictis and agreed with Matthew's (1937) placement of D. haydenianus in a separate subgenus. With the description of new forms from the Crazy Mountain Field of Montana, Simpson stated (Simpson, 1937, p. 209) "It is quite possible that one or more of these (Didymictis) can be and should be separated generically but the criteria for doing so are poor at present".

Additional collections have been made in several different basins in the Rocky Mountains since Simpson's initial study. Several better or equally sampled localities are now available for comparison with the Gidley Quarry samples collected by the U. S. National Museum and the American Museum of Natural History. Each well sampled locality, Swain Quarry on the east flank of the Washakie Basin and Rock Bench from the Big Horn Basin in northern Wyoming, did distinguish 3 separate vivarravine miacids recognizably distinct within their faunas. A concept of their populational variability is now available that makes the retention of so many forms in a single genus, Protictis, unnecessary and confusing.

Mac Intyre (1966) hinted that a tripartite division of Protictis may be warranted with the addition of specimens and more complete sampling but refrained from naming new genera on what he deemed poor evidence. He did name three subgenera, P. (Protictis), P. (Bryanictis), and P. (Simpsonictis), using size and morphologic variation of the known forms. Encouragement for making such a division was received with the discovery of the new form B. vanvaleni, which showed that the recognized genus Protictis contained several separate phylogenetic histories.

With the addition of S. jaynanneae it is no longer appropriate to retain so many diverse forms within the genus Protictis, which hides the relationships of the subgenera designated by Mac Intyre (1966). Mac Intyre (per. comm. 1976) suggests that Protictis s. s. is most closely related to Didymictis and that Bryanictis and Simpsonictis are genera now thought to be most closely related to Viverravus.

Order Primates

Genus Paromomys Gidley, 1923

Paromomys Gidley, 1923, p. 3

Paromomys maturus Gidley, 1923

Plate VII, figs. 1-6; Table 31

Paromomys maturus Gidley, 1923, p. 3

Type: AMNH 94375, dentary fragment with P_4-M_3 and anterior alveoli from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH 88093, maxilla fragment with P^{3-4}; 100226, maxilla fragment with P^4-M^3; 100227, maxilla fragment with M^1; P^4's, 80979a-g, 87794a-r, 100240c-d, 100761a-f, 100963a-j; M^1's, 86933a-p, 86935a-l, 86940a-h, 86949a-p, 86950a-g, 100767a-p, 100770a-c; M^2's, 86942a-h, 86951a-f, 86962a-h, 86963a-p, 86964a-p, 100223, 100768a-o, 100769a-h; M^3's, 86956a-m, 86957a-r, 86958a-n, 88088a-c, 100763a-m; 80887, dentary fragment with M_2; 80990, dentary fragment with P_{2-4}; 80991, dentary fragment with P_4; 80992, dentary fragment with M_{1-2}; 80994, dentary fragment with P_4-M_1; 80995, dentary fragment with M_{1-3}; 80996, dentary fragment with M_{2-3}; 80997, dentary fragment with P_3-M_2; 80998, dentary fragment with M_{1-2}; 80999, dentary fragment with M_{2-3}; 89501, dentary fragment with P_3-M_1; P_3's, 89655h-i; P_4's, 89655b-d, f-g, j; M_1's, 89644a-i, 86945a-i, 86960a-i, 86961a-i, 86970a-h, 87516, 100524a, c-k, m-r, 100525a-c, 100534, 100724a-b; M_2's, 86936a-i, 86937a-i, 86947a-i, 86948a-i, 86950a-i, 86953a-i, 86954a-i, 86972a-i, 86974a-i, 100522a-r, 100523a-e, 100524b, l, 100725a-b; M_3's, 86938a-i, 86959a-i, 86965a-i, 86971a-b, 86973a-r, 87774, 100272a-b, 100521a-p, 100722a-c.

Description: Szalay (1968) figured AMNH 89501, a dentary fragment with P_3-M_1 and alveoli documenting the presence of six antemolar teeth. AMNH 80990 has now been prepared and shows the complete anterior dentary of P. maturus. There is no doubt that two incisors are present, the posterior of which is smaller than either the canine or anterior incisor. The lower dental formula is 2.1.3.3 as diagnosed by Szalay (1968).

No consistent differences have been found between the Swain Quarry sample and the sample from Gidley Quarry although some minor differences in width of individual dental elements were noted. Length variability of teeth from Swain Quarry are modally wider with M_3 longer and wider than P. maturus from Gidley Quarry. The difference is not sufficient to formalize the designation of a new taxon and such action would only confuse the relationship of two very closely related forms, of which the Swain Quarry form is more derived in the nature of the expanded M_3.

Paromomys depressidens Gidley, 1923

Plate IV, figs. 9-11; VI, 1-4; VIII, 1-2; Table 32

Paromomys depressidens Gidley, 1923, p. 4

Type: USNM 9546, maxilla fragment with P^4-M^3 from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH 80966, maxilla fragment with M^{1-3}; 80967, maxilla fragment with M^2; P^4's, 80976a-b, 100224a-b; M^1's 80972c-e, g, p, 80974b, e-d, i, l-n, 100765c-e, g-i, 100766d-f, h-i; M^2's 80972a-b,

Table 31

<u>Paromomys</u> <u>maturus</u>

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^3	L	1				2.00		2.00	
	W					1.65		1.65	
P^4	L	40	.152	.130	2.87	2.55-3.05	.166	2.93	5.67
	W					2.90-3.60	.142	3.25	4.36
M^1	L	53	.426	.587	2.35	2.85-3.40	.146	3.14	4.65
	W					3.85-4.55	.201	4.20	4.79
M^2	L	65	.001	.003	4.35	2.95-3.45	.132	3.15	4.19
	W					4.05-4.85	.275	4.36	6.31
M^3	L	60	.266	.475	2.76	2.15-2.75	.140	2.40	5.83
	W					3.55-4.65	.250	3.90	6.41
P_2	L	2				1.60-1.70		1.65	
	W					1.05-1.10		1.08	
P_3	L	4				1.95-2.10		2.00	
	W					1.35-1.40		1.39	
P_4	L	10	.377	.235	1.29	2.40-2.95	.164	2.75	5.96
	W					1.75-2.10	.102	1.94	5.26
M_1	L	53	.288	.334	1.23	2.75-3.45	.121	3.17	3.82
	AW					2.01-2.60	.141	2.29	6.16
	L	53	.343	.378	1.29	2.75-3.35	.121	3.17	3.82
	PW					2.25-2.80	.134	2.49	5.38
	AW	53	.802	.759	.76	2.01-2.60	.141	2.29	6.16
	PW					2.25-2.80	.134	2.49	5.38

Table 31 cont.

Paromomys maturus

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M_2	L	73	.363	.336	1.58	2.90-3.55	.150	3.17	4.73
	AW					2.10-2.60	.141	2.29	6.16
	L	73	.349	.313	1.67	2.90-3.55	.150	3.17	4.75
	PW					2.45-2.90	.135	2.67	5.06
	AW	73	.832	.805	.53	2.10-2.60	.141	2.29	6.16
	PW					2.45-2.90	.135	2.67	5.06
M_3	L	66	.242	.198	1.52	3.60-4.30	.169	3.92	4.31
	W					1.95-2.65	.138	2.29	6.03

Table 32

Paromomys depressidens

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^4	L	4				1.77-1.85		1.79	
	W					2.10-2.25		2.11	
M^1	L	25	.138	.231	2.47	1.95-2.30	.099	2.09	4.70
	W					2.60-3.30	.165	2.96	5.57
M^2	L	27	.582	1.22	.58	1.80-2.25	.106	2.08	5.10
	W					2.70-3.55	.223	3.12	7.15
M^3	L	5				1.35-1.65		1.42	
	W					2.45-2.70		2.54	
P_4	L	3				1.85		1.85	
	W					1.20-1.40		1.30	
M_1	L	23	.341	.258	1.00	1.75-2.15	.123	2.01	6.12
	AW					1.75-2.00	.093	1.52	6.12
	L	23	.289	.241	1.19	1.75-2.15	.123	2.01	6.12
	PW					1.55-1.90	.102	1.67	6.11
	AW	23	.482	.531	.87	1.75-2.00	.093	1.52	6.12
	PW					1.55-1.90	.102	1.67	6.11
M_2	L	41	.415	.392	.11	1.90-2.20	.094	2.03	4.63
	AW					1.75-2.00	.089	1.83	4.86
	L	41	.406	.376	.11	1.90-2.20	.094	2.03	4.63
	PW					1.65-2.10	.087	1.87	4.65
	AW	41	.703	.691	.63	1.75-2.00	.089	1.83	4.86
	PW					1.65-2.10	.087	1.87	4.65
M_3	L	16	.190	.105	1.34	2.25-2.80	.171	2.43	7.04
	W					1.40-1.70	.095	1.60	5.94

f, h-o, q-r, 80974a, c, f-h, j-k, o-r, 100765a-b, f, 100766g; M^3's, 80973, 100764a-d; 80968, dentary fragment with M_{2-3}; 80969, dentary fragment with M_{2-3}; 80970, dentary fragment with M_{1-3}; 80971, dentary fragment with M_{1-3}; 100228, dentary fragment with M_1; P_4's, 80983a-c; M_1's, 80981a-g, i-r, 80982a, c-d, 100538e, 100728; M_2's, 80980a-g, 80981h, 80982b, 80985a-r, 100527a-c, 100528a-d, 100727a-b; M_3's, 80978a-h, 100526a-v, 100726.

Description: I have not been able to distinguish the sample from Swain Quarry from the sample from Gidley Quarry, which contains the type specimen. Although some minor individual differences occur, the samples are inseparable.

Discussion: Szalay (1968a) lists the dental formula of Paromomys as 2.1.3.3. Paromomys depressidens has a distinctly different anterior dentition, as can best be seen on AMNH 35546 from Gidley Quarry. It preserves two incisor alveoli, the more posterior of which is proportionately reduced thus differing substantially from P. maturus. Szalay (1968a) makes reference to USNM 9416, which questionably retains an I_2, and USNM 9482 which does not. Re-evaluation of these specimens shows that USNM 9416 has been broken slightly but the questioned alveolus does exist in both specimens, although smaller in USNM 9482.

Although most of its dental morphology is similar to P. maturus, retention of P. depressidens in the same genus may be misleading. Of closely related forms it is most similar to Phenacolemur because both forms show a high lingual paraconid closely approximating the metaconid, and anteroposteriorly compressed molar trigonids. P. depressidens may be considered to represent most of the primitive state of a monophyletic group of which Phenacolemur is a well known element and possibly generically separate from Paromomys.

Order Primates, incertae sedis

Genus Palenochtha Gidley, 1923

Palenochtha Gidley, 1923, p. 7

Palenochtha cf. minor

Plate V, figs. 15-17; Table 33

Distribution: Middle Paleocene (Torrejonian), Swain Quarry.

Referred material: AMNH 80986, dentary fragment with M_3; 80987, dentary fragment with M_{2-3}; 80988, dentary fragment with M_2; 88084, dentary fragment with M_{1-2}; 88085, dentary fragment with M_2; 89511, dentary fragment with P_4; 100362, dentary fragment with M_1; 100363, dentary fragment with M_{1-2}.

Description: This animal may best be described as being intermediate between Palenochtha and Palaechthon. No elements of the upper dentition are known from the fauna. AMNH 89511 preserves P_4 and alveoli of several anterior teeth, including two for a double-rooted P_3, and a single large alveolus anterior to it which is fully as wide as the P_4. M_1 preserves a well-developed mesoconid and a cristid obliqua which is confluent with a crest that descends medially from the metaconid apex. M_2 displays less topographic relief than M_2 of P. minor and has decreased the angle of the posterior trigonid shear face, giving the impression of a more anteriorly inclined trigonid. The paraconid-paralophid complex of M_2 is recurved, as in Jepsenella but less pronounced.

The M_3 shows less talonid expansion than P. minor and is considerably shorter. A posterior trigonid pit is present. The mesoconid is well developed. The hypoconulid is placed on the extreme internal margin and is larger than the etoconid or entoconulid, which are both preserved as equal cuspules. The metaconid is slightly smaller and posterior to the protoconid. The paraconid is moderately developed and placed anteriorly.

Discussion: The form is closely related to P. minor from Gidley Quarry, but there are several distinct differences including the enlarged canine or incisor and anteriorly inclined and expanded trigonid. Both are of the same general dimensions.

Table 33

Palenochtha cf. minor

A.M.N.H. No.	Tooth	L	W(AW)	PW
89511	P_4	1.05	1.00	
100362	M_1	1.35	.95	1.00
88084	M_1	1.30	.85	.85
88084	M_2	1.55	1.10	1.10
88085	M_2	1.50	1.10	1.10
80987	M_2	1.45	1.00	1.05
	M_3	1.30	.85	
80986	M_3	1.50	1.05	

Palenochtha weissae, n. sp.
Plate V, figs. 12-14; Table 34

Etymology: Named for Amy Weiss, member of the 1973 field party.

Type: AMNH 100356, dentary fragment with P_4 and 5 anterior alveoli from Swain Quarry, Middle Paleocene (Torrejonian).

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH 100355, dentary fragment with P_4; 100362, dentary fragment with M_1.

Diagnosis: Similar to P. minor but with a small P_1 present, about the size as P_2. M_1 trigonid anteriorly expanded with paraconid extremely lingual. Cristid obliqua ascends the metaconid apex.

Description: This species is extremely rare, perhaps due to its small size. AMNH 100356, the holotype of the species, is an extremely valuable specimen in that it preserves at least 5 alveoli anterior to P_4. A large, nearly vertical alveolus occurs anteriorly and a small circular alveolus lies immediately posterior to it. The third alveolus is belobate and is presumed to have held a double-rooted tooth, presumably P_2. Two additional alveoli must have contained roots of P_3, which would have been substantially smaller than P_4 based on the comparative sizes of the respective alveoli. P_4 is very similar to that of P. minor and has a large protoconid and separate metaconid. The paraconid lies at the anterior base and is lingually displaced. The talonid preserves two unequal cusps on the posterior margin, the labial cusp being larger.

The M_1 is very similar to that of P. minor but the paraconid is anteriorly placed to produce a broad, open trigonid. The cristid obliqua ascends to the metaconid apex and the hypoconulid and entoconulid are essentially equal; both are posterior to the hypoconid. A small entoconulid is also present to help form a true basin.

Discussion: This species is definitely related to *P. minor* but retains at least one additional and possibly several teeth lost in *P. minor*.

Table 34

Palenochtha weissae, n. sp

A.M.N.H. No.	Tooth	L	W(AW)	PW
100356	P_4	1.25	.80	
100355	P^4	1.25	.75	
100362	M_1	1.30	.95	1.00

Genus *Palaechthon* Gidley, 1923

Palaechthon Gidley, 1923, p. 6
Plesiolestes Jepsen, 1930, p. 505
Torrejonia Gazin, 1968, p. 4
Torrejonia (Gazin): Szalay, 1973, p. 86

Palaechthon problematicus Jepsen, 1930
Table 35

Plesiolestes problematicus Jepsen, 1930, p. 505
Torrejonia wilsoni Gazin, 1968, p. 4
Plesiolestes wilsoni (Gazin): Szalay, 1973, p. 86

Type: USNM 9523, dentary fragment with P_2M_2, from Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana; Rock Bench Local Fauna, Fort Union Formation, Polecat Bench, Park County, Wyoming; Nacimiento Formation, San Juan Basin, New Mexico.

Referred material: AMNH P^4's, 86981a-r, 87502, 87504a-j; M^1's, 86946i, l, p, 86980a-b, 86989a-i, k-p, 86997, 88091a-r, 88092g, 100229; M^2's, 86946a-h, j-k, m-o, q-r, 86989j, 88092a-f, h-q; M^1's and M^2's undifferentiated, 86977a-r, 86978a-r, 86987a-r, 87511a-r, 88089a-l, 100733a-r, 100734a-r; M^3's, 87507, 87509a-r, 87512e, 87515, 100764a-h; 100346, dentary fragment with M_{1-3}; P_4's, 86990a-d, 86998a-i, 86999a-r, M_1's, 86995a-e, g-r, 86996a-g, j-q, 87503a-r, 87505a-r, 88095a-i, 100347, 100531a-n, 100532o, 100541a-d, l, 100731a-c; M_2's, 86979a-r, 86982a-i, 86983a-i, 86984, 86988a-p, 86995f, 86996h-i, 87512a-d, e-i, 87513a-i, 87601a-d, 100532a-n, p-r, 100533a-e, 100730a-b, 101093; M_3's, 86986a-b, 87501a-b, 87510a-h, 88093a-i, 100530a-h, 100729; undifferentiated lower teeth, 86993.

Description: The Swain Quarry sample of *Palaechthon* is unimodal in all characters. It contains teeth indistinguishable from the Rock Bench sample, yet the Swain Quarry form shows P^4 with a larger parastyle and metacone and with a variably present paraconule.

M^{1-2} of the Swain form are inseparable from those of the Rock Bench locality, even though the Swain form is modally slightly larger. The parastyle of M^3 is more protruding and the conules are better developed

Table 35

Palaeechthon problematicus

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^4	L	37	.568	.776	.72	2.15-2.65	.129	2.34	5.50
	W					2.20-3.00	.176	2.54	6.93
M^1	L	15	.142	.105	3.54	2.35-2.80	.116	2.46	4.72
	W					3.15-3.40	.085	3.29	2.59
M^2	L	30	.316	.527	2.43	2.25-2.55	.110	2.37	4.65
	W					3.40-3.90	.183	3.68	4.98
M^3	L	22	.277	.354	2.57	1.40-1.65	.065	1.58	4.11
	W					2.95-3.25	.083	3.13	2.64
P_4	L	32	.457	.354	.57	2.10-2.40	.088	2.20	4.00
	W					1.20-1.45	.068	1.35	5.03
M_1	L	52	.335	.356	.78	2.15-2.55	.083	2.37	3.50
	AW					1.45-1.85	.088	1.63	5.43
	L	52	.267	.283	1.06	2.15-2.55	.083	2.37	3.50
	PW					1.65-1.90	.088	1.73	5.09
	AW	52	.629	.632	.71	1.45-1.85	.088	1.63	5.43
	PW					1.65-1.90	.088	1.73	5.09
M_2	L	53	.494	.478	.63	2.25-2.55	.092	2.39	3.83
	AW					1.60-2.00	.089	1.77	5.00
	L	53	.469	.584	.43	2.25-2.55	.092	2.39	3.83
	PW					1.65-2.05	.114	1.83	6.24
	AW	53	.730	.932	.18	1.60-2.00	.089	1.77	5.00
	PW					1.65-2.05	.114	1.83	6.24
M_3	L	28	.590	.420	.45	2.40-2.80	.107	2.60	4.10
	W					1.40-1.65	.076	1.54	4.93

in the Swain Quarry form.

The P_4 is anteriorly much more quadrate than the Rock Bench form, with the paraconid varying from a slightly swollen crest to a distinct cusp placed medially to internally on the paralophid. The metaconid is present but may vary from an irregular swelling on the lingual slope of the protoconid to a distinct cusp, isolated with or without associated crest development. Two posterior cusps occur on the talonid. The more labial is generally larger or rarely equal to the internal. M_1 has the protoconid and metaconid transversely opposed as in the Rock Bench P. problematicus and P. "wilsoni". The symmetrical nature of the bifurcation of the hypoconulid may vary to produce a lingually slightly divided projection or one that has the larger portion of the double hypoconulid located labially. Other than a lesser degree of talonid expansion, M_3 is inseparable from P. problematicus from the Rock Bench Local Fauna, Park County, Wyoming.

Discussion: Jepsen (1930) named Plesiolestes problematicus and related it to plesiadapids on the basis of the enlarged incisor, shape of molar trigonids and the character of the M_3 talonid, which can now be shown to be exceptionally variable. He did not compare it with the previously described Palaechthon alticuspis (Gidley, 1926).

Gazin (1968) named "Torrejonia wilsoni" from the Nacimiento Formation, San Juan Basin, New Mexico. Szalay (1973) correctly related it generically to Plesiolestes, from which it differs primarily in its slightly larger size. There are very few differences of morphology which could be given any significance at all. Size differences exist as well as the slightly smaller paraconid typical of larger forms. No character could be found of generic significance. Retention of Plesiolestes as a separate genus is no longer useful in that it hides relationships of samples all of which can be shown to represent a single taxonomic unit.

With the addition of the new material from Swain Quarry, the separation maintained by Szalay (1973) of P. problematicus from P. "wilsoni" no longer exists. P. wilsoni therefore becomes a junior synonym of P. problematicus.

The genus Palaechthon is thus defined to contain P. alticuspis, P. problematicus, and P. sirokyi. P. problematicus will probably be shown to be a large form of P. alticuspis and further taxonomic revision may be necessary, but for the present, an intermediate form is lacking.

Bown an Gingerich (1973) have referred Palaechthon ("Plesiolestes") to the Microsyopidae but failed to clarify the relationship of microsyopids to paromomyid primates. It is obvious that both groups share derived features of the M_3 not shared by non-primate groups and are therefore related. The nature of their P_4, however, is substantially different in that Palaechthon retains a primitive form similar to Purgatorius and several hyopsodont ungulates including Promioclaenus and Litaletes. Paromomys has a derived P_4 and high basined molar trigonid typical of later primates. The relationship may be best defined by referring to the family Microsyopidae as the sister group of the primates. Until the situation is further studied, Microsyopidae is placed incertae sedis within the order Primates.

Family Picrodontidae

Genus Picrodus Douglass, 1908

Picrodus Douglass, 1908, p. 17

Picrodus silberlingi Douglass, 1908

Type: CM 1670, dentary fragment with P_4-M_1, from Silberling Quarry; CM 1675, dentary fragment with M_2 and talonid of M_1 from Silberling Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry and Silberling Quarries, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH M^1's, 89508a-c, 89509a-d, 87901, dentary fragment with M_1; 89502, dentary fragment with $I_{?1}$ and M_1; 89503, dentary fragment with M_2; 89504, dentary fragment with M_{1-2}; 89505, dentary fragment with P_4-M_1; 89506, dentary fragment with M_1; M_1's, 89507a-g, 87912a-b, 100529a-c; fragments, 87911a-h.

Description: Nothing can be added to the description of referred material contained in Szalay (1968).

Order Taeniodonta

Genus Psittacotherium Cope, 1882

Psittacotherium Cope, 1882, p. 157

Psittacotherium multifragum Cope, 1882

Plate XI, figs. 1-3; Table 36

Psittacotherium multifragum Cope, 1882, p. 157

Type: AMNH 3413, lower jaws, from the Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico; Dragon Local Fauna, Joe's Valley Member, North Horn Formation, Dragon Canyon, Emery County, Utah; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana.

Referred material: AMNH M^1's, 100563, 87598.

Description: The sample from Swain Quarry compares remarkably well with specimens from the Torrejon Arroyo in the San Juan Basin and Gidley Quarry from the Crazy Mountain Field. AMNH 16731 from the Torrejon Arroyo is a relatively unworn M^1 which is inseparable from that of Swain Quarry. Conules of the latter are slightly more elongate along the transverse tooth margins.

The additional material adds little to the definition of the taxon except to record unworn complete teeth where such items are rare.

Table 36

Psittacotherium multifragum

A.M.N.H. No.	Tooth	L	W
100563	M^1	15.00	9.85
87598	M^1	14.80	10.50

Order Arctocyonia

Family Arctocyonidae

Genus Chriacus Cope, 1883

Lipodectes Cope, 1881, p. 1019 (in part)

Chriacus Cope, 1883, p. 314 (in part)

Chriacus pelvidens (Cope, 1881)

Table 37

Lipodectes pelvidens Cope, 1881, p. 1019

Chriacus pelvidens (Cope, 1881): Cope, 1883-4, p. 314, (in part)

Chriacus stenops Cope, 1888, p. 341

Type: AMNH 3097, dentary fragment with P_4-M_3 from the Nacimiento Formation (Torrejon Formation of Matthew, 1937), San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian:) Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico. Upper Paleocene (Tiffanian): Saddle Locality, Bison Basin, Fremont County, Wyoming.

In addition to these known references, several others contain elements identified as *Chriacus* sp. in middle and upper Paleocene localities.

Referred material: AMNH P^3, 100204; P^4's, 100204a-c; M^1's, 87686a-m, 87694a-b, 87753, 87823, 100202a-c, e-g; M^2's, 87630, 87631a-c, 87694c-e, 87695a-b, 87733a-b, 100202d, 100205a-b; M^3's, 87744a-e, 87746a-d, 87752, 100203a-e; 100560, dentary fragment with P_4-M_1; 100561, dentary fragment with M_{2-3}; P_1, 100206f; P_2, 100206e; P_3's, 87759, 87760, 100206b, d; P_4's, 100206a, 100212; M_1's, 87656, 87669a-b, g, 87671b, 87718a-d, 100201a, c, 100213a-c, 100214, 100215, 100312c-d, 100313; M_2's, 87669c-f, 87670, 87671a, c, 87716, 100201b, 100213b, 100216, 100312a-b, e; M_3's, 87634, 87767a-f, 100207, 100304, 100826a-b; DP^4's, 100208a-b, and questionably referred 100209a-b; DP_4's, 87925, 100210, 100211a-b, 100671.

Description: All dental elements preserved in the Swain Quarry collection are inseparable from *C. pelvidens* from the *Pantolambda* beds of the Nacimiento Formation, San Juan Basin. The upper molars of the Swain Quarry sample have a slightly more accentuated hypocone, more internal on M^1 and more posteriorly isolated on M^2. M^{1-2} of the Swain form are generally longer, with parastyle and metastyle less acute, than those from the San Juan Basin. Lower molars from Swain Quarry are slightly larger and more quadrate on the basis of the total sample than those of the Nacimiento Formation.

Discussion: *C. pelvidens* found in the Swain Quarry collection may be slightly more derived than the form in the San Juan Basin because of the accentuated hypocone on upper molars and the more robust lower teeth. However, both forms are remarkably similar and no consistent morphologic separation can be seen between them.

Genus *Mimotricentes* Simpson, 1937

Tricentes Gidley, Simpson, 1935, p. 236

Mimotricentes Simpson, 1937, p. 203

Mimotricentes subtrigonus (Cope), 1881

Plate VIII, figs. 3-8; Table 38

Mioclaenus subtrigonus Cope, 1881, p. 491

Phenacodus zuniensis Cope, 1881, p. 492

Mioclaenus bucculentus Cope, 1881, p. 555

Tricentes subtrigonus (Cope) Cope, 1884, p. 315

Mimotricentes subtrigonus (Cope): Van Valen and Sloan, 1965, p. 745

Type: AMNH 3227, partial skull with parts of both upper dentitions from the Nacimiento Formation (Torrejon Formation of Matthew,

Table 37

Chriacus pelvidens

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^3	L	1				4.95		4.95	
	W					4.50		4.50	
P^4	L	3				5.25-5.70		5.45	
	W					5.55-6.30		5.86	
M^1	L	17	.270	.331	5.22	6.15-7.35	.285	6.54	4.36
	W					6.45-7.65	.350	7.39	4.74
M^2	L	11	.734	.732	3.54	6.75-7.80	.488	6.94	7.03
	W					7.95-9.45	.486	8.62	5.64
M^3	L	14	.552	1.564	.51	4.65-5.25	.161	5.08	3.17
	W					7.65-9.30	.455	8.45	5.38
P_1	L	1				3.15		3.15	
	W					2.85		2.85	
P_2	L	1				3.90		3.90	
	W					2.25		2.25	
P_3	L	4				4.80-5.70		5.11	
	W					2.85-3.45		3.07	
P_4	L	3				5.70-6.75		6.31	
	W					3.00-3.45		3.28	
M_1	L	19	.266	.236	3.29	6.45-7.65	.390	7.14	5.48
	AW					3.90-5.10	.281	4.39	6.40
	L	19	.721	.495	1.29	6.45-7.65	.390	7.14	5.48
	PW					4.20-5.40	.268	4.82	5.56

Table 37 cont.

Chriacus pelvidens

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M_1	AW	19	.828	.790	1.35	3.90-5.10	.281	4.39	6.40
	PW					4.20-5.40	.268	4.82	5.56
M_2	L	15	.266	.236	3.29	6.45-7.65	.328	7.09	4.63
	AW					4.35-5.25	.291	4.97	5.86
	L	15	.365	.390	2.35	6.45-7.65	.328	7.09	4.63
	PW					4.50-5.70	.327	5.10	6.41
	AW	15	.792	.849	.82	4.35-5.25	.315	4.97	6.34
	PW					4.50-5.70	.338	5.04	6.71
M_3	L	11	.242	.125	3.32	7.05-8.10	.451	7.64	5.90
	W					3.90-4.65	.233	4.27	5.46

Table 38

<u>Mimotricentes</u> <u>subtrigonus</u>

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M^1	L	55	.490	.570	2.85	4.65-6.45	.323	5.61	5.76
	W					5.25-7.20	.370	6.05	6.12
M^2	L	56	.410	.530	4.39	5.25-6.60	.395	5.86	6.74
	W					6.60-8.85	.514	7.55	6.81
M^3	L	52	.690	.500	.97	5.40-6.75	.317	4.15	7.64
	W					3.45-5.95	.436	6.27	6.95
P_3	L	1				4.35		4.35	
	W					2.70		2.70	
P_4	L	3				5.10-5.40		5.25	
	W					3.15-3.30		3.23	
M_1	L	68	.320	.510	.90	5.10-6.45	.268	5.87	4.57
	AW					3.30-4.35	.235	3.86	6.09
	L	68	.470	.430	1.68	5.10-6.45	.268	5.87	4.57
	PW					3.75-4.95	.264	4.10	4.50
	AW	68	.740	.760	1.29	3.30-4.35	.235	3.86	6.09
	PW					3.75-4.95	.264	4.10	4.50
M_2	L	62	.730	.670	.42	5.55-6.90	.288	6.30	4.57
	AW					4.20-5.10	.265	4.70	5.64
	L	62	.650	.660	.51	5.55-6.90	.288	6.30	4.57
	PW					4.05-5.25	.292	4.75	6.15
	AW	62	.830	.910	.44	4.20-5.10	.265	4.70	5.64
	PW					4.05-5.25	.292	4.75	5.64
M_3	L	75	.440	.530	.67	5.70-7.20	.357	6.44	5.54
	W					3.30-4.80	.427	4.10	10.41

1937), San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico; Dragon Local Fauna, Joe's Valley Member, North Horn Formation, Emery County, Utah; Rock Bench Locality, Polecat Bench, Fort Union Formation, Park County, Wyoming.

Referred material: AMNH M^1's, 87687a-l, 87689a-l, 87692a-m, 100574a-l, 100575a-l, 100576a-c; M^2's, 87694a-l, 87698a-l, 100278, 100578a-l, 100579a-l, 100580a-g; M^3's 87684a-n, 87690a-n, 87691a-n, 87739a-g, 87828, 100582a-n, 100583a-n, 100584a-n, 100781a-b; 87562, dentary fragment with M_{1-3}; 87568, dentary fragment with M_{2-3}; 87569 dentary fragment with P_4-M_1; 87571, dentary fragment with M_{2-3}; 87573, dentary fragment with M_{2-3}; 87574, dentary fragment with M_{2-3}; 87575, dentary fragment with M_{2-3}; 87576, dentary fragment with M_{2-3}; 100266, dentary fragment with P_{3-4}; 100294, dentary fragment with P_4-M_2; 100298, dentary fragment with M_{2-3}; M_1's, 87510, 87664a-b, 87666a-l, 87667a-k, 87672a-l, 87713a-c, 100291, 100292, 100597a-k; M_2's, 87564, 87566, 87570, 87577, 87663a-e, 87668a-g, 87669a-k, 87713b-c, 100276, 100277, 100293, 100295, 100306, 100307a-h, 100308, 100309, 100310, 100311, 100314a-b, 100595a-n; M_3's, 87563, 87565, 87567, 87572, 87704a-b, 87764a-c, 87766a-d, 87777a-l, 100296, 100297, 100300, 100301, 100302a-g, 100303a-l, 100584a-l, 100701a-h, 100715.

Description: All dental elements from Swain Quarry are inseparable from M. <u>subtrigonus</u> 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 P_4's have been assigned to the taxon. M^{1-2} show variably developed cingula around the base of the protocone. M^2's have a complete cingulum although a few show only a continuous wrinkle. The cingulum of M^1 has a suggestion of continuity but is generally incomplete. M^2'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 M^1's and M^3'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 the anterior cingulum and preparacrista. M^1 and M^2, when represented only by isolated teeth, may be easily separated because of the more quadrate nature of the M^1. M^3's are exceptionally variable, particularly in width, which affects the metaconule, posterior cingulum, and confluence of the labial and posterior cingula.

Lower premolars are generally large and do not show the reduced nature of some related forms. P_4 has a paraconid developed as a cusp anteriorly and lingually, on the anterior cingulid. The metaconid may vary from a small, poorly developed cuspule to a well defined cusp. The talonid shows 1-3 cusps of various sizes with the medial one always present and largest, but the medial cusp may vary greatly in size.

M_1 has a labial cingulid which is remarkably variable and accounts for most of the variation seen in Table 38. The metaconid is generally posterior to and smaller than the protoconid but may be transversely opposed and nearly equal to it in size. The hypoconulid is arcuate and the hypoconid large. The hypoconulid and entoconid are intimately associated but their proximity may vary considerably from nearly fused in the extreme posterior lingual corner of the talonid to well separated with the hypoconulid medially located. An entoconulid is variably present.

M_2 is more quadrate than M_1, with the paraconid not so anteriorly projecting but more medially located, the entoconulid more distinct, hypoconulid distinct and medially separate and the entoconid posterior to the hypoconid. Each of these characters varies similarly to those of M_1.

M_3 is posteriorly too variable for taxonomic use. Most M_3 characters, especially talonid features, can be seen to vary greatly. For example, the talonid may be rounded, inflated or pointed, with a moderately projecting hypoconulid. The cristid obliqua may be arcuate and inflated or sharp and well defined. The paraconid may also be seen to vary considerably in position on the anterior lingual portion of the tooth.

Discussion: The Swain Quarry collection does not add significantly to the known range of variability of Mimotricentes but it is the only major sample of the taxon from a single locality and therefore demonstrates how much variability is to be expected within deme samples.

Genus Prothryptacodon Simpson, 1935

Prothryptacodon cf. furens

Table 39

Distribution: Middle Paleocene (Torrejonian): Swain Quarry.

Referred Material: AMNH M_1's, 100627b-c, e, 100660a; M_2's, 87924a-c, 87935a-c, 100590, 100596, 100627a, d, f, 100644, 100660b-c; M_3, 100589, questionably referred are also DP_4's, 87934, 100661a-b.

Description: No elements of the upper or antemolar lower dentition are referred. If present, they are confused with teeth of Pantinomia hilli. M_1 is differentiated from M_2 on the basis of the anteriorly projecting paraconid. Both teeth are nearly the same size and similar in form to M_1 and M_2 of P. furens from Gidley Quarry. Both M_1 and M_2 are variable in paraconid placement and development of the entoconulid, mesoconid, and posterior trigonid pit. However, all molars are as long as P. furens but are distinctly narrower. M_2 is anteriorly expanded and has a separate low paraconid. All teeth show more trigonid relief, with conical cusps and more acute crest development than is preserved in material of P. furens from Montana.

Discussion: Although the Swain Quarry sample may represent a new species, neither the Gidley or Swain Quarry samples are adequately known. It is now evident, however, that two animals morphologically similar to Prothryptacodon are present in the Torrejonian and can be recognized on the degree of lingual inclination of molar teeth. The presence of both animals in the Swain Quarry collection lends further support to the argument that there are indeed two genera: Prothryptacodon, characterized by erect molar teeth, and Pantinomia, characterized by inclined to strongly inclined molar teeth.

Genus Pantinomia Van Valen, 1967

Pantinomia Van Valen, 1967, p. 222

Pantinomia hilli, n. sp.

Plate IX, fig. 4; Table 40

Etymology: Named for Orrin Hill, member of the 1973 field party.

Type: AMNH 100600i, isolated M_2 from the Middle Paleocene (Torrejonian), Swain Quarry, east flank of the Washakie Basin, Carbon County, Montana.

Table 39

Prothryptacodon cf. furens

Swain Quarry, Carbon County, Wyoming

		N	OR	M
M_1	L	4	5.00-5.25	5.11
	AW	4	3.00-3.50	3.15
	PW	4	3.15-3.45	3.30
M_2	L	13	4.50-5.25	4.97
	AW	13	2.70-3.45	3.11
	PW	13	2.85-3.60	3.23
M_3	L	1	5.61	5.61
	W	1	3.48	3.48

Table 40

Pantonomia hilli, n. sp.

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
M^1	L	27	.137	.204	4.77	4.05-4.95	.226	4.59	4.92
	W					5.25-6.30	.336	5.72	5.87
M^2	L	19	.433	.661	3.35	4.20-5.25	.259	4.91	5.27
	W					6.00-7.35	.395	6.60	5.98
M_1	L	16	.456	.263	2.11	3.90-4.80	.295	4.51	6.54
	AW					3.20-3.50	.171	3.30	5.19
	L	16	.507	.364	1.80	3.90-4.80	.295	4.51	6.54
	PW					3.60-4.20	.212	3.44	6.17
	AW	16	.887	1.090	-.16	3.20-3.50	.171	3.30	5.19
	PW					3.60-4.20	.212	3.44	6.17
M_2	L	18	.391	.345	2.06	4.70-5.40	.205	5.16	3.97
	AW					3.50-4.10	.180	3.84	4.69
	L	18	.648	.607	.84	4.70-5.40	.205	5.16	3.97
	PW					3.60-4.20	.191	3.97	4.81
	AW	18	.849	.903	.51	3.50-4.10	.180	3.84	4.69
	PW					3.60-4.20	.191	3.97	4.81
M_3	L	28	.267	.329	1.72	4.40-5.30	.286	4.81	5.94
	W					2.90-3.80	.355	3.31	10.72

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH M^1's, 87673a, f, 87699a-k, 100704j, l, 100705a, d-e, 100706a-l, 100707a-c; M^2's, 87673b-e, 87699l, 100704a-i, k, 100705b-c, f-h; M_1's, 87784a-l, 100599a-f; M_2's, 100600a-h, j-k, 100601a-h; M_3's, 87771a-k, 87783a-b, 100598a-i, 100700a-f.

Diagnosis: It is larger than P. ambigua, with a greater inclination of lower molar teeth. The external cingulum is enlarged similar to that of Haplaletes. The M_3 is slightly reduced. The paraconid and metaconid, although separate and distinct, closely approximate each other on the internal margin. The talonid is proportionately larger than the trigonid. Local cusp relief is considerably less than in known forms of Pantinomia, Haplaletes, and Mimotricentes. The posterior lingual margin of the metaconid is developed into a crest-like border which descends to the talonid notch, unlike Prothryptacodon and Mimotricentes but similar to Haplaletes and Pantinomia.

Description: Upper and lower premolars are not found in association with molar teeth and are therefore unknown, but are undoubtedly present in the collection based upon the number of referred molar teeth.

Upper teeth are very similar to those of Prothryptacodon and those referred here to Pantinomia may include some specimens referable to Prothryptacodon cf. furens. Upper molars are characteristically simple with few diagnostic features. They have lost the complete internal cingulum, which if present appears in this form as an interrupted wrinkle at the base of the protocone. The hypocone is not lingually displaced as in Haplaletes but remains simple, low and separate, directly posterior to the protocone. The protocone is high and simple but only slightly higher than the paracone and metacone. Both conules are present, equally large and equidistantly placed on the slope of the protocone. The conulecristas are simple with the internal pair slightly smaller and less well defined than the external pair. The paracone and metacone are conical and equal in size. The parastyle is slightly enlarged when compared to Haplaletes and Prothryptacodon but the metastyle is similarly developed in all three forms.

The lower molars are most diagnostic in possessing an expanded external portion with an enlarged external cingulum which accentuates an internal or lingual inclination of the teeth. In this character Pantinomia hilli most closely resembles Haplaletes disceptatrix from Gidley Quarry, Montana, but differs strongly from it in the nature of the molar paraconids. The paraconid of M_1, although similar to M_2, is placed more anteriorly and medially. All M_2's preserve a separate distinct cusp, at the termination of the paralophid (paraconid), which is generally located near the apex of the metaconid or slightly internal to it. These two cusps share a common base and appear to form a functional unit. The metaconid is larger and higher than the transversely opposed protoconid. All teeth show proportionately less trigonid relief than Pantinomia ambigua, Haplaletes, Thryptacodon, Prothryptacodon, Tricentes and Mimotricentes. The talonid portion is expanded and is larger than the trigonid. The hypoconid is large and comprises half of the talonid. The hypoconulid is small and lingually displaced. A small entoconid is present but varies considerably in size and shape. The talonid forms an actual basin with poor trigonid notch development.

Discussion: Van Valen (1967, p. 222) named Pantinomia ambigua from a single specimen (AMNH 16591, a dentary fragment with P_4 and M_2). He included a lengthy discussion of similarities with Propalaeosinopa, Palaeosinopa and Oxyclaenus, where he offered several alternatives for relationships. He later substituted (p. 225) a footnote in which he stated a belief that Pantinomia is an arctocyonid based upon comparison with Protungulatum. The additional material of P. hilli, from Swain Quarry further substantiates this opinion. Both Prothryptacodon and Pantinomia are present in the fauna and are readily separated on the basis of the inclined nature of lower molar teeth of Pantinomia.

The comparison with Haplaletes, however, is striking. The small paraconid of Haplaletes, if present, is variably placed low on the metaconid slope, a character shared with Adapisorex, Litolestes, and not Prothryptacodon, Thryptacodon, and Pantinomia. The relationship of these forms is confused. I presently regard the strong lingual inclination of molar teeth as a character derived at least twice; once among the erinaceoids and once among the artocyonids, the extreme case of which is preserved in Pantinomia hilli.

Genus Protogonodon Scott, 1892

Mioclaenus Cope, 1888, p. 325 (in part)

Protogonodon Scott, 1892, p. 322

Protogonodon criswelli n. sp.

Plate IX, figs. 1-3

Etymology: Named for the Criswell family of Dixon, Wyoming.

Type: AMNH 87582, dentary fragment with M_{1-2} from Swain Quarry.

Distribution: Swain Quarry is the only known locality.

Diagnosis: Morphologically similar to Protogonodon pentacus but 1/2 its size. Molars are quadrate and very inflated, with the protoconid-metaconid separation equal to 1/3 the width of the tooth. M_3, by alveolar inference, is only slightly reduced. Major molar cusps are slightly less inflated with better crest development than in P. pentacus. The paraconid is more labially located. A posterior trigonid pit between the protoconid and metaconid is present in P. criswelli but absent in P. pentacus. Measurements in mm.: M_1, L, 5.25; AW, 4.70; PW, 4.35. M_2, L, 5.40; AW, 4.95; PW, 4.60.

Discussion: P. criswelli is represented by a single dentary fragment with M_{1-2} and alveoli for M_3.

P. criswelli extends to the Torrejonian the range of a genus previously known only from Puercan deposits. If size differences could be overlooked, the type specimens of P. criswelli and the Puercan P. pentacus would be nearly identical. P. criswelli also provides evidence that tooth inflation, observed in so many Paleocene ungulates, has taken place in several different lineages at different times and should not be used as a taxonomic character unless it is clearly stated at what level it is being used to distinguish taxa. Mioclaenus, Phenacodus, and Protogonodon all greatly inflate their teeth but in different ways. Protogonodon maintains major trigonid cusps in close proximity to each other and inflates the surrounding portions of the teeth. Mioclaenus maintains a wide separation of the major trigonid cusps with the paraconid lingually placed and reduces the paraconid. Phenacodus maintains all cusps in the primitive position but inflates the whole tooth instead of just external portions as does Protogonodon.

Subfamily Arctocyoninae

Genus Arctocyon Blainville, 1841

Arctocyon Blainville, 1841, p. 73
Hyodectes Cope, 1880, p. 79
Heteroborus Cope, 1880, p. 79
Claenodon Scott, 1892, p. 298 (in part)
Arctotherium Lemoine, 1896, p. 342, nec Bravard, 1857

Arctocyon ferox (Cope), 1883

Table 41

Mioclaenus ferox Cope, 1883, p. 547
Claenodon ferox (Cope): Scott, 1892, p. 298
Arctocyon ferox (Cope): Russell, 1964, p. 137

Type: AMNH 3268, teeth and parts of a postcranial skeleton from the Nacimiento Formation (Torrejon Formation of Matthew, 1937), San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico; Gidley Quarry, upper Lebo Formation, Sweetgrass County, Montana.

In addition to these references, several others have been made, including 3 separate localities from the Bison Basin Paleocene deposits, Silberling and Scarritt Quarries of the Crazy Mountain Field, Circle Local Fauna, Rock Bench Quarry of Polecat Bench, and Paskapoo Formation of Alberta, Canada.

Referred material: AMNH 87851, maxilla fragment with P^{3-4}; M^1, 100558; M^2, 87635; P_4's, 87758, 100556; M_1's, 87632, 87742, 100557; M_2, 87762; M_3's, 87626a-b, 87768.

Description: Most dental elements are indistinguishable from the type specimen of A. ferox, AMNH 3268, but some upper molars compare favorably with those of A. montanensis. The sample from Swain Quarry is so small that variability is not securely known.

Discussion: The stratigraphy, distribution, and systematics of A. ferox and its relatives are among the most irritating problems of Paleocene mammalian taxa. Seldom is there an adequate sample from any locality where sufficient stratigraphic data are available. In collections where more than one individual is present, bimodal characters are observed and authors often feel compelled to erect new taxa. Little has been stated about sexual dimorphism or deme variability because of inadequate samples. It is difficult to let such an intriguing problem rest. All that can be said at the present about the Swain Quarry problematical A. ferox, is that it is an intermediate form between A. ferox and A. procyonoides and spans the variation displayed by A. montanensis. Perhaps Van Valen's planned review of the arctocyonids will help resolve the issue.

Genus Goniacodon (Cope) Cope, 1883

Goniacodon (Cope) Cope 1883, p. 546
Triisodon Cope, 1883, p. 546
Goniacodon Scott, 1892, p. 301

Goniacodon levisanus

Plate XI, figs. 4-6

Goniacodon levisanus (Cope) Cope, 1883, p. 546
Triisodon levisanus Cope, 1883, p. 546
Goniacodon levisanus Scott, 1892, p. 301

Type: AMNH 3217, right lower jaw fragment with broken P_4

Table 41

<u>Arctocyon</u> <u>ferox</u>

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
87815	P^3	7.50	5.25	
100558	M^1	9.75	10.65	
100556	P_4	10.65	5.55	
87742	M_1	9.35	6.30	7.20
87762	M_2	11.40	8.10	8.70
87626a	M_3	11.10	7.50	
87768	M_3	10.20	6.15	

and M_2, from Nacimiento Formation, San Juan Basin, New Mexico (Torrejon Formation of Matthew).

Distribution: Middle Paleocene (Torrejonian), Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico.

Referred material: AMNH 87745, isolated lower molar.

Discussion: The material is inseparable from the sample of G. levisanus from the Nacimiento Formation of the San Juan Basin, New Mexico. Measurements in mm.: L. 6.82; AW, 5.61; PW, 4.70.

Family Periptychidae
Subfamily Periptychinae
Genus Periptychus Cope, 1881

Periptychus Cope, 1881, p. 337

Periptychus carinidens Cope, 1881
Plate XIV, figs. 7-9; Table 42

Periptychus carinidens Cope, 1881, p. 337
Periptychus rhabdodon Cope, 1885, p. 403

Type: AMNH 3620, dentary fragments with DP_3 and DP_4. From the Nacimiento Formation (Torrejon Formation of Matthew, 1937), San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian); Swain Quarry; Nacimiento Formation, San Juan Basin, New Mexico.

Referred material: AMNH P^2's, 87710, 87580a; P^3, 87850b; P^U fragment, 87740; M^1 fragment, 87591; M^1, 100564; 87579, dentary with M_{1-2}, M_1 fragment, 100564; M_3, 87761.

Description and Discussion: Cope (1881) named P. carinidens on the basis of a deciduous dentition which was not recognized as such until after the permanent dentition had been named by him (Cope, 1885) as P. "rhabdodon". Matthew (1937) synonymized them in his review of Paleocene mammals from the San Juan Basin. The specimens from Swain Quarry are inseparable from AMNH 3627, the type specimen of P. "rhabdodon", which is the permanent dentition of P. carinidens. Some slight differences were noted on the M_1, including stronger, better developed crests and obliconid (p. 28) with a higher and larger protoconid. Little can be said about variability because of insufficient material, but observed differences are taken to be well within expected variability.

Subfamily Anisonchinae
Genus Anisonchus (Cope), 1881

Mioclaenus Cope, 1881, p. 831
Anisonchus Cope, 1881, p. 488

Anisonchus willeyi, n. sp.
Plate X, figs. 1-10; Table 43

Etymology: Named for the Willey family of Baggs, Wyoming.

Type: AMNH 100260, dentary fragment with P_4-M_1, from Swain Quarry, middle Paleocene (Torrejonian), Fort Union Formation, east flank of the Washakie Basin, Carbon County, Wyoming.

Distribution: Swain Quarry is the only known locality.

Referred material: AMNH 87624, maxilla with M^{1-2}; 87623, maxilla with M^{2-3}; M^1's, 100220a, d-g; M^2's, 87721, 100219a-b, 100220b-c; M^3's, 87706a-d; P_3's, 87645, 87903c, h; P_4's, 87903a-b, d-g; M_1's, 87822e-g; M_2's, 87621, 87822a-d, 100261; M_3's, 87649, 87773a-b; DP^4, 87678a; DP_4's

Table 42

Periptychus carinidens

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
87580a	P^2	11.70	10.20	
87710	P^2	12.00	9.75	
87580b	P^3	10.80	10.50	
100564	M^1	9.00	10.20	
87579	M_1	11.40	8.85	8.40
	M_2	10.50	9.15	8.70
87761	M_3	12.00	7.80	

Table 43

Anisonchus willeyi, n. sp

Swain Quarry, Carbon County, Wyoming

		N	OR	M
M^1	L	4	3.40-3.90	3.68
	W	4	5.10-5.55	5.25
M^2	L	7	3.60-4.15	3.87
	W	7	5.55-6.15	5.96
M^3	L	5	3.60-3.70	3.64
	W	5	5.50-5.90	5.77
P_3	L	3	4.45-4.65	4.53
	W	3	2.25-2.80	2.53
P_4	L	7	4.40-4.70	4.53
	W	7	2.85-3.25	3.01
M_1	L	4	3.95-4.10	4.05
	AW	4	2.75-2.90	2.80
	PW	4	2.85-3.15	3.00
M_2	L	6	3.90-4.35	4.09
	AW	6	3.10-3.40	3.23
	PW	6	3.10-3.45	3.40
M_3	L	3	4.50-5.10	4.87
	W	3	2.60-3.05	2.90

87678b-c.

Diagnosis: Smaller than A. gillianus, with a distinct posterior metacristid developed on M_{1-2} and two variably confluent crests present, one from the anterior face of the metaconid and the other from the posterior face of the paraconid. They completely ring the trigonid of all molars with intercusp crests. The paraconid of M_1 labially and anteriorly displaced, causing the tooth to taper anteriorly. Posterior cingular ring is complete on M_3. Conules of upper molars are present but poorly developed.

Description and discussion: Upper dental elements preserved in the collection are limited to the molar row. These teeth are similar to A. sectorious and would be confused with it were it not for the large size disparity. The only often consistent difference is the nearly total lack of conules in A. sectorious. A. willeyi has upper molars with small variable parastyle, metastyle poorly developed and hypocone slightly more posterior than in A. sectorious. The hypocone is only slightly expanded internally but the teeth retain a quadrate nature.

P_3 is a simple anisonchine tooth with a small distinct paraconid on the anterior protoconid crest but not separate from it. It has a small talonid basin with a single cusp at the apex of two posteriorly ascending crests, which also ascend the posterior slope of the protoconid. No metaconid is present.

P_4 is similarly constructed to P_3 but with anterior and posterior cingulids, metaconid and larger talonid basin.

M_1 is narrow anteriorly and is widest across the talonid. Anterior and posterior cingulids are present and complete. The paraconid is separate and equal in size to the metaconid and protoconid. It is lower on the crown of the tooth and lingually placed so as to be at or lingual to the midline of the tooth. A posterior metacristid is present and well developed. The cristid obliqua is moderately developed and reaches the trigonid base midway between the protoconid and metaconid. There are only three talonid cusps; all are nearly equal and equidistantly spaced. The hypoconulid is medial and posteriorly placed, the entoconid and hypoconid are transversely opposed, and all are connected with simple low crests which enclose a true basin.

M_2 is similarly constructed to M_1, with the exception of a less laterally displaced paraconid. Better than on other molars, it displays the very diagnostic feature of additional trigonid crest development. All molar teeth possess two crests, one anteriorly directed from the metaconid and the other posteriorly directed from the paraconid which may meet at the valley separating the two major cusps. This is typically open in other anisonchines, without any restriction. The trigonid of A. willeyi is almost completely ringed by crests.

The trigonid of M_3 is similar to that of M_2. The posterior cingular ring is present, low and complete. Talonid cusps are separate, conical and high; all are connected by crests to form a true basin.

Deciduous elements of the dentition are also known. AMNH 87678 is a DP^4. It has a diagnostic triangular shape with the hypocone large and exaggerated medially. The conules are poorly developed and the internal conulecristae are present and terminate at the base of their respective cones. The posterior cingulum is complete, uninterrupted, and confluent with the labial cingulum. The latter is also complete and uninterrupted. There is no metastyle but a strong separate parastyle is present. All three of the major trigonid cusps are equal and equidistantly separated.

DP_4 is known by AMNH 87678b and c. It is slightly bilobate with complete anterior, labial and posterior cingulids. The trigonid is molariform but longitudinally expanded. The paraconid is separate, distinct, and large with a small pit separating it from the protoconid. An anterior crest descends from the paraconid and recurves posteriorly but does not interrupt the anterior cingulum. The protoconid is simple and high and is connected to the metaconid by a simple crest. The metaconid is very large, with a single posteriorly descending crest which may or may not be notched at its lowest point which is confluent with crests which ring the talonid basin. Only three cusps are present on the talonid; the hypoconid is the largest, the hypoconulid very small and questionably present. The cristid obliqua is directed toward the base of the metaconid.

Discussion: The closest relative of A. willeyi probably is A. oligistus from the Wagonroad locality, Puercan, of the North Horn Formation. They share the extra crest development in the trigonid and the greater degree of cusp separation. However, the M_1 of A. willeyi is substantially tapered and anteriorly elongated, a character not exhibited by M_1 of A. oligistus. Such characters as additional trigonid crests, poor conule development, and the posterior cingular ring on M_3 separate A. willeyi from all other known anisonchines.

It is now apparent that there are at least two separate phyletic groups now contained within the genus Anisonchus. Although no formal action is taken at present, two separate genera could be designated. One could include A. sectorius and the questionably distinct A. dracus based upon larger size and incomplete talonid basins. The other could include A. gillianus, A. onostus, A. oligistus and A. willeyi based upon complete talonid basins, small size and a much more pronounced hypocone on upper molars.

Anisonchus sectorius (Cope), 1881
Plate IX, figs. 5-7; Table 44

Mioclaenus sectorius Cope, 1881, p. 831
Mioclaenus mandibularis Cope, 1881, p. 831
Anisonchus sectorius (Cope): Cope, 1881, p. 488

Type: AMNH 3527, upper and lower jaws containing P^4-M^2, P_4-M_2, from the Nacimiento Formation (Torrejon Formation of Matthew, 1937), San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana; Nacimiento Formation, San Juan Basin, New Mexico.

Referred material: AMNH P^4, 101098; M^1's, 87705a-e; M^2's, 87625a-b; M^3's, 87715a-c; dentary fragment with P_3-M_1, 100218; dentary fragment with P_2-P_4, 87583; dentary fragment with M_2-M_3, 87584; P_3's, 87611, 87643, 87809a-b, 87842, 87904f-g; P_4's, 87654, 87904a-e, h; M_1's, 87646, 87648, 101100a-b; M_2, 101100c; M_3's, 101100d-f; DP^4, 101099d; DP_3, 101099a; DP_4's, 100554, 101099b-c.

Description: The sample from Swain Quarry in Wyoming is similar to samples from both the Nacimiento Formation of New Mexico and the Lebo Formation of Montana. Some differences from both samples are noted but they seem insufficient to call for the addition of a new species. The premolar row of the Swain Quarry form is consistently longer and the individual teeth are wider but the P_{2-3} are essentially as long as those

Table 44

Anisonchus sectorius

Swain Quarry, Carbon County, Wyoming

		N	OR	M
M^1	L	5	4.95-5.25	5.10
	W	5	6.45-7.50	6.94
M^2	L	2	5.55-5.85	5.70
	W	2	6.75	6.75
M^3	L	3	4.05-4.20	4.15
	W	3	5.10-5.85	5.55
P_2	L	1	6.09	6.09
	W	1	3.55	3.55
P_3	L	9	5.55-6.60	5.79
	W	9	3.30-3.75	3.76
P_4	L	9	5.40-6.30	5.89
	W	9	3.60-4.05	3.87
M_1	L	5	5.10-6.00	5.79
	AW	5	3.60-3.75	3.70
	PW	5	3.75-3.90	3.85
M_2	L	2	5.40-5.55	5.47
	AW	2	3.90-4.20	4.09
	PW	2	3.60-4.20	3.94
M_3	L	5	5.40-6.00	5.85
	W	5	3.60-3.75	3.70

of related forms. In occlusal view, the principal cusps are in straight lines with very little lateral displacement of any single cusp. Samples of A. sectorius from the San Juan Basin and Montana all have some lateral displacement. The talonid cusps of P_{3-4} are much simpler than in A. sectorius from Montana or New Mexico. Lower molar samples from New Mexico, Montana and Swain Quarry are indistinguishable.

Upper dental elements of A. sectorius from the San Juan Basin are very similar to those of the Swain Quarry sample. The base of the protocone of M^{1-2} is expanded, making these teeth of the Swain form appear more quadrate. The presence of cuspules on the external cingulum of M^{1-2} further differentiates it from the Nacimiento sample.

The deciduous dentition is now known at least in part. AMNH 101099d is definitely anisochine and is identified as a DP^4. It has a large hypocone lingual to the protocone and both cusps have long sloping internal bases. It is very triangular, possesses a poorly developed paraconule and strong prominent parastyle and has poor cingular development.

DP_3, AMNH 101099a, is at least as long as its permanent counterpart but is drastically narrower. It has an anterior cingulum, a large isolated paraconid placed low on the crown and a large central protoconid with two posteriorly descending ridges. The internal ridge has a swelling where the metaconid would be expected to appear. It also has a single talonid cusp developed as a swelling on the posterior crest. Several DP_4's are present and are characteristically large robust teeth. All possess large prominent paraconids, anterior cingula, central large protoconids, and well developed talonid basins with a full molar complement of cusps. The hypoconid and entoconid are equal to each other. A small medial hypoconulid is separated by a valley from the hypoconid. All molars possess a mesoconid swelling on the cristid obliqua, posterior cingula and a variable external cingulid, which may have several small cuspules on the thicker anterior parts.

Discussion: Although definitely referable to A. sectorius, the material from Swain Quarry appears to be more derived in its larger size, expanded protocone base and loss of premolar paraconid lateral displacement. I do not believe the difference is sufficient to call for its separation as a different species.

Genus Haploconus Cope, 1882

Haploconus Cope, 1882, p. 417

Haploconus sp.

Plate IX, figs. 8-10

Distribution: Middle Paleocene (Torrejonian): Swain Quarry.

Referred material: M_2, AMNH 101102.

Description and discussion: A single lower molar has been found in the collection from Swain Quarry which can be referred to Haploconus. The entire collection was searched to obtain more material of what is obviously a rare animal from Swain Quarry and none was found.

The tooth has the diagnostic Haploconus features of the reduced paraconid and robust nature caused by some degree of inflation, which does not allow it to be confused with other anisochines.

Of the four known species of Haploconus, AMNH 101102 most closely resembles M_2 of H. inopinatus from the Dragon local fauna, it being as long as M_2 of H. angustus but distinctly broader. USNM 16255 from the Dragon locality preserves a part of M_2 of H. inopinatus and comparison with H. angustus shows the former to be slightly broader but not to the degree expected to define a separate species. The single dental element from Swain Quarry is significantly broader than M_2 of both species but is not so large as that of H. corniculatus. H.? elachistus from the Wagonroad locality in Dragon Canyon, Emery County, Utah, is much too small and can be readily eliminated from comparison. Haploconus from Swain Quarry may therefore represent a new species but insufficient material is at hand to properly define its characters.

Its measurements in millimeters are: L, 4.15; AW, 3.55; PW, 3.40.

Order Acreodi

Family Mesonychidae

Genus Dissacus Cope, 1884

Mesonyx Cope, 1881, p. 484

Dissacus (Cope): Cope, 1884, p. 267

Dissacus navajovius (Cope), 1881

Plate XI, figs. 7-9; Table 45

Mesonyx navajovius Cope, 1881, p. 484

Dissacus navajovius (Cope) Cope, 1884, p. 267

Dissacus carnifex Cope, 1882, p. 834 (not D. carnifex of Osborn and Earle, 1895)

Type: AMNH 3356, dentary fragments, with P_3-M_3 and P_4-M_3; locality unknown, but presumed to be from the Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry.

Additional references have been made to forms similar to D. navajovius from a number of other localities including the type Tiffanian, Ledge locality of the Bison Basin, the Tiffanian Buckman Hollow locality.

Referred material: P^2, 87719; P^3, 87712; P^4, 87711; M^1's, 87599, 87720, 100565; two lower molar fragments, 87734, 87825.

Description and discussion: The material from Swain Quarry probably represents teeth referable to D. navajovius. The material can add little to the definition of the taxon because of its scarcity but all specimens are indistinguishable from AMNH 3356, the type specimen from the San Juan Basin, New Mexico.

Table 45

Dissacus navajovius

A.M.N.H. No.	Tooth	L	W
87719	P^2	9.45	6.30
87712	P^3	9.60	8.40
87711	P^4	10.20	10.05
81599	M^1	11.70	12.30

Order Condylarthra

Family Hyopsodontidae

Subfamily Mioclaeninae

Genus Promioclaenus Trouessart, 1904

Promioclaenus Trouessart, 1904, p. 43

Promioclaenus acolytus (Cope) Wilson, 1956

Plate XII, figs. 1-9; XIV, 4-6; Table 46

Hyopsodus acolytus Cope, 1882, p. 462

Mioclaenus acolytus (Cope), 1882, p. 462

Mioclaenus minimus Cope, 1882, p. 468

Table 46

Promioclaenus acolytus

Swain Quarry, [illegible] County, Wyoming

		N	r	m	b	OR	s	M	V
M^1	L	84	.374	.501	27.94	3.00-3.75	.149	3.34	4.46
	W					3.90-4.80	.199	4.47	4.45
M^2	L	82	.418	.580	31.28	3.00-3.75	.172	3.44	5.00
	W					4.50-5.55	.235	5.08	4.63
M^3	L	84	.304	.465	24.28	2.10-2.70	.160	2.32	6.90
	W					3.00-3.90	.245	3.51	6.98
P_3	L	10	.941	.833	-.09	3.00-3.90	.140	3.75	3.73
	W					2.10-2.40	.120	2.23	5.38
P_4	L	20	.878	.835	5.94	3.45-4.35	.248	4.07	6.09
	W					2.55-3.15	.196	2.77	7.08
M_1	L	60	.751	.756	1.38	3.15-4.05	.238	3.58	6.65
	AW					2.40-3.45	.240	2.84	8.85
	L	60	.787	.766	2.53	3.15-4.05	.238	3.58	6.65
	PW					2.55-3.45	.232	3.01	7.70
	AW	50	[illegible]	.857	5.69	2.40-3.45	.240	2.84	8.85
	PW					2.55-3.45	.232	3.01	7.70
M_2	L	55	.735	.735	5.14	3.45-…	.277	3.92	7.08
	AW					2.85-3.90	.273		8.01
	L	55	.673	.588	9.61	3.45-4.50	.277	3.9.	7.08
	PW					2.85-3.75	.242	3.42	.08
	AW	55	.794	.704	8.61	2.85-3.90	.273	3.41	8.01
	PW					2.85-3.75	.242	3.42	7.08
M_3	L	50	.738	.547	6.60	3.15-4.35	.270	3.82	7.07
	W					2.40-3.15	.201	2.75	7.31

Mioclaenus acolytus (Cope): Osborn, 1902, p. 170
Promioclaenus acolytus (Cope): Trouessart, 1904, p. 43
Ellipsodon aquilonius Simpson, 1935, p. 242
Promioclaenus acolytus (Cope): Wilson, 1956, p. 115

Type: AMNH 3208, upper and lower jaws with P^3-M^2, P_3-M_3, from the Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; several localities from the Nacimiento Formation, San Juan Basin, New Mexico; Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana; Black Peaks Formation, Big Bend National Park, Texas.

Referred material: AMNH 87587, maxilla fragment with M^{1-3}; 87588, maxilla fragment with M^{1-2}; 87627, maxilla fragment with M^{1-2}; 100232, maxilla fragment with M^1; M^1's, 87628a-n, 87696a-n, 87723a-n, 100235a-p, 100236a-n, 100237a-e, 100239, 100760a-n, 100759a-p, 100773a-b; M^2's, 87743a-p, 100231a-k, 100238a-b, 100248a-p, 100249a-p, 100757a-p, 100758a-l, 100774; M^3's, 100753a-r, 100754a-r, 100755a-r, 100756a-c, 100836; 87610, dentary fragment with P_{3-4}; 87616, dentary fragment with P_4; 87619, dentary fragment with P_4; 87637, dentary fragment with M_3; 87638, dentary fragment with M_3; 87651, dentary fragment with M_3; 87525, dentary fragment with M_{1-2}; 87526, dentary fragment with P_4-M_2; 87529, P_4-M_2; 87530, dentary fragment with P_{3-4}; 87531, dentary fragment with M_{1-2}; 87532, dentary fragment with M_{1-2}; 87545, dentary fragment with M_{1-2}; 87546, dentary fragment with P_{3-4}; 87547, dentary fragment with M_3; 87548, dentary fragment with M_2; 87550, dentary fragment with M_{2-3}; 87551, dentary fragment with M_2; 87553, dentary fragment with M_3; 87554, dentary fragment with M_2; 87555, dentary fragment with M_3; 87556, dentary fragment with P_{3-4}; 87558, dentary fragment with P_4, M_2; 87559, dentary fragment with M_{1-3}; 87560, dentary fragment with M_3; 87756, dentary fragment with P_4-M_2; 87757, dentary fragment with P_3-M_1; 87814, dentary fragment with M_1; 87915, dentary fragment with P_{3-4}; 87918, dentary fragment with P_{3-4}; 100257, dentary fragment with M_{1-2}; 100259, dentary fragment with M_2; 100262, dentary fragment with M_{1-3}; 100268, dentary fragment with M_2; 100269, dentary fragment with M_2; 100270, dentary fragment with P_4-M_1; 100274, dentary fragment with P_{3-4}; 100275, dentary fragment with M_1; 100475, dentary fragment with M_2; 100550, dentary fragment with M_3; 100551, dentary fragment with M_3; P_4's, 100719a-c; M_1's, 100244a-r, 100245a-r, 100246, 100247e, h-i, 100504a, e, h-i, l-m, 100506a-f, 100508, 100511a-r, 100512a-c, 100535, 100722; M_2's, 87682a-n, 100247a-d, f-g, 100502a-n, 100503a-n, 100504b-d, f-g, j-k, n, 100505a-n, 100512d, 100513a-r, 100514a-e, 100717a-c; M_3's, 87549, 87552, 87778a-d, 87779a-p, 100240a-i, 100241, 100242a-b, 100243a-f, 100510a-n, 100536, 100542, 100543, 100555, 100716; DP^4's, 100252a-d, 100815a-r, 100816a-d; DP_4's, 87683a-p, 100670a-q, 100674a-d.

Description: Upper molars from the Swain Quarry collection closely resemble those of *P. acolytus* and *P. "aquilonius"* except that the parastyle is smaller, conules are greatly variable, and the hypocone varies from a simple low cusp to a structure similar to the "Hanopithex fold" of some early primates. Some dental elements, when preserved as isolated teeth, are very difficult to assign to a specific taxon because of similarity with a variety of species, particularly in the case of many condylarth premolars. Isolated premolars are therefore not referred. A single P_2, in association with P_3 in AMNH 87610, is referred to the taxon. It is a simple tooth, slightly anteriorly inclined, with no talonid or accessory cuspule development. Were it not in association with P_3, it would easily be confused with several other taxa. Lower P_4's most closely resemble those of P. acolytus from the Nacimiento Formation although the range of variability is great in that P_4 may have a well-defined metaconid or it may be totally absent. M_{1-2} are similar to M_{1-2} of P. acolytus but size is much more variable than anticipated. Molar paraconids are present and most teeth show them as well defined but small. Paraconids range from separate, high, distinct cusps to slight inflations on the anterior surface of the metaconid. The metaconid is equal to or slightly larger than the protoconid. The talonid of M_1 shows three distinct cusps with a variable entoconid and entoconulid and associated talonid notch development. The M_2 talonid, generally narrower than the trigonid, has a reduced entoconid and entoconulid, producing a descending ridge of equally proliferated cuspules. M_3 is similar to that of P. acolytus from the Nacimiento Formation but with a much more variable projecting hypoconulid and paraconid development.

The Swain Quarry sample also preserves elements of the deciduous dentition. DP^4 is characteristically triangular with variably complete anterior, posterior, and external cingula. The parastyle is moderately large, accompanied by a small to poorly developed metastyle. Both conules are present but the paraconule is larger and higher on the slope of the protoconid. The hypocone is small and most commonly near the base of the protocone, unlike its permanent replacement. The DP_4 is quite similar to USNM 9686 and KU 9629. The talonid has three separate, distinct cusps equidistantly spaced with an externally directed cristid obliqua from the middle of the tooth. The protoconid and metaconid are nearly equal in size, with the protoconid slightly larger. The paraconid is large and well separated anteriorly from the other two trigonid cusps. The tooth is widest near the posterior part of the talonid and thins anteriorly.

Discussion: The specimens from Swain Quarry are puzzling in that they do not easily lend themselves to comparison with other known samples of Promioclaenus. The collection as a whole, as can be seen by reference to Table 46, has a much larger degree of variation than would be expected by comparison with similar samples from Gidley Quarry and samples from the Nacimiento Formation such as those from Kutz Canyon. Coefficients of variation lead one to suspect the presence of two taxa, but there is no other evidence to support such a conclusion.

Simpson (1935d, p. 242) lists the diagnostic features of P. aquilonius. Based on this list, most diagnostic features lose their significance in the light of additional and more recently collected material. The teeth are more slender in the type specimen of P. acolytus than in the additional referred material from the type and other localities in the San Juan Basin. Most specimens of P. aquilonius do display a better developed metaconid on P_4 than P. acolytus but this feature also loses most of its diagnostic value when other samples from Rock Bench, Shotgun, and Swain Quarry are added to the pool of available information. The enlarged metaconid on P_4 seems to be associated with the larger specimens and smaller ones have lost the metaconid entirely or have it substantially reduced. A similar trend can be seen in the Gidley Quarry sample in the American Museum of Natural History collections made after Simpson (1937) wrote his monograph on the Crazy Mountain Field.

M_1^1 seems to be the least variable element of the dentition and therefore offers a method on comparison by eliminating the effects of size to determine the relative degree of M_3 reduction. Ratios of

Length M_1:Length M_3 and similarly for width were computed for several samples of *Promioclaenus*. The AMNH collection from Gidley Quarry has a length ratio of .97 and a width ratio of 1.04, *P. acolytus* from the Kutz Canyon collection yields ratios of .99 and 1.09 respectively. *P. acolytus* from the Torrejon Arroyo has ratios of .97 and 1.02. Samples of *P. acolytus* can therefore be shown to bracket the ratios of *P. aquilonius*. The reduction of M_3 certainly has some generic significance when compared with *Mioclaenus* and *Hyopsodus* but it has little or no significance on the nominal species level.

Lack of a protocone on P^3 is a character shared by both taxa. The hypocone on M^{1-2} is exceptionally variable and exists as a simple low isolated cusp or ascends the protocone to its crest in a structure comparable to the "Nanopithex fold" in some early primates. This feature also varies in the same way in the Gidley Quarry sample, but the protocone apex extremes are not reached. Tooth size is almost identical with some moderately small San Juan Basin specimens, including the type specimen of *P. acolytus*.

Based on this evidence *P.* "*aquilonius*" is no longer considered a separate species and is snyonymous with *P. acolytus*.

Subfamily Hyopsodontinae

Genus *Litaletes* Simpson, 1935

Litaletes Simpson, 1935, p. 242

Jepsenia Gazin, 1939, p. 285

Litaletes mantiensis (Gazin), 1939

Plate XIII, figs. 1-6; XIV, 1-3; Table 47

Litaletes mantiensis (Gazin), 1939, p. 285

Type: USNM 15747, maxilla fragment with M^{1-3}, from the Dragon locality, Joe's Valley Member, North Horn Formation, Emery County, Utah.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Dragon locality, Joe's Valley Member, North Horn Formation, Emery County, Utah.

Referred material: AMNH 87589, maxilla fragment with M^{1-3}; 87593, maxilla fragment with M^3; 87695, maxilla fragment with P^4-M^3; 87596, maxilla fragment with M^{2-3}; 87597, maxilla fragment with M^2; 87605, maxilla fragment with M^{2-3}; 100230, maxilla fragment with M^{2-3}; 100231, maxilla fragment with M^3; M^1's, 87707a-l, 97709a-h; M^2's, 87697a-k, 100234a-g; M^3's 87747a-h, 87729, 87751a-e; 87581, dentary fragment with M_{1-2}; 87594a, dentary fragment with M_2; 87594b, dentary fragment with M_2; 87594c, dentary fragment with M_2; 87594d, dentary fragment with M_2; 87594e, dentary fragment with M_2; 87594f, dentary fragment with M_2; 87644, dentary fragment with P_4-M_2; 100273, dentary fragment with a broken M_1-M_2; 100299, dentary fragment with M_2; M_1's, 87661a-f, 100507; M_2's, 87677a-h; M_3's, 87590a-c. AMNH 87680, an M_2, is questionably referred.

Description: No upper premolars are known to be in association with other elements of the dentition. Although they are undoubtedly present in the sample, their similarity to premolars of other forms does not allow specific identification.

M^1 is quadrate with complete anterior, exterior and posterior cingula. The parastyle is well developed but is significantly smaller than on M^2. There is no metastyle and the conulecristas are poorly developed and cause

Table 47

Litaletes mantiensis

Swain Quarry, Carbon County, Wyoming

		N	r	m	b	OR	s	M	V
P^4	L	1				3.30		3.30	
	W					4.80		4.80	
M^1	L	22	.568	.496	3.20	4.35-5.10	.227	4.75	4.78
	W					5.25-5.70	.198	5.56	3.56
M^2	L	24	.410	.566	3.95	4.95-5.85	.268	5.33	5.03
	W					6.30-7.50	.371	6.97	5.32
M^3	L	20	.839	1.210	1.38	3.60-4.50	.308	3.98	7.74
	W					5.70-6.90	.441	6.18	7.14
P_4	L	1				4.80		4.80	
	W					3.15		3.15	
M_1	L	8	.199	.147	4.40	5.40-6.45	205	4.83	4.24
	AW					4.05-4.95	.148	3.70	4.00
	L	10	.065	.041	4.02	5.40-6.45	.198	4.85	4.08
	PW					4.20-4.80	.128	3.82	3.35
	AW	9	.923	.900	.50	4.05-4.95	.150	3.70	4.05
	PW					4.20-4.80	.144	3.83	3.76
M_2	L	19	.809	.658	.63	4.50-4.95	.405	5.97	6.77
	AW					3.45-3.90	329	4.55	7.23
	L	19	.834	.623	.79	4.50-4.95	.405	5.97	6.77
	PW					3.60-4.05	.144	3.83	3.76
	AW	19	.836	.768	1.01	3.45-3.90	.329	4.55	7.23
	PW					3.60-4.05	.144	3.83	3.76
M_3	L	4				5.85-6.00		5.95	
	W					3.75-4.05		3.94	

little interruption of the cingula. The conules are simple, conical and equal to each other in size and placed equally high on the protocone slope. The paracone and metacone are equal in size and the metacone is not labially displaced. The protocone is only slightly larger than either the paracone or the metacone and is slightly compressed laterally to produce two shallow excavations on the protocone slope. There is no lingual cingulum and the hypocone is simple, conical, isolated, and low on the posterior base of the protocone. M^2 is similarly constructed to M^1, with a larger, more protruding parastyle, massive and enlarged protocone, and with the hypocone variably placed on the posterior protocone slope and continuous with a variable but continuous internal cingulum. M^3 is posteriorly reduced; its variably developed metacone, which is only slightly smaller than the paracone, is lingually directed to produce in occlusal view a labially pointed ellipse. The development of the parastyle is variable but it is generally strong and separate. Cingula are complete and not interrupted appreciably by conulecristas. The conules are well developed. The metaconule is only slightly reduced and is lingually directed. There is a small "hypocone" swelling on the posterior cingulum, continuous with the labial cingulum. No metastyle is present.

A lower dentition preserves a P_4 in association with M_1 and M_2 to allow for confident reference to L. mantiensis. The P_4 is broad, inflated and molariform, with a well-developed metaconid with significant crest development connecting to the protoconid. A separate, inflated, well-defined paraconid is present, slightly displaced medially on the descent of the anterior crest from the protoconid. Two separate subequal cusps are located posteriorly on the talonid, the more labial of which is generally connected to the protoconid by a single crest. The P_4 is very reminiscent of that of Hyoposodus and early perissodactyls.

M_1 and M_2 are similar to M_1 and M_2 of L. disjunctus but with some differences. The cristid obliqua of the Swain sample is nearer to the base of the metaconid. There is a small persistent entoconulid present and the entoconid is smaller and more posteriorly directed on M_1 in L. disjunctus. M_2 is much more derived in the extremely low nature of the talonid notch and the posterior expansion of the posterior talonid margin, with three distinct swellings in addition to the large hypoconid. M_3 is very similar to that of Hyoposodus. It is unreduced, with a large, medially projecting hypoconulid nearly isolated from the rest of the tooth by crest development from the hypoconid and entoconid. The paralophid is slightly recurved and there is a persistent entoconulid present.

Discussion: This is by far the most primitive of the hyoposodontine condylarths and provides an adequate picture of what the primitive state of Hyoposodus should be except for the M_2 talonid expansion. On the basis of P_4 and M_3 characters, its relationships with other groups can be demonstrated even though its own development in the nature of the M_2^2 is sufficiently derived to preclude ancestry. L. mantiensis is also more derived than L. disjunctus in the nature of the base of the protocone expansion and talonid expansion.

Family Phenacodontidae

Genus Tetraclaenodon Scott, 1892

Tetraclaenodon Scott, 1892, p. 299

Tetraclaenodon puercensis Cope, 1881

Plate XI, figs. 10-15; Table 48

Table 48

<u>Tetraclaenodon puercensis</u>

Swain Quarry, Carbon County, Wyoming

A.M.N.H. No.	Tooth	L	W(AW)	PW
87602	M^1	8.55	11.40	
	M^2	8.55	12.30	
87603	M^1	7.95	9.45	
	M^2	7.80	10.35	
87703	M^1	8.40	9.90	
87674	M^2	8.85	10.20	
87688	M^2	8.25	10.20	
100571	M^2	7.65	9.90	
87765	M^3	6.75	9.45	
100569	M^3	5.85	7.95	
100570	M^3	5.70	8.25	
87701	M_1	9.30	7.35	7.35
87662	M_2	9.75	8.55	7.95
88094	M_2	9.00	8.70	8.85
87626	M_3	9.15	7.80	
87749	M_3	9.75	6.60	
87821	DP^3	8.10	6.75	
87604	DP^4	8.40	8.70	
87737	DP^4	8.40	8.55	
87685	DP_4	9.30	6.00	

<u>Phenacodus puercensis</u> Cope, 1881, p. 492
<u>Protogonia subquadrata</u> Cope, 1881, p. 492
<u>Protogonia plicifera</u> Cope, 1882, p. 833
<u>Phenacodus calceolatus</u> Cope, 1883, p. 561
<u>Mioclaenus floverianus</u> Cope, 1888, p. 330
<u>Protogonia zuniensis</u> Cope, 1888, p. 330
<u>Euprotogonia minor</u> Matthew, 1897, p. 310
<u>Tetraclaenodon symbolicus</u> (Simpson) Gidley, 1935, p. 239

Type: AMNH 3832, maxilla and dentary fragments from the Nacimiento Formation, San Juan Basin, New Mexico.

Distribution: Middle Paleocene (Torrejonian): Swain Quarry; Nacimiento Formation (Torrejon Formation of Matthew, 1937), San Juan Basin, New Mexico.

Cf. <u>T. puercensis</u>, Middle Paleocene (Torrejonian), Gidley Quarry, upper Lebo Formation, Crazy Mountain Field, Sweetgrass County, Montana; Paskapoo Formation, southern Alberta, Canada.

Referred material: AMNH 87602, maxilla fragment with M^{1-2}; 87603, maxilla fragment with M^{1-2}; M^1, 87703; M^2's, 87674, 87688, 100571; M^3's, 87765, 100569, 100570; M_1, 87701; M_2's, 87662, 88094; M_3's, 87626, 87749; DP^3, 87821; DP^4's, 87604, 87737; DP_4, 87685.

Description: The specimens from Swain Quarry are slightly smaller than those from the San Juan Basin, New Mexico but are indistinguishable from the type specimen of <u>T. puercensis</u>, AMNH 3832. Two maxilla fragments, AMNH 87602 and 87603, do show a considerable size difference but both specimens are taken to represent possible variation of a single deme sample and are therefore not referred to separate species.

Hyopsodont Relationships

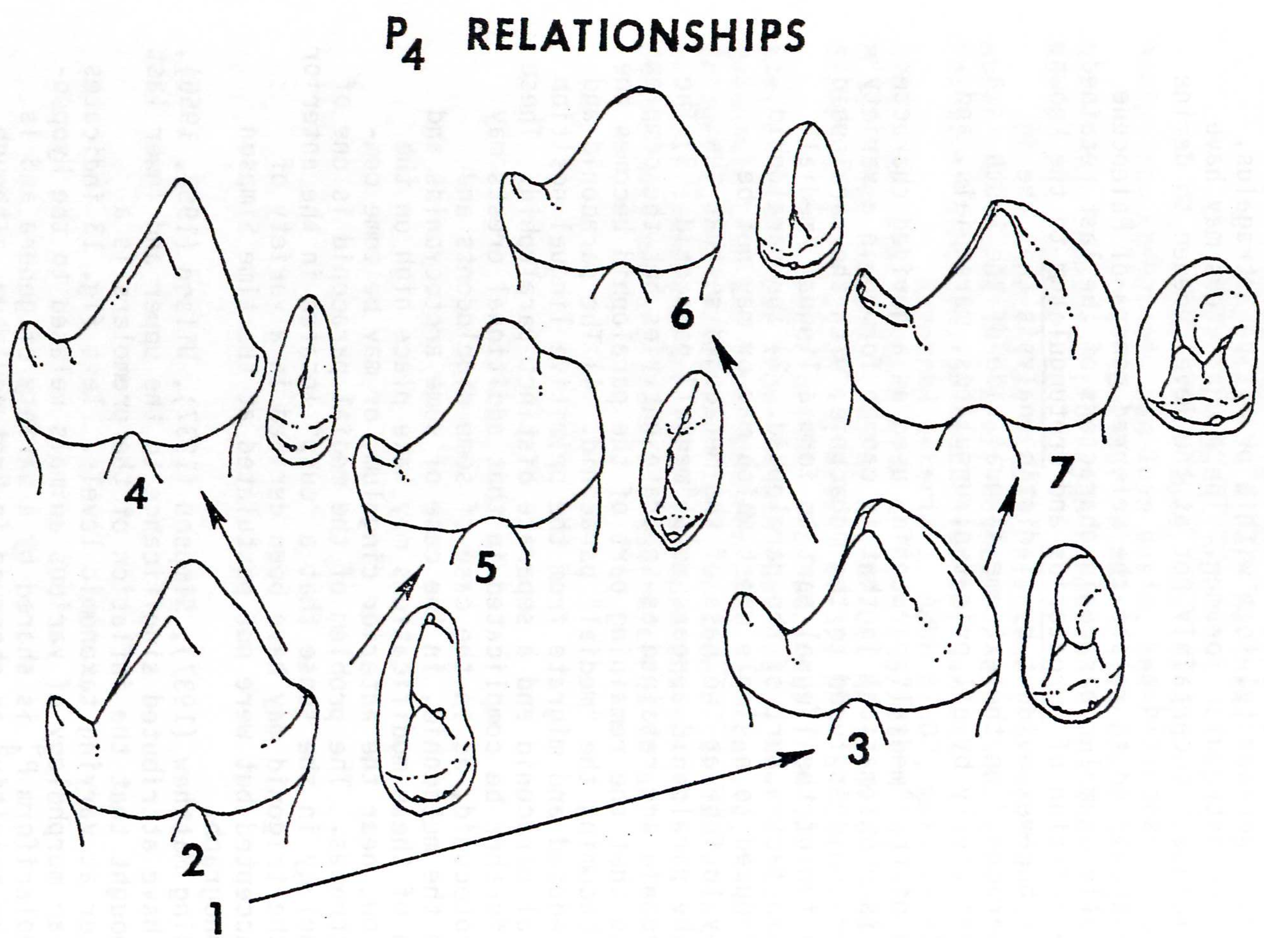
Hyopsodus and its related genera are common in most Paleocene and Eocene faunas and are known from Europe, Asia, North and South America. They have been united classically on a degree of similarity which has been governed by the presence of a large number of primitive characters such as bunodont quadritubercular teeth, differentiated canine, variable quadritibercular upper teeth, pentadactyl feet with a primitive astragalus, and the presence of the astragular foramen. These characters may have phylogenetic significance but certainly not at the level needed to define the character of the Hyopsodontidae.

Simpson (1937) attempted to relate the referred genera of Paleocene hyopsodontids basically on molar paraconid characters of the last retained premolar. With the addition of Purgatorius and Protungulatum to the known Cretaceous fauna, it becomes evident by cladistic analysis that the presence of molar paraconid on the extreme lingual side of the tooth is a character shared primitively by all primates, ungulates, marsupials, and some "insectivores".

The derivation of the "medial" paraconid, used as a derived character by Simpson (1937), is problematical in that it can be formed in a variety of ways: 1) The paraconid is fused to the metaconid, with the paralophid developing a separation of the lingual part to form a lingual "medial" paraconid which is in fact a part of the paralophid. 2) The paralophid and paraconid are reduced to a simple crest which may or may not be recurved posteriorly to fuse at the base of the metaconid so that the remaining part of the paralophid appears as a "medial" paraconid. 3) The paralophid and paraconid are retained as separate entities but the complex is simply reduced so that the remaining part of the paralophid becomes the largest part, thus becoming the "medial" paraconid. 4) The paraconid and paralophid may be reduced and migrate from the primitive lingual position to form a true medial paraconid and a separate distinct paralophid. These basic patterns may further be complicated in that additional crests may develop from the protoconid, as in the case of some didolodonts and litopterns, or from the metaconid, in the case of some arctocyonids and phenacodonts. Each of these modifications may take place high on the trigonid crown or low, near the anterior cingulum, or may be some combination of both extremes. The problem of the medial paraconid is one of convergence and homology in the sense that a "cusp" located in the anterior medial portion of the trigonid may have been derived in a variety of ways that are now accepted but were not postulated at the time Simpson (1937) wrote his monograph.

Workers including Matthew (1937), Simpson (1937), Wilson (1952, 1956), and McKenna (1960) have attributed significance to the upper and lower last premolar. It is thought that the inflation of the premolars is a significant character at varying taxonomic levels. Text fig. 13 indicates the range of premolar morphology of various animals related to the Hyopsodontidae. The submolariform P^4_4 is shared by a variety of genera and is therefore taken to be primitive as observed in Protungulatum, although its protoconid is more acute, Purgatorius, Promioclaenus, and a variety of other related genera. The molarization of the tooth in Hyopsodus, Litaletes, phenacodonts, and some didolodonts is taken to be a derived character different and separate from a similar molarization of other groups including Cynodontomys, Microsyops, and artiodactyls.

Postcranial remains are almost entirely unknown except in the case of



Text-Figure 13. P_4 relationships of primitive ungulates: 1) primitive condition probably typified by Mckennatherium; 2) Protungulatum; 3) Promioclaenus, in part; 4) Oxyclaenus, Tricentes, Mimotricentes; 5) Protoselene, Anisonchus; 6) Promioclaenus, in part, Mioclaenus, Choeroclaenus; 7) Hyopsodus, Asmithwoodwardia, Tetraclaenodon.

Hyopsodus, where complete skulls and partially articulated skeletons are known. This does not allow for extensive comparison within the family but does give some indication of the relationship of *Hyopsodus* to other similarly known forms. This lack of associated material necessitates that comparisons of taxa be made almost totally on the basis of dental characters.

The present study of hyopsodontid relationships represents initial conclusions of a continuing study. Simpson (1937) and Matthew (1937) have reviewed the history of most North American taxa. The classification of Simpson (1945) reflects conclusions based upon his and Matthew's work. In addition to numerous publications reporting Paleocene faunas, several works have had a greater affect upon the systematics of the group. Wilson (1956) reviewed the genus *Ellipsodon* and revived Trouessart's (1904) genus *Promioclaenus* for "E." *acolytus*, "*aquilonius*", *lemuroides*, and *shepherdi*. McKenna (1960) referred the Apheliscinae as a subfamily to the group based upon molar similarity shared with some hyopsodonts, notably *Litomylus*. *Litomylus* is most closely related to *Mckennatherium* and has been removed from the Hyopsodontidae. The striking premolar similarity between pentacodonts and the Apheliscinae suggests close relationship. The Apheliscinae is therefore referred to the Pentacodontidae as a separate subfamily, as originally suggested by Gazin (1959). Russell (1964) referred several European forms to the Hyopsodontidae. *Yuodon*, described by Chow, Chang, Wang, and Ting (1973), has been referred to the group but is too poorly known to ascertain its affinities if it is indeed a primitive ungulate. I therefore place it *incertae sedis* within the Arctocyonia.

Simpson's (1945) classification appears as Table 49a. A classification currently in use is provided in Table 49b. Changes suggested by the present study, represented by the cladogram, Table 51, appear as Table 50. Table 52 summarizes derived characters used in the construction of relationships. The characters are number-keyed to the cladogram.

Table 49a

Simpson (1945)
Hyopsodontidae
Mioclaeninae
Tiznatzinia
Choeroclaenus
Mioclaenus
Ellipsodon
Litaletes
Jepsenia
?Mioclaeninae
Phenacodaptes
Hyopsodontinae
Oxyacodon
Oxytomadon
Litomylus
Haplaletes
Dracoclaenus
Protoselene
Litolestes
Haplomylus
Hyopsodus

Table 49b

Currently in Use (1976)
Hyopsodontidae
Mioclaeninae
Tiznatzinia
Choeroclaenus
Mioclaenus
Ellipsodon
Promioclaenus
Litaletes
Jepsenia
Paratricuspiodon
Tricuspiodon
Hyopsodontinae
Oxyacodon
Oxytomodon
Litomylus
Haplaletes
Protoselene
Yuodon
Louisina
Microhyus
Paschatherium
Haplomylus
Hyopsodus
Apheliscinae
Phenacodaptes
Apheliscus
Epapheliscus

Table 50

Suggested revision of hyopsodontid candylarths

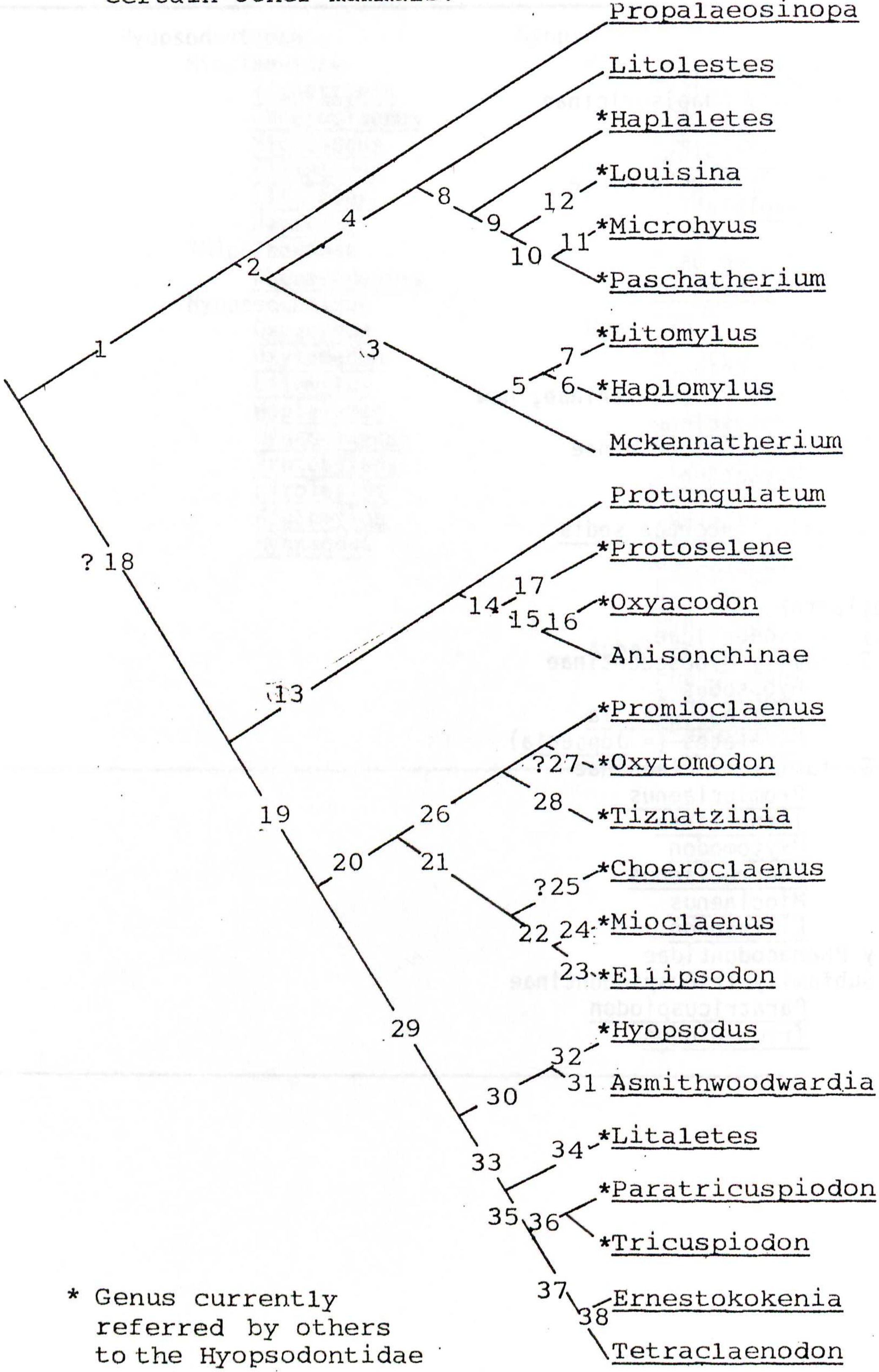
Order Insectivora
- Family Adapisoricidae
  - Subfamily Adapisoricinae
    - Litomylus
    - Haplomylus
  - Subfamily Creotarsinae
    - Haplaletes
    - Louisina
    - Microhyus
    - Paschatherium

Order Arctocyonia
- Family Periptychidae
  - Subfamily Protoseleninae, new
    - Protoselene
  - Subfamily Anisonchinae
    - Oxyacodon

Order Arctocyonia, incertae sedis
- Yuodon

Order Condylarthra
- Family Hyopsodontidae
  - Subfamily Hyopsodontinae
    - Hyopsodus
    - Asmithwoodwardia
    - Litaletes (= Jepsenia)
  - Subfamily Mioclaeninae
    - Promioclaenus
    - Tiznatzinia
    - Oxytomodon
    - Choeroclaenus
    - Mioclaenus
    - Ellipsodon
- Family Phenacodontidae
  - Subfamily Tricuspiodontinae
    - Paratricuspiodon
    - Tricuspiodon

Table 51. Relationships of Hyopsodontid Condylarths and certain other mammals.



* Genus currently referred by others to the Hyopsodontidae

Table 52 Characters Used for the Determination of Cladistic Relationships

1. Protoconid and metaconid transversely opposed; small paralophid high on the molar crown with a small, sometimes poorly differentiated paraconid.
2. Reduced molar trigonid height; inflation of the metaconid and protoconid; paralophid complex further reduced; hypocone is a separate cusp and not a swollen or inflated cingulum.
3. Partial elongation of P_4 by lengthening the protoconid-paraconid distance; poorly differentiated paraconid.
4. Slight lingual inclination of lower molars; P_4 simplified by shortening and by reducing or losing the metaconid and/or paraconid; unique molar trigonid notch formed by the anterior metaconid crest and the nonconfluent paralophid complex; decreased definition of the paraconid as a separate cusp by inflation of the paralophid.
5. P_4 protoconid-paraconid elongation; anteroposterior compression of the molar trigonids to produce a "medial" paraconid (= paralophid); paraconid reduced or lost.
6. M_1 metaconid posterior to protoconid; cristid obliqua continuous to M_1 metaconid apex; P_4 laterally enlarged with large, medial paraconid; P_4 metaconid large and slightly posterior to protoconid.
7. Trenchant P_3-P_4; very reduced paralophid.
8. Labial expansion of lower teeth to produce a strong lingual tilt of the molar row; loss of the medial projecting hypoconulid on M_3 by talonid reduction.
9. Enlarged hypocone; molar talonids strongly reduced, accomplished by hypoconulid loss or severe reduction and by enlargement of the entoconid.
10. Quadrate upper molars with very large hypocones; little or no conule or major crest development.
11. Paraconule and metaconule lost.
12. Expanded protoconid base (best observed on M_2).
13. P_4 labial talonid cusp, 2 primitively present, lost or strongly reduced; P_4 laterally compressed and simplified by the reduction of metaconid and paraconid.
14. Premolar paraconids medial and high on the protoconid slope; small premolar talonid with a single cusp formed at the confluence of two posterior crests; mesostyle present on upper molars.
15. Anteriorly open and expanded molar trigonids with paralophids high on the crown; simple conical cusps with little trigonid basin development.
16. P_3-P_4 paraconids reduced or lost.
17. Strong molar mesostyle; posteriorly elongate M_3 with some structural isolation of the hypoconulid; low anteriorly projecting molar paralophid with paraconid lost or reduced (very similar to artiodactyls).
18. ? (Relationship uncertain)
19. Molar paraconid and metaconid inflated; paralophid descends low on the crown; paraconid remains high on the metaconid but is substantially reduced and may appear all but fused to the metaconid.
20. M^3_3 reduced; P^4_4 simplified and inflated; P_4 metaconid and paraconid reduced or lost; lower premolar talonid cusps reduced with the lingual cusp occasionally lost.
21. P^4_4 larger than M^1_1; P_4 talonid reduced to a single cusp with no basin

present.

22. Greatly inflated M_2 trigonid with paralophid and paraconid reduced; M^3_3 greatly reduced.
23. Reduced dentition (1 premolar and 1 incisor lost); unique bicrescentric lower premolars.
24. Greatly inflated premolars.
25. M^3_3 unreduced; premolars greatly inflated. (Choeroclaenus is poorly understood and its assumed relationship to Mioclaenus and Ellipsodon is dubious.)
26. P_4 with small paraconid on anterolingual face.
27. Large paraconids on M_2-M_3.
28. P_4 paraconid is distinct and isolated on the anterolingual surface; P_4 metaconids are very small or lost; Molar paraconids and paralophids are very small.
29. Partial molarization of P_4 by enlarging the metaconid and extending and enlarging the paralophid; M^3_3 enlarged.
30. Molar metaconid posterior to protoconid; Molar paraconids fused to metaconids; a questionable metaconid present on P_3; conules present on P^4.
31. Increased molarization of P^4_4; M_3 hypoconulid projection reduced.
32. Paraconids completely fused; paralophids reduced, usually not reaching the metaconid base.
33. Increased molarization of P^4_4; small, inconsistent mesostyle present.
34. Enlarged parastyles; Enlarged M^2 protocone and M_2 talonid basin; M_2 talonid notch extremely low and wide.
35. Mesostyle present as swelling or inflation of the external cingulum; large hypocone present on upper molars, approaching the protocone in height; large conules present; molariform P^4_4 present; P^4 with incipient conules.
36. Isolation of molar hypoconulids by crests between the hypoconid and entoconid; arguments of Russell (1964).
37. All teeth inflated but not selectively where some part is exaggerated and others remain in the primitive condition; molar paraconids are slightly labially displaced; paralophid becomes high with no downward warp or anterior depression of the trigonid.
38. P_4 molariform with the metaconid equal to the protoconid in size.

APPENDIX I

Dead Bull Run Valley

The geologic section has been measured along both sides of Dead Bull Run Valley to take advantage of the best exposures available. The section was broken and an offset made where there could be little doubt of the continuity of the units involved. All units were physically correlated and where faults had to be crossed similar stratigraphic sections were matched across the fault to avoid any repetition or deletion of section. The section is located in the southern halves of sections 15 and 16 of T. 16 N., R. 92 W., Carbon County, Wyoming.

Unit	Meters	Description
59	4.6	Cyclothemic lacustrine sequence with 2.5m of siltstones and silty mudstones above the sandstone of Unit 58. These are overlain by a thin carbonaceous shale. The upper portion is a similar silty mudstone as that found at the base. There is an ironstone concretion band associated with the upper part of the lower mudstone under a covered interval to the south where it is truncated by the fault. This subunit forms the nose of the ridge immediately south of Dead Bull Run Valley. There may be some additional section preserved at that point but it is almost completely covered by valley fill and further description is not warranted.
58	2.1	Sandstone, medium to locally fine grained, spheroidally weathered, cross-bedded, with some slump or collapse disturbance observed locally. The spheroidally weathered concretions may be up to 2m in diameter with fine grained, platy, weathered separations within the concretions. They weather to a dark brown on exposed surfaces but protected weathered surfaces are light yellow grey and are similar to other observed sandstones. The concretionary development is best developed here but weathering phenomena are best observed across the fault above locality 3.
57	4.3	Cyclothemic lacustrine sequence of mudstones and shales. The basal siltstone, 15-20 cm thick is overlain by grey green mudstones, a 5-6 cm carbonaceous shale, and upper grey green silty mudstones.
56	7.3	Cyclothemic lacustrine sequence repeated twice within the unit involving mudstones and shales with basal silty sandstone, 15-20 cm thick. The basal sandstone is overlain by two meters of light grey-green mudstone, 10-15 cm of black brown carbonaceous, silty shales, a zone of ironstone concretions below the overlying grey-green mudstones. The sequence is repeated again and at the top of the unit is locality 5 where fossil vertebrates were found in an algal-ball conglomerate within the upper grey-green mudstone. Localities 5 and 3 can be shown to be the same horizon reconstructed across the fault.

Unit	Meters	Description
54	2.4	Sandstone, medium to fine grained, poorly sorted, variably cross-bedded, questionably ripple-marked with a basal clay-pebble conglomerate. The unit is cemented primarily by clay with minor amounts of calcium carbonate and limonite derived from the weathering of the clay. The unit is discontinuous to the south where it can be seen to thin and grade into siltstones, ironstone concretions and ultimately into mudstones and carbonaceous shales before it is truncated by the fault. Northward it thickens to a massively bedded channel sandstone which is equivalent to a poorly cemented very thick sandstone north of the Dead Bull Run Fault near the juniper covered plateau.
53	7.6	Cyclothemic lacustrine sequence alternating with shales and mudstones repeated three times within the unit. The general succession is a basal grey-green mudstone overlain by black grading into brown silty carbonaceous shales with associated ironstone concretions in upper and lower sequences, capped by grey-green mudstone with an upper siltstone or silty shale completing the sequence.
52	1.5	Sandstone, fine to medium grained poorly sorted, cross-bedded with weathered partings developed on silty planes. The unit is massive and thickens appreciably to the south but forms a distinct small ledge on the traverse ridge crest.
51	2.7	Cyclothemic lacustrine sequence of shales and mudstones with basal sandy siltstone. The basal siltstone is preserved only as chips of cross-bedded, ripple-marked siltstone on the weathered surface and by a slight increase in erosional resistance. It is overlain by a light grey-green mudstone, black to brown silty carbonaceous shales and topped by mudstone similar to those at the base.
50	3.7	Cyclothemic lacustrine sequence of shales and mudstones. It has a basal grey-green mudstone overlain by black grading into brown silty carbonaceous shales with grey-green silty mudstone top.
49	.6	Sandstone, poorly sorted, medium grained with fine grained silty stringers throughout. It is cross-bedded, ripple-marked, and grades into silty mudstones to the north and thickens appreciably to the south where it is medium bedded, cross-bedded with some basal clay-pebble conglomerate.
48	8.2	Cyclothemic lacustrine sequence of shales and mudstones repeated twice within the unit. It begins with a basal carbonaceous mudstone overlain by a brown silty shale and light green mudstone beneath a thin siltstone associated with ironstone concretions to the south. The same sequence is repeated in the upper 2/3 of the unit. The basal carbonaceous shale has been clinkered to the south indicating the presence of a coal within that subunit, obviously better developed to the south.

Unit	Meters	Description
47	.6	Sandstone, fine grained, silty, minutely cross-bedded and ripple-marked. The unit thins to an ironstone concretionary zone 70 m to the south and is lost in a covered zone as it thickens to the north.

Offset: The section is broken and continued at the top of the ridge.

Unit	Meters	Description
46	8.2	Mudstone, grey, poorly exposed with rare ironstone concretions littering the surface not limited to a particular horizon.
45	.9	Sandstone, silty, minutely cross-bedded, ripple-marked, discontinuous to the north but forms a resistant lip on the ridge crest. It is poorly sorted with silty stringers scattered throughout, tan colored on weathered surfaces and grey-green on fresh surfaces. Fossil leaves were found on weathered surfaces in the thicker parts of the unit.
44	4.9	Mudstone, repetitive lacustrine sequence of basal siltstone overlain by a poorly cemented siltstone with ironstone concretions along strike, every 2-3 meters, and by a carbonaceous shale with upper and lower brown silty units with carbonized plant fragments enclosing a carbonaceous shale and thin coal. The basal siltstone is the same that produced the excellently preserved leaf material from Tidwell Quarry on strike to the north of the traverse line.
43	5.2	Mudstone with a middle carbonaceous shale which may contain some small coal lenses in the most carbonaceous parts. The basal mudstone contains some thin siltstone stringers and ironstone concretions which form a minor lip on the ridge crest. A carbonaceous mudstone lies above it and is in turn overlain by a carbonaceous shale which first increases then decreases in its organic content from a basal siltstone. The uppermost part is a grey-green mudstone with little organic material observable. In the upper parts of the carbonaceous shales a few selenite crystals were observed.
42	.6	Sandstone, medium grained, poorly sorted, locally cross-bedded in 10 cm beds. The unit is variable along strike from a medium-bedded 12. m thick body to a thinly bedded platy sandstone associated with several ironstone concretions. These and the neighboring siltstones contain numerous well-preserved fossil leaves.

Offset: The section is broken and continued on the ridge crest.

Unit	Meters	Description
41	2.7	Mudstone, grey-blue and carbonaceous as its base grading into pale grey-green massive mudstone beneath several thin siltstone stringers in the uppermost part of the unit. The siltstones are minutely cross-bedded and are locally discontinuous where individual .2-.5 cm beds have a lateral continuity of .6 m.

Unit	Meters	Description
40	3.1	Shale, carbonaceous with a basal coal, 20 cm thick and alternating brown carbonaceous silty shale and black carbonaceous shale. All shales have carbonaceous shaly partings and limonite stains on fractures and weathered surfaces. The two brown shale subunits are slightly more resistant than their black shale counterparts and form two slight lips on the ridgecrest profile.
39	1.5	Mudstone, massive, green to light grey-green with limonite stained siltstone stringers. It is slightly more resistant than units below.
38	7.9	Shale, carbonaceous with very thin basal coals. The basal part above the coals is thinly bedded, silty and loses its organic content upwards in the section, through a brown and a blue-grey sequence until the upper parts are carbon free. The plant material is unidentifiable in the basal part where it appears as finely disseminated coaly flecks but the upper part may yield identifiable plant remains. There is a zone of ironstone concretion just above the basal coals and seems to be fairly continuous along strike although they decrease in frequency to the north. Bedding surfaces are limonite stained; most apparent on surfaces with the least carbon content. The unit forms a slope on the ridge crest.
37	4.0	Siltstone and sandstone interbedded, poorly sorted. The siltstone, localized in the lower parts of the unit, is minutely cross-bedded and is the most continuous along strike. The sandstone, locally developed, fine to medium grained is present on upper surfaces of siltstone and is concentrated in the upper part of the unit. Several subunits can be seen to thin to the north where the siltstone produced beautifully preserved fossil leaves. The unit thickens to the south.
36	2.4	Shale, carbonaceous with several 5-10 cm thick coals at its base. The unit loses its carbon content toward the top passing from a silty violet-brown shale to a pale army-green mudstone. This may be the same unit or at least nearly correlatable with the large coal and shale sequence immediately below locality 2.
35	2.1	Siltstone, basally carbonaceous, poorly sorted with stringers of medium grained sandstone present on the upper surfaces of cross-beds. The basal part is claystone on traverse but this lithology appears only as a local phenomenon. Several ironstone concretions are located in the middle part and display some lateral continuity as they are spaced 3-5 m along strike. To the north they produce well-preserved leaf remains in association with several siltstone stringers where the unit is better developed and more resistant.
34	4.0	Shale, carbonaceous, losing its carbon content upward in the section. The basal part is a series of interbedded coals and shaly siltstones with a major .4 m thick coal developed at the top of the interbedded sequence. The shales become silty above

Unit	Meters	Description
34	cont.	the coal and form a slightly more resistant profile. Fossil plant material is present throughout the section but little is identifiable.
33	.6	Siltstone, carbonaceous, with fine grained, 5 cm thick sandstone stringers randomly distributed throughout the better cemented parts, lithologically similar to the rest of the unit. It is grey when fresh, light grey when weathered, and forms a slightly more resistant profile than surrounding units.
32	2.1	Shale, carbonaceous, silty, selentic with silty stringers at its base and ironstone concretions in its upper part. The selenite crystals are limited to the middle part where the carbonaceous content appears to be greatest and its resistance to erosion least.
31	4.1	Siltstone with interbeds of cross-bedded silty sandstone, poorly sorted, fine to medium grained, ripple-marked with platy separations developed on cross-bedding planes. Ironstone concretions are common in a .6 m sequence near the middle of the unit which is traceable along strike for some distance. The unit varies from tan at its base to chalky white in the vicinity of the ironstone concretions to a pale buff at its uppermost part. It forms a slope on the ridge crest but is a semiresistant unit.

Offset: The section is broken at the top of a major sandstone body continued across the valley.

Unit	Meters	Description
30	12.8	Sandstone, massive bedded, chalky-white when weathered, pale green when fresh. The sandstone is predominantly a quartz sandstone with 10-15% black chert and 10% clay fragments. It is clay cemented and contains occasional 1.5 cm diameter grapestone concretions. The more thinly bedded parts are better cemented and produce small resistant units generally in the same plane as ironstone concretions observed in the middle part of the unit. Its upper part forms a semi-resistant lip on the ridge crest capped by a thin layer of spheroidally weathering concretions.
29	13.7	Sandstone, medium grained, cross-bedded, poorly sorted, less resistant than units above and below but otherwise lithologically similar to them. It consists of 80% subangular quartz and 20% black chert grains and cemented by clay and limonite developed in the proximity of carbonized organic material.
28	10.7	Sandstone, medium grained, poorly sorted, quartzose with lenses of fine to coarse grained sandstone. Most of the unit is cross-bedded but bed thickness and continuity are extremely variable. The basal part is tan to dark brown, indurated and locally coarse grained with occasional lenses of clay and quartz-pebble conglomerate. The middle part, 2-4 m above the base, contains a zone of limonite stain associated with several

Unit	Meters	Description
28	cont.	large tree trunks and organic debris. The trunks are represented only by bark impressioned collapsed vacuities oriented northwest-southeast. It is overlain by 6 m of massive cross-bedded sandstone with the uppermost meter being characterized by a spheroidally weathering sandstone to produce a surface littered with grape to golf-ball sized nodules. Each concretion contains a limonite stained center but may vary in the degree of development. The unit forms a resistant ledge in a small valley north of the summer drainage tank.
27	9.5	Sandstone, siltstone, shale and clay pebble-conglomerate interbedded. The shales are carbonaceous and locally form poor coals in the lowest part of the unit. The interbedded sandstones and siltstones are tan when weathered but have a green tinge on fresh surfaces. The yellow-orange color is derived from weathering clays in the cement and pebbles within local conglomeratic stringers to produce limonite. Some rare sideritic ironstone concretions and fossil wood have been observed. The unit forms the ridge crest and dip-slope northeast of the summer drainage tank where the road continues from the valley floor to the juniper covered plateau.
26	.9	Sandstone, with poorly sorted interbeds of siltstone. The sandstone is medium bedded and the siltstone is thinly bedded in an alternating sequence each comprised of one set of crossbeds. The unit has a laterally discontinuous basal clay-pebble conglomerate that is 15-20 cm in its thickest part. The clay pebbles weather leaving holes with limonitic concretionary rings around them. This conglomerate is the same as that of locality 7.
25	3.1	Shale, carbonaceous, thinly bedded, mostly covered by <u>in-situ</u> weathered shale so its nature is obscured. Shale chips preserved on the surface show a general carbonaceous nature decreasing in carbonized plant material upward in the section with shaly partings developed on carbon rich planes. The chips on the surface represent more resistant silty parts of what is otherwise a nonresistant unit forming a slope between sandstone units on the ridge crest.
24	2.4	Siltstone, poorly sorted, tan when weathered, yellow-green when fresh, thinly bedded at its base and massively bedded at its top. It forms a semiresistant lip on the ridge crest. Fossil plants were not observed on the line of traverse; however, in the thinner parts to the north and south complete fossil leaves have been seen.
23	7.9	Shale, carbonaceous, thinly bedded with shaly partings developed on organic-rich planes. It loses its carbonaceous content upward in the unit while its base contains a thin coal, 3-5 cm, in a very carbonaceous base. The unit is primarily covered but the basal and uppermost parts are well exposed.

Unit	Meters	Description
22	6.1	Siltstone, thinly bedded, 5-8 cm, with shaly partings. It is lithologically very similar to sandstone units but finer grained. Plant fragments, primarily leaves and twigs, are found in the upper parts of the semiresistant slope.
21	5.5	Sandstone, medium to coarse grained, poorly sorted, medium to thick bedded with lenticular beds of clay-pebble conglomerate separating major sandstone units. The clay pebbles are 1-2 cm in diameter and are in association with numerous wood fragments, some of which may have been 15-20 cm in diameter and up to 60 cm long, now removed and preserved as impressions. Much fossil wood, however, still litters the surface. This unit is the same depositional unit which contains the locality 8 on the south side of the valley where it forms a lip of moderate size on the ridge crest descending to the valley floor east of the summer drainage tank.

Offset: The section is continued 400 meters to the north where the sandstone of unit 21, present near the base of the ridge northwest of the clinkered hill in the middle of the valley, now forms the resistant unit forming the ridge crest.

Unit	Meters	Description
20	14.6	Shale, carbonaceous with several subunits. Three thin siltstones divide the unit into four subunits of shale which decrease in carbonaceous content from the bottom to the top. The basal shale approaches a coal in the amount of carbon content. The uppermost subunit is only slightly carbonaceous and has become a carbonaceous shaly siltstone with shaly partings developed on organic rich planes. The middle of the three siltstones, minutely crossbedded and 10 cm thick, is the thickest and can be seen to be most continuous along strike. The shaly section immediately above it is only moderately carbonaceous but is distinctive because of selenite gypsum crystals littering the surface. Below the middle sandstone the shales are silty and may produce some identifiable plant material with careful excavation.
19	2.4	Sandstone, medium grained, silty and locally thinly bedded but generally medium bedded with minute cross-beds. It is light grey-green when fresh and pale grey when weathered. Platy limonite stained chips litter the surface and allow for tracing laterally.
18	7.6	Sandstone, massively bedded, cross-bedded, comprised almost entirely of subangular to subrounded quartz grains loosely cemented with a grey-green clay cement and minor amounts of calcium carbonate. It forms a gentle nonresistant slope where the exposed sandstone is friable but less weathered parts are substantially more indurated, particularly in the vicinity of several limonitic stringers and ironstone concretions. Its upper part loses its massive nature and numerous thin limonite stained platy fragments can be seen littering the surface. Locally, within the middle part,

Unit	Meters	Description
18	cont	collapse and slump features can be seen which have totally disrupted any bedding and may have a lateral continuity of up to 2m.
17	4.9	Sandstone, well cemented, silty, tan on a weathered surface, pale grey-green when fresh with small limonite stains where clay cement has been weathered. The upper part forms a distinct boundary with the overlying sandstone at the base of the ridge to the west. To the north the unit loses some of its limonite stain, is clinkered at the base and produces a surface littered with tan and orange-tan chips on a slightly green shaly surface.
16	12.2	Shale, silty, carbonaceous, with three distinct equidistantly spaced sideritic ironstone concretion zones which produce a maroon and dark grey-blue stained angular gravel which litters a weathered surface. The uppermost part becomes a thinly bedded sandstone, poorly cemented and is unexposed except in erosional valleys. The upper 4 m of the unit is a massive quartzose, cross-bedded, poorly cemented sandstone. The sandstone has the same topographic expression as the carbonaceous shales. The reason it is so nonresistant must be in the nature of its cement as individual clasts are identical with previously described units.
15	15.6	Covered zone. Although on traverse the unit is covered, stream valleys to the north and south have soil indications that suggest the major part of the unit is a carbonaceous shale which produces a dark grey brown soil. 400 m to the north numerous silty stringers and thin sandstones can be observed in brown carbonaceous shales.
14	5.8	Sandstone, medium to coarse grained, 80% quartz, 10% chert, 10% limestone and igneous rock fragments cemented with calcareous and clay cement. The unit is thinly bedded at its base with limonite stained siltstone stringers plentiful. Its upper part is massively cross-bedded with cross-beds dipping 30°, 5° steeper than the regional dip, into the basin. There is a single 4 m thick lenticular clay-pebble conglomerate midway through the unit. Individual clasts range from 0.5-8 cm diameter. The unit thins to the south and is discontinuous immediately to the north where it thins rapidly.
13	40.3	Covered interval. Little information about underlying sediment is observable on the traverse; however, the section is well exposed 200 m to the north. It may be hazardous to equate the lithologic bodies to the north with those covered along the traverse because demonstrable variability is so great. It is a safe assumption that most of the underlying sediment is shale or minor sandstone bodies because major sandstone bodies are observable in the valley floor as isolated sandstone nobs. These covered units, however, will represent some facies of units observable to the north. These units and estimates of

Unit	Meters	Description
13	40.3	their thicknesses follow: A. Shale, carbonaceous, silty base and top, 12 m. B. Sandstone, basal part partially clinkered, thinly bedded, otherwise, massive cross-bedded with platy upper and lower parts, 12 m. C. Shale, carbonaceous, beds 2-3 m. D. Sandstone, cross-bedded, beds 2-3 m thick, rip-up clasts and limonite concretion rings around large pieces of organic material in its base. Bed thickness decreases toward the top, 14 m.
12	.6	Shale, carbonaceous, grading from basal charcoal grey with sulfur-yellow streaks to a gypsiferous, limonite-streaked light-grey when weathered, black to black-brown when fresh. There is a 15 cm zone in the middle of the unit which produces common selenite crystals. Small plant fragments are recognizable in the selenite zone and beneath the uppermost light-grey shales. The unit is very thinly bedded at its base and grades to a middle massive mudstone then to a thinly bedded silty shale toward the top.
11	.9	Sandstone, silty, medium to fine grained, less resistant than the underlying beds, light grey-green when fresh, weathers to a light chalky grey. The unit has a clay rich cement and small clay pebbles are observed most plentifully at its base but frequently throughout.
10	3.7	Sandstone, coarse grained at its base, medium to fine grained at its top, massive cross-bedded. The basal part contains several stringers of quartzose, cherty, lenticular conglomeratic stringers. Most are cross-bedded gritstones with several 1 cm diameter observable quartz and chert pebbles. Several ironstone concretions are 1.5-2 m above the base and are elongated parallel to cross-beds which are dipping more than the 25° regional dip. The unit forms the base of a rounded knoll near the valley floor. The weathered conglomerates produce a graveled surface, absent to the south where the conglomerate thins but are more continuous and are numerous toward the north where the unit thickens.
9	1.8	Sandstone, medium to coarse grained, massive bedded, cross-bedded, with gritstone and conglomeratic stringers composing 10% of the unit with coarse clasts of chert and quartz. There are two subunits of platy limonite-stained, minutely cross-bedded siltstones in association with conglomeratic stringers equidistantly spaced within the unit. The base of these units contain clay-pebble conglomerates which weather to produce yellow-orange limonitic boundaries on vacuities in association with coarser clastic sediments. Fresh, unweathered surfaces show pale green clay cement similar in nature to the clay of fresh unweathered clay pebbles. The unit is discontinuous along strike, but forms a small semiresistant ledge along traverse. It is covered to the south and weathers spheroidally

Unit	Meters	Description
9	cont	as it thins to the north.
8	.9	Sandstone, medium grained with some coarse to conglomeratic lenticular stringers scattered throughout. Basal clay-pebble conglomerates weather to be preserved as limonite ringed vacuities. The conglomeratic stringers are from 2-5 cm thick, very lenticular and discontinuous with clasts of quartz and some black chert. The better-cemented parts have limonite and calcareous cement where as less-resistant parts are clay cemented. The unit has a platy nature along traverse but can be observed to lose this nature along strike where it becomes more massive and cross-bedded.
7	- -	The unit represents a dip slope from which shales and easily removed materials have been stripped. The surface is covered by plates of conglomeratic sandstone from the uppermost part of unit 6. Some lenticular units of gritstone and conglomeratic sandstone, 5-20 cm thick, can be observed with thin platy sandstone above and below coarser clastic sediment. The conglomeratic pebbles, 1-2 cm in diameter, are black chert quartz and quartzite with minor amounts of limestone and igneous pebbles. Gritstones are of similar material but with less observable limestone and igneous material. Coarse clastic rocks are separated by medium to coarse grained, minutely cross-bedded, and on occasion current ripple-marked sandstone which weathers orange-tan but is pale green or white when fresh. Coarse clastic sediment composes 25% of the upper portion of unit 6 as observed on the dip slope.
6	4.3	Sandstone, medium to coarse grained, 80% quartz, 20% black chert, poorly cemented at its base, slightly more cemented at its top. It contains isolated limonite concretions, 5-15 cm in diameter, scattered in 1-2 m intervals. It is massive, clay cemented, weathers white and is pastel green when fresh. The unit thins along strike north and south and its limonite content decreases as the unit thins.
5	5.5	Sandstone, thin, platy, poorly cemented, less resistant than the sandstones previously described on the ridge crest. The top of this unit is a limonite concretion sandstone similar to the sandstone in Unit 4 except it is thin, platy, and numerous limonite concretions make it weather to grape-like nodules. The unit is primarily covered but, better exposed to the south it consists of medium fine grained platy sandstone with interbedded shale. In the north the unit produces a graveled surface composed of limonite concretions.
4	2.1	Sandstone, fine to coarse grained, tar stained, consists of quartz, black chert and calcareous rock particles. It has lenticular cross-beds with platy spheroidal weathering beds 30-50 cm thick. To the south this unit thins and becomes platy. To the north the unit becomes more nodular and massively bedded.

Unit	Meters	Description
Contact of the Fort Union Formation with the Lance Formation		
3	2.4	Conglomerate with interbedded sandstone, medium grey, medium to fine grained, slightly platy, with occasional limonitic concretions. The sandstone weathers spheroidally in unit's upper part with a thin to medium bedded platy limonite stained base. The conglomerate consists of chert, quartz and some limestone pebbles with clay and calcareous cement.
2	.6	Massive sandstone, cross-bedded medium grained, resistant, smoky grey, with medium grained stringers throughout, consisting primarily of quartz and chert clasts.
1	1.8	Sandstone, weathers chalky white, white when fresh, slight salt and pepper tint in the upper part as it becomes interbedded with slightly larger clasts of conglomeratic stringers of black and white chert, granite, and limestone pebbles. Rip-up clasts are present in lower part with interbedded thin stringers of sandstone and shale. Cross-beds dip to the southwest at about 25°.

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Plate I

Figs. 1-3. Xyronomys swainae, (Swain Quarry) new genus and new species: 1, isolated M_b (AMNH 87897), type specimen, labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X6.

Figs. 4-11. Xanclomys mcgrewi, (Swain Quarry) new genus and new species: 4, dentary fragment with P_L-M_b and alveoli for M_1 (AMNH 87860), type specimen, labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view; 7, isolated M^b (AMNH 101018j), paratype, labial view; 8, same, lingual view; 9, same, stereo pair, occlusal view; 10, isolated M_b (AMNH 87587i), paratype, labial view; 11, same, lingual view. All figures X6.

Figs. 12-17. Ectypodus sylviae, (Swain Quarry) new species: 12, isolated M_b (AMNH 100939e), type specimen, labial view; 13, same, lingual view; 14, same, stereo pair, occlusal view; 15, isolated M^b (AMNH 97895c), labial view; 16, same, lingual view; 17, same, stereo pair, occlusal view. All figures X6.

Figs. 18-20. Ectypodus c., (Swain Quarry) unnamed new species: 18, composite upper dentition (M^b, 101076g; M^1, 101058f; M^2, 101059c), labial view; 19, same, lingual view; 20, same, stereo pair, occlusal view. All figures X6.

Figs. 21-23. Neoplagiaulax cf. hunteri, (Swain Quarry): 21, dentary fragment with P_L-M_b (AMNH 100963), labial view; 22, same lingual view; 23, same, stereo pair, occlusal view. All figures X6.

Plate I

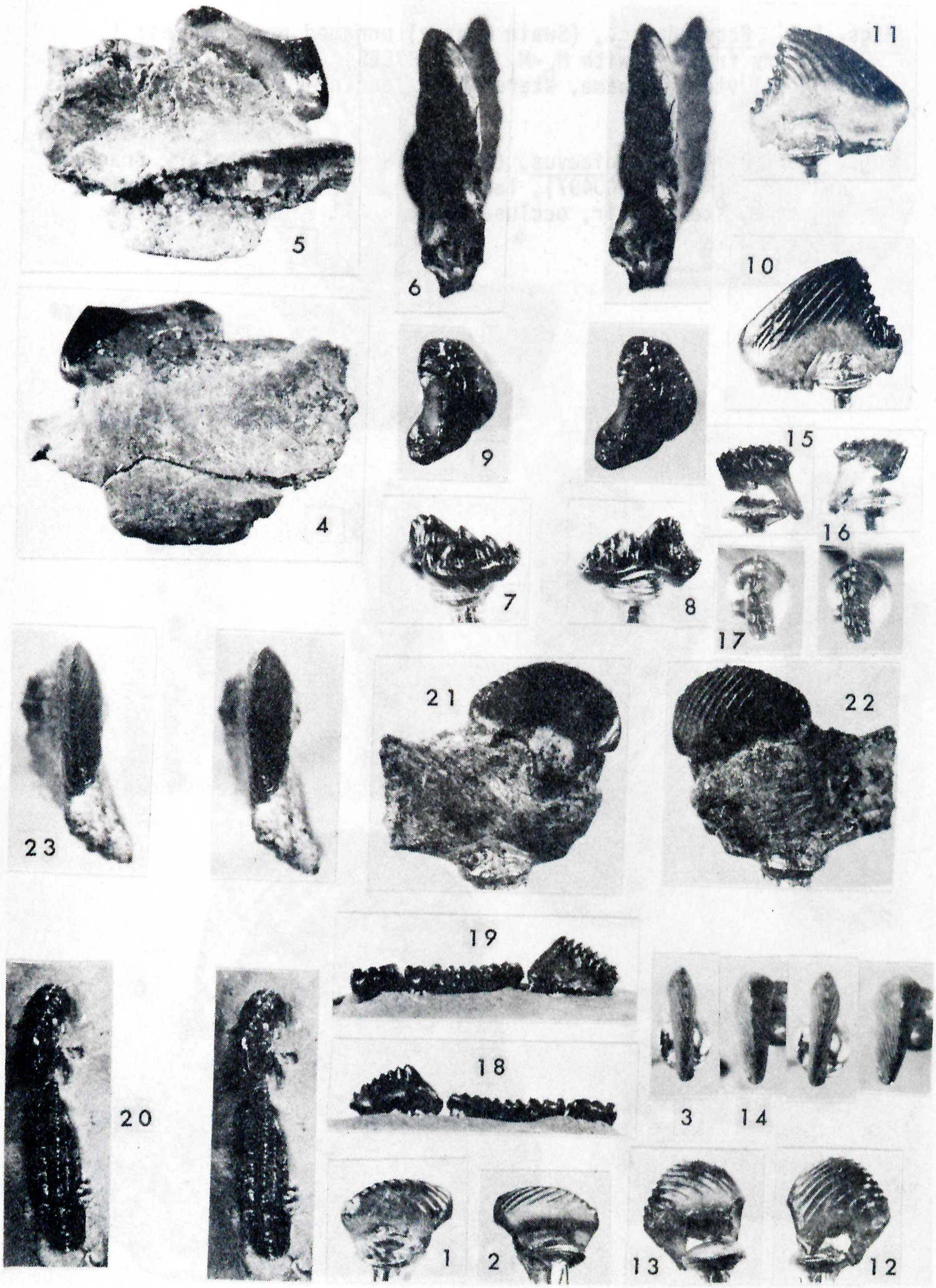


Plate II

Figs. 1-3. *Ectypodus c.*, (Swain Quarry) unnamed new species: 1, dentary fragment with M_b-M_1 (AMNH 87855), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X6.

Figs. 4-6. *Ptilodus mediaevus*, (Swain Quarry): 4, dentary fragment with P_L-M_b (AMNH 100497), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X6.

Plate II

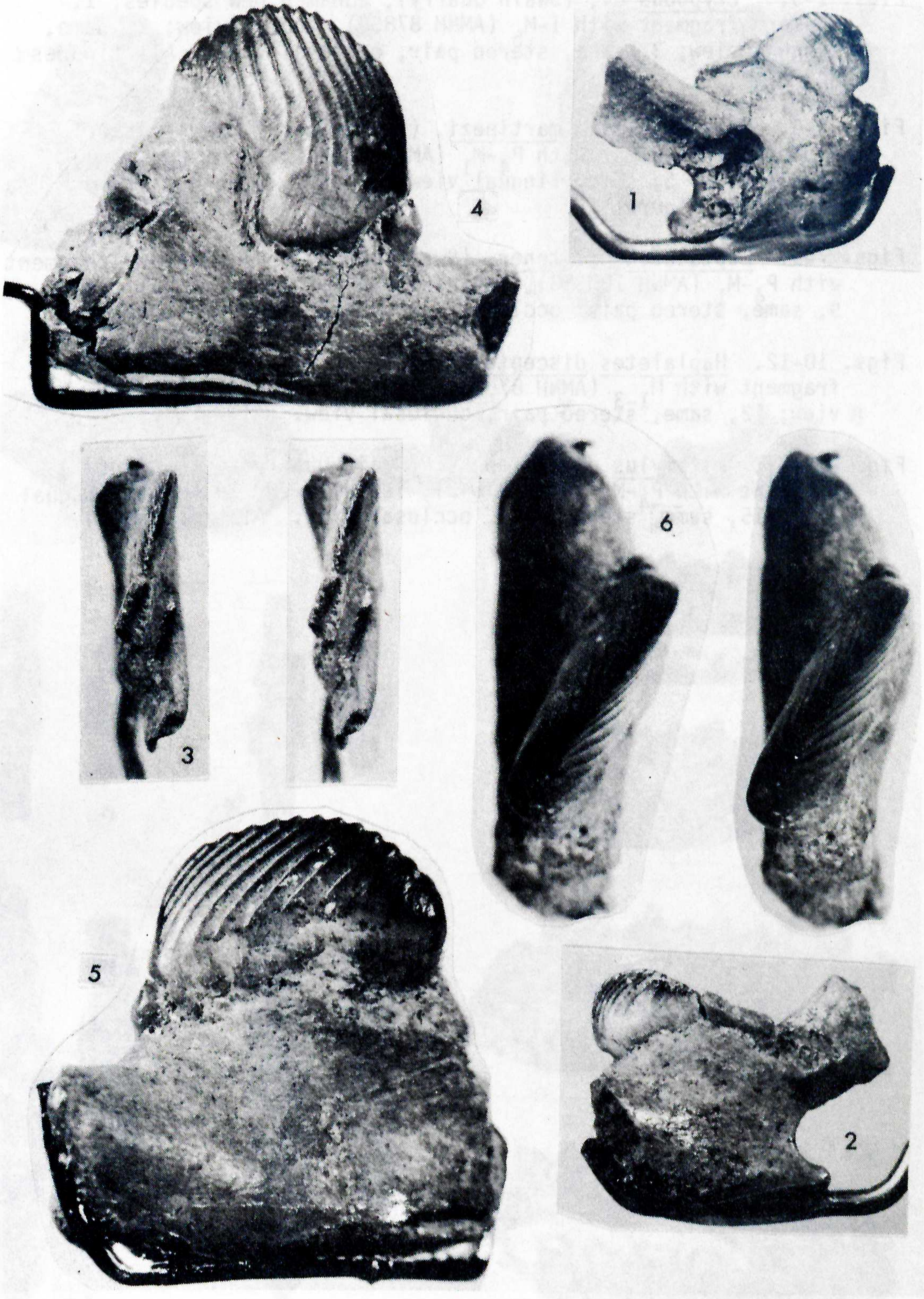


Plate III

Figs. 1-3. *Ectypodus* *c.*, (Swain Quarry), unnamed new species: 1, dentary fragment with I-M_b (AMNH 87856), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X6.

Figs. 4-6. *Mckennatherium martinezi*, (Swain Quarry) new species: 4, dentary fragment with P_4-M_1 (AMNH 100351, type specimen), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X6.

Figs. 7-9. *Leptacodon* cf. *tener*, (Swain Quarry): 7, dentary fragment with P_4-M_1 (AMNH 100353), labial view; 8, same, lingual view; 9, same, stereo pair, occlusal view. All figures X6.

Figs. 10-12. *Haplaletes disceptatrix*, (Swain Quarry): 10, dentary fragment with M_{1-3} (AMNH 87518), labial view; 11, same, lingual view; 12, same, stereo pair, occlusal view. All figures X4.

Figs. 13-15. *Litomylus dissentaneus*, (Swain Quarry): 13, dentary fragment with P_4-M_3 (AMNH 87543), labial view; 14, same, lingual view; 15, same, stereo pair, occlusal view. All figures X4.

Plate III

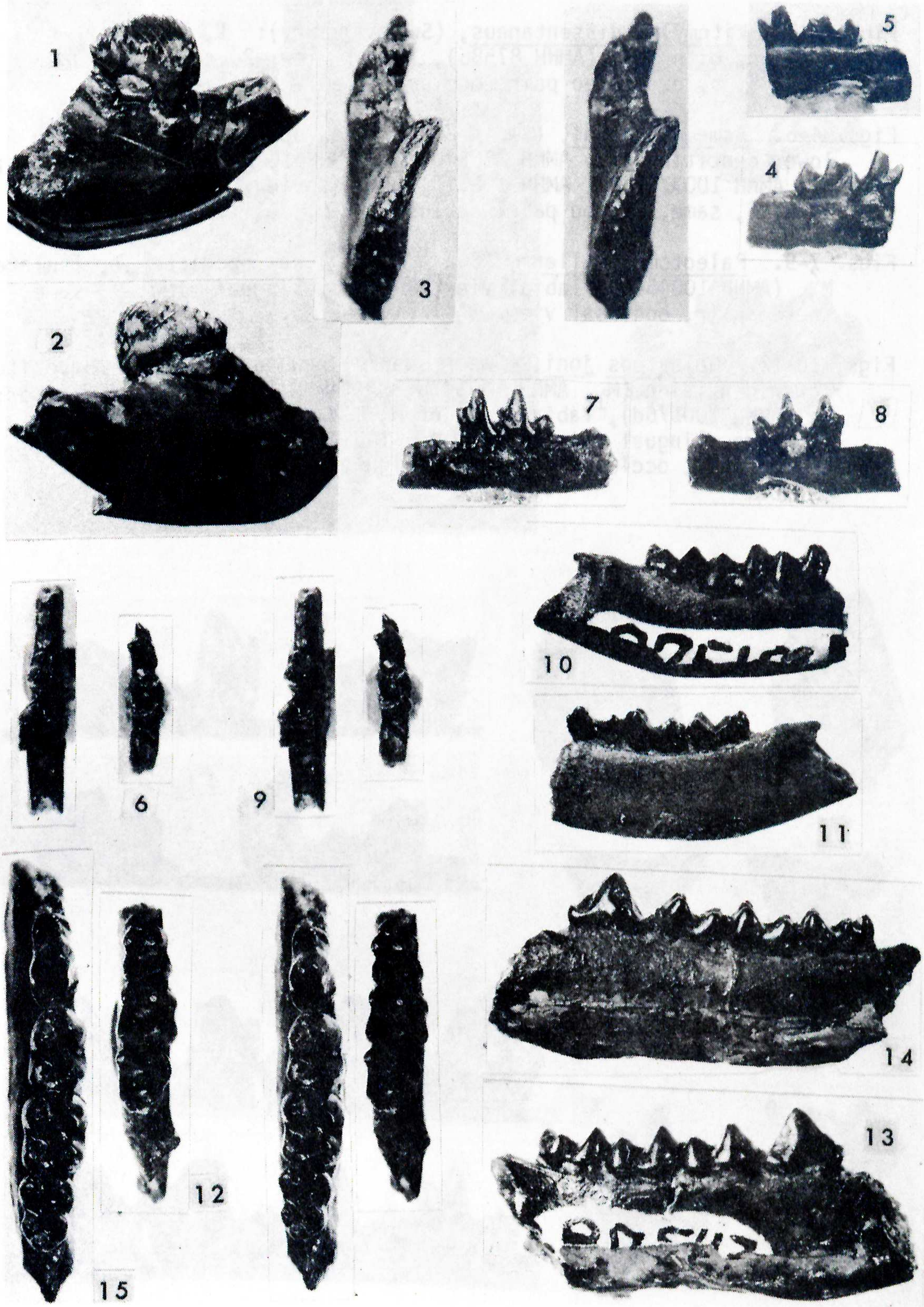


Plate IV

Figs. 1-3. Litomylus dissentaneus, (Swain Quarry): 1, maxilla fragment with M^{1-2} (AMNH 87586), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X4.

Figs. 4-6. Acmeodon hyoni, (Swain Quarry) new species; 4, composite lower dentition (P_4, AMNH 100540; M_1, AMNH 100369e, type specimen; M_2, AMNH 100375; M_3, AMNH 100371), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X6.

Figs. 7-9. Paleotomus milleri, (Swain Quarry) new species: 7, isolated M^2, (AMNH 100454a), labial view; 8, same, lingual view, 9, same, stereo pair, occlusal view. All figures X6.

Figs. 10-12. Gelastops joni, (Swain Quarry) new species: 10, composite lower dentition (M_1, AMNH 100377b; M_2, AMNH 100378, type specimen; M_3, AMNH 100376d), labial view of M_2 & M_3, lingual view of M_1; 11, same, lingual view of M_2 & M_3, labial view of M_1; 12, same, stereo pair, occlusal view. All figures X6.

Plate IV

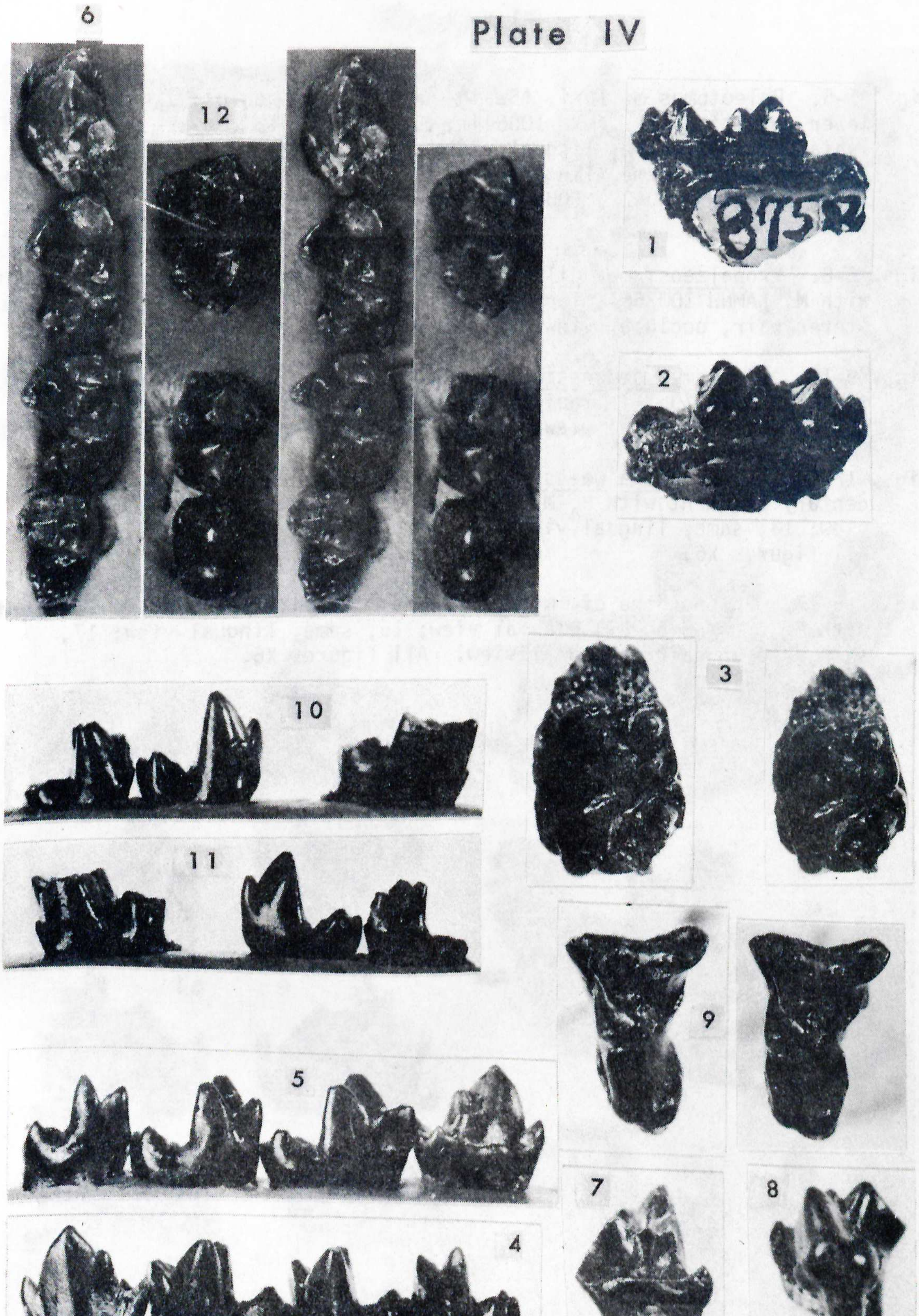


Plate V

Figs. 1-5. *Paleotomus milleri*, (Swain Quarry) new species: 1, composite lower dentition (M_1, AMNH 100644m; M_3, AMNH 100423, type specimen), labial view; 2, same, lingual view; 3, isolated M_2 (AMNH 100422), labial view; 4, same, lingual view; 5, composite lower dentition (AMNH 100644m, 100422, 100423), stereo pair, occlusal view. All figures X6.

Figs. 6-8. *Propalaeosinopa diluculi*, (Swain Quarry): 6, dentary fragment with M_3 (AMNH 100366), labial view; 7, same, lingual view; 8, same, stereo pair, occlusal view. All figures X6.

Figs. 9-11. *Paromomys depressidens*, (Swain Quarry): 9, dentary fragment with P_4 (AMNH 79511), labial view; 10, same, lingual view; 11, same, stereo pair, occlusal view. All figures X6.

Figs. 12-14. *Palenochtha weissae*, (Swain Quarry) new species: 12, dentary fragment with P_4-M_1 (AMNH 100355, type specimen), labial view; 13, same, lingual view; 14, same, stereo pair, occlusal view. All figures X6.

Figs. 15-17. *Palenochtha* cf. *minor*, (Swain Quarry): 15, dentary fragment with M_{2-3} (AMNH 80987), labial view; 16, same, lingual view; 17, same, stereo pair, occlusal view. All figures X6.

Plate V

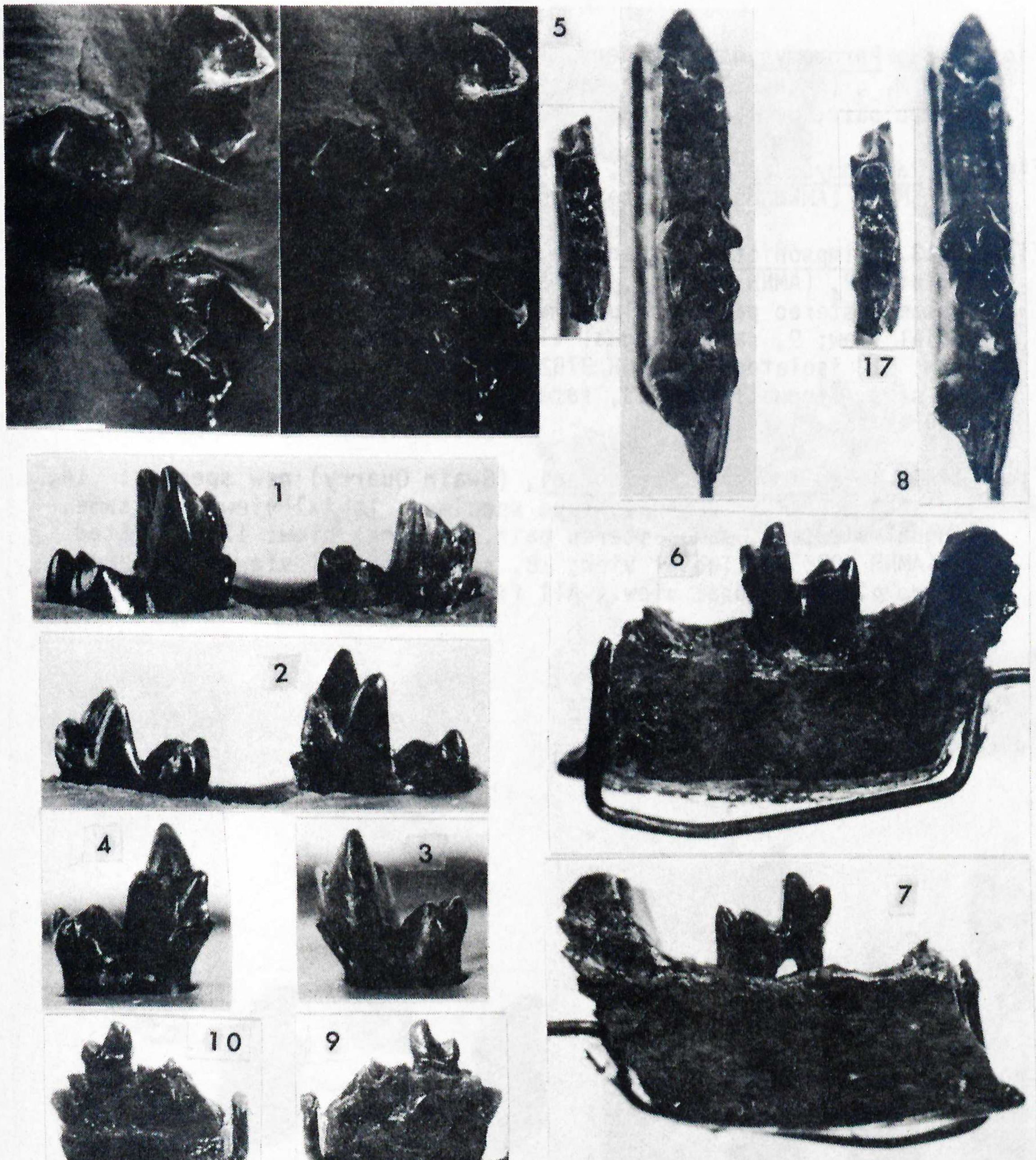


Plate VI

Figs. 1-3. Paromomys depressidens, (Swain Quarry): 1, dentary fragment with M_{1-3} (AMNH 80970), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X6.

Fig. 4. Paromomys depressidens, (Gidley Quarry): 4, dentary fragment with M_{1-3} (AMNH 35550), stereo pair, occlusal view. Figure i5 X6.

Figs. 5-13. Simpsonictis jaynanneae, (Swain Quarry) new species: 5, isolated P_4 (AMNH 87932b), labial view; 6, same, lingual view; 7, same, stereo pair, occlusal view; 8, isolated M^1 (AMNH 100449), labial view; 9, same, lingual view; 10, same, stereo pair, occlusal view; 11, isolated P^4 (AMNH 87922), type specimen, labial view; 12, same, lingual view; 13, same, stereo pair, occlusal view. All figures X6.

Figs. 14-19. Prolimnocyon macfaddeni, (Swain Quarry) new species: 14, isolated M^2 (AMNH 100640a), type specimen, labial view; 15, same, lingual view; 16, same, stereo pair, occlusal view; 17, isolated M_1 (AMNH 100639), labial view; 18, same, lingual view; 19, same, stereo pair, occlusal view. All figures X6.

Plate VI

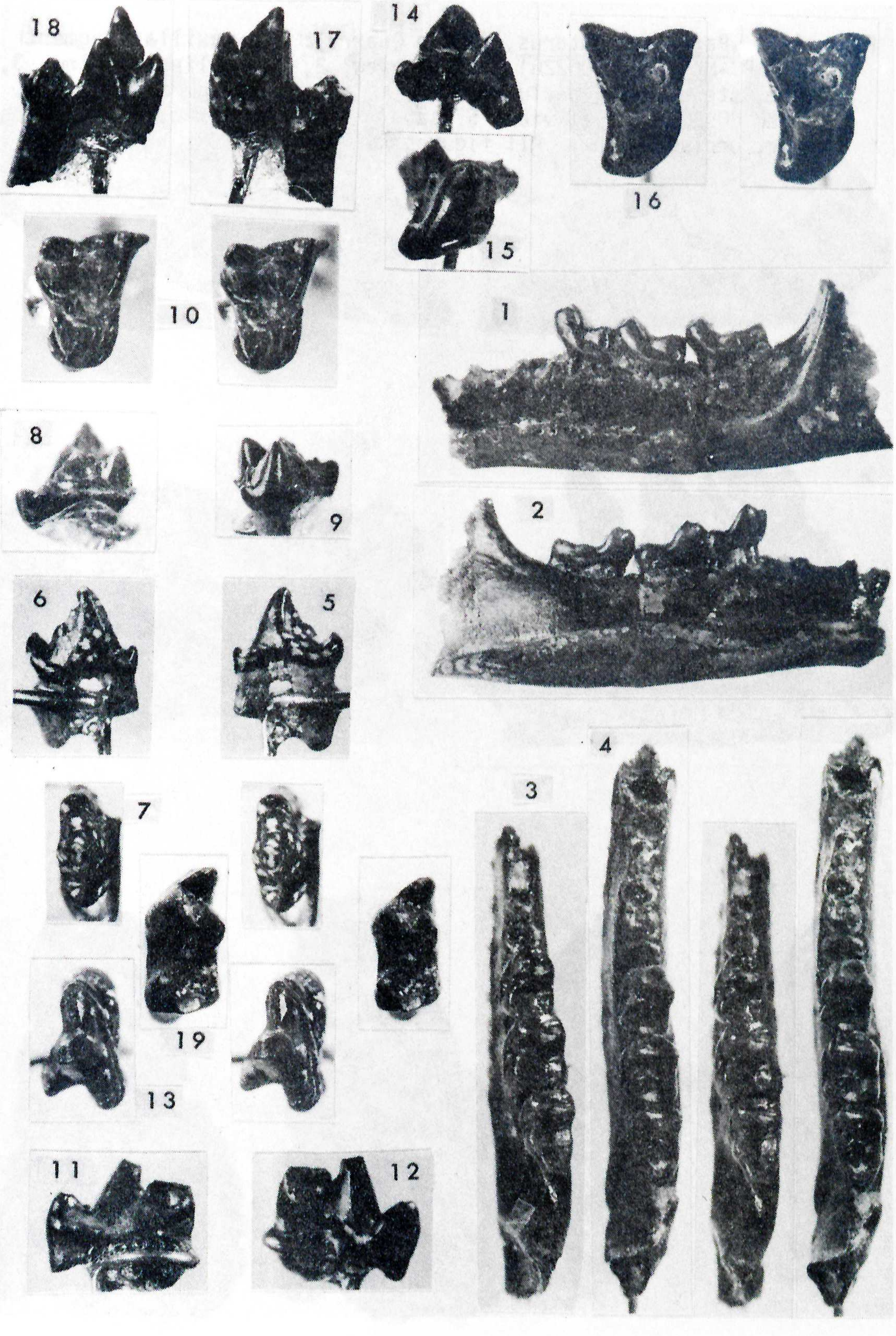


Plate VII

Figs. 1-6. *Paromomys maturus*, (Swain Quarry): 1, maxilla fragment with P^4-M^3 (AMNH 100226), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view; 4, dentary fragment with P_{2-4} (AMNH 80990), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X6.

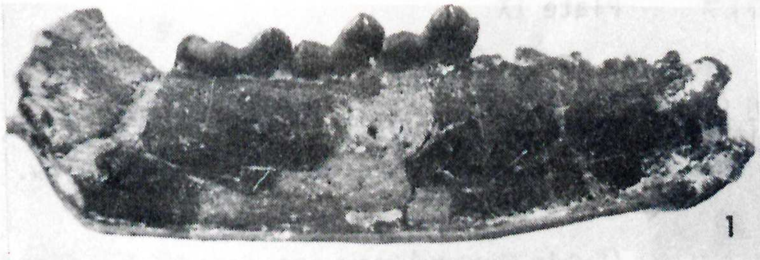
Plate VII

Plate VIII

Figs. 1-2. Paromomys depressidens, (Gidley Quarry): 1, dentary fragment with M_{1-3} (AMNH 35550), labial view; 2, same, lingual view. All figures X6.

Figs. 3-8. Mimotricentes subtrigonus, (Swain Quarry): 3, dentary fragment with M_{1-3} (AMNH 87562), labial view; 4, same, lingual view; 5, same, stereo pair, occlusal view; 6, dentary fragment with P_4-M_1 (AMNH 87569), labial view; 7, same, lingual view; 8, same, stereo pair, occlusal view. All figures X4.

Plate VIII



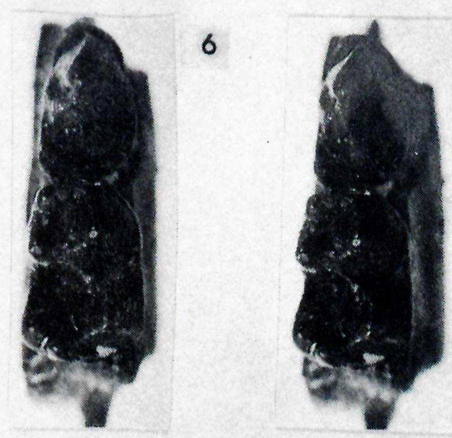


Plate IX

Figs. 1-3. *Protogonodon criswelli*, (Swain Quarry) new species: 1, dentary fragment with M_{1-2} (AMNH 87587), type specimen, labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X4.

Fig. 4. *Prothryptacodon hilli*, (Swain Quarry) new species: 4, composite lower dentition (M_1, AMNH 87784h; M_2, AMNH 100600i, type specimen; M_3, AMNH 87771d), stereo pair, occlusal view. Figure is X4.

Figs. 5-7. *Anisonchus sectorius*, (Swain Quarry): 5, dentary fragment with P_3-M_1 (AMNH 100218), labial view; 6, same, lingual view; 7, same, stereo pair, occlusal view. All figures X2.

Figs. 8-10. *Haploconus* sp., (Swain Quarry): 8, isolated M_2, (AMNH 101102), labial view; 9, same, lingual view; 10, same, stereo pair, occlusal view. All figures X6.

Plate IX

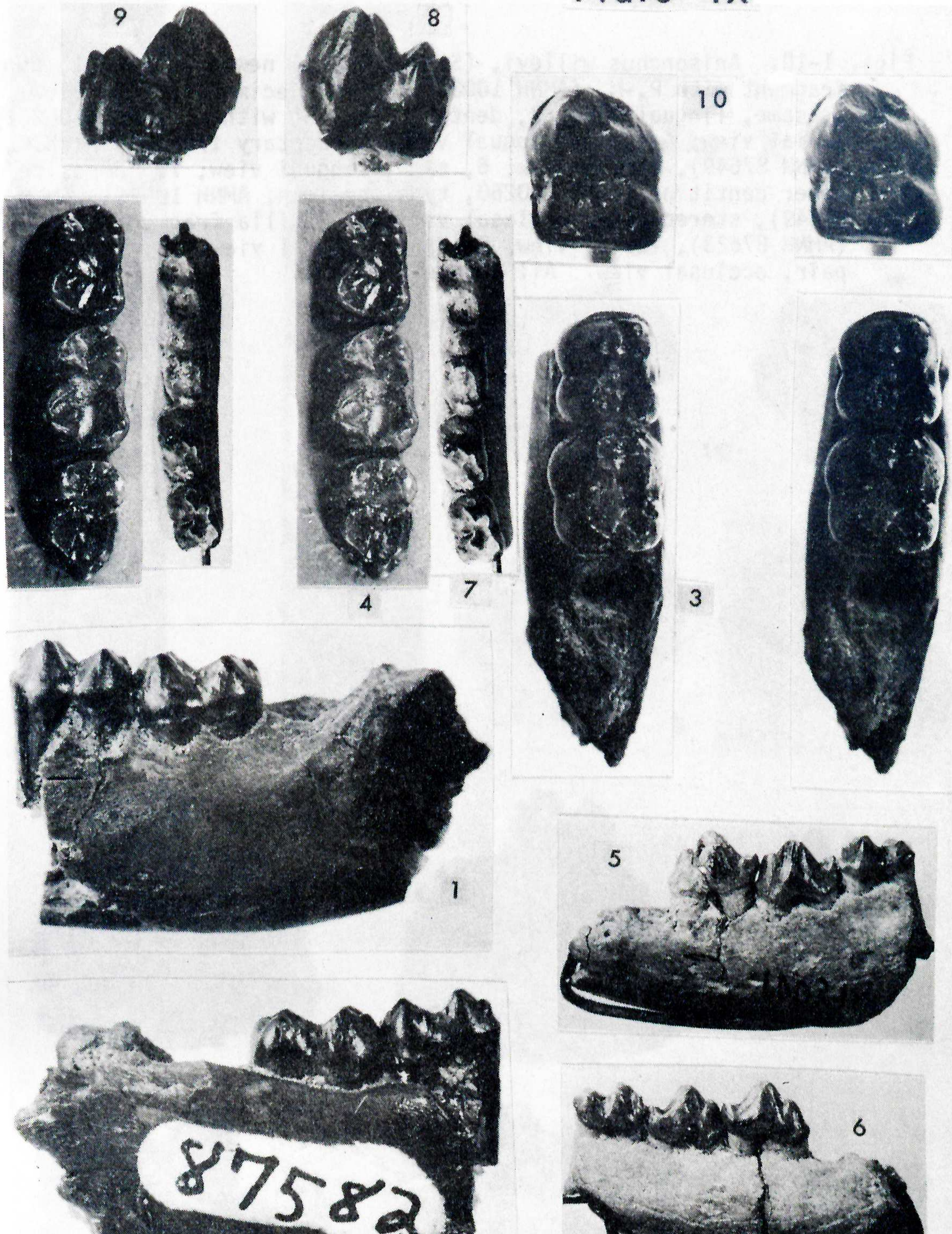


Plate X

Figs. 1-10. Anisonchus willeyi, (Swain Quarry) new species: 1, dentary fragment with P_4-M_1 (AMNH 100260), type specimen, labial view; 2, same, lingual view; 3, dentary fragment with M_2 (AMNH 100261), labial view; 4, same, lingual view; 5, dentary fragment with M_3 (AMNH 87649), labial view; 6, same, lingual view; 7, composite lower dentition (AMNH 100260, type specimen, AMNH 100261, AMNH 87649), stereo pair, occlusal view; 8, maxilla fragment with M^{2-3} (AMNH 87623), labial view; 9, same, lingual view; 10, same, stereo pair, occlusal view. All figures X4.

Plate X

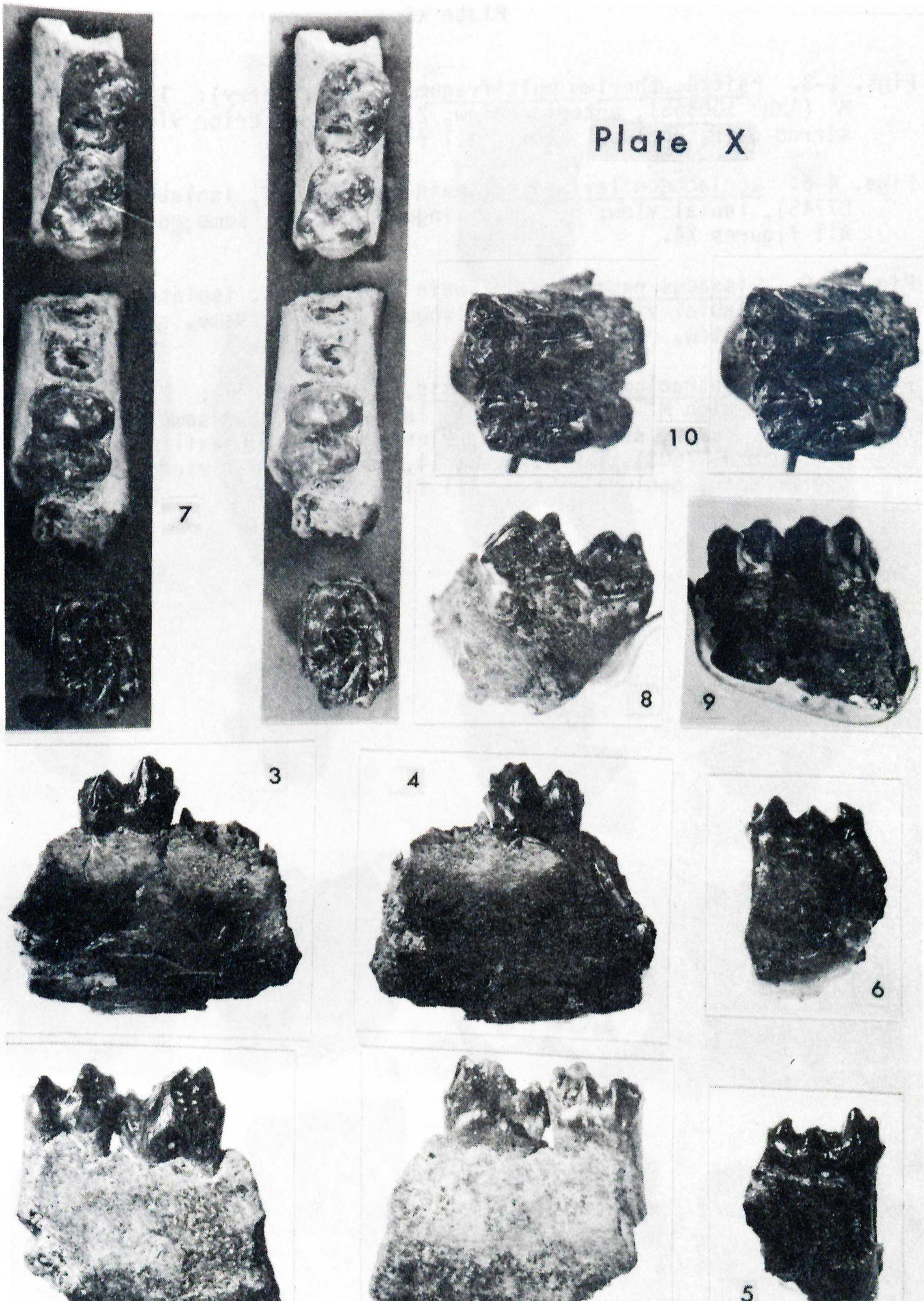


Plate XI

Figs. 1-3. *Psittacotherium multifragum*, (Swain Quarry): 1, isolated M^1 (AMNH 100563), anterior view; 2, same, posterior view; 3, same, stereo pair, occlusal view. All figures X2.

Figs. 4-6. *Goniacodon levisanus* (Swain Quarry): 4, isolated M_2 (AMNH 87745), labial view; 5, same, lingual view; 6, same, occlusal view. All figures X4.

Figs. 7-9. *Dissacus navajovius*, (Swain Quarry): 7, isolated M^1 (AMNH 87599), labial view; 8, same, lingual view; 9, same, stereo pair, occlusal view. All figures X2.

Figs. 10-15. *Tetraclaenodon puercensis*, (Swain Quarry): 10, maxilla fragment with M^{1-2} (AMNH 87602), labial view; 11, same, lingual view; 12, same, stereo pair, occlusal view; 13, maxilla fragment with M^{1-2} (AMNH 87603), labial view; 14, same, lingual view; 15, same, stereo pair, occlusal view. All figures X2.

Plate XI

Plate XII

Figs. 1-9. Promioclaenus acolytus, (Swain Quarry): 1, dentary fragment with P_4-M_2 (AMNH 87756), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view; 4, dentary fragment with P_{3-4} (AMNH 87556), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view; 7, dentary fragment with M_{1-3} (AMNH 87559), labial view; 8, same, lingual view; 9, same, stereo pair, occlusal view. All figures X4.

Plate XII

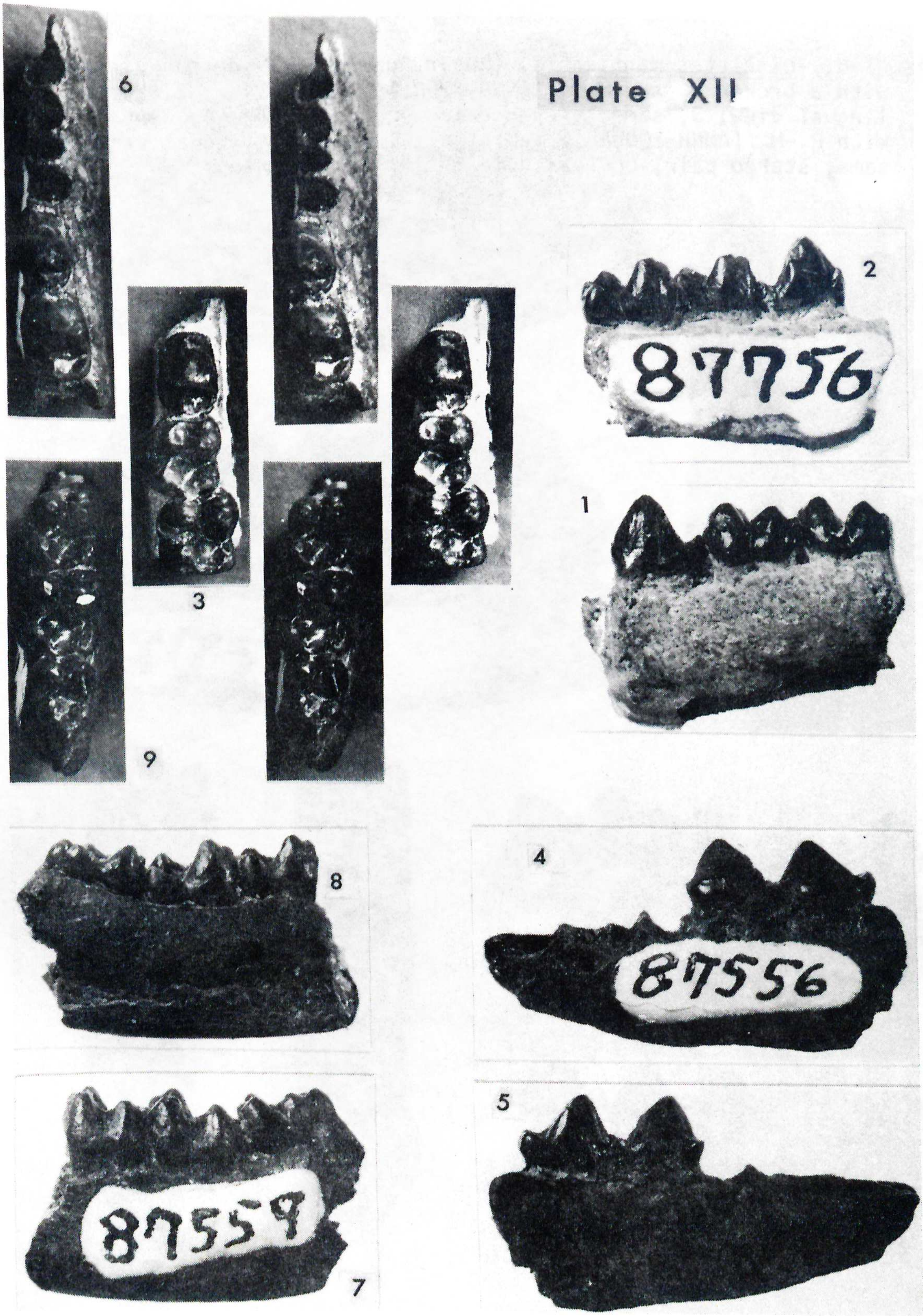


Plate XIII

Figs. 1-6. *Litaletes mantiensis*, (Swain Quarry): 1, dentary fragment with a broken M_1 and M_{2-3} (AMNH 87581), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view; 4, dentary fragment with P_3-M_2 (AMNH 100548), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X4.

Plate XIII

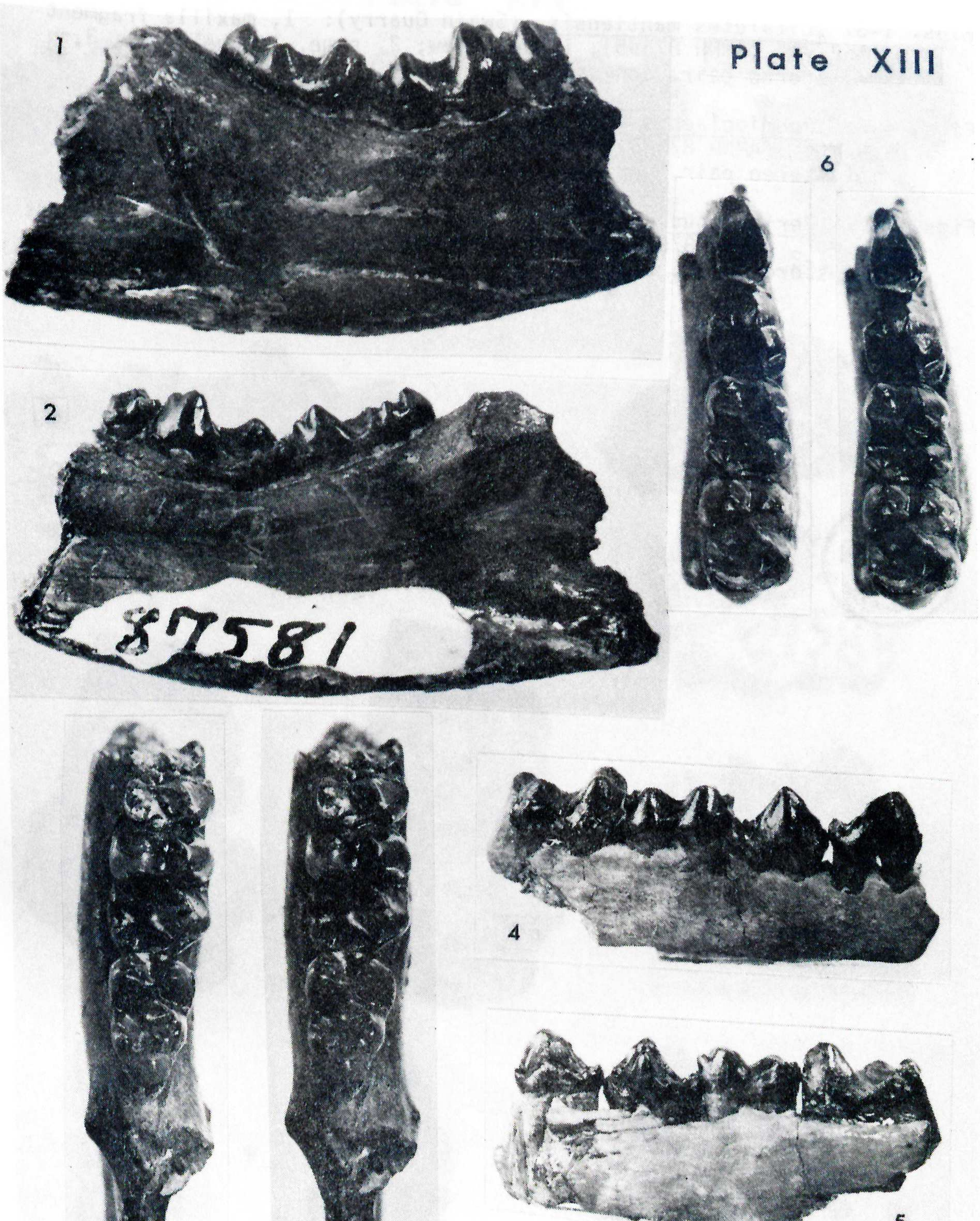


Plate XIV

Figs. 1-3. *Litaletes mantiensis*, (Swain Quarry): 1, maxilla fragment with P^4-M^3 (AMNH 87595), labial view; 2, same, lingual view; 3, same, stereo pair, occlusal view. All figures X4.

Figs. 4-6. *Promioclaenus acolytus*, (Swain Quarry): 4, maxilla fragment with M^{1-2} (AMNH 87588), labial view; 5, same, lingual view; 6, same, stereo pair, occlusal view. All figures X4.

Figs. 7-9. *Periptychus carinidens*, (Swain Quarry): 7, dentary fragment with M_{1-2} (AMNH 87579), labial view; 8, same, lingual view; 9, same, stereo pair, occlusal view. All figures X2.

Plate XIV

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