

## **Importance of Dinosaur Remains (Mostly Footprints) for Science Tourism in the National Park Brijuni Islands (Istria, Croatia)**

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*First research on the dinosaur footprints, of the Brijuni Archipelago began in 1925, with the paper of the Austrian industrialist Bachofen-Echt, who described two types of footprints. After him few others were interested in the same region. Today's territory of Istria with the Brijuni Archipelago made up a part of the larger paleogeographic unit, so-called Adriatic-Dinaridic carbonate platform, more or less isolated within the known Mesozoic Tethys ocean. However, it should necessarily be presumed that there existed some sort of connection between the platform and the continent since numerous fossil footprints are autochthonous, so that the platform was raised above the sea level and partially under shallow seas and inhabited by mainland vertebrates. Such continental phases – emersions in the evolution of the platform enabled the existence of dinosaurs in these areas. The presumption and the question of whether the platform was connected to the African continent still need to be answered (judging by the similarity of the faunas) although there were temporary isolations during the Cretaceous period (Albian-Cenomanian stages). The Brijuni Archipelago is today certainly one of the most attractive tourist destinations in Croatia. The paleontological findings of the dinosaurs are undoubtedly one of the prime issues of the so-called scientific tourism.*

The results of geologic and sedimentologic research indicate that the Adriatic-Dinaridic carbonate platform in its continental phase very probably had the shape of a numerous flat islands surrounded by tidal flats, shallow bays and lagoons. The arrangement of the oceans and continents in the period of dinosaurs was completely different from today, so that the look of our planet Earth differed from today. Thus, during the Cretaceous period, the area of the Adriatic was partially dry land and partially shallow sea area (the so-called carbonate platform), divided from the former Tethys ocean by numerous islets.

Proofs of the existence, behavior, locomotion and diet of the dinosaurs in Istria and the Brijuni Archipelago, like in the rest of the world, are related to the findings of their skeletons and fragmentarily preserved bones, and, especially in Istrian area, of their footprints, which can be preserved either as individual footprints or as a sequence of footprints (trackway). Based on such findings, we can decipher their characteristics: were they quadrupedal or bipedal dinosaurs; were they walking by means of leaning on the entire foot or on toes only, what was the shape of feet and number of toes, the existence of claws, as well as the possibility of estimating the size of individual animals. The trackways help us “read” whether the animal ran or moved slowly, lived alone or in herds, and similar.

According to the size of footprints, we can estimate the size of dinosaurs, whereas the distance between the sequences of footprints made by the same leg indicates the speed of dinosaurs. Such estimates are based on the ratio between the stride length and the hip height. Dinosaur footprints are usually found within sedimentary rocks, in layers deposited at depths lower than 3 meters and on shoals what is proved with the other fossils whose life indicates such shoals such as various fossil calcareous algae (*Salpingoporella melatae*, *S. genevensis*, *S.*

*urladanasi*) foraminifera (*Nezzazata isabellae* Arnaud-Vanneauj & Sliter ., *Scandonea* aff. *phoenissa* Saint-Marc, *Pseudonummoloculina aurigerica* Calvez, *P. heimi* (Bonet); as well as indicative sedimentary structures – ripple marks.

Dinosaurs that moved across Istrian area, judging primarily by reconstructions based on the footprints and fossil bones, compared to similar dinosaur fauna of Africa and Eurasia, as we have already stated, had smaller dimensions. This fact (in case the specimens were not juvenile or sub-adult) proves the biologic thesis that large specimens in isolated areas (islands) become smaller, dwarfish, and endemic in a relatively short period (e.g. elephants on Channel Islands, California became smaller during Pleistocene over the period of thousands of years). On the other hand, the same period was not that short in geologic sense for dinosaurs; it could have lasted for several millions of years. In terms of time, it would correspond to the middle part of the Cretaceous period (between about 110 million years and 90 million years ago).

Herbivorous dinosaurs that lived in the area ate leaves from large trees (various conifers, ferns, cycas, ginkgo and other angiosperms of the period), while carnivorous dinosaurs fed on all what they would catch, including herbivorous dinosaurs.

Dinosaur footprints can be preserved in the form of ichnofossils in the case they moved across soft soil thus leaving traces. The traces could be preserved if the footprints were covered with sediment relatively quickly. The covering sediment had to be different from the surface into which the footprints were imprinted and they had to remain untouched until the diagenetic processes lithified the sediment transforming it into consolidated rock.

We know that when we walk on the beaches and leave our footprints in wet sand or mud, they get washed away by waves or by tides and rains. It is thus easy to conclude that the probability of the preservation of footprints is quite exceptional, so that fossil tracks of dinosaurs are relatively rare and thus quite valuable.

Austrian industrial Bachofen-Echt discovered the first dinosaur traces on Veliki Brijun Island in 1925 [1]. Bachofen-Echt assigned the tridactyl footprints to the *Iguanodon* species. We now know with certainty that the prints nevertheless belong to “some” carnivorous dinosaur from the group of Theropoda. In subsequent periods, footprints were also documented by Polšak [2], Velić & Tišljarić [3], and others.

First substantial and intensive paleoichnologic research began in the 1990s, as a global trend of the so called "dino-tracking". The research was undertaken by the Italians, especially by F.M. Dalla Vecchia and his team of the Paleontology Museum in Monfalcone [4], as well as by the authors of this text [5].

### **Localities with dinosaur footprints on Veli Brijun island**

Four localities with nicely recognizable dinosaur footprints have been discovered on the island of Veli Brijun. The localities are situated on promontories Pogledalo/Barban, Ploče, Kamik/Plješivac, and Trstike/Debela Glava (Fig. 1). There are more than two hundred single footprints as well as numerous trackways.

61 footprints of a large bipedal carnivore have been found on the Pogledalo/Barban promontory (Fig. 2). Based on footprint length, the length of dinosaurs has been estimated to 7.5 - 8 m. The diversity of dinosaur footprints is related to different sediment consistency.

They are of Late Barremian age, and we presume that these dinosaurs were most similar to alosaurid theropods.

The remaining three localities are found in sediments of the Upper Albian stage. 60 footprints of small bipedal carnivore whose lengths have been estimated to 3 - 4 m (Fig. 3) were found on the Ploče promontory, which would most probably indicate the fact that they were small 'coelurosaurian' carnivores, very aggressive and agile predators.

About sixty footprints have been found on the Kamik/Plješivac promontory. They belong to large bipedal herbivores and small bipedal carnivores (Fig. 4). Bipedal herbivores attained the length from 6 – 6.5 m, and the carnivora the length of 3.5 m. Herbivores probably belonged to the iguanodontid dinosaurs, and the carnivora like the already mentioned representatives of the 'coelurosaurian' dinosaurs.

The locality Trstike/Debela Glava has about thirty footprints of four-legged herbivorous dinosaurs. Their lengths have been estimated to about fifteen meters, and they were most probably representatives of the Sauropoda group.

It is assumed on the basis of calculated parameters that the speed of dinosaurs inhabiting these localities ranged from 2 – 2.5 km/h for sauropod dinosaurs (herbivores), (which equals the speed of slow walk) and from 5 – 7 km/h, even up to 10 km/h for theropod carnivorous dinosaurs.

Along with these four localities, individual tracks can be seen immediately upon leaving the ship and stepping on the main pier of the port of Veli Brijun island. In the one of the limestone block which was brought there, one can see a tridactyl footprint, probably belonging to a large carnivorous dinosaur of the Theropoda group.

Together with Veli Brijun Island, we can find remnants of dinosaur locomotion and their trackways also in the rest of the Brijuni archipelago (Vanga, Galija and other islands).

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**FIGURES:**



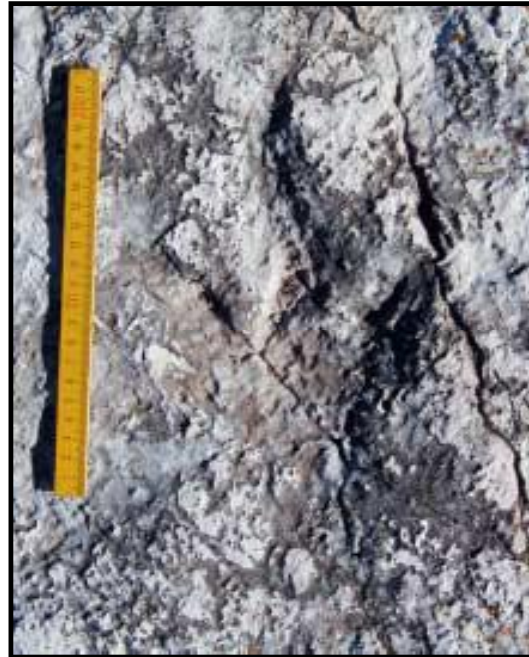
Figure 1: Localities with dinosaur footprints on the Veli Brijun Island.



Figure 2: Footprint of the theropod dinosaur on the Pogledalo/Barban promontory (Late Barremian)



**Figure 3: Footprint of the theropod dinosaur from the Ploče promontory (Late Albian).**



**Figure 4: Footprint of the theropod dinosaur from the Kamik/Plješivac promontory (Late Albian).**