THE SIGNIFICANCE OF FOSSIL FOOTPRINTS

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The art of animal tracking is an old one that goes back to the time when man was young in experience. Obermaier in his book, "The Fossil Man in Spain," shows some drawings made by Magdalenian man in the Pileta cave at Mágdala, Spain. In these drawings ancient man himself has shown how he used these as an aid in the hunt. Since the art is not confined to man alone, it is probable that it is one of the oldest of the arts, developed through long generations of experience. A modern development of this old art may be seen in the literature that has grown up around the tracks of fossil animals. With the rise of geology and palaeontology, a new science has developed that consists of a study and interpretation of the footprints found in the rocks. Nothing appears in the literature to show that any significance was attached to them until after 1800, when a Mr. Duncan wrote about those found in the Bunter sandstones at Dumfries, Scotland. There is a record that these tracks were found about 1812 but the description was given by Mr. Duncan in 1828.

In America the first interest in tracks came through the activities of Professor E. Hitchcock of Amherst, a teacher of geology. He reports that the first notice made was through one Pliny Moody, who found tracks around South Hadley in 1802. Other discoveries were made but nothing was written until Hitchcock began his long series of contributions to the subject. He called the study Ichnology, and coined the word Lithichnozoa or Stony Track Animals. His first paper was published in 1826, to be followed by a long series of books and papers that were a real contribution to the new field of animal study through their tracks.

Since Palaeontology was comparatively new, it added very little to the study and Hitchcock had to depend largely on modern material for comparison. This led him into many errors of interpretation. He collected large numbers of specimens and classified them into classes, and gave the individual specimens scientific

names, giving the argument that it was just as justifiable to give a track a name as to name an animal from a bone. The fine distinctions that he made are interesting in their variation. In his "Ichnology of New England", he lists on page 74 the following classification of the tracks:—

Bipeds	31
Quadrupeds	55
Marsupialoid animals	5
Thick toed birds	14
Narrow toed birds	17
Ornithoid lizards or batrachians	10
Lizards	17
Batrachians	11
Chelonia	8
Fishes	4
Crustacea, Myriopods, and Insects	18
Annelids	8

Lull, in 1915, worked over the material then available in the schools and institutions of the east, and published in "Triassic Life of the Connecticut Valley" a new list of the tracks that differed materially from those of the early writers. Aided by a thorough knowledge of the fossil animals of the region and by the advances that had been made in Palaeontology and Comparative Anatomy, he was able to determine with accuracy most of the specimens studied and described by Hitchcock. He narrowed down the list to 104:

Parasuchia	7
Dinosauria	38
Reptilia	37
Amphibia	15
Doubtful vertebrates	3
Invertebrates	4

These summaries from the two authors are quoted to show the growth of the subject with time and research. The birds have been completely eliminated from the group and placed in their proper places as tracks of reptiles. This belt of the Connecticut River Valley is

famous for having supplied some of the most magnificent specimens known to the scientific world. Although only a small area ninety miles long and three miles wide, it must have been the home of thousands of early tetrapods who left their footprints on the shores of the brackish, Triassic sea.

The conditions under which tracks are made are very closely circumscribed, since the mud must be soft enough to take an impression, and at the same time firm enough to hold it after it is made. If the mud is too soft the form of the impression is lost, and if it is too hard but faint impressions will be made. After they are made they must be filled with silt, eventually submerged, and finally turned to stone. Sun drying with final submergence will produce the same effect, as sun tracks are frequently seen in rock formations.

The readers of tracks become as expert as any of the primitive trackers, using the impressions to fill in gaps where the actual remains of animals have never been found. This knowledge becomes very important since often these foot imprints are all that remain of the animals that once lived in a locality. The large fauna of the Connecticut Valley would never have been suspected had it not been for the remains left in this form. The information gained from such a study is somewhat varied in its details but certain facts can be determined with exactness. Questions as to size and weight are fairly well answered if the class of the animal is known. The relation of the feet to the size of the animal varies much, since an animal with large feet may weigh no more than one with a much smaller foot. A bear and an elk may weigh the same but the foot proportion is very different, and no estimate of the weight of the animal could be given without certain information regarding the group to which it belonged.

The question as to whether the form is bipedal or quadrupedal is usually answered, especially when the imprint of the tail is found. Since bipedal animals generally have a much smaller forelimb, the imprint shows this fact very clearly. Many quadrupeds show the imprints of all four feet, but some troublesome

forms have the habit of planting the hind foot exactly in the imprint of the fore foot, thus obliterating or destroying the definiteness of the track of the anterior limb. The habit of pointing the posterior limbs posteriorly causes some of the amphibians to make a track that appears to be going both forward and backward at the same time. The gait of the animals is usually plain, since hopping, running, walking, and jumping each leave a very distinctive form. The type of the foot is very essential in placing the animal in its proper group, as the phalangeal formula is usually diagnostic and is well known in a comparative way. Some of the reptile imprints give very definite indications of the exact toe formulas, thus making the identification more certain.

A short summary of some of the known tracks gives an idea of the amount of valuable information that has been obtained from this part of the investigations of the paleontologists. Walcott describes Annelid tracks from Pre-Cambrian and a number of Trilobite tracks from the Cambrian. In "Cambrian Geology and Paleontology" he has identified these tracks with the actual species that made them. Arthropod tracks are quite common since they live under conditions that make preservation possible. Hitchcock described a number in his work on the Triassic. The specimens shown to the members of the Academy of Science represent a series collected by the writer in a bed of Triassic shale near Flagstaff, Arizona. They were quite plentiful at this place, but because of the sandy shale their preservation was not so good, and much material had to picked over to secure a fair series of the forms represented. A preliminary study shows that at least three forms were represented in this Arthropod fauna and that they are of a type undescribed in the literature, in so far as the writer has been able to discover. It is hoped that a more thorough report and analysis may be made at a future meeting of the Academy. A study has been made by a comparison with the tracks made by some of the modern forms, but nothing definite has been arrived at, because of the limited amount of material available. That they

represent some kind of Crustacea seems certain, but no idea of relationship can be stated at this time.

The amphibia have left many imprints to tell of their presence in the coal measures and in other formations, and this is to be expected, since they lived around water where preservation was possible. Since the amphibia do not live around salt water, their tracks must be looked for in fresh water deposits. A number have been found in coal measures in different parts of the world. The earliest tetrapod track known is probably an amphibian. The form known as Thinopus antiquus was found in Warren County, Pennsylvania, and presented to Yale University where it was described by Marsh. It is frequently pictured in the textbooks. Judging from the marked peculiarities of the foot it is a very early type of tetrapod and seems to be in some stage of transition. Martin, 1922, describes a specimen that he collected in the bed of a small stream near Lawrence, Kansas. It consists of a series of tracks in good condition, so that some estimate may be made of the form making it. He has called it Onychopus gigas and gives its probable weight as four or five hundred pounds. The coal measures of Kansas have supplied many other specimens of amphibian imprints that have been fully described by Marsh and others.

The tracks of reptiles seem to be the most common of all and have been found in all the countries of the world. Different parts of America have supplied them in large numbers, while France, Germany, England and South Africa have contributed their share. It is interesting to note that in the reptiles, a considerable number of the tracks have been associated with the animals that made them. This is made possible by the extensive study of this class and the well known characters of their feet and the imprint that they would make.

A colleague tells of a region in Texas where Dinosaur tracks in rock slabs are used as watering troughs for chickens—which is rather a wasteful use of scientific material of this kind.

Birds and mammals have left few evidences of their presence in this form, since they spent very little time

around places where their tracks could be preserved. The wading and water birds do live under conditions where track making is possible, but very little evidence has been discovered of unquestioned bird tracks. The large number of birds described by Hitchcock were all redescribed as those of reptiles by Lull in his studies. Tracks of birds have been reported from Kansas and from Mexico but they are doubtful specimens at the best.

One of the earlier tracks found in Europe was described as that of Archaeopteryx, but later investigation showed that it belonged to one of the smaller reptiles. At some future time we may expect to hear of the discovery of the track of Hesperornis regalis or some of the other well known water birds, but it is probable that both bird and animal foot prints will remain among the rare finds. It seems that our best examples of mammal tracks will be found in those of Canis and Homo, left in the cement of our modern sidewalks.

The chief interest of the fossil footprint lies in the fact that they make the animals live again in our imagination and give intimate records of their activities.

The finding of the tracks of animals long since extinct make a new and vital contact with these forms and adds materially to our interest, since they give us something that their fossil skeletons cannot tell.