

**Vertebrate ichnological diversity and census studies,
Lower Jurassic Navajo Sandstone**

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Abstract

Only a small body fauna is known from the Navajo Sandstone, and includes a crocodylomorph, a few partial tritylodonts and prosauropods, and a small theropod. In contrast, 18 ichnogenera have been discovered, representing up to 9 vertebrate families. Whilst the animals known from skeletal remains are represented by tracks, the ichnites suggest that large theropods, lizards, thyreophorans, and possibly basal ornithischians and pterosaurs also inhabited this environment. Clearly where tracks are present they can increase our knowledge of the vertebrate component of the ecosystem in strata with a poor body fossil record.

Tracks provide information on the environments frequented by particular animals because they are *in situ* biogenic sedimentary structures; however this also means that substrate conditions can play an important role in determining track morphology and preservation. In the Navajo Sandstone only the smallest tracks are found on dune foresets, and the whole range of track sizes (except for the smallest) are preserved in interdune environments. This size sorting is due to differences in substrate texture and composition rather than being behaviorally or paleoecologically determined. However the predominance of carnivore tracks around wet interdune deposits (oases) is probably a result of behavioral and sedimentological variations on a daily basis.

Introduction and Setting

The Glen Canyon Group is a Lower Jurassic terrestrial sequence comprising the eolian Wingate and Navajo Sandstones separated by the largely-fluvial Kayenta Formation. The Navajo Sandstone is the uppermost unit, interfingering with the Kayenta Formation in the southern part of their extent, representing the Navajo dune-field encroaching on the fluvial Kayenta system.

The Navajo Sandstone outcrops over much of southern and central Utah and northern Arizona. In the southeastern part of this region generally only the lower half of the unit is present, the upper part having been truncated by the J-2 unconformity; this lower part contains many lacustrine (playa) deposits, which are rare in the upper half (Blakey, 1994). In northern Utah and Colorado, and southern Idaho and Wyoming, the Glen Canyon Group is equivalent to the Nugget and Glen Canyon

Sandstone (Peterson and Pipiringos, 1979); in southern California and Nevada the Aztec Sandstone is the Glen Canyon Group-equivalent (Marzolf, 1988). These latter units are not subdivided into Wingate-, Kayenta- or Navajo-equivalents.

This paper is based on fieldwork by the author and by other members of the University of Colorado at Denver Dinosaur Trackers Research Group (UCD DTRG), and on published information by other authors. Some of the tracksites studied have been written up previously (see Appendix 1 for details). Fieldwork was conducted mainly in the Navajo Sandstone of southeastern Utah; Nugget Sandstone tracksites in northern Utah and Idaho were also briefly visited, although their position in the Nugget is unknown.

The purpose of this paper is to compile data from all known Navajo/Nugget/Aztec Sandstone (hereafter referred to as Navajo) vertebrate tracksites in an effort to define the vertebrate paleoecology of this particular ancient desert system. Whilst invertebrate tracks (Albers, 1975; Rainforth and Lockley, 1996a; Stokes, 1978), wood (Stokes, 1991) and rhizoliths (Loope, 1988) have been observed and recorded in the Navajo during the course of this study, they will not be discussed here.

It is beyond the scope of this paper to evaluate the sedimentology and stratigraphy of the Navajo, or the biostratigraphic potential of vertebrate tracks from this unit.

Tracksites

Vertebrate tracks occur in several facies of the Navajo Sandstone; these can be classified as dune or interdune environments. Tracks in the dune environments occur on the foresets; generally the trackways are trending up-slope. The interdune environment can be further subdivided into truncation (or bounding) surfaces between dune sets; and horizontally-bedded interdunal deposits. Tracks in these environment are usually, perhaps always, undertracks. These latter have a range of lithologies even within a single vertical interdune sequence, varying from siliciclastic to calcareous sand to limestone, which in some instances can be demonstrated to have algal laminations. Pseudomorphs after evaporitic structures occur in some of the limestones, for example at the North Wash 2 site. The limestone interdunal sequences would have formed in ephemeral playa lakes. Appendix 1 provides lithology and interpreted-environment information for each tracksite.

Reconnaissance fieldwork has been undertaken by the author at 51 of the 88 known tracksites; some of these have been previously reported in print (Albers 1975; Lockley and Hunt, 1995; Lockley et al., 1992a,b,c, 1997; Stokes, 1978; Stokes and Madsen, 1979). An additional 20 unpublished sites have been visited by members of the DTRG, and data made available for this study;

finally 17 sites have not been visited either by myself or other members of the DTRG and are known from literature reviews (Baird, 1980; Baker, 1946; Chronic, 1983; Davies, 1992; Faul and Roberts, 1951; Gilland, 1979; Jones, 1991; Kayser, 1964; Reynolds, 1989; Sanderson, 1974). Appendix 1 gives a detailed breakdown of this information by site.

Track morphotypes

It is important to be consistent in measuring tracks. Figure 1 illustrates the methods used in this study. By convention, digit I is the medial (innermost) digit, and digit V is the lateral (outer-most) digit. Only digits II-IV are represented in tridactyl dinosaur tracks. The individual pads on track digits correspond to the joints between the phalanges. Digit divarication can be highly variable within a single trackway, and should not therefore be used as a diagnostic property of an ichnotaxon.

It is assumed that each trackway at a site represents a different individual. Whilst this is obviously the case where the footprints in different trackways are different sizes, the most parsimonious interpretation is that this is also true where there are multiple trackways of the same size track (see Lockley and Hunt, 1994 for further discussion). This may lead to overestimation of the number of individuals because a single animal may have made more than 1 trackway. However the alternate end-member interpretation is to consider all tracks the same size to have been made by a single animal, which assumes that only one individual of each size was present. Detailed measurements should be taken for each trackway (and for isolated tracks); this data is not presented here due to space considerations.

Many of the tracks are preserved with sufficient morphological detail as to merit assignation of an ichnotaxonomic name at the generic level. In general ichnospecies can not be assigned because (a) the tracks are not well-enough preserved, and (b) the taxonomy of Late Triassic and Early Jurassic vertebrate tracks is in a confused state at the present time, with an excess of names that in many cases are junior synonyms of other ichnotaxa. With such constraints, I do not think it particularly valuable to attempt to assign ichnospecific names. Exceptions are *Navahopus falcipollex*, an ichnogenus and ichnospecies known only from a single trackway in the Navajo of northern Arizona (Baird, 1980; Figure 2); *Trisauropodiscus moabensis*, an ichnospecies known only from the Navajo near Moab, Utah (Lockley and Hunt, 1995; Figure 3); and *Otozoum*, which has two easily distinguishable ichnospecies (*O. moodii*, *O. minus*; Figure 4), both of which are known from the Navajo.

Unfortunately there are tracks which it is not possible to identify, owing to their poor preservation. Such tracks can occur in any of the facies within the Navajo, and are of limited

usefulness. In the case of tridactyl tracks, it may be possible to determine whether there are claw impressions; their presence usually indicates a theropod, rather than ornithischian, trackmaker. However there are some tridactyl tracks for which this can not be determined.

Preservation of tracks on dune foresets is of variable quality. Generally tracks are preserved pointing upslope; it has been observed that most animals destroy their footprints when moving downslope (McKee, 1947). Dune foreset tracks tend to be small – larger animals do not leave well-defined footprints (McKee, 1947; Figure 5).

Below is a list of the ichnotaxa known from the Navajo. They are not described in detail, although most are illustrated; complete descriptions can be found in the referenced works. (NB Whilst Lull's 1953 monograph illustrates many of these ichnotaxa, these illustrations are often ideal examples of tracks; however the Navajo tracks can generally not be identified below the ichnogenetic level, so I consider his illustrations sufficient when taken together with the published descriptions.) For the unvisited sites (see "Tracksites" section) it is not possible to assess the accuracy of the authors' identifications; the track descriptions are generally poor, and illustrations either absent or simply line drawings. In these cases the identifications are initially taken at face value, and then discussed in the context of the more common ichnotaxa in the Navajo. These tracks contribute significantly to the apparent high ichnodiversity of this unit (see "Discussion").

Grallator

Small (up to 18 cm long) tridactyl track with well-defined pad and claw impressions. Narrow divarication. Phalangeal formula 2-3-4. See Lull, 1953 and Figure 6.

Eubrontes

Large (longer than 25 cm) tridactyl track with well-defined pad and claw impressions. Narrow divarication. Phalangeal formula 2-3-4. See Lull, 1953 and Figure 7.

Anchisauripus

Medium-sized (15-30 cm long) tridactyl track with well-defined pad and claw impressions. Narrow divarication. See Lull, 1953.

It is possible that *Grallator*, *Anchisauripus* and *Eubrontes* are artificial divisions of a continuous ontogenetic growth series (Olsen, 1980). However, that assumes that there were no small trackmakers of this type. In addition, the relative lengths and positions of the digits varies between these ichnotaxa; however, modern ratites' feet grow at different rates, resulting in slightly different morphologies with age (Farlow, personal communication, 1996). This track is uncommon relative to

Grallator and *Eubrontes*.

Anomoepus

Small tridactyl track with well-defined pad and claw impressions; metatarsal impression often present. Manus tracks present in type material, but not seen in Navajo examples. Wider divarication than *Grallator*. See Lull, 1953 and Figure 6.

It is likely that *Anomoepus* is a behavioral variant of *Grallator* – a single trackway from the Newark Supergroup changes from *Grallator* to *Anomoepus*. This suggests that digit divarication is not an adequate criterion on which to distinguish tracks, because trackmakers could change the angle of divarication during locomotion (i.e. with different behavior).

cf. *Sauropus*

Small tridactyl track with well-defined pad and claw impressions. Extremely narrow divarication – digits are almost parallel. See Lull, 1953 and Figure 8. It is possible that this ichnogenus is a behavioral variant of *Grallator*; it may be a junior synonym.

Only one example of this track is known from the Navajo (Nugget at Redfleet Reservoir); it is fairly well preserved. Whilst *Grallator* (and *Eubrontes*) are very common ichnotaxa at this site, this single track resembles *Sauropus* more closely than it does *Grallator*; this may very well be a preservational rather than osteological artifact.

cf. *Apatichnus*

Small tridactyl track with well-defined pad and claw impressions. Track is asymmetrical – divarication between digits II and III is much less than that between digits III and IV. See Lull, 1953 and Figure 8. This ichnogenus may be a behavioral variant of *Grallator*.

As is the case for *Sauropus* from the Navajo, cf. *Apatichnus* is known from a single track near Moab; for the same reasons as given above for cf. *Sauropus* this single track is referred to here as cf. *Apatichnus*.

cf. *Wildeichnus*

Very small (up to 5 cm long) tridactyl track with narrow divarication. Pad impressions may be present. See Haubold, 1971 and Figure 3. This ichnogenus may be a juvenile *Grallator*.

This ichnogenus is known from 2 foreset surfaces at a single locality; although the tracks are not well-preserved, I have chosen to refer them to cf. *Wildeichnus* rather than *Grallator*.

Trisauropodiscus moabensis

Very small (up to 6 cm long) tridactyl track with very wide divarication. Pad impressions present but indistinct. See Lockley and Hunt, 1995 and Figure 3.

This ichnogenus may be a juvenile *Anomoepus* (and therefore possibly a juvenile *Grallator*), although it also resembles some Early Cretaceous bird tracks.

Dilophosauripus

Large tridactyl track with fairly well-defined pad and claw impressions. Quite wide divarication. See Welles, 1971 and Figure 7.

This ichnogenus may be a behavioral variant of *Eubrontes*.

Tridactyl morph A

This track morphology occurs at several sites in the Navajo, and will be described semi-formally here.

Holotype: CU-MWC 184.43; Figure 9.

Paratype: CU-MWC 180.31; Figure 9.

Stratigraphic context: Interdune (playa) deposits in the lower part of the Navajo.

Locality: Holotype – UCD L-00280, North Wash 2, near Bullfrog, SE Utah.

Paratype – UCD L-00223, Cedar Canyon, Lake Powell, SE Utah.

Holotype collected by DTRG crew, July 1996.

Dimensions:

Specimen	Width	Length	te	te:fl	Divarication II-IV	Divarication II-III	Divarication III-IV
CU-MWC 184.43	39 cm	35 cm	12 cm	0.34	89°	41°	48°
CU-MWC 180.31	18.8 cm	18.3 cm	5.4 cm	0.3	70°	38°	43°

Description: A small to medium sized tridactyl track lacking ungual impressions; the distal ends of digits are blunt and rounded. Digits II and IV are subequal in length; digit III is longest. Width of all digits similar (approximately 5.8 cm for holotype). Digits are slightly curved. Phalangeal impressions are absent – each digit comprises a single cigar-shaped pad, indicative of a very fleshy foot, possibly with reduced digital flexibility. Short metatarsal impression may be present. These tracks are often found as single tracks on small float blocks; trackways have been reported from Cedar Canyon (Lockley et al., 1997). Manus tracks are unknown, suggesting a bipedal trackmaker.

Affinities: This track morphotype is most similar to *Moyenisauripus* (Ellenberger, 1974), although this ichnogenus sometimes has pad impressions and manus tracks. It is slightly less similar to *Paratrisauropus mendrezi* (Ellenberger, 1972), *Pseudotrisauropus maserui* (Ellenberger, 1972) and *Gyrotrisauropus* (several species; Ellenberger, 1972).

Otozoum

Usually bipedal trackway. Pes large (up to 50 cm long), functionally tetradactyl, phalangeal formula 2-2-3-4-0; manus small, functionally tetradactyl. Claws present on both manus and pes tracks. See Lull, 1953 and Figure 4.

Navahopus

Subcircular pes approximately 14 cm long, claw impressions visible but no pads on digits. Tridactyl, but some impressions apparently tetradactyl. Manus tracks tridactyl; digit I directed inwards perpendicular to midline of trackway; digits II and III directed forwards. Manus smaller than pes, approximately 4 cm long and 5-8 cm wide (variability in track size due to variation in digit I orientation). It has been suggested that this ichnogenus is simply a large *Brasilichnium* (Lockley and Hunt, 1995); however the morphological differences between these two ichnogenera are too great to be attributed to preservational differences.

See Baird, 1980 and Figure 2.

cf. Navahopus

Quadrupedal trackway. Pes oval, tridactyl or tetradactyl (unclear from the material described and illustrated by Faul and Roberts, 1951), up to 15 cm long. Manus possibly tetradactyl, very similar in size to pes. These tracks from the Navajo in Colorado were assigned to *Tetrasauropus* by Baird (1980); however this ichnogenus is much larger (pes length $\gg 25$ cm) than the tracks figured by Faul and Roberts (1951).

See Figure 2.

Tetradactyl morph A

This track morphology is represented by a single track in the Navajo (CU-MWC specimen #184.52), from the Dewey Bridge locality (UCD L-00240). It is preserved as a cast in eolian sandstone (Figure 10). It is unknown whether it is a manus or pes track, or whether the trackmaker was a biped or quadruped. For the purposes of this description it is assumed that this is a right footprint, and that the shortest digit (which has a posterior projection) is digit I. Digit I is directed inwards; digits II-IV are subequal in length and directed slightly outwards. The track is 6.6 cm wide, 5.1 cm long to the “palm”, or base of digits II-IV, and 6.9 cm long to the base of digit I. The total divarication is 59° ; the divarication between both digits I and II, and between digits II and III, is 32° ; digit IV points towards digit III.

This track is superficially similar to several tracks: *Hylopus*, *Batrachichnus* and *Limnopus* from the Carboniferous and Permian, attributed to temnospondyl amphibians (Haubold, 1984); *Gilmoreichnus* and *Ichnoterium* from the Permian, attributed to synapsids (Haubold, 1984); and *Chirotherium* and *Brachychirotherium* from the Triassic, attributed to non-dinosaurian archosaurs (Haubold, 1984). However, there are differences between the Navajo track and these earlier ichnogenera. Without the presence of a trackway it is impossible to determine whether the Navajo track is a manus or pes, and therefore equally impossible to determine a trackmaker. Possible trackmaker candidates include protomammals, non-dinosaurian archosaurs, and dinosaurs (e.g. if this is a manus track).

Brasilichnium

Quadrupedal trackways. Pes subcircular, pentadactyl, although often not all the digits are preserved. Digits represented by claw impressions only. Pes usually less than 5 cm long. Manus rarely preserved, possibly because most of the animal's weight was borne on its hind legs; where seen it is much smaller than the manus, and possibly tridactyl – due to its size, and preservation on dune foresets, morphological detail is difficult to discern. See Leonardi, 1981 and Figure 11.

cf. *Batrachopus*

Small tetradactyl pes and manus. Pes digits increase in size from I to III, digit IV is slightly smaller than digit III. In the Aztec such tracks are approximately 7 cm long (Reynolds, 1989). I consider it unlikely that these examples are distorted *Brasilichnium*, because (1) undistorted *Brasilichnium* are always smaller than cf. *Batrachopus*; (2) cf. *Batrachopus* has clearly defined digits, relatively larger than those of *Brasilichnium*, which are often represented only by claw marks; and (3) cf. *Batrachopus* are clearly tetradactyl; *Brasilichnium* is a pentadactyl track. However tracks referred to as *Batrachopus* from the Navajo (Lockley and Hunt, 1995 and references therein) may very well be distorted *Brasilichnium* (Lockley, personal communication, 1997). See Lull, 1953; Olsen and Padian, 1986; Figure 10.

“Lacertilian”

Supposed lacertilian tracks have been reported from a single site in the Navajo (Sand Wash, UCD L-00287; Lockley and Hunt, 1995). These have not been adequately illustrated or described, and will not be discussed further here. They may simply be distorted *Brasilichnium* tracks, which is an abundant track type from this site (Lockley, personal communication, 1997).

Pteraichnus

Pterosaurian tracks were reported from the same site (and slab) as the “lacertilian” tracks mentioned above. I am unable to evaluate the accuracy of this report, and these tracks will not be described here. See Stokes and Madsen, 1979 for description of the Navajo examples; Lockley et al., 1995 for a review of all known pterosaur tracks; and Lockley and Hunt, 1995 for an illustration of the “pterosaur” track-bearing slab. It is possible that they are distorted *Brasilichnium* tracks (Lockley, personal communication, 1997).

It is clear from the above descriptions and comments that several of these ichnotaxa are extremely rare in the Navajo; they are also lacking in fine morphological detail. The most parsimonious approach, based on the assumption that these tracks are poorly preserved, would be to assign *Anomoepus*, *Trisauropodiscus*, cf. *Sauropus*, cf. *Apatichnus*, and cf. *Wildeichnus* to *Grallator*; and cf. *Batrachopus*, *Pteraichnus* and “lacertilian tracks” to *Brasilichnium*; it is also possible that many of these ichnotaxa should in the future be synonymized. However they have been presented as 10 distinct ichnotaxa because it is easier to lump taxa together once split, than to split up lumped taxa.

Appendix 2 gives a listing of the ichnogenera present at each tracksite. Localities in italics have not had a complete ichnological survey undertaken. The numbers of individuals for each ichnotaxon is given (“I’tax census”), in addition to the total number of individuals who left their tracks at each site (“Total # individuals”).

Possible Trackmakers

Knowledge of ichnological diversity alone is not sufficient when attempting to build a paleoecological picture for a particular environment. It is therefore necessary to attempt to determine what animal made a particular track. Unfortunately, due to the incompleteness of the fossil record it is only possible to make a “best guess” in most cases; and generally only to family level.

Appendix 3 shows that several reptilian and mammalian families are known from the Early Jurassic (Carroll, 1988; Weishampel, 1990). Fish, aquatic reptiles and amphibians have been excluded from this listing because it is assumed here that these water-dependent forms could not survive in the Navajo environment. This listing also shows the diet of these families (C-carnivorous; H-herbivorous; O-omnivorous), whether they were facultative or obligate bipeds or quadrupeds, and the number of functional digits on the pes.

It is also assumed that only those families with North American representatives are possible

Navajo trackmakers. Of these, many are represented in the Glen Canyon Group. The Kayenta Formation contains a sphenodontid lepidosaur, a sphenosuchid crocodylomorph, 2 protosuchid crocodylomorphs, a rhamphorhynchid pterosaur, *Massospondylus* (a plateosaurid prosauropod), 2 ceratosaurian theropods (*Syntarsus* and *Dilophosaurus*), 2 early thyreophorans (*Scutellosaurus* and *Scelidosaurus*), 3 tritylodontid protomammals (*Kayentatherium*, *Dinnebitodon* and *Oligokyphus*) and a true mammal (*Dinnetherium*) (Carpenter and Morales, 1996). Few body fossils are known from the Navajo, but they include *Protosuchus* (a crocodylomorph), *Ammosaurus* (a plateosaurid prosauropod), *Segisaurus* (a ceratosaurian theropod known from a single subadult specimen) and an unnamed tritylodontid protomammal (Jensen and Morales, 1996; Sues et al., 1994).

Ichnotaxon	# functional digits	Biped/ quadruped	Footprint length (cm)	Hip height (cm)	Possible Trackmaker
<i>Grallator</i>	3	Biped	<18	<75	Ceratosaur – small
<i>Anomoepus</i>	3	Biped	<16	<65	Ceratosaur – small
Cf. <i>Sauropus</i>	3	Biped	14	~55	Ceratosaur – small
Cf. <i>Apatichnus</i>	3	Biped	20	80	Ceratosaur – small
Cf. <i>Wildeichnus</i>	3	Biped	<5	<20	Ceratosaur – tiny/juvenile
<i>Trisauropodiscus moabensis</i>	3	Biped	<6	<25	Ceratosaur – tiny/juvenile
<i>Anchisauripus</i>	3	Biped	12-30	50-120	Ceratosaur – medium
<i>Eubrontes</i>	3	Biped	>25	>100	Ceratosaur – large
<i>Dilophosauripus</i>	3	Biped	20-35	80-140	Ceratosaur – large
Tridactyl morph A	3	Biped	20-25	80-100	Ornithischian
<i>Otozoum moodii</i>	4	Bi. or Quad.	30-36	120-140	Thyreophoran
<i>Otozoum minus</i>	4	Biped	~30	~120	Thyreophoran
<i>Navahopus falcipollex</i>	3	Quadruped	13-15	50-60	Prosauropod
Cf. <i>Navahopus</i>	4	Quadruped	20	~80	Prosauropod
Tetradactyl morph A	4	unknown	5	20	Unknown
<i>Brasilichnium</i>	5	4	<7	<30	Protomammal/mammal
<i>Batrachopus</i>	4	4	5	20	?Crocodylomorph/protomammal
“Lacertilian”	5	?Quadruped	<5	<20	Lacertilian
<i>Pteraichnus</i>	4	Quadruped	<6	<25	Pterosaur – rhamphorhynchid

Table 1: Ichnotaxa from the Navajo Sandstone. Number of functional digits = number of digits used during locomotion; Hip height is assumed to be approximately 4 times foot length (after Alexander, 1976).

Table 1 provides a summary of Navajo Sandstone ichnotaxa and their possible trackmakers, which will be discussed below. It is important to note that although body genera are discussed, these are the animals that are closest in age, distribution and size to the actual trackmakers; such generic identifications should be taken as inferences rather than undisputed fact!

Grallator, cf. *Sauropus*, cf. *Apatichnus*, *Anomoepus*, cf. *Wildeichnus*, *Trisauropodiscus*

The presence of claw impressions and the phalangeal formula suggests that these tracks were made by small theropods. The only Early Jurassic theropods are the ceratosaurs; *Segisaurus* may have

grown large enough to make these tracks; *Syntarsus* from the underlying Kayenta Formation is also in the right size range. It is likely that one of these genera, or an as-yet-unknown small ceratosaur, made these grallatorid tracks.

Eubrontes, Dilophosauripus

As with the grallatorid footprints, these tracks were also probably made by theropods. The only large Early Jurassic North American ceratosaur is *Dilophosaurus*, found in the underlying Kayenta Formation.

Anchisauripus

This ichnogenus is intermediate in size between grallatorid and *Eubrontes* tracks, and is very similar to both. It is likely that either a medium-sized ceratosaur, or a subadult large ceratosaur such as *Dilophosaurus*, made these tracks.

Tridactyl morph A

This morphology lacks claw impressions and pads, and has wide divarication, suggesting a non-theropod trackmaker (Lull, 1953). Various ornithischian dinosaurs are tridactyl; basal ornithomorphs, although bipedal, are both too small and not known from North America at this time. Basal thyreophorans such as *Scutellosaurus* and *Scelidosaurus* were facultative bipeds but functionally tetradactyl. It appears either that the ornithischian trackmaker for this track type is unknown from the body fossil record at the present time, or that Lull's distinction between theropod and ornithischian trackmakers is not valid and that these tracks were actually made by theropods (ceratosaurs).

Otozoum

Otozoum has a pedal phalangeal formula of 2-2-3-4. The manus is rarely preserved, but when present it is tetradactyl. Different workers have attributed these tracks to a variety of trackmakers. Skeletal reconstructions (not illustrated here) and comparison with known foot skeletons are essential when attempting to determine the affinity of these tracks.

Lull (1953) attributed *Otozoum* to prosauropods. They have functionally tridactyl pedes, and a phalangeal formula of 1-2-3-4-0. Digit I of the functionally-tridactyl prosauropod manus is directed in towards the midline of the animal, approximately perpendicular to the remaining digits.

Illustrations of modern crocodilian tracks (Padian and Olsen, 1984) resemble *Otozoum moodii* fairly closely. Whilst the crocodylomorph pes is functionally tetradactyl, the number of phalanges on digit IV is less than that of *Otozoum* trackmaker.

Gierlinski (1995) suggested that *Otozoum* tracks were made by thyreophorans such as *Scelidosaurus*. This genus has a pedal phalangeal formula of 2-3-4-5-0, with robust digits; the animal is up to 4 m long. Both *Scelidosaurus* and *Scutellosaurus* have been found in the Kayenta Formation.

Skeletal reconstructions undertaken by the present author suggest that the “best-fit feet” for the *Otozoum* tracks are thyreophoran.

Navahopus, cf. *Navahopus*

For the reasons discussed above for *Otozoum* tracks, *Navahopus falcipollex* is attributed to a prosauropod trackmaker, in keeping with Baird’s (1980) original assessment. The pes and manus of *Ammosaurus*, a plateosaurid from the Navajo (Galton, 1976), are of about the correct size to have made these tracks. The tracks described by Faul and Roberts (1951) (cf. *Navahopus*) are here attributed to a plateosaur.

Tetradactyl morph A

Because this morphology is known only from a single track, it is virtually impossible to assign a trackmaker. Possible candidates include protomammals, non-dinosaurian archosaurs, and dinosaurs (e.g. if this is a manus track).

Brasilichnium

The plantigrade nature of these tracks, taken together with their small size and the number of digits on the manus and pes, suggest that these tracks could be attributable to cynodonts (protomammals) or true mammals (e.g. Haubold, 1984; Leonardi, 1981). Of the cynodont families known from North America, the trithelodonts are too small to have made these tracks. Tritylodonts are known from the Navajo and Kayenta, and morganucodonts are found in the Kayenta. The Navajo tritylodont specimens are approximately the size expected of the *Brasilichnium* trackmakers.

These tracks occur only on dune foresets, and are often indistinctly preserved, suggesting they are often undertracks. Manus tracks are rare in this ichnogenus, and when present they are much smaller than the pes. This suggests that most of the trackmaker’s weight was borne by the hind legs, hence leaving only light manus impressions which would not be transmitted to underlying layers of the substrate.

Batrachopus

This track was probably made by a crocodylomorph (Olsen and Padian, 1986). *Protosuchus* is of approximately the correct size to have made these tracks.

“Lacertilian”

These tracks are similar to modern lizard tracks, and Mesozoic examples attributed to lizards. The original reports (e.g. Albers, 1975) and subsequent mention (e.g. Lockley and Hunt, 1995) of these tracks assumed a lacertilian trackmaker. It is important to note that these tracks are poorly preserved on dune foresets, and may be distorted *Brasilichnium* tracks.

Pteraichnus

The original report of these tracks (Stokes and Madsen, 1979) referred them to a pterosaurian trackmaker. Unfortunately they are so poorly preserved that ichnotaxonomic designation is difficult – they could be distorted *Brasilichnium*, *Batrachopus* or “lacertilian” tracks (e.g. Lockley and Hunt, 1995). If they are not distorted but simply lacking in preservation of fine detail, it is possible that they are crocodylomorph tracks, for example *Protosuchus* tracks (Padian and Olsen, 1984).

Discussion

The data can either be considered as presented in the figures and appendices – with many different ichnotaxa; or more parsimoniously assuming that some of these ichnotaxa are either synonyms (and hence invalid) or poorly-preserved examples of more common Navajo ichnites. For the purposes of this discussion, the “more parsimonious” approach assumes that *Anomoepus* + *Wildeichnus* + indeterminate small theropod tracks = *Grallator* and *Pteraichnus* + *Batrachopus* + lacertilian tracks = *Brasilichnium*.

The patterns of ichnological and faunal diversity for the dune (Figures 12, 13) and interdune (Figures 14, 15) environments, and the subenvironments within the interdune environments (Figures 16-19), consistently reflect the diversity patterns of individual sites (Appendices 2, 5).

Figure 20 illustrates the distribution of tracksites among the different sedimentary facies of the Navajo. It clearly shows that the majority of tracks occur in the interdune environments, especially playas. This is partly an artifact of field methodology: horizontally-bedded playa sequences typically cap outcrops, making them extremely easy to spot; and almost every playa sequence contains track-bearing surfaces, even if the tracks are not well-preserved. In contrast, although the dune facies is the predominant Navajo facies both volumetrically and areally, foreset slopes are relatively rarer and often are devoid of vertebrate tracks (although invertebrate traces may be present).

When the total census for the Navajo is subdivided into the different facies, it is apparent that by far the majority of animals left their tracks in the interdune environments, mostly in the playa deposits (Figure 21). Whilst this can be accounted for in part by the larger number of playa tracksites compared with other facies, it is also likely that these areas were isolated watering holes essential for the maintenance of life in the desert, and hence visited by large numbers of animals (compared with random dune slopes!).

The dune foresets appear to have a higher ichnological diversity than the interdune deposits (Figure 22). However this may be an artifact of the relatively poor preservation typical of tracks on dune slopes, resulting in incorrect identification of tracks. The more parsimonious interpretation is that the ichnodiversity is greater in the interdunes (6 ichnotaxa) than the dunes (3 ichnotaxa). When the ichnotaxa are translated into trackmakers (to family level; Figure 23) the dune foreset facies again apparently have a more diverse fauna represented; but the more parsimonious approach again results in a higher diversity in the interdunes (5 taxa) than in the dunes (3 taxa).

Figures 12, 14, 16 and 17 summarize the data provided in Appendices 2 and 4. Figures 16 and 17 show the ichnological diversity for the 2 subenvironments of the interdunes; whilst the truncated surfaces (Figure 16) have a much lower diversity than the horizontally-bedded sequences (Figure 17), the general pattern is similar; thus the total diversity for the interdunes (Figure 16) resembles that of the separate components. (This is even clearer when taking the more parsimonious ichnodiversity.) This is also the case for the trackmaker diversity (Figures 13, 15, 18-19).

Figure 12 shows census data for the ichnotaxa on the dune foresets. All the ichnotaxa in this facies are small (less than 15 cm long). It is immediately apparent that *Brasilichnium* is the most common ichnotaxon in this facies, followed by *Grallator*. Other ichnotaxa are rare but contribute to the high diversity of this facies (12 ichnotaxa). However if the more parsimonious approach is taken then only 4 ichnotaxa are represented in this facies – and 2 of these are represented by only 3 individuals. This conclusion is in far better agreement with published preliminary reports (e.g. Rainforth and Lockley, 1996a).

Figure 14 shows the ichnotaxa found in the interdunal facies. Almost half the tracks are *Grallator*; grallatorids (in the parsimonious sense) account for 65%. Less than 10% of the tracks are not tridactyl. The ichnological diversity of the truncation surfaces is illustrated in Figure 16. More than 75% of the tracks are *Grallator*; except for a single *Eubrontes* track, the remainder are *Otozoum*. Figure 17 illustrates the diversity of tracks in the horizontally-bedded interdunes. 75% of the tracks are *Grallator*, *Eubrontes* and *Anomoepus*, in roughly equal proportions (55% of the total are grallatorids). The remainder are *Otozoum* and other tridactyl ichnogenera.

Figures 13, 15, 18 and 19 illustrate the data provided in Appendices 4 and 5. The diversity of

trackmakers in the dune facies is shown in Figure 13. Protomammals/mammals are the most common trackmakers, with small ceratosaurs the other important component of the fauna. Other trackmakers are rare but contribute to the apparent faunal diversity indicated by the large variety of tracks in this facies. Only small animals are represented.

The apparent diversity of the interdune facies is much less than that of the dune facies, and much less than suggested by the number of ichnotaxa (Figure 15). This is because several of the ichnotaxa can be attributed to a single type of trackmaker (e.g. small ceratosaurs). Over 85% of the tracks were made by ceratosaurs. However with the more parsimonious approach, the diversity is actually greater than that of the dune facies.

On truncation surfaces, small ceratosaurs are the dominant element of the fauna (approximately 75%); thyreophorans comprise the bulk of the remainder (Figure 18). In the horizontally-bedded interdunes ceratosaurs comprise the bulk of the fauna (89%), of which over half are small forms. The rest of the fauna is thyreophoran and ornithischian (Figure 19).

The most striking pattern in the data is the correlation of ichnological assemblages with sedimentary facies – the ichnofacies concept (Lockley et al., 1994). It is immediately apparent that assemblages of small tracks, dominated by *Brasilichnium*, occur on the dune foresets (Lockley et al. 1994). Track assemblages on truncated surfaces consist of grallatorids and *Otozoum*, the former being the dominant track type. In the horizontally-bedded interdunes grallatorids comprise approximately 70% of the fauna, with the remainder being large *Eubrontes* tracks (20%) and *Otozoum* (10%). Whilst these patterns could reflect behavior (e.g. substrate preference) of the different trackmakers, it is more likely that these patterns are controlled by the preservational aspects of the substrate. For example, only small tracks are observed on dune foresets, usually trending up-slope. It has been observed during experiments on modern animals (McKee, 1947) that animals typically destroy their own tracks when moving down-slope; and very large animals cause slumping of sediment around their tracks (Figure 5). The result is that only the smallest, up-slope-trending tracks are usually preserved.

The horizontally-bedded interdune deposits contain tracks spanning almost the entire size range of Navajo tracks, with the exception of the smallest tracks such as *Brasilichnium*. Many of the limestone deposits contain algal structures; it is possible that these oasis deposits had an algal crust which the smallest animals could not break through, hence not making tracks in the underlying sediment.

Another aspect to consider is the diet of the trackmakers (Appendix 3). Of the Early Jurassic terrestrial vertebrates, ceratosaurs, crocodylomorphs, lepidosaurs, trithelodontid synapsids, and morganucodontid mammals are all carnivorous; prosauropods, sauropods, ornithischians and tritylodontid synapsids are herbivores. The base of the Navajo food chain was probably the algae in

the carbonate playa systems, and the flora represented by wood (Stokes, 1991; personal observation) and rhizoliths (Loope, 1988; personal observation). Invertebrate trace fossils suggest that insects and other invertebrates were probably fairly common, and diverse (Rainforth and Lockley, 1996a), and probably would have sustained insectivorous vertebrates. Carnivorous vertebrates no doubt fed on herbivorous, insectivorous and carnivorous vertebrates.

It is unknown whether *Brasilichnium* was made by a primitive mammal or a cynodont; the presence of tritylodonts in the Navajo and Kayenta suggest that such herbivores probably made these tracks. Tridactyl morph A may represent either a herbivorous ornithischian or a carnivorous ceratosaur.

Table 2 shows the percentage of herbivorous trackmakers present. Clearly the track evidence suggests that the Navajo ecosystem was dominated by carnivores – unusual when compared with modern ecosystems. Assuming correct identification of trackmakers (although Table 2 allows for uncertainty in the case of several ichnotaxa), this could be either (1) a real paleoecological signal, or (2) an artifact of taphonomy and preservation.

The first case assumes that the track record is an accurate representation and sample of the vertebrate ecology of the Navajo – implying that carnivores were indeed the dominant faunal element. The second situation is a little more complex. It has already been noted that very small trackmakers can only leave tracks on the dune foresets – and these trackmakers are generally herbivores. The scarcity of herbivore tracks in the interdune environments may therefore be due to the inability of small herbivores to create impressions in such environments. However even the larger herbivore tracks are rare in the interdunes. It is possible that herbivores and carnivores frequented these oases at different times of the day, and that substrate conditions varied during the daily cycle; if herbivores visited such areas when the substrate was drying out they would be unlikely to leave any tracks (see Cohen et al., 1991 for studies of the tracks of modern animals around lake environments). Another factor to consider is the areal extent of dunes vs. interdunes, and the present-day landscape. Whilst the interdunes make up only a small proportion of the Navajo Sandstone, dune foreset surfaces are relatively rare – track-bearing surfaces can be difficult to find (personal observation). It is therefore possible that small herbivore tracks are far more common than suggested by the known sample – such tracksites have simply not been discovered.

Herbivorous trackmakers	Dunes	Interdunes	Total
(cf.) <i>Navahopus</i> , <i>Otozoum</i> , <i>Brasilichnium</i> , tridactyl morph A	63%	13%	20%
(cf.) <i>Navahopus</i> , <i>Otozoum</i> , <i>Brasilichnium</i> ,	63%	10%	17%
(cf.) <i>Navahopus</i> , <i>Otozoum</i> , tridactyl morph A	2%	13%	11%

Table 2: Percentage of herbivorous trackmakers in dune and interdune facies, and for the Navajo Sandstone considered as a whole.

Conclusions

The Navajo environment has been shown to have a far more diverse vertebrate fauna than previously thought (Jensen and Morales, 1996; Sues et al., 1994). At least 550 individuals left their tracks – a much larger number than indicated by the body fossil record (less than a dozen skeletons). Whilst only four taxa are known from skeletal remains, conservatively the track data suggests the presence of up to 7 osteological families represented by at least 8 ichnotaxa, of which 4 (grallatorids, *Eubrontes* etc., *Brasilichnium* and *Otozoum*) are very common (comprising over 92% of the total). It is possible that up to 18 ichnotaxa are present in the Navajo – inferring the presence of 9 families! However many of these additional ichnotaxa are very rare, poorly preserved, and have not been studied by the present author; therefore these are considered of minor importance at present.

Most of the skeletal taxa known from the Navajo are probably represented by tracks (*Ammosaurus* by *Navahopus*; *Segisaurus* by grallatorid tracks; and tritylodonts by *Brasilichnium*); crocodylomorph (*Protosuchus*) tracks may or may not be present (e.g. cf. *Batrachopus*). However some of the ichnotaxa are not represented by body fossils in the formation – thyreophorans such as *Scelidosaurus* (*Otozoum*), medium and large-sized ceratosaurs (*Anchisauripus*, *Eubrontes*, *Dilophosauripus*), and possibly tridactyl basal ornithischians (tridactyl morph A).

There are distinctive assemblages of tracks associated with different sedimentary environments within the Navajo – the so-called *Brasilichnium* ichnofacies (Lockley et al., 1994) on the dune foresets, a grallatorid-dominated assemblage in horizontally-bedded interdunes, and a *Grallator-Otozoum* assemblage on truncated surfaces. These assemblages can also be defined by track size - very small tracks on dune surfaces, and larger tracks in interdune environments – and hence are probably controlled by the mechanics of foot emplacement and sedimentary aspects of the substrate (McKee, 1947).

The track evidence suggests that the Navajo was dominated by carnivores. However this may be an artifact of sampling bias (track-bearing foresets being much harder to find than interdune deposits, almost all of which contain tracks), rather than a trend of paleoecological significance.

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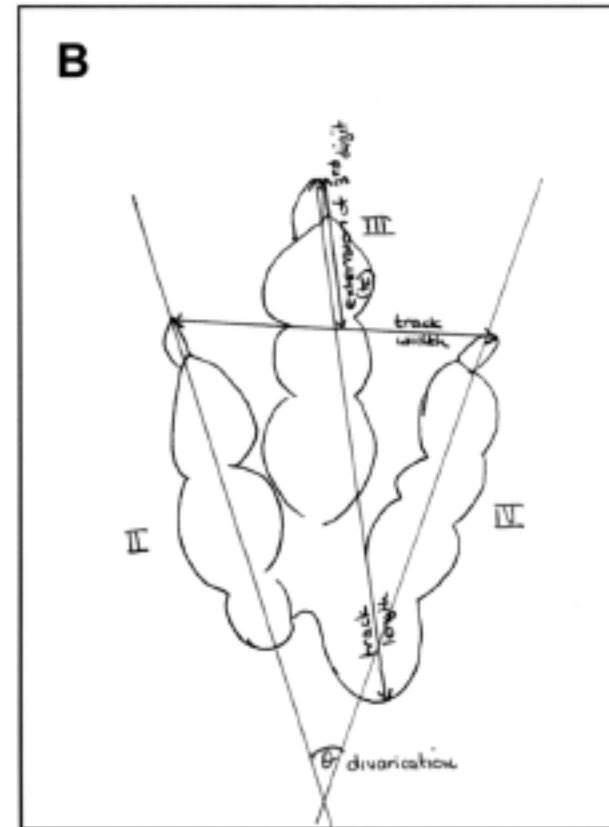
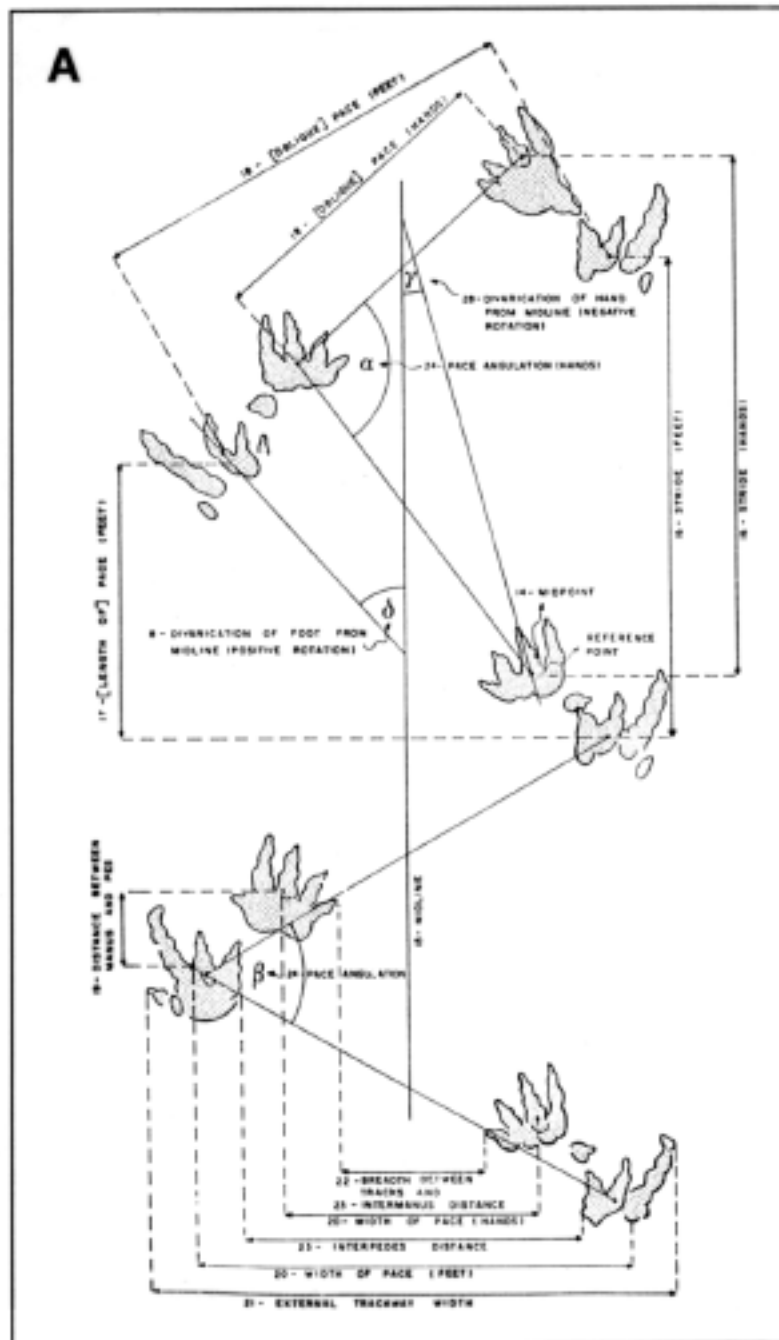


Figure 1. A: Trackway measurements
(from Leonardi (ed.), 1987).
B: Track measurements.

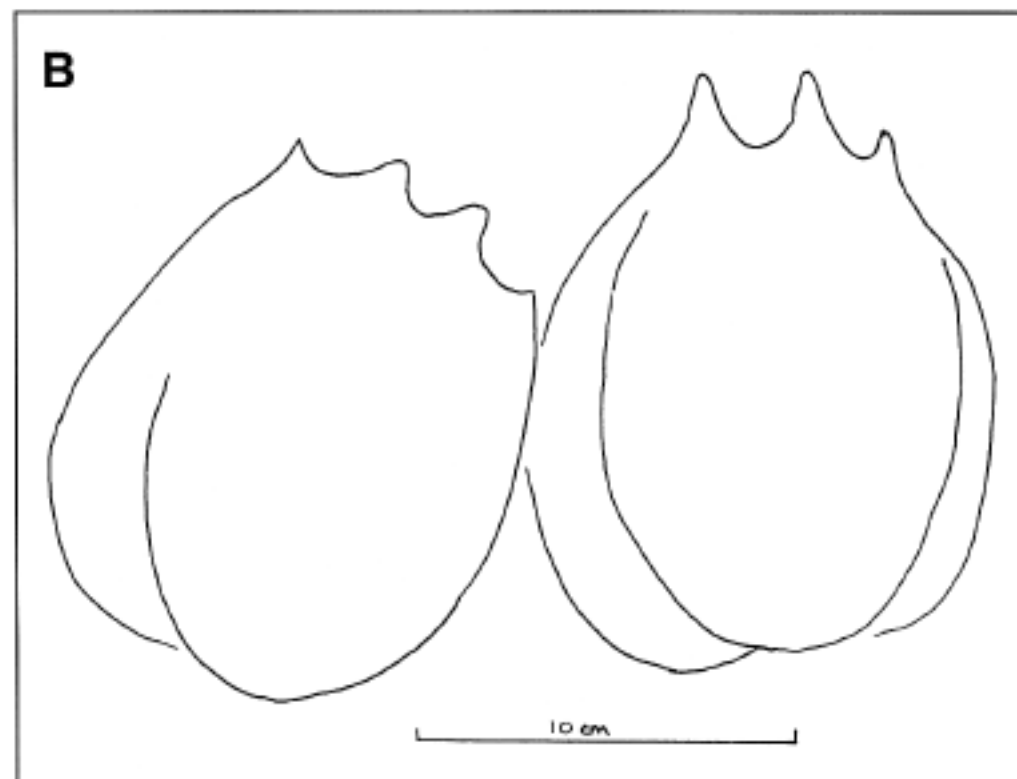
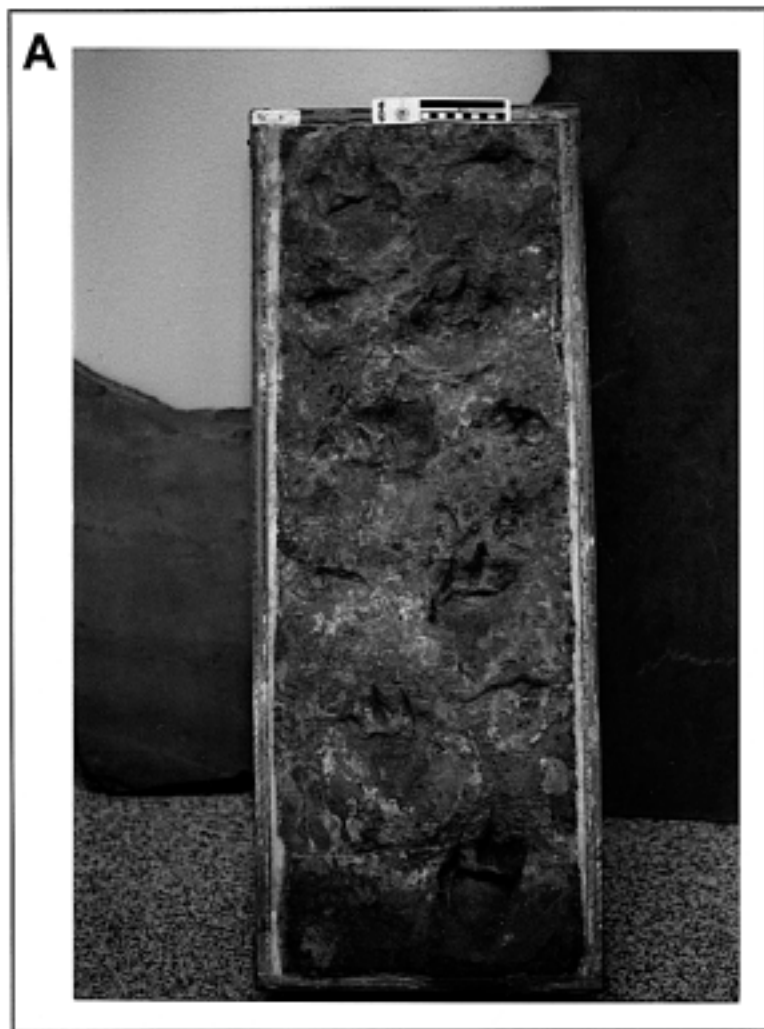


Figure 2. A: *Navahopus falcipollex* type specimen, Coppermine locality; Museum of Northern Arizona.
B: *Tetrasauropus unguiferus*, Flag Creek, Colorado (after Faul and Roberts, 1951).

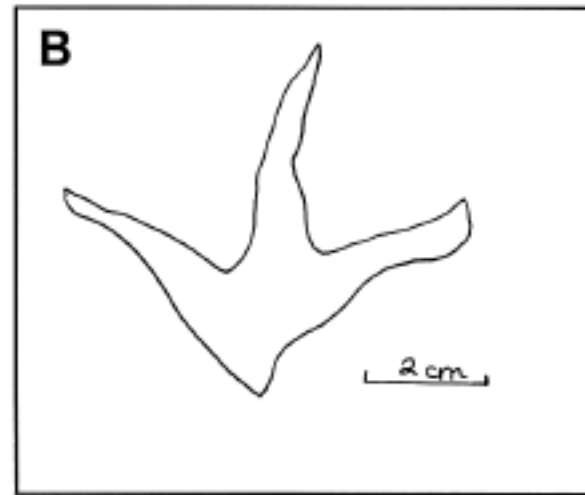
A**B**

Figure 3. A: *Wildeichnus*. Coppermine Well South, level 2. (Photo courtesy of Martin Lockley.)
B: *Trisauropodiscus moabensis*, type specimen. (After Lockley and Hunt, 1995.)

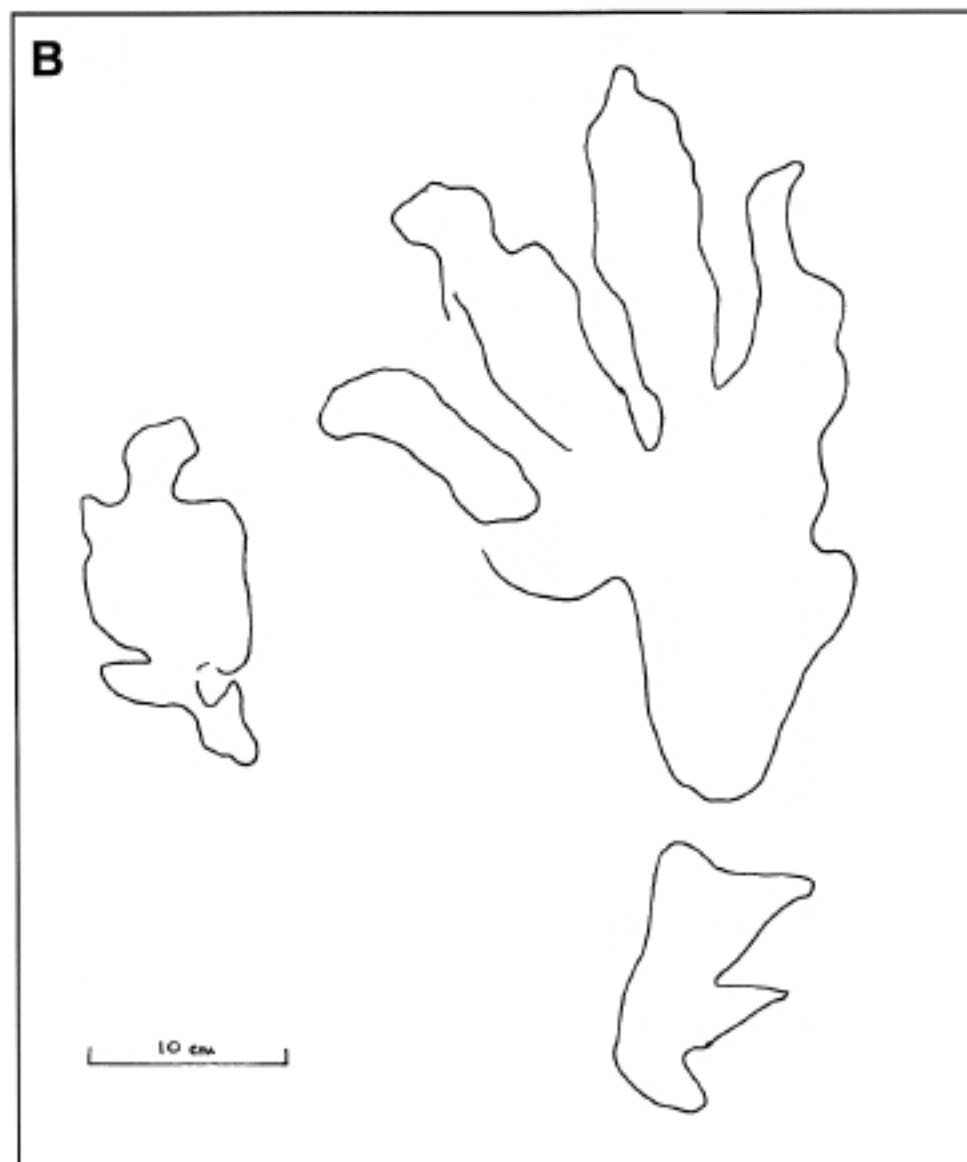


Figure 4. A: *Otozoum minus*, Moab North locality.
 B: *Otozoum moodii*, Kane Springs Canyon Road North locality.

5



6A



6B



Figure 5. Human tracks parallel to dune crest. Great Sand Dunes National Monument, Colorado.

Figure 6. A: *Anomoepus* track. North Wash 2 locality.
B: *Grallator* track. North Wash 1 locality.

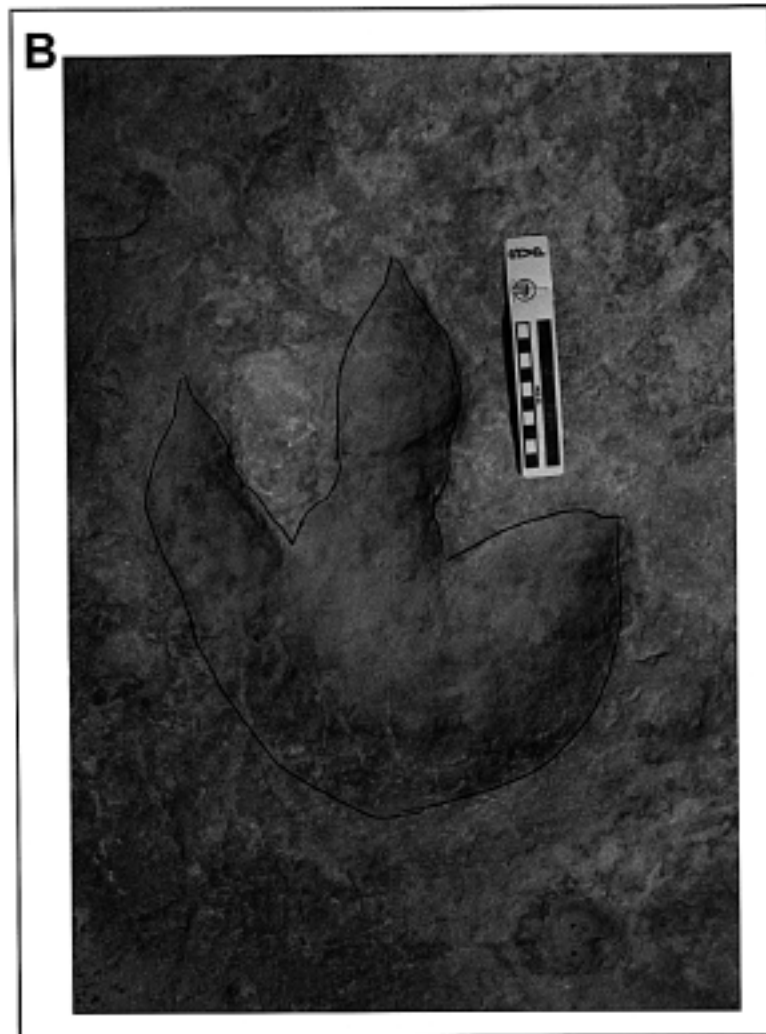


Figure 7. A: *Eubrontes* track. Hidden Valley A locality.
 B: *Dilophosauripus* track. Buckhorn Wash locality.



Figure 8. A: *Apatichnus* track. Negro Bill Canyon - MGL locality.
 B: *Sauropus* track. Redfleet Reservoir locality.

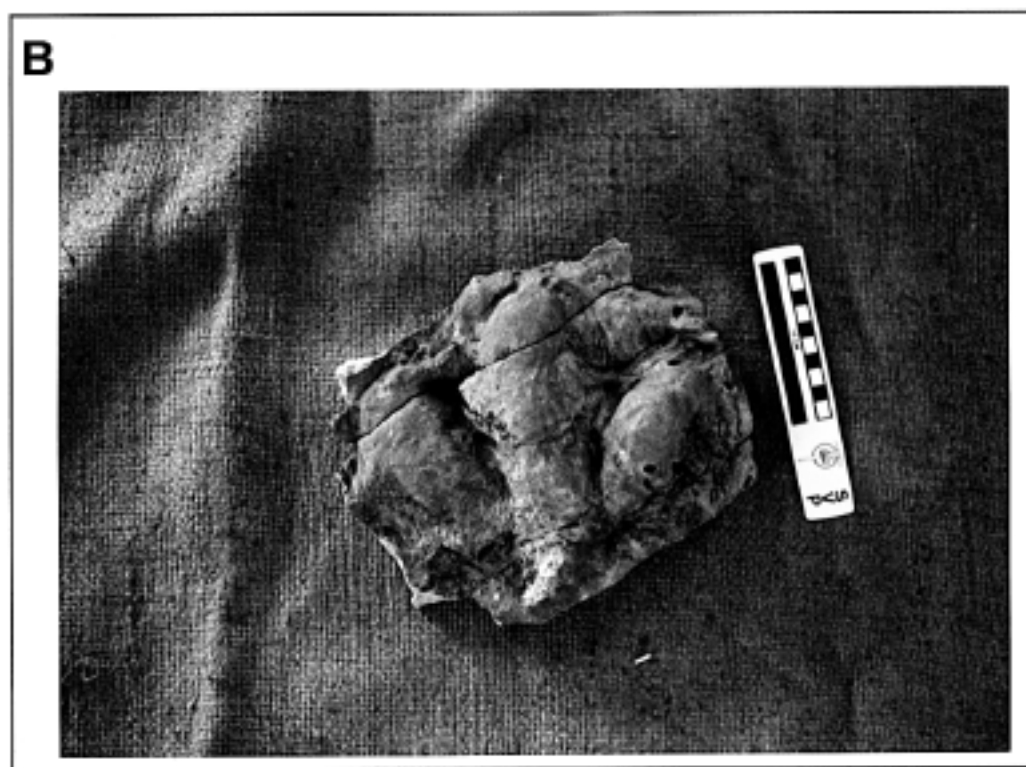
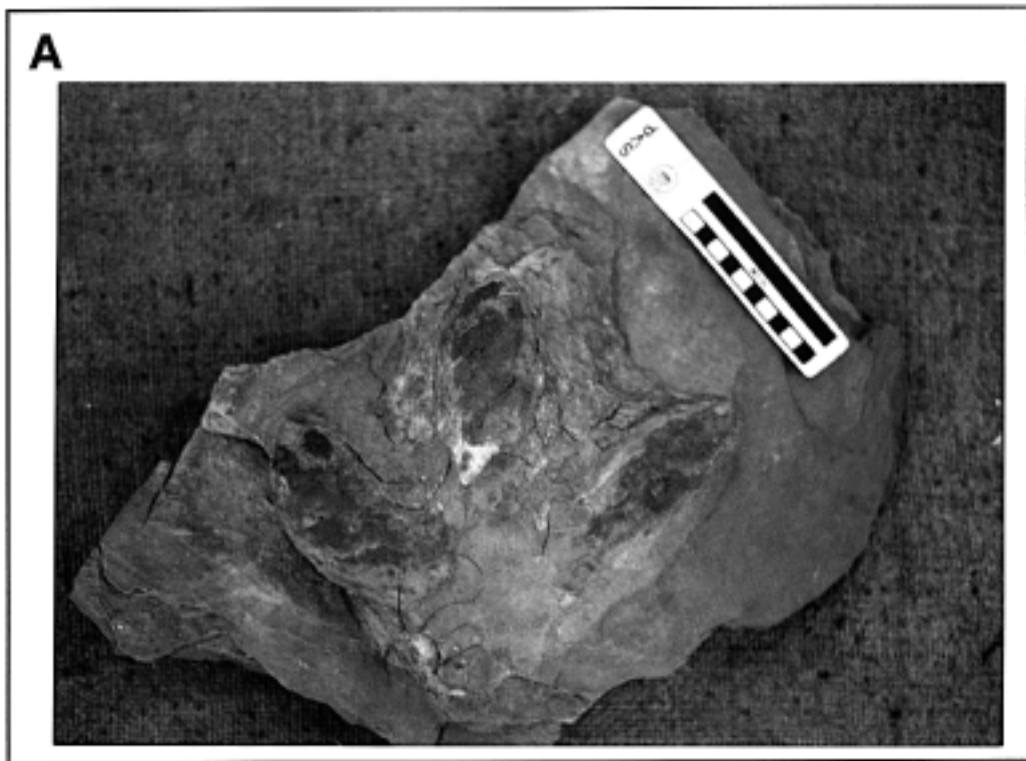


Figure 9. A: Tridactyl morph A. North Wash 2 locality.
B: Tridactyl morph A. Cedar Canyon locality.

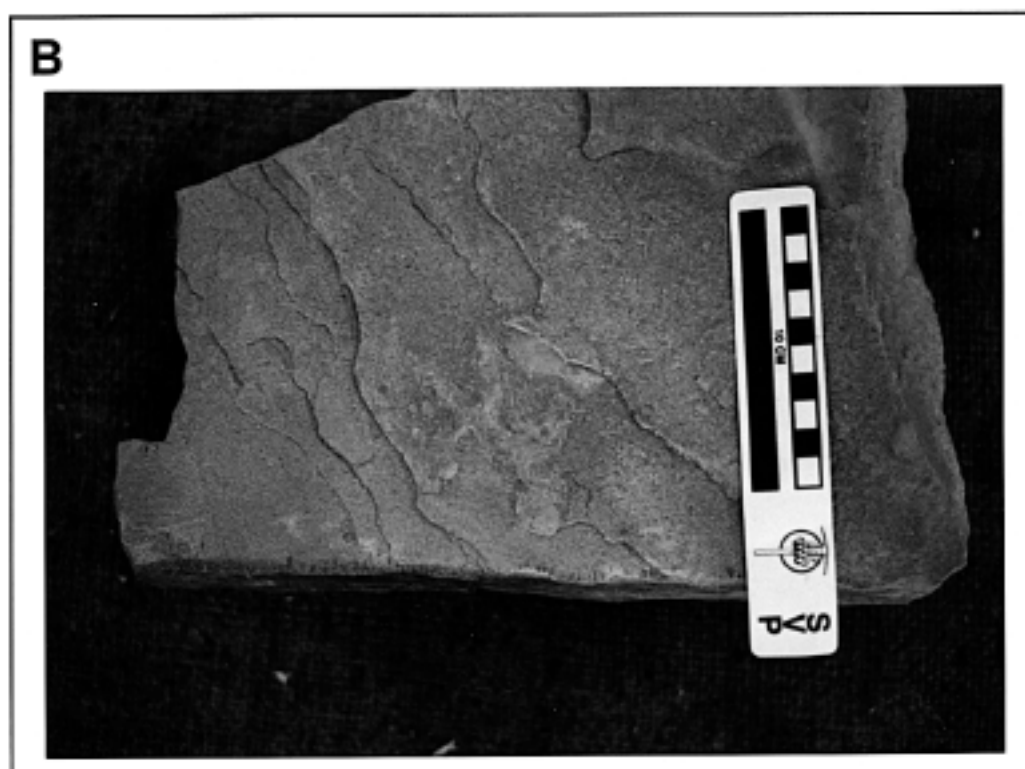
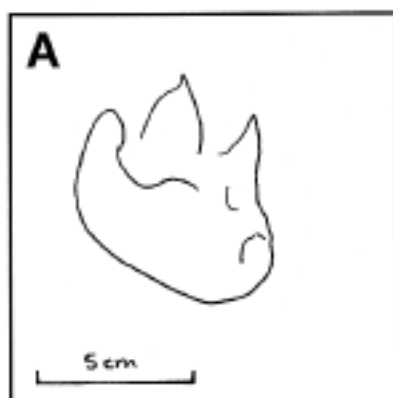


Figure 10. A: *Batrachopus* track. Sand Wash locality.
 B: Tetradactyl morph A. Dewey Bridge locality.

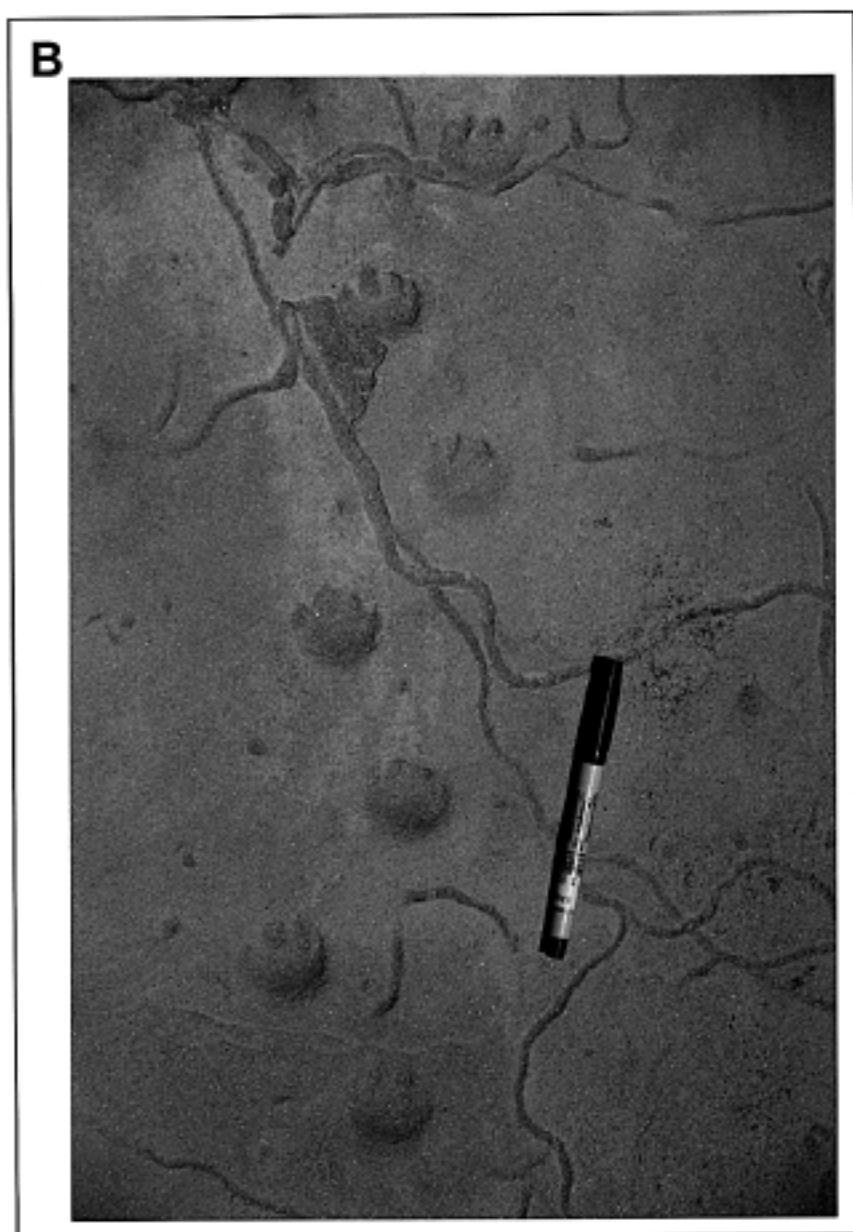
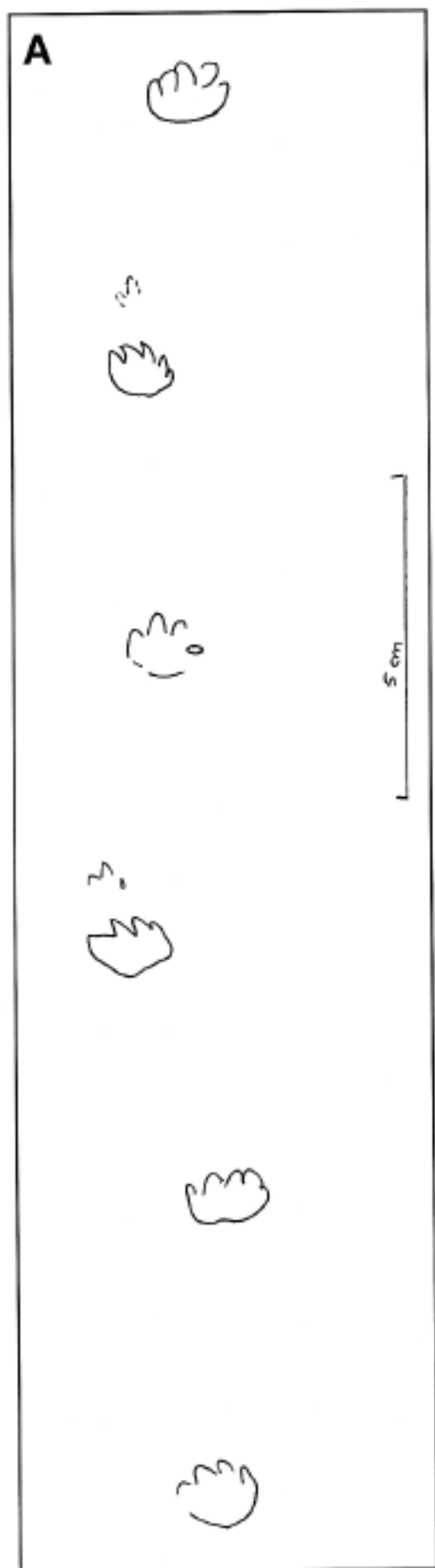


Figure 11. A: *Brasilichnium* trackway; tridactyl manus present. Dewey Bridge locality.
 B: *Brasilichnium* trackway and crane-fly traces. Coppermine Well South level 2.

Fig. 12. Ichnotaxa in Dune Foreset Facies

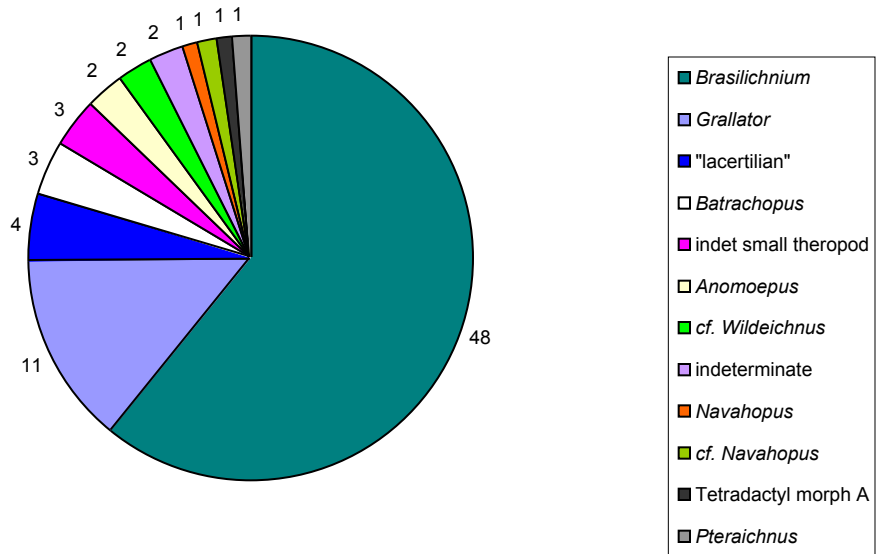


Fig. 13. Body Taxa Represented by Tracks - Dune Facies

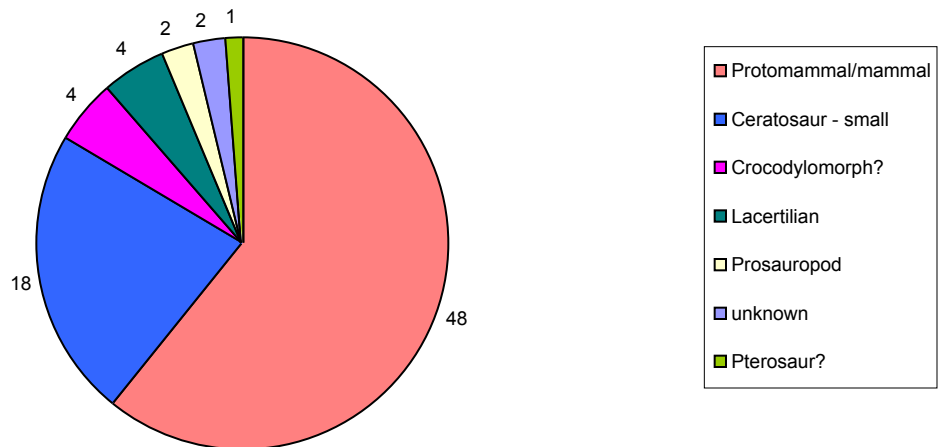


Fig. 14. Ichnotaxa in Interdunal Facies

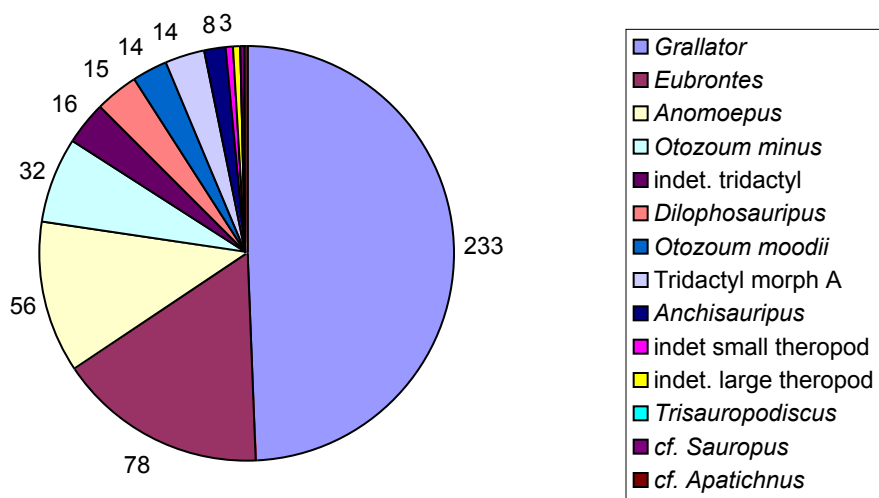


Fig. 15. Body Taxa Represented by Tracks - Interdune Facies

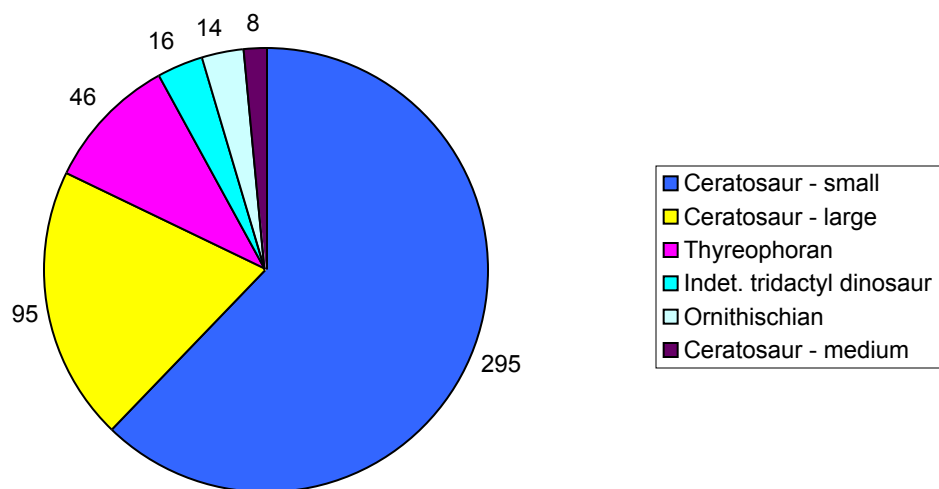


Fig. 16. Ichnotaxa on Bevelled Surfaces

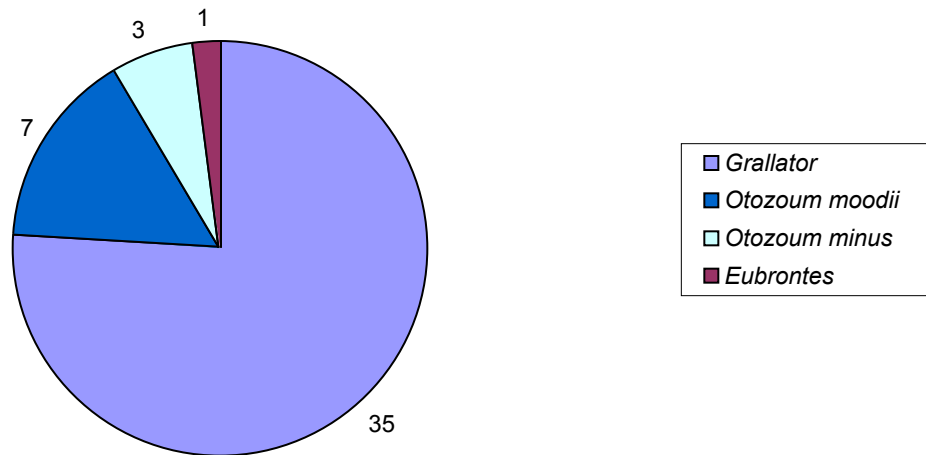


Fig. 17. Ichnotaxa in Horizontally-Bedded Interdunes

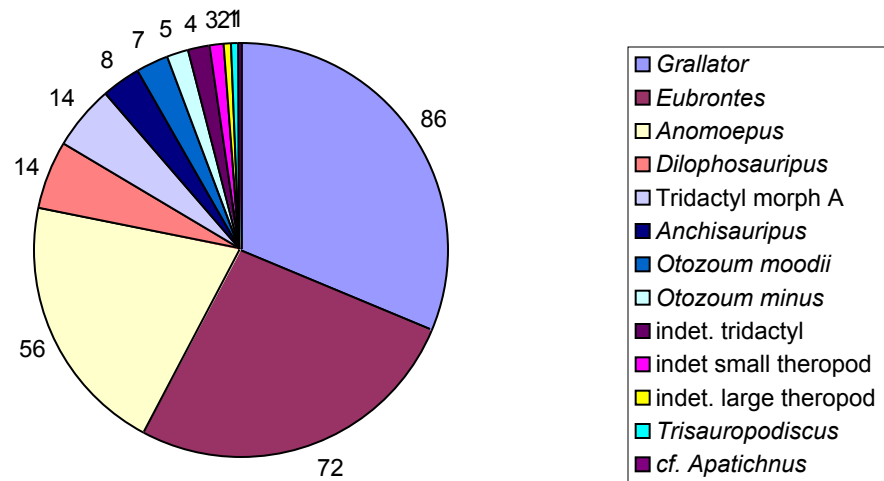


Fig. 18. Body Taxa Represented by Tracks - Bevelled Surfaces

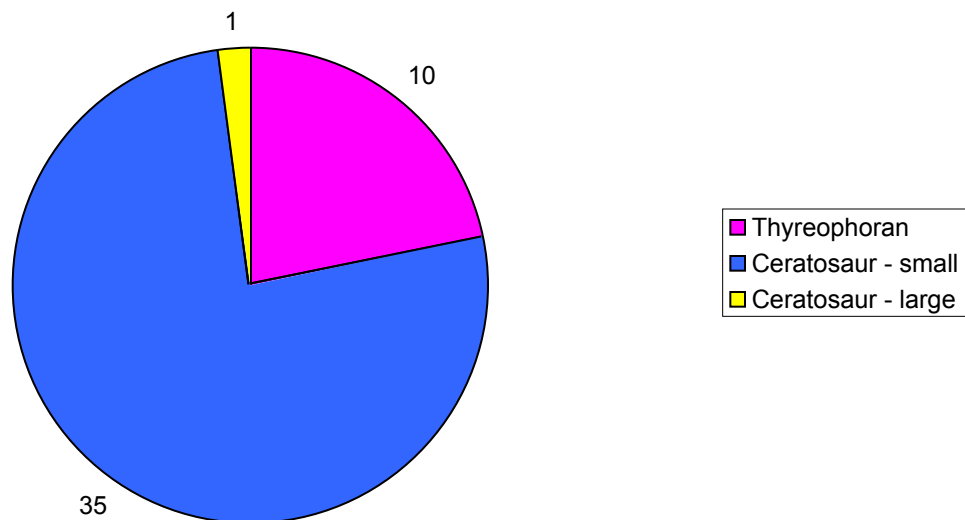
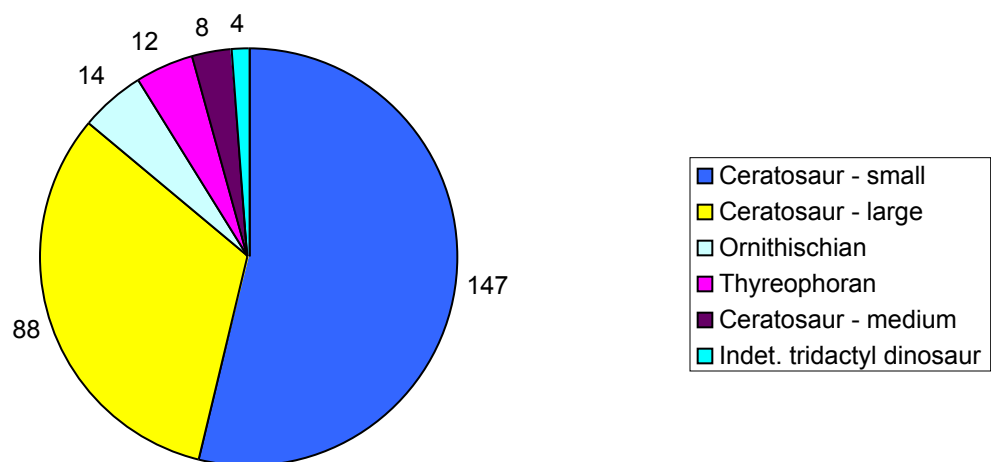
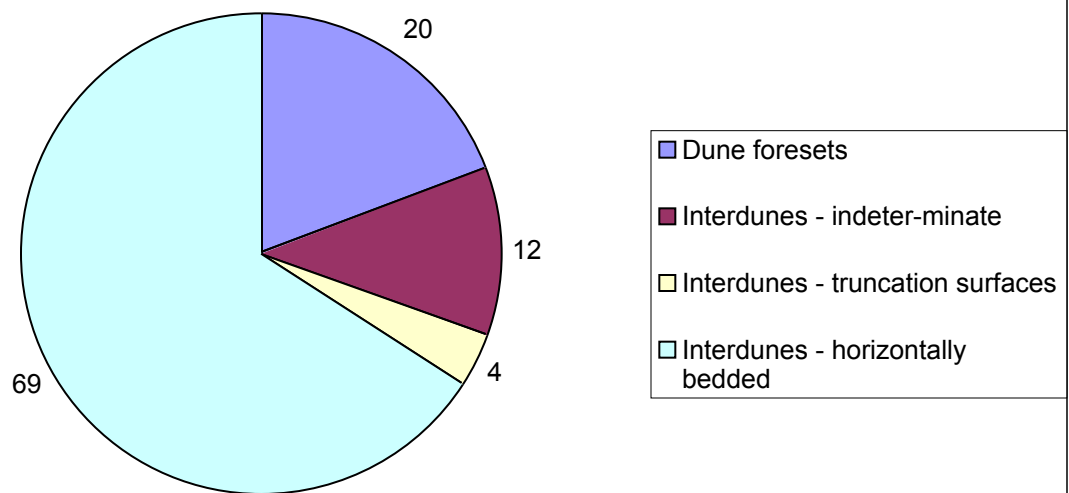


Fig. 19. Body Taxa Represented by Tracks - Horizontally-Bedded Interdune Facies



**Fig. 20. Distribution of Tracksites
by Sedimentary Facies**



**Fig. 21. Proportion of Individuals
in each Facies**

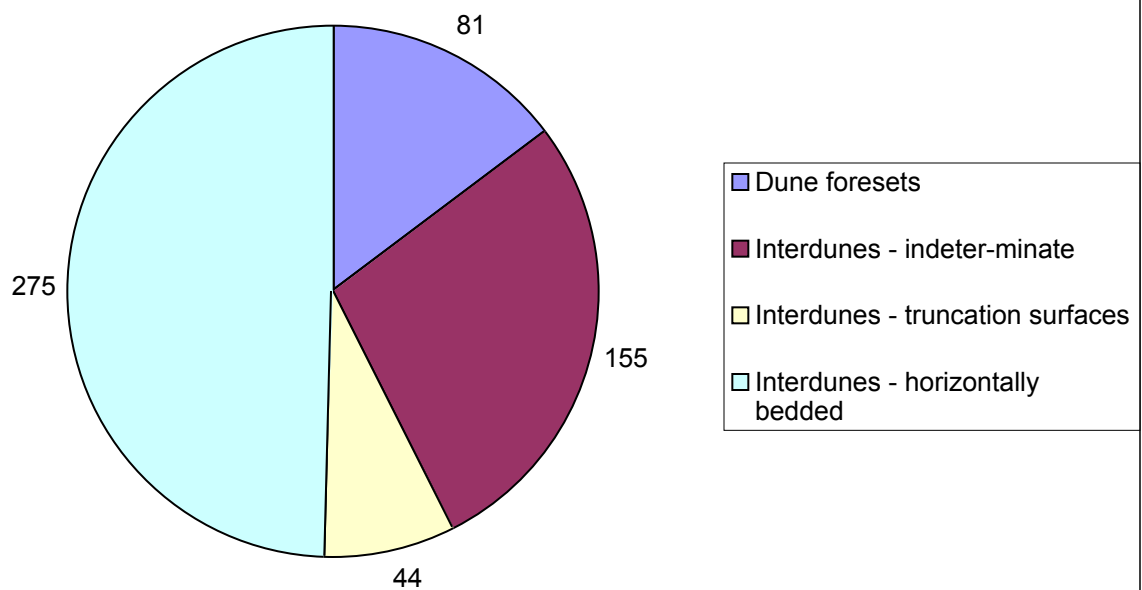


Fig. 22. Distribution of Ichnotaxa in each Facies

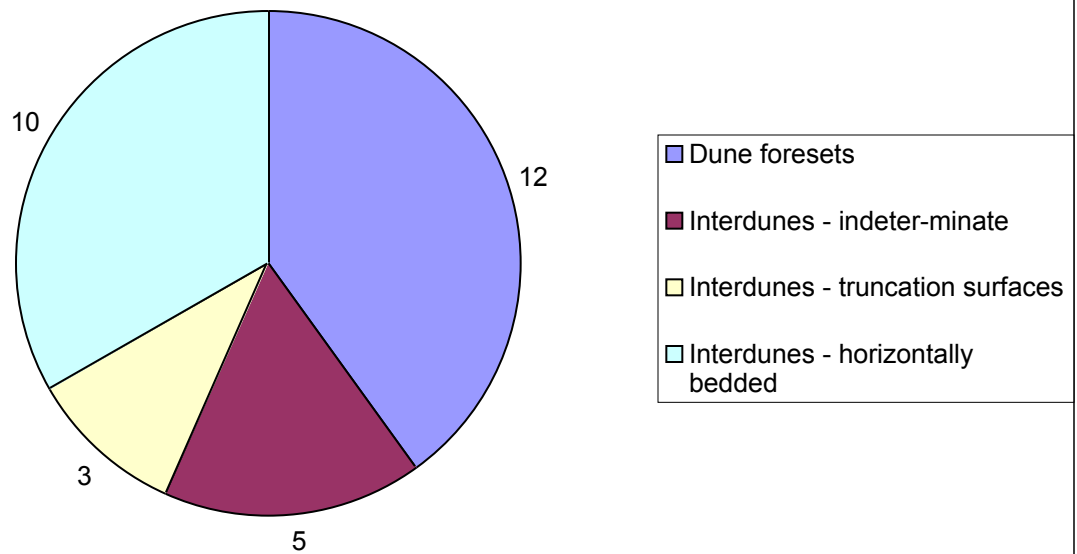
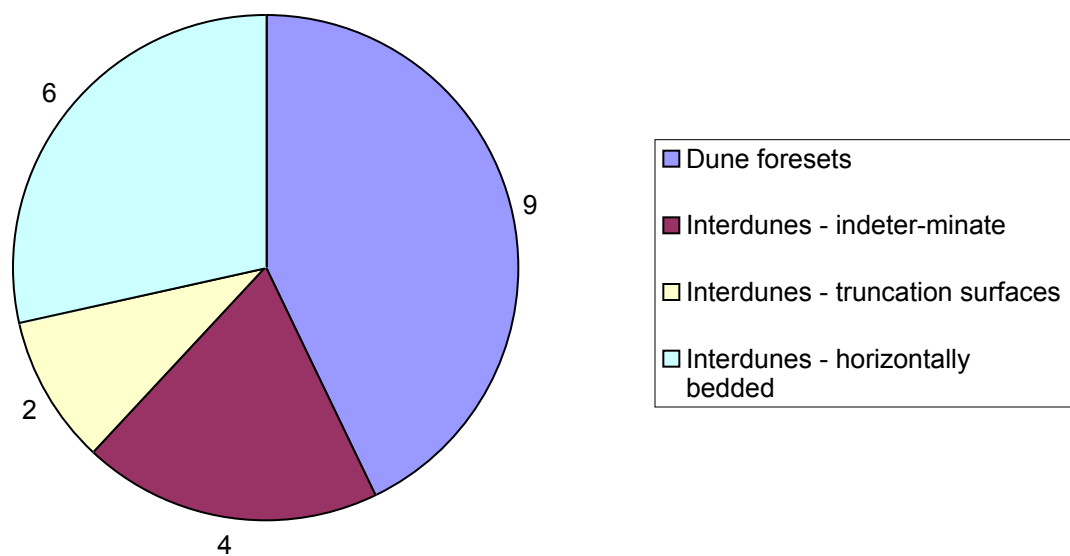


Fig. 23. Distribution of Trackmakers by Facies



UCD LOC #	LOCALITY	LITHOLOGY	DEPOSITIONAL ENVT.	SUPPLEMENTAL INFORMATION
L-00220	Annie's Canyon	IB limestone/sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00221	Boundary Butte Well	Sandstone	Interdune/truncation surface	
L-00222	Buckhorn Wash	Sandstone	Interdune deposits/playas	Stokes, 1978
L-00223	Cedar Canyon	Calcareous sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00224	Choal Canyon	unknown	unknown	Jones, 1991
L-00225	Cleopatra's Chair	unknown	unknown	Gilland, 1979
L-00226	Comb Ridge	Limestone, sandstone	Interdune deposits/playas	
L-00227	Copper Globe Road	Sandstone	Interdune deposits/playas	
L-00228	Coppermine	Sandstone	Dune foresets	Baird, 1980
L-00229	Coppermine North	Sandstone	Interdune/truncation surface	
L-00230	Coppermine Well South - 1	Sandstone	Dune foresets	
L-00231	Coppermine Well South - 2	Sandstone	Dune foresets	Rainforth and Lockley, 1996b
L-00232	Coppermine Well South - 3	Sandstone	Dune foresets	
L-00233	Coppermine Well South - 4	Sandstone	Truncation surface	
L-00234	Coppermine Well South - 5	Sandstone	Dune foresets	
L-00236	Dennehotso	Limestone	Interdune deposits/playas	
L-00237	Dennehotso - mm 423 (Cooley)	Limestone	Interdune deposits/playas	Cooley, pers. comm. 1995; Blakey, pers. comm. 1996
L-00238	Devil's Canyon (Stokes 7)	unknown	unknown	Stokes, 1978; Sanderson, 1974
L-00240	Dewey Bridge (Stokes 9)	Sandstone	Dune foresets	Stokes, 1978; Lockley and Hunt, 1995.
L-00239	Dewey Bridge North	Sandstone	Dune foresets	
L-00241	Dirty Devil River	Sandstone	Interdune deposits/playas	Gilland, 1979
L-00305	DNM - UCD 92-17.1a	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00305	DNM - UCD 92-17.1b	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00305	DNM - UCD 92-17.1c	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00306	DNM - UCD 92-17.2a	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00306	DNM - UCD 92-17.2b	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00306	DNM - UCD 92-17.2c	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00304	DNM - UCD 92-17.2d	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00307	DNM - UCD 92-17.3a	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00307	DNM - UCD 92-17.3b	Sandstone	Interdune/truncation surface	Lockley et al. 1992a,b
L-00242	Driftwood Canyon	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00243	Dungeon Canyon	Sandstone/limestone	Interdune deposits/playas	
L-00244	Escalante River Valley (Stokes 11)	Sandstone	Dune foresets	Stokes, 1978
L-00314	Flag Creek (Stokes 5)	Sandstone	Dune foresets	Faul and Roberts, 1951; Stokes, 1978; Baird, 1980
L-00246	Glen Canyon Dam	unknown	Interdune deposits/playas	Stokes, 1978; Lockley et al., 1997
L-00247	Granite Creek	Sandstone & limestone	Dune foresets & interdunes	Lockley, pers. comm. 1997
L-00248	Harts Draw Rim	Limestone	Interdune deposits/playas	
L-00308	Heber Stone Quarry (Stokes 3)	Sandstone	Dune foresets	Albers, 1975; Stokes, 1978
L-00250	Hidden Valley - A	Limestone	Interdune deposits/playas	
	Hole in the Rock - level ??	Sandstone	Dune foresets	Lockley et al., 1997
L-00253	Hole in the Rock - level 1	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00254	Hole in the Rock - level 2	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00255	Hole in the Rock - level 3	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00309	Indian Creek Road (Stokes 2)	Sandstone	Dune foresets	Stokes, 1978
L-00256	Iron Wash	unknown	unknown	Stokes, 1978; Baker, 1946
L-00258	Kammenetsky (MNA)	Sandstone	Truncation surface	Lockley and Hunt, 1995; Davies, 1992
L-00259	Kane Springs Canyon	Limestone	Interdune deposits/playas	
L-00259	Kane Springs Canyon	Sandstone	Interdune/truncation surface	
L-00260	Kane Springs Canyon Road North - LS	Limestone	Interdune deposits/playas	
L-00260	Kane Springs Canyon Road North - SS	Sandstone	Dune foresets	
L-00262	Last Chance Bay	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00263	Lockhart Rims - Car park playa	Sandstone	Interdune deposits/playas	
	Long Ridge	unknown	unknown	Stokes, 1978
L-00310	McConkie Ranch	Mudstone	Interdune deposits/playas	
L-00265	Merrimac Butte	Limestone	Interdune deposits/playas	
L-00008	Mescal Range	Sandstone	Dune foresets	Reynolds, 1989
L-00266	Moab North	Sandstone	Interdune deposits/playas	Lockley and Hunt, 1995
L-00267	Moab North-east	Limestone	Interdune deposits/playas	
L-00299	Near Moab	Sandstone	Dune foresets	
L-00300	Near Moab 2	unknown	unknown	
L-00313	near Redfleet Reservoir	unknown	unknown	Lockley, 1992
L-00268	Needles - level 1	Limestone	Interdune deposits/playas	
L-00269	Needles - level 2	Limestone	Interdune deposits/playas	
L-00270	Needles - level 3	Limestone	Interdune deposits/playas	
L-00271	Negro Bill Canyon 1	Sandstone	Dune foresets	
L-00275	Negro Bill Canyon 2	Sandstone	Interdune deposits/playas	
L-00273	Negro Bill Canyon MGL	Limestone	Interdune deposits/playas	
L-00277	Nokai Dome Road	Limestone	Interdune deposits/playas	
L-00278	North Wash	unknown	unknown	Middleton and Blakey, 1993
L-00279	North Wash 1 (mm 29)	Limestone	Interdune deposits/playas	
L-00280	North Wash 2 (mm 28)	Limestone & evaporites	Interdune deposits/playas	
L-00281	Old Dead Horse Point Road	Limestone	Interdune deposits/playas	
L-00282	Orange Cliffs	unknown	unknown	NPS files
L-00283	Poison Spring Canyon	unknown	unknown	
L-00284	Potash Road	Limestone	Interdune deposits/playas	Lockley and Hunt, 1995
	Pritchett Canyon	Limestone/calc. Sandstone	Interdune deposits/playas	Lockley, pers. comm. 1997

UCD LOC #	LOCALITY	LITHOLOGY	DEPOSITIONAL ENVT.	SUPPLEMENTAL INFORMATION
L-00311	Redfleet Reservoir	Sandstone	Interdune/truncation surface	
L-00286	Sand Flats Road	Sandstone	Interdune deposits/playas	
L-00287	Sand Wash	Sandstone	Dune foresets	Stokes, 1978; Stokes and Madsen, 1979; Lockley and Hunt, 1995
L-00289	Slick Rock Canyon 1	Limestone	Interdune deposits/playas	Lockley et al., 1997
L-00290	Slick Rock Canyon 2	Sandstone, minor limestone	Interdune deposits/playas	Lockley et al., 1997
L-00291	Slick Rock Canyon 3	Limestone, sandstone	Interdune deposits/playas	Lockley et al., 1997
	Somewhere Arizona	Sandstone	Dune foresets	Chronic, 1983
L-00292	Steens Road	Sandstone	Interdune deposits/playas	
L-00293	Tapestry Wall	Sandstone	Interdune deposits/playas	Lockley et al., 1997
L-00294	Three Mile Well	Limestone	Interdune deposits/playas	
L-00296	Upper Spring Canyon Rim	Limestone	Interdune deposits/playas	
L-00297	West Canyon	Sandstone	Truncation surface	Lockley et al., 1992a, 1997
L-00312	Wind River Mountains (Stokes 1)	unknown	unknown	Kayser, 1964, Stokes, 1978

UCD LOC. #	LOCALITY	# OF I/TAXA	ICHNOTAXON	I'TAX. CENSUS	TOTAL # INDIVIDUALS
L-00220	Annie's Canyon	2	<i>Grallator</i>	12	13
L-00220	Annie's Canyon		<i>Otozoum</i> sp.	1	
L-00221	Boundary Butte Well	1	indeterminate theropod	1	1
L-00222	Buckhorn Wash	1	<i>Dilophosauripus</i>	1	1
L-00223	Cedar Canyon	2	<i>Anomoepus</i>	27	32
L-00223	Cedar Canyon		tridactyl morph A	5	
L-00224	<i>Choal Canyon</i>		no data		
L-00225	<i>Cleopatra's Chair</i>		indeterminate tridactyl		
L-00226	Comb Ridge	3	<i>Anomoepus</i>	5	16
L-00226	Comb Ridge		<i>Dilophosauripus</i>	1	
L-00226	Comb Ridge		<i>Grallator</i>	10	
L-00227	Copper Globe Road	1	tridactyl	1	1
L-00228	Coppermine	1	<i>Navahopus falcipollex</i>	1	1
L-00229	Coppermine North	2	<i>Anomoepus</i>	1	2
L-00229	Coppermine North		<i>Eubrontes</i>	1	
L-00230	Coppermine Well South - 1	1	cf. <i>Wildeichnus</i>	1	1
L-00231	Coppermine Well South - 2	3	<i>Anomoepus</i>	1	4
L-00231	Coppermine Well South - 2		<i>Brasilichnium</i>	2	
L-00231	Coppermine Well South - 2		cf. <i>Wildeichnus</i>	1	
L-00232	Coppermine Well South - 3	1	<i>Brasilichnium</i>	1	1
L-00233	Coppermine Well South - 4	2	<i>Grallator</i>	5	8
L-00233	Coppermine Well South - 4		<i>Otozoum minus</i>	3	
L-00234	Coppermine Well South - 5	1	<i>Brasilichnium</i>	1	1
L-00236	Dennehotso	1	<i>Eubrontes</i>	4	4
L-00237	<i>Dennehotso - mm 423 (Cooley)</i>	1	<i>Eubrontes</i>	>>2	>>2
L-00238	Devil's Canyon (Stokes 7)	1	<i>Eubrontes</i>	1	1
L-00240	<i>Dewey Bridge (Stokes 9)</i>	3	<i>Brasilichnium</i>	>>6	>>8
L-00240	<i>Dewey Bridge (Stokes 9)</i>		<i>Grallator</i>	>1	
L-00240	<i>Dewey Bridge (Stokes 9)</i>		tetradactyl morph A	1	
L-00239	<i>Dewey Bridge North</i>	1	<i>Brasilichnium</i>	1	1
L-00241	Dirty Devil River		no data		
L-00305	<i>DNM - UCD 92-17.1a</i>	1	<i>Grallator</i>	12	12
L-00305	<i>DNM - UCD 92-17.1b</i>	1	<i>Grallator</i>	84	84
L-00305	<i>DNM - UCD 92-17.1c</i>	2	<i>Grallator</i>	10	15
L-00305	<i>DNM - UCD 92-17.1c</i>		<i>Otozoum</i> sp.		
L-00306	<i>DNM - UCD 92-17.2a</i>	1	<i>Otozoum</i>	?	>1
L-00306	<i>DNM - UCD 92-17.2b</i>	1	indeterminate tridactyl	?	>1
L-00306	<i>DNM - UCD 92-17.2c</i>	1	indeterminate tridactyl	?	>1
L-00304	<i>DNM - UCD 92-17.2d</i>	1	indeterminate tridactyl		
L-00307	<i>DNM - UCD 92-17.3a</i>	2	indeterminate tridactyl	1	>17
L-00307	<i>DNM - UCD 92-17.3a</i>		<i>Otozoum</i> sp.	>16	
L-00307	<i>DNM - UCD 92-17.3b</i>	2	indeterminate tridactyl	8	12
L-00307	<i>DNM - UCD 92-17.3b</i>		<i>Otozoum</i> sp.	4	
L-00242	Driftwood Canyon	3	<i>Dilophosauripus</i>	9	17
L-00242	Driftwood Canyon		<i>Eubrontes</i>	5	
L-00242	Driftwood Canyon		<i>Grallator</i>	3	
L-00243	Dungeon Canyon	1	<i>Eubrontes</i>	1	1
L-00244	Escalante River Valley (Stokes 11)	1	<i>Brasilichnium</i>		
L-00314	<i>Flag Creek (Stokes 5)</i>	2	<i>Brasilichnium</i>	>3	>>4
L-00314	<i>Flag Creek (Stokes 5)</i>		cf. <i>Navahopus</i>	1	
L-00246	Glen Canyon Dam	1	<i>Eubrontes</i>	1	1
L-00247	<i>Granite Creek</i>	3	<i>Anchisauripus</i>	2	31
L-00247	<i>Granite Creek</i>		<i>Brasilichnium</i>	1	
L-00247	<i>Granite Creek</i>		<i>Grallator</i>	28	
L-00248	Harts Draw Rim	1	cf. <i>Anomoepus</i>	1	1
L-00308	Heber Stone Quarry (Stokes 3)	1	<i>Brasilichnium</i>	6	6
L-00250	Hidden Valley - A	3	<i>Anchisauripus</i>	4	11
L-00250	Hidden Valley - A		<i>Anomoepus</i>	5	
L-00250	Hidden Valley - A		<i>Eubrontes</i>	2	
	Hole in the Rock - level ??	1	<i>Grallator</i>	3	3
L-00253	<i>Hole in the Rock - level 1</i>	3	<i>Anchisauripus</i>	1	>4
L-00253	<i>Hole in the Rock - level 1</i>		<i>Eubrontes</i>	>2	
L-00253	<i>Hole in the Rock - level 1</i>		<i>Grallator</i>	>1	

Localities in italics have incomplete census data.

UCD LOC. #	LOCALITY	# OF I/TAXA	ICHNOTAXON	I'TAX. CENSUS	TOTAL # INDIVIDUALS
L-00254	Hole in the Rock - level 2	2	<i>Anchisauripus</i>	1	3
L-00254	Hole in the Rock - level 2		<i>Eubrontes</i>	2	
L-00255	Hole in the Rock - level 3	1	<i>Eubrontes</i>	1	1
L-00309	Indian Creek Road (Stokes 2)	1	<i>Brasilichnium</i>	2	2
L-00256	Iron Wash	1	indeterminate tridactyl	1	1
L-00258	Kammenetsky (MNA)	2	<i>Grallator</i>	28	31
L-00258	Kammenetsky (MNA)		<i>Otozoum moodii</i>	3	
L-00259	<i>Kane Springs Canyon</i>	3	<i>Eubrontes</i>	2	>9
L-00259	<i>Kane Springs Canyon</i>		<i>Grallator</i>	>5	
L-00259	<i>Kane Springs Canyon</i>		<i>Otozoum sp.</i>	2	
L-00260	Kane Springs Canyon Road North - LS	1	<i>Otozoum moodii</i>	3	3
L-00260	Kane Springs Canyon Road North - SS	1	<i>Grallator</i>	1	1
L-00262	Last Chance Bay	1	<i>Eubrontes</i>	1	1
L-00263	Lockhart Rims - Car park playa	2	<i>Grallator</i>	1	2
L-00263	Lockhart Rims - Car park playa		tridactyl morph A	1	
	Long Ridge	1	indeterminate tridactyl	1	1
L-00310	<i>McConkie Ranch</i>	?1	indeterminate tridactyl	>>1	>>1
L-00265	<i>Merrimac Butte</i>	1	indeterminate theropod	>>1	>>1
L-00008	<i>Mescal Range</i>	3	cf. <i>Batrachopus</i>	>2	>7
L-00008	<i>Mescal Range</i>		<i>Grallator</i>	2	
L-00008	<i>Mescal Range</i>		indeterminate theropod	>3	
L-00266	Moab North	1	<i>Otozoum minus</i>	5	5
L-00267	Moab North-east	2	<i>Dilophosauripus</i>	1	2
L-00267	Moab North-east		<i>Eubrontes</i>	1	
L-00299	Near Moab	1	<i>Brasilichnium</i>	1	1
L-00300	Near Moab 2	1	<i>Eubrontes</i>	1	1
L-00313	near Redfleet Reservoir	1	<i>Eubrontes</i>	1	1
L-00268	Needles - level 1	1	<i>Dilophosauripus</i>	1	1
L-00269	Needles - level 2	1	indeterminate tridactyl	1	1
L-00270	Needles - level 3	1	<i>Eubrontes</i>	1	1
L-00271	Negro Bill Canyon 1	1	<i>Grallator</i>	2	2
L-00275	Negro Bill Canyon 2	1	indeterminate	1	1
L-00273	Negro Bill Canyon MGL	1	cf. <i>Apatichnus</i>	1	1
L-00277	Nokai Dome Road	3	<i>Dilophosauripus</i>	1	5
L-00277	Nokai Dome Road		<i>Eubrontes</i>	2	
L-00277	Nokai Dome Road		<i>Grallator</i>	2	
L-00278	North Wash		no data		
L-00279	North Wash 1 (mm 29)	4	<i>Anomoepus</i>	1	4
L-00279	North Wash 1 (mm 29)		<i>Eubrontes</i>	1	
L-00279	North Wash 1 (mm 29)		<i>Grallator</i>	1	
L-00279	North Wash 1 (mm 29)		indeterminate; ? <i>Grallator</i>	1	
L-00280	<i>North Wash 2 (mm 28)</i>	2	<i>Anomoepus</i>	>12	>>13
L-00280	<i>North Wash 2 (mm 28)</i>		tridactyl morph A	1	
L-00281	Old Dead Horse Point Road	1	<i>Eubrontes</i>	1	1
L-00282	Orange Cliffs		no data		
L-00283	Poison Spring Canyon		no data		
L-00284	Potash Road	4	<i>Anomoepus</i>	2	44
L-00284	Potash Road		<i>Eubrontes</i>	23	
L-00284	Potash Road		<i>Grallator</i>	16	
L-00284	Potash Road		<i>Grallator</i> (baby)	2	
L-00284	Potash Road		<i>Trisauropodiscus moabensis</i>	1	
	Pritchett Canyon	4	<i>Eubrontes</i>	1	8
	Pritchett Canyon		<i>Grallator</i>	1	
	Pritchett Canyon		<i>Otozoum moodii</i>	4	
	Pritchett Canyon		tridactyl morph A	2	
L-00311	<i>Redfleet Reservoir</i>	5	<i>Dilophosauripus</i>	1	>13
L-00311	<i>Redfleet Reservoir</i>		<i>Eubrontes</i>	>5	
L-00311	<i>Redfleet Reservoir</i>		<i>Grallator</i>	>4	
L-00311	<i>Redfleet Reservoir</i>		indeterminate; ? <i>Grallator</i>	2	
L-00311	<i>Redfleet Reservoir</i>		cf. <i>Sauropus</i>	1	
L-00286	<i>Sand Flats Road</i>	1	<i>Eubrontes</i>	>4	>4
L-00287	<i>Sand Wash</i>	6	" <i>Batrachopus</i> "	>1	>28
L-00287	<i>Sand Wash</i>		<i>Brasilichnium</i>	>20	

Localities in italics have incomplete census data.

UCD LOC. #	LOCALITY	# OF I/TAXA	ICHNOTAXON	I'TAX. CENSUS	TOTAL # INDIVIDUALS
L-00287	<i>Sand Wash</i>		<i>cf. Lacertipus</i>	>2	
L-00287	<i>Sand Wash</i>		<i>Grallator</i>	1	
L-00287	<i>Sand Wash</i>		<i>Grallator</i> (baby)	1	
L-00287	<i>Sand Wash</i>		<i>lacertilian</i>	>2	
L-00287	<i>Sand Wash</i>		<i>Pteraichnus</i>	>1	
L-00289	<i>Slick Rock Canyon 1</i>	1	<i>Grallator</i>	>2	>2
L-00290	<i>Slick Rock Canyon 2</i>	3	<i>cf. Otozoum</i>	1	>9
L-00290	<i>Slick Rock Canyon 2</i>		<i>Eubrontes</i>	>6	
L-00290	<i>Slick Rock Canyon 2</i>		<i>Grallator</i>	2	
L-00291	<i>Slick Rock Canyon 3</i>	3	<i>Brasilichnium</i>	1	6
L-00291	<i>Slick Rock Canyon 3</i>		<i>Eubrontes</i>	2	
L-00291	<i>Slick Rock Canyon 3</i>		tridactyl morph A	3	
	<i>Somewhere Arizona</i>	2	<i>Brasilichnium</i>	>3	>5
	<i>Somewhere Arizona</i>		indeterminate	>2	
L-00292	<i>Steens Road</i>	3	tridactyl morph A	2	6
L-00292	<i>Steens Road</i>		<i>Anomoepus</i>	3	
L-00292	<i>Steens Road</i>		indeterminate; ? <i>Grallator</i>	2	
L-00293	<i>Tapestry Wall</i>	1	<i>Eubrontes</i>	7	7
L-00294	<i>Three Mile Well</i>	1	indeterminate tridactyl	1	1
L-00296	<i>Upper Spring Canyon Rim</i>	1	<i>Eubrontes</i>	5	5
L-00297	<i>West Canyon</i>	2	<i>Grallator</i>	1	5
L-00297	<i>West Canyon</i>		<i>Otozoum moodii</i>	4	
L-00312	<i>Wind River Mountains (Stokes 1)</i>	1	indeterminate tetradactyl	1	1

CLASS/ Subclass	Superorder	Order	Suborder	Family	Genera from Canyon Group	Glen	Occurrence	Diet	Biped/ Quadruped	# functional digits (pes)
REPTILIA										
Diapsida	Lepidosauria	Sphenodontida		Pleurosauridae			Eu	C	Oblig. quad.	5
				Sphenodontidae	unnamed.		GI	C	Oblig. quad.	5
		Squamata	Lacertilia	Fulgidae			As	C	Oblig. quad.	5
				Kuehneosauridae			NA, Eu	C	Oblig. quad.	5
	Archosauria	Crocodylia	Protosuchia	Protosuchidae	<i>Protosuchus</i> , unnamed, <i>Eopneumatosuchus</i>		NA, SA, SAf, As	C	Oblig. quad.	4
			Sphenosuchia	Sphenosuchidae	unnamed.		NA, SA, SAf, As	C	Facul. biped	4
		Pterosauria	Rhamphorhynchoidea	Dimorphodontidae			Eu	C	Oblig. biped	4
				Rhamphorhynchidae	unnamed.		NA, Eu, Af, As	C	Oblig. biped	4
		Saurischia	Prosauropoda	Anchisauridae			NA, As	H	Facul. biped	3
				Massospondylidae			NA, Af	H	Facul. biped	3
				Melanorosauridae			As	H	Facul. biped	3
				Plateosauridae	<i>Ammosaurus</i> , <i>Massospondylus</i>		NA, Af	H	Facul. biped	3
				Yunnanosauridae			As	H	Facul. biped	3
			Sauropoda	Vulcanodontidae			Eu, As, Af	H	Oblig. quad.	3
			Theropoda	Ceratosaurs	<i>Segisaurus</i> , <i>Syntarsus</i> , <i>Dilophosaurus</i>		NA, Eu, Af	C	Oblig. biped	3
		Ornithischia		<i>Lesothosaurus</i>			Af	H	Facul. biped	3
			Ornithopoda	Fabrosauridae			Af	H	Oblig. biped	3
				Heterodontosauridae			As, Af	H	Oblig. biped	3
			Thyreophora	Scelidosauridae	<i>Scutellosaurus</i> , <i>Scelidosaurus</i>		NA, Eu, As	H	Facul. biped	4
Synapsida		Therapsida	Cynodontia	Trithelodontidae			NA, SA, SAf	C	Oblig. quad.	5
				Tritylodontidae	<i>Unnamed</i> , <i>Kayentatherium</i> , <i>Dinnebitodon</i> , <i>Oligokyphus</i>		NA, As, Eu, SAf	H	Oblig. quad.	5
MAMMALIA										
Allotheria		Multituberculata	Haramiyioidae	Haramiyidae			Eu	O	Oblig. quad.	5
Prototheria		Triconodonta		Morganucodontidae	<i>Dinnetherium</i>		NA, Eu, As, SAf	C	Oblig. quad.	5
				Sinocondontidae			As	C	Oblig. quad.	5
Theria	Trituberculata	Symmetrodonta		Kuehneotheriidae			Eu	C	Oblig. quad.	5

From Carroll '88; Morales '96; Weishampel et al. '90.

Families in bold occur in N America; genera in bold occur in Navajo Ss, rest are in Kayenta Fm.

Occurrence: Af-Africa, As-Asia, Eu-Europe, GI-Global, NA-N America, Mad-Madagascar, SAf-S Africa, SA-S America.

	Dune foresets	Interdunes - indeter- minate	Interdunes - truncation surfaces	Interdunes - horizontally bedded	Interdunes - total
# of sites	20	12	4	69	85
# of individuals	81	155	44	275	474
# ichnotaxa	12	5	3	10	13
# body taxa	9	4	2	6	6
Ichnotaxon					
<i>Grallator</i>	11	112	34	86	232
<i>Anomoepus</i>	2			56	56
cf. <i>Wildeichnus</i>	2				
<i>Trisauropodiscus</i>				1	1
cf. <i>Sauropus</i>		1			1
cf. <i>Apatichnus</i>				1	1
indet small theropod	3			3	3
<i>Anchisauripus</i>				8	8
<i>Eubrontes</i>		5	1	72	77
<i>Dilophosauripus</i>		1		14	15
indet. large theropod				2	2
Tridactyl morph A				14	14
indet. tridactyl		12		4	16
<i>Otozoum minus</i>		24	3	5	32
<i>Otozoum moodii</i>			7	7	14
<i>Navahopus</i>	1				
cf. <i>Navahopus</i>	1				
<i>Brasilichnium</i>	48				
<i>Batrachopus</i>	3				
Tetradactyl morph A	1				
"lacertilian"	4				
<i>Pteraichnus</i>	1				
indeterminate	2				
Trackmaker					
Ceratosaur - small	17	113	35	147	294
Ceratosaur - medium				8	8
Ceratosaur - large		6	1	88	94
Ornithischian				14	14
Indet. tridactyl dinosaur		12			12
Crocodylomorph?	4				
Thyreophoran		24	10	12	46
Prosauropod	2				
Protomammal/mammal	48				
Lacertilian	4				
Pterosaur	1				
unknown	2				

"Interdunes-total" column is the sum of bevelled surfaces, horizontally bedded interdunes, and non-dune tracksites for which characteristics are unknown.

UCD LOC. #	LOCALITY	# OF TAXA	TAXON	TAX. CENSUS	TOTAL # INDIVIDUALS
L-00220	Annie's Canyon	2	Ceratosaur - small	12	13
L-00220	Annie's Canyon		Thyreophoran	1	
L-00221	Boundary Butte Well	1	Ceratosaur - large	1	1
L-00222	Buckhorn Wash	1	Ceratosaur - large	1	1
L-00223	Cedar Canyon	2	Ceratosaur - small	27	32
L-00223	Cedar Canyon		Ornithischian dinosaur	5	
L-00226	Comb Ridge	2	Ceratosaur - large	15	16
L-00226	Comb Ridge		Ceratosaur - small	1	16
L-00227	Copper Globe Road	1	Indeterminate tridactyl dinosaur	1	1
L-00228	Coppermine	1	Prosauropod	1	1
L-00229	Coppermine North	2	Ceratosaur - large	1	2
L-00229	Coppermine North		Ceratosaur - small	1	
L-00230	Coppermine Well South - 1	1	Ceratosaur - small	1	1
L-00231	Coppermine Well South - 2	2	Ceratosaur - small	2	4
L-00231	Coppermine Well South - 2		Protomammal/mammal	2	
L-00232	Coppermine Well South - 3	1	Protomammal/mammal	1	1
L-00233	Coppermine Well South - 4	2	Ceratosaur - small	5	8
L-00233	Coppermine Well South - 4		Thyreophoran	3	
L-00234	Coppermine Well South - 5	1	Protomammal/mammal	1	1
L-00236	Dennehotso	1	Ceratosaur - large	4	4
L-00237	Dennehotso - mm 423 (Cooley)	1	Ceratosaur - large	>>2	>>2
L-00238	Devil's Canyon (Stokes 7)	1	Ceratosaur - large	1	1
L-00240	Dewey Bridge (Stokes 9)	2	Ceratosaur - small	>1	>>8
L-00240	Dewey Bridge (Stokes 9)		Protomammal/mammal	>>7	
L-00239	Dewey Bridge North	1	Protomammal/mammal	1	1
L-00305	DNM - UCD 92-17.1a	1	Ceratosaur - small	12	12
L-00305	DNM - UCD 92-17.1b	1	Ceratosaur - small	84	84
L-00305	DNM - UCD 92-17.1c	2	Ceratosaur - small	10	15
L-00305	DNM - UCD 92-17.1c		Thyreophoran		
L-00306	DNM - UCD 92-17.2a	1	Thyreophoran	?	>1
L-00306	DNM - UCD 92-17.2b	1	Indeterminate tridactyl dinosaur	?	>1
L-00306	DNM - UCD 92-17.2c	1	Indeterminate tridactyl dinosaur	?	>1
L-00304	DNM - UCD 92-17.2d	1	Indeterminate tridactyl dinosaur		
L-00307	DNM - UCD 92-17.3a	2	Thyreophoran	>16	>17
L-00307	DNM - UCD 92-17.3a		Indeterminate tridactyl dinosaur	1	
L-00307	DNM - UCD 92-17.3b	2	Thyreophoran	4	12
L-00307	DNM - UCD 92-17.3b		Indeterminate tridactyl dinosaur	8	
L-00242	Driftwood Canyon	2	Ceratosaur - large	14	17
L-00242	Driftwood Canyon		Ceratosaur - small	3	
L-00243	Dungeon Canyon	1	Ceratosaur - large	1	1
L-00244	Escalante River Valley (Stokes 11)	1	Protomammal/mammal		
L-00314	Flag Creek (Stokes 5)	2	Prosauropod	1	>>4
L-00314	Flag Creek (Stokes 5)		Protomammal/mammal	>3	
L-00246	Glen Canyon Dam	1	Ceratosaur - large	1	1
L-00247	Granite Creek	3	Ceratosaur - medium	2	31
L-00247	Granite Creek		Ceratosaur - small	28	
L-00247	Granite Creek		Protomammal/mammal	1	
L-00248	Harts Draw Rim	1	Ceratosaur - small	1	1
L-00308	Heber Stone Quarry (Stokes 3)	1	Protomammal/mammal	6	
L-00250	Hidden Valley - A	3	Ceratosaur - large	2	11
L-00250	Hidden Valley - A		Ceratosaur - medium	4	
L-00250	Hidden Valley - A		Ceratosaur - small	5	
	Hole in the Rock - level ??	1	Ceratosaur - small	3	3
L-00253	Hole in the Rock - level 1	3	Ceratosaur - large	>2	>4
L-00253	Hole in the Rock - level 1		Ceratosaur - medium	1	
L-00253	Hole in the Rock - level 1		Ceratosaur - small	>1	
L-00254	Hole in the Rock - level 2	2	Ceratosaur - large	2	3
L-00254	Hole in the Rock - level 2		Ceratosaur - medium	1	
L-00255	Hole in the Rock - level 3	1	Ceratosaur - large	1	1
L-00309	Indian Creek Road (Stokes 2)	1	Protomammal/mammal	2	2
L-00256	Iron Wash	1	Indeterminate tridactyl dinosaur	1	1
L-00258	Kammenetsky (MNA)	2	Ceratosaur - small	28	31
L-00258	Kammenetsky (MNA)		Thyreophoran	3	
L-00259	Kane Springs Canyon	3	Ceratosaur - large	2	>9
L-00259	Kane Springs Canyon		Ceratosaur - small	>5	

UCD LOC. #	LOCALITY	# OF TAXA	TAXON	TAX. CENSUS	TOTAL # INDIVIDUALS
L-00259	Kane Springs Canyon		Thyreophoran	2	
L-00260	Kane Springs Canyon Road North - LS	1	Thyreophoran	3	3
L-00260	Kane Springs Canyon Road North - SS	1	Ceratosaur - small	1	1
L-00262	Last Chance Bay	1	Ceratosaur - large	1	1
L-00263	Lockhart Rims - Car park playa	2	Ceratosaur - small	1	2
L-00263	Lockhart Rims - Car park playa		Ornithischian dinosaur	1	
	Long Ridge	1	Indeterminate tridactyl dinosaur	1	1
L-00310	McConkie Ranch	?1	Indeterminate tridactyl dinosaur	>>1	>>1
L-00265	Merrimac Butte	1	Ceratosaur - medium	>>1	>>1
L-00008	Mescal Range	2	Ceratosaur - small	>5	>7
L-00008	Mescal Range		Crocodylomorph?	>2	
L-00266	Moab North	1	Thyreophoran	5	5
L-00267	Moab North-east	1	Ceratosaur - large	2	2
L-00299	Near Moab	1	Protomammal/mammal	1	1
L-00300	Near Moab 2	1	Ceratosaur - large	1	1
L-00313	near Redfleet Reservoir	1	Ceratosaur - large	1	1
L-00268	Needles - level 1	1	Ceratosaur - large	1	1
L-00269	Needles - level 2	1	Indeterminate tridactyl dinosaur	1	1
L-00270	Needles - level 3	1	Ceratosaur - large	1	1
L-00271	Negro Bill Canyon 1	1	Ceratosaur - small	2	2
L-00273	Negro Bill Canyon MGL	1	Ceratosaur - small	1	1
L-00277	Nokai Dome Road	2	Ceratosaur - large	3	5
L-00277	Nokai Dome Road		Ceratosaur - small	2	
L-00279	North Wash 1 (mm 29)	2	Ceratosaur - large	1	4
L-00279	North Wash 1 (mm 29)		Ceratosaur - small	3	
L-00280	North Wash 2 (mm 28)	2	Ceratosaur - small	>12	>>13
L-00280	North Wash 2 (mm 28)		Ornithischian dinosaur	1	
L-00281	Old Dead Horse Point Road	1	Ceratosaur - large	1	1
L-00284	Potash Road	2	Ceratosaur - large	25	44
L-00284	Potash Road		Ceratosaur - small	19	
	Pritchett Canyon	4	Ceratosaur - large	1	8
	Pritchett Canyon		Ceratosaur - small	1	
	Pritchett Canyon		Thyreophoran	4	
	Pritchett Canyon		Ornithischian dinosaur	2	
L-00311	Redfleet Reservoir	2	Ceratosaur - large	>6	>13
L-00311	Redfleet Reservoir		Ceratosaur - small	>7	
L-00286	Sand Flats Road	1	Ceratosaur - large	>4	>4
L-00287	Sand Wash	5	Crocodylomorph?	>1	>28
L-00287	Sand Wash		?Pterosaur	>1	
L-00287	Sand Wash		Ceratosaur - small	2	
L-00287	Sand Wash		Lacertilian	>4	
L-00287	Sand Wash		Protomammal/mammal	>20	
L-00289	Slick Rock Canyon 1	1	Ceratosaur - small	>2	>2
L-00290	Slick Rock Canyon 2	3	Ceratosaur - large	>6	>9
L-00290	Slick Rock Canyon 2		Ceratosaur - small	2	
L-00290	Slick Rock Canyon 2		Thyreophoran	1	
L-00291	Slick Rock Canyon 3	3	Ceratosaur - large	2	6
L-00291	Slick Rock Canyon 3		Ornithischian dinosaur	3	
L-00291	Slick Rock Canyon 3		Protomammal/mammal	1	
	Somewhere Arizona	2	Indeterminate trackmaker	>2	>5
	Somewhere Arizona		Protomammal/mammal	>3	
L-00292	Steens Road	2	Ornithischian dinosaur	2	6
L-00292	Steens Road		Ceratosaur - small	5	
L-00293	Tapestry Wall	1	Ceratosaur - large	7	7
L-00294	Three Mile Well	1	Indeterminate tridactyl dinosaur	1	1
L-00296	Upper Spring Canyon Rim	1	Ceratosaur - large	5	5
L-00297	West Canyon	2	Ceratosaur - small	1	5
L-00297	West Canyon		Thyreophoran	4	

Errata:

Track morphotypes, para 2: This may lead to overestimation of the number of individuals because a single animal may have made more than 1 trackway.

However the alternate end-member interpretation is to consider all tracks the same size to have been made by a single animal, which assumes that only one individual of each size was present.

Possible trackmakers, para 2: Fish, aquatic reptiles...

Discussion, para 11: On truncation surfaces, small ceratosaurs are the dominant element of the fauna (approximately 75%); thyreophorans comprise the bulk of the remainder (Figure 18).

Figure 23: 3 taxa on truncation surfaces.