

Paleontological resource management, systematic recording, and preservation of vertebrate tracks within Death Valley National Park, California

Vincent L. Santucci, *National Park Service P.O. Box 592, Kemmerer, WY, 83101*
Torrey G. Nyborg, *National Park Service, 4400 SW 179th Ave., Aloha, Oregon 97007*

Introduction

The earliest reports of fossil tracks from Death Valley are attributed to a Native American named Tom Wilson. Wilson discovered both bird and mammal tracks within sandstone layers in the Salt Creek Hills Track Locality. In early 1937, Wilson led park naturalist H. Donald Curry to the track locality. A few weeks later, while doing geological research in the park, Don Curry discovered a large number of mammal and bird tracks of various kinds within Copper Canyon. During the same week, T. P. Thayer of the United States Geological Survey discovered another site near the Cow Creek residence facilities. These three track localities, along with two camel tracks found within the lacustrine deposits of Twenty Mule Canyon, are discussed briefly in this report.

Curry was the first to recognize the rarity and importance of the fossil vertebrate tracks in Copper Canyon. He collected a number of track specimens, assigned names to specific track sub-localities (i.e., "Carnivore Ridge", "Barnyard"), and published the first descriptive report on the fossil tracks in Death Valley (Curry, 1939; 1941).

Copper Canyon Track Locality

In 1941, based upon the initial reports produced by Curry, Max Bauer, a geologist from Yellowstone National Park, and Neil Grunigan, produced a plane-table map of the Copper Canyon Track Locality. Bauer and Grunigan located and described twenty fossil track sites within the Copper Canyon Track Locality (Bauer, 1942).

In the 1950s and early 1960s, Raymond Alf collected a number of fossil tracks from Death Valley. These specimens are accessioned within the Raymond Alf Museum in

Claremont, California. There are no field notes or catalog records associated with these specimens, and insufficient data exists from the actual collecting locality within Death Valley National Park.

During the 1980s, Reuben Scolnick updated Bauer's locality map and established photo-points for the fossil mammal track sites contained within the Copper Canyon Track Locality. He expanded Bauer's original twenty track sites by an additional twenty-one track sites. Additionally, Scolnick established a track site monitoring system for future work (Scolnick, 1987).

In 1984, Paul Scrivner conducted a morphological study of the Copper Canyon Track Locality for his master's thesis (Scrivner, 1984; Scrivner and Bottjer, 1986). Scrivner was the first to apply Vialov's morphological classification scheme to the tracks (Vialov, 1966).

Santucci (1998) was the next paleontologist to visit the Copper Canyon Track Locality, and initiated an assessment



Figure 1: The white lacustrine deposits stand out among the surrounding volcanics. Taken from ridge looking northwest along the Black Mountains.

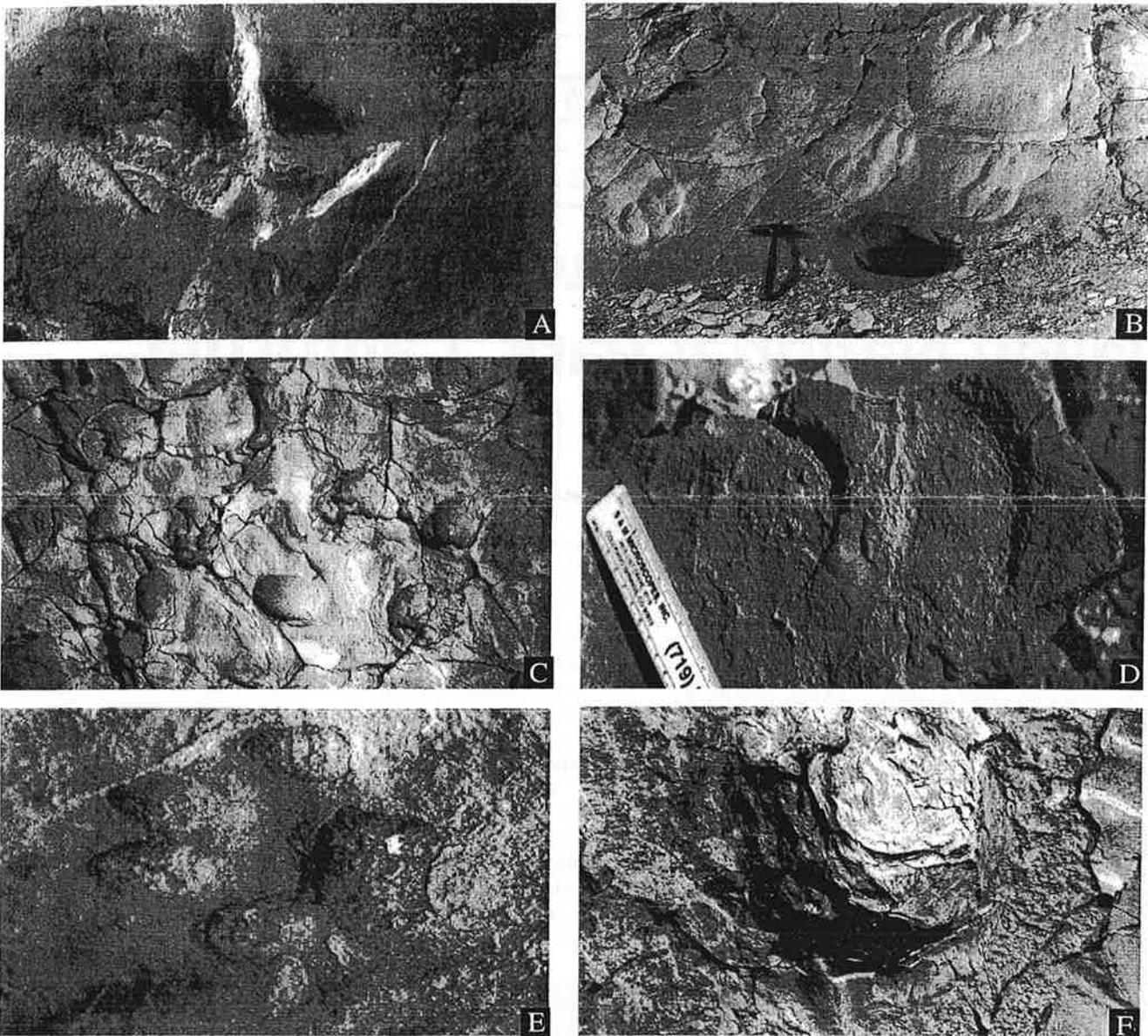


Figure 2: Composite of vertebrate tracks from Death Valley. A, *Avipeda* ichnospecies (cast) from the Cow Creek Track Locality; B, *Pecoripeda* (*Ovipeda*) ichnospecies B (imprint) from the Copper Canyon Track Locality; C, Bioturbated trampled tracks in soft sediment from the Copper Canyon Track Locality at the "Barnyard" Sub-locality; D, *Hippipea* ichnospecies A (imprint) from the Copper Canyon Track Locality at the "Carnivore Ridge" Sub-locality; E, *Bestiopedea* (?) ichnospecies E (cast) from the Cow Creek Track Locality; F, *Proboscipeda* ichnospecies (imprint) from the Copper Canyon Track Locality.

of the paleontological resources preserved in the canyon. Based upon Santucci's recommendations, Torrey Nyborg was recruited as a paleontology intern through the National Park Service's "Geologist-In-the-Park Program" in 1998.

Nyborg (1998) utilized Scolnick's and Bauer's baseline data on the Copper Canyon Track Locality and added an additional sixteen track sites. Nyborg expanded the number of track sites within the Copper Canyon Track Locality, and doubled the number of ichnospecies described by Scrivner (1984). These include (see appendix A):

- twelve different *Avipeda* ichnospecies;
- five different *Felipeda* ichnospecies;
- five different *Ovipeda* ichnospecies;
- three different *Hippipea* ichnospecies;
- one tridactyl track "cf. *Tapirpeda* n. sp." ichnospecies;
- one *Proboscipeda* ichnospecies.

Cow Creek Track Locality

The Cow Creek Track Locality is preserved in a medium grained sandstone unit containing intermittent lacustrine beds. The track locality is located just west of the Cow Creek housing facility. The site is limited in exposure and preserves a low diversity of fossil vertebrate tracks. The Cow Creek Track Locality appears initially to represent a different depositional environment than the Copper Canyon Track Locality. The Cow Creek Track Locality preserves very large avian tracks (*Avipeda* ichnospecies L), a panel with three carnivore tracks (*Felipeda* ichnospecies F), and two types of artiodactyl tracks (*Ovipeda* ichnospecies C & E). Although the age of this track locality has not been determined, it appears to be contemporaneous with the lacustrine deposits within the Copper Canyon Track Locality.

Salt Creek Track Locality

The Salt Creek Track Locality is located within an isolated outcrop in the Central Death Valley Playa. The track-bearing unit is contained within a conglomeratic lacustrine deposit. The track locality was first noted by Curry (1939; 1941) and archival photographs indicate the locality was excavated extensively in the late 1930s. Curry (personal Communication, 1998) has reported avian, artiodactyl, perissodactyl, and even possibly proboscidian tracks from the lacustrine deposits within the Salt Creek Hills.

Twenty Mule Canyon Track Locality

Two artiodactyl tracks were collected from Twenty Mule Canyon Track Locality in the 1980s. These specimens are curated in the Death Valley Museum collection. The poorly preserved tracks are found within a coarse grained lacustrine unit which is exposed throughout the canyon.

Systematic Recording and Preservation

Fifty-eight fossil vertebrate track sites were recorded in Death Valley National Park utilizing photo-points and GPS data. In addition, a paleontological resource site map was produced for the Copper Canyon Track Locality. The baseline track site data will provide a system for long-term monitoring of the sensitive paleontological resources. The paleontological resource map will be valuable for park resource management, protection and interpretive planning.

Many important track panels remain undocumented and are managed *in situ* at Death Valley National Park. These paleontological resources are too large and/or fragile to successfully remove from the field. Over time, these exposed tracks will be subjected to weathering and erosion. Eventually, the tracks will be lost, along with the scientific values associated with them.

The fossil track specimens currently curated in the Death Valley museum collection do not represent the highest quality specimens available. Additionally, many of the ichnospecies types are not represented in the park collections. The logistics of collecting large track slabs from remote locations in the park has inhibited researchers and staff from obtaining better quality specimens.

Given the challenges of transporting large track specimens from the field, the preferred alternative strategy is to produce lightweight, high-resolution casts of the significant track types. The replication of tracks can be valuable in documenting ichnofossil types for both research and interpretation. For inaccessible tracks, detailed blueprinting and photodocumentation should be undertaken.

Conclusion

Thirty-six ichnospecies of cat, camel, horse, mastodon, and bird tracks have been identified from Death Valley National Park. A possible new and undescribed tridactyl track was discovered in 1998. These tracks are preserved within deposits located within Copper Canyon, Cow Creek, Salt Creek, and Twenty-Mule Canyon Track Localities.

The fossil vertebrate tracks are Late Miocene through Pleistocene in age. The tracks provide clues regarding paleoecology and past depositional environments within Death Valley National Park.

The research conducted on the fossil vertebrate track localities within Death Valley will assist park management

in compiling baseline paleontological resource data. The significance of the fossil tracks, combined with the fragile nature of the resource, requires specific management strategies for protecting these track localities. Collectively, the Death Valley track localities represent one of the richest and most diverse Late Cenozoic vertebrate trace fossil assemblages in North America.

Acknowledgements

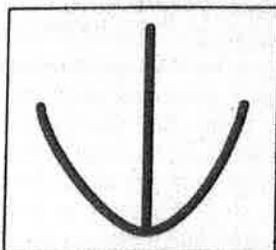
Thanks to both the management and other staff at Death Valley National Park for providing interest and support towards the park's paleontological resources. Additional thanks to Bob Reynolds, of San Bernardino County Museum, for sharing his understanding of the fossil vertebrate tracks of Death Valley. The volunteer efforts of Reuben Scolnick are recognized and his work will serve as the foundation from which future work will develop. Arvid Aase, David Hays, Kris Thompson and Shawn Duffy provided technical support and editorial review. This project was funded by the National Park Service Geologic Resource Division.

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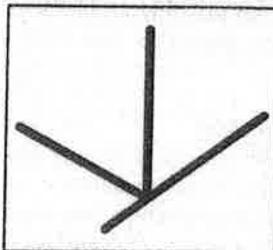
Appendix A

Avipeda ichnospecies A (Scrivner, 1984)



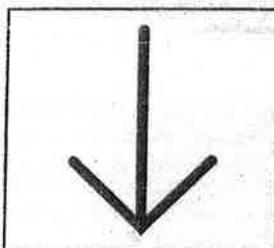
Dimensions:
4.4 - 9 cm L, 6.5 - 8 cm W
Description:
Large tracks. Long, straight central toe; lateral toes shorter, anteriorly curved.

Avipeda ichnospecies F (Nyborg, 1998)



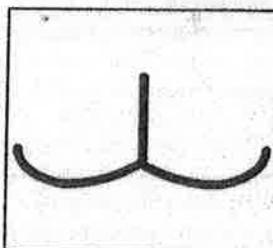
Dimensions:
1.9 cm L, 2.9 cm W
Description:
Small tracks of subequal length toes. Hind toe in line with outer toe. Lateral toes at fifty degree angle from central toe.

Avipeda ichnospecies B (Scrivner, 1984)



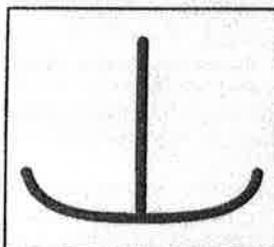
Dimensions:
7.5 - 11 cm L, 5.5 - 12 cm W
Description:
Long central toe, lateral toes shorter. Like species A, except lateral toes straight to slightly curved anteriorly. Toe impressions wider than A. ichnospecies A. Central and lateral toes separated by thirty to fifty degrees.

Avipeda ichnospecies G (Nyborg, 1998)



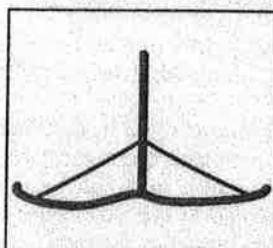
Dimensions:
3.5 cm L, 8 cm W
Description:
Like A. ichnospecies C, but lateral toes much longer than central toe. Side toes straight; distal tips curved anteriorly. Large indentation where side toes meet central toe. No webbing or hind toe.

Avipeda ichnospecies C (Scrivner, 1984)



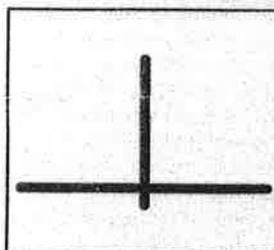
Dimensions:
2 - 2.2 cm L, 2.3 - 2.8 cm W
Description:
Small tracks of subequal length toes. Side toes straight, distal tip curved anteriorly; approximately ninety degrees from central toe. No indications of webbing or hind toe.

Avipeda ichnospecies H (Nyborg, 1998)



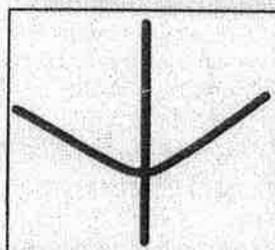
Dimensions:
2.3 cm L, 3.7 cm W
Description:
Track with equal toe length. Webbing present. Lateral toes curve slightly at central toe. No hind toe.

Avipeda ichnospecies D (Scrivner, 1984)



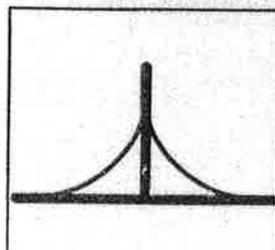
Dimensions:
1.7 cm L, 2.3 cm W
Description:
Small tracks of subequal length toes; hind toe present. Lateral toes at ninety degrees from central toe. No indication of webbing.

Avipeda ichnospecies I (Nyborg, 1998)



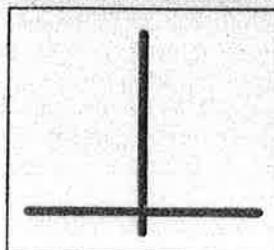
Dimensions:
4.8 cm L, 6.5 cm W
Description:
Track with subequal toe length. Hind toe in line with central toe. Lateral and central toes meet at sixty degrees. No webbing present.

Avipeda ichnospecies E (Scrivner, 1984)



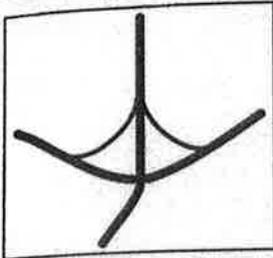
Dimensions:
7.6 cm L, 8.4 cm W
Description:
Tracks of subequal length toes, webbing present. Lateral toes at ninety degrees from central toe. May have short hind toe.

Avipeda ichnospecies J (Nyborg, 1998)



Dimensions:
4.9 cm L, 3.4 cm W
Description:
Long central toe; lateral toes half centimeter shorter than central toe. Like A. ichnospecies D, except no webbing present and lateral toes shorter than central toe. Indication of very small hind toe or knob where lateral toes meet central toe.

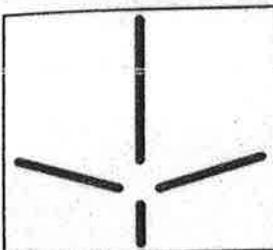
Avipeda ichnospecies K (Nyborg, 1998)



Dimensions:
4.3 cm L, 4.4 cm W

Description:
Track with anterior toes of equal length. Hind toe angled adaxially from central toe. Like *A.* ichnospecies I, except webbing present and a seventy degree angle between central and lateral toes.

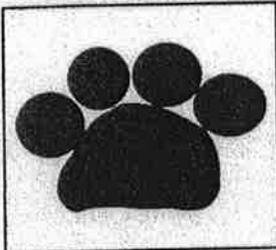
Avipeda ichnospecies K (Nyborg, 1998)



Dimensions:
19 cm L, 15 cm W

Description:
Very large track, lateral toes shorter than central toe. Distinct hind toe in line with central toe. Lateral toes angled seventy degrees from central toe.

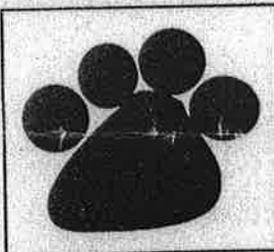
Bestiopeda (felipeda) ichnospecies A (Scrivner, 1984)



Dimensions:
max. pad: 7.2 cm L, 4.8 cm W
max. toes: 2.4 cm L, 2.5 cm W

Description:
Large, roughly hemispherical pad with four toes in curved row along anterior edge. Pad deeply impressed, toe impressions more shallow. No claw marks present.

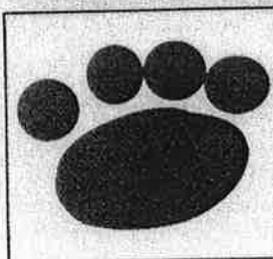
Bestiopeda (felipeda) ichnospecies B (Scrivner, 1984)



Dimensions:
max. pad: 7.6 cm L, 8 cm W
max. toes: 3 cm max. L, 2.6 cm W

Description:
Like *B.* ichnospecies A except pad more triangular in shape. Right side of pad inflated more than left. Depression near posterior edge of pad. Pad deeply impressed, toe impressions more shallow. No claw marks present.

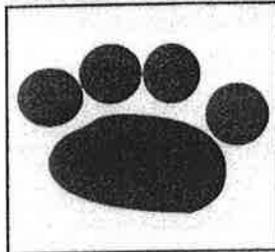
Bestiopeda (felipeda) ichnospecies C (Scrivner, 1984)



Dimensions:
max. pad: 3.9 cm L, 4.8 cm W
max. toes: 1.2 cm L, 2.2 cm W

Description:
Large, oblong-shaped pad with four toes in curved row along anterior edge. No claw marks present.

Bestiopeda (felipeda) ichnospecies D (Scrivner, 1984)



Dimensions:
max. pad: 2.1 cm L, 2.4 cm W
max. toes: 0.7 cm L, 0.9 cm W

Description:
Small track with oblong-shaped pad with four toes in curved row along anterior edge. One toe impression (far right toe) closer to pad than others. Toes nearly round. No claw marks.

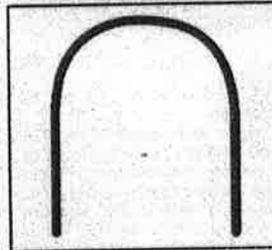
Bestiopeda (?) ichnospecies E (Nyborg, 1998)



Dimensions:
max. pad: 4.5 cm L, 4 cm W
max. toes: 2.5 cm L, 0.75 cm W

Description:
Large, roughly hemispherical pad. Narrow pear-shaped toes arranged in curved row along anterior edge of pad. One toe impression (far right toe) close to pad. Central toes set close together and distant from pad. Far left toe positioned left of pad moderate distance. No claw marks.

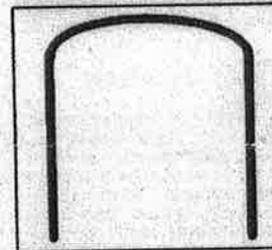
Hippipeda ichnospecies A (Scrivner, 1984)



Dimensions:
8 - 11.9 cm L, 5.3 - 7.2 cm W

Description:
Inverted U-shaped track, lateral edges parallel. Inside area of track may be concave downward. May have subtle v-mark at posterior end of track.

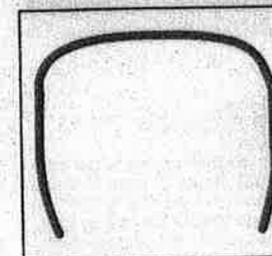
Hippipeda ichnospecies B (Scrivner, 1984)



Dimensions:
6.4 - 8.8 cm L, 6.2 - 8.8 cm W

Description:
Like *H.* ichnospecies A, except more square-shaped, wider with shorter sides. Inside area of track may be concave downward. No v-mark at posterior end of track.

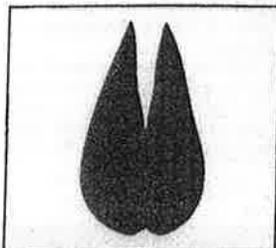
Hippipeda ichnospecies C (Scrivner, 1984)



Dimensions:
5.4 - 8 cm L, 5.4 - 7 cm W

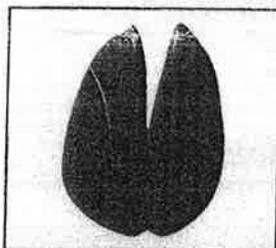
Description:
Inflated square-shaped track. Sides bowed out, posterior tips curve more strongly inward.

***Pecoripeda (Ovipeda) ichnospecies A* (Scrivner, 1984)**



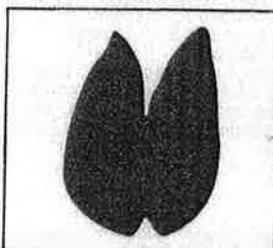
Dimensions:
6.5 - 26.5 cm L, 5.1 - 21 cm W
Description:
Oval-shaped tracks generally longer than wide. The outer margins of pads rounded, both pads subequal in size and shape. Pads widest near center of track, tapering to toes and somewhat to heel. Toe outlines sharp, toes pointing forward. The interdigital septum, or ridge, straight and narrow, connecting the space between toes with small indentation between the two pads in heel region.

***Pecoripeda (Ovipeda) ichnospecies B* (Scrivner, 1984)**



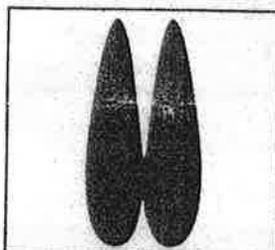
Dimensions:
6 - 22.7 cm L, 5.5 - 22.7 cm W
Description:
Similar to *P. ichnospecies A* except tracks more circular in shape, nearly as wide as long. Outside boundaries of pads considerably rounder. Toes sharp and point forward. Impression of septum straight and narrow. Indentation between pads in heel region connects to interdigital septum.

***Pecoripeda (Ovipeda) ichnospecies C* (Scrivner, 1984)**



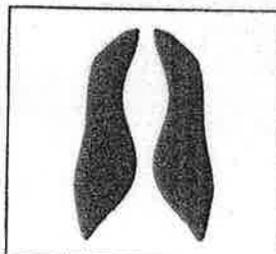
Dimensions:
4.2 - 13.7 cm L, 4.8 - 13 cm W
Description:
Track width subequal to length. Equal sized pads, very bulbous at heel, tapering towards toes. Points of toes may curve outward. Impression of interdigital septum straight, connects toes with deep indentation between pads in heel region.

***Pecoripeda (Ovipeda) ichnospecies D* (Scrivner, 1984)**



Dimensions:
13 - 17.5 cm L, 6.5 - 7 cm W
Description:
Narrow, trapezoidal shaped tracks, longer than wide. Pads equal in size, may be slightly bulbous at heel. Outside boundaries of pads straight to slightly curved. Toes usually directed slightly inward. Interdigital septum straight and narrow, commonly extends from heel to toe, generally deep in well-preserved casts.

***Pecoripeda (Ovipeda) ichnospecies E* (Nyborg, 1998)**



Dimensions:
5 cm long, 3.5 cm wide
Description:
Half-moon shaped tracks, longer than wide. Pads equal in size, bulbous near back. Two toes nearly come to point, heels widely spaced at forty-five degree angle. Broad gap midway along septum, pads do not contact.