



**BRIJUNI**  
NACIONALNI PARK



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# Šetalište dinosaura Promenade of Dinosaurs

ZLATAN BAJRAKTAREVIĆ & ALEKSANDAR MEZGA



Ilustracije / *Illustrations*: Joe Tucciarone

# Brijuni

Šetalište dinosaura

Promenade of Dinosaurs

Brijunsko otočje ili brijunski arhipelag danas svakako predstavlja jednu od najatraktivnijih turističkih destinacija u Hrvatskoj, gdje u okviru tzv. znanstvenog turizma značajno mjesto zauzimaju i paleontološki nalazi tragova kretanja dinosaura, tih veličanstvenih “strašnih guštera” koji su vladali Zemljom oko 160 milijuna godina (od razdoblja gornjeg trijasa, prije oko 220 mil. g., pa do kraja razdoblja krede, prije 65 milijuna godina, kada izumiru, slika 1).

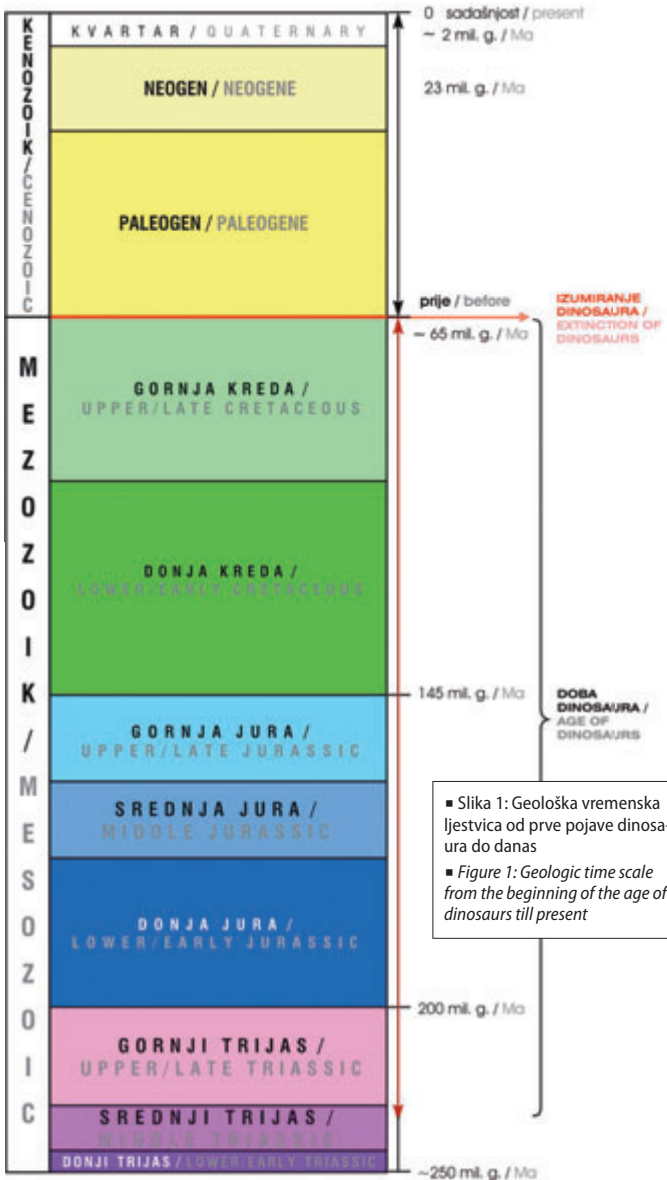
Najveći pronađeni skeleti koji su u cjelosti sačuvani (nađeni u Americi, Aziji i Africi) dužine su preko 25 m. Nalazi necjelovitih skeleta, na temelju hipotetskih rekonstrukcija iznose i oko 40-tak metara, te težine i preko 50-tak tona. Dinosauri su u okviru značajne mezozojske skupine gmazova (Reptilia) vladali svjetskim kontinentima.

Nastanjivali su i područje današnje, posebno zapadne Istre, a u okviru nekadašnjeg zajedničkog kopna i područje Brijuna. No, tu je bitno naglasiti da se na temelju rekonstrukcija i proračuna zaključilo da su “hrvatski” dinosauri po dimenzijama bili manji u usporedbi s navedenim divovima.

*The Brijuni Archipelago is today certainly one of the most attractive tourist destinations in Croatia. The paleontological findings of the dinosaurs, the magnificent “horrible reptiles” which ruled planet Earth for more than 160 million years (from Late Triassic period, about 220 million years ago, to the end of the Cretaceous period 65 million years ago when they went extinct, Figure 1). They are undoubtedly one of the prime issues of the so-called scientific tourism.*

*These giants with largest skeletons found in America, Asia, and Africa were over 25 m long, while, based on some fragmentary skeletons, they even reached the length of more than 40 meters and weighed over 50 tons.*

*Dinosaurs were the part of a significant Mesozoic group of reptiles (Reptilia), supremely rules world continents and they also inhabited the area of today's Istria including Brijuni archipelago, which were then a part of the larger continent. However, it needs to be pointed out that reconstructions and calculations have indicated that the dimensions of the “Croatian” dinosaurs were somewhat smaller than their contemporary relatives.*



■ Slika 1: Geološka vremenska ljestvica od prve pojave dinosa-ura do danas  
 ■ Figure 1: Geologic time scale from the beginning of the age of dinosaurs till present

U čitavoj priči treba naglasiti da je raspored mora i kontinenta u geološkoj prošlosti bio bitno drugačiji, odnosno paleogeografska pozicija čitavog područja današnje Istre bila je mnogo južnije nego danas. Jednostavnije rečeno raspored litosfernih ploča u doba dinosaura bio je potpuno različit od današnjeg, tako da je naša Zemlja kao planet imala drugačiji izgled nego danas. Tako je tijekom krednog perioda, Jadransko područje bilo dijelom kopno, a dijelom plitkomorsko područje (tzv. karbonatna platforma), kojeg su brojni otočići dijelili od tadašnjeg velikog Tethys oceana.

Današnje područje Istre s brijunskim otočjem činilo je dio tzv. Jadransko – dinaridske karbonatne platforme, koja je djelomice bila izolirana unutar poznatog mezozojskog Tethys oceana (tzv. “intraoceanska platforma”). No evidentno je i za pretpostaviti, da je morala postojati povezanost takve platforme s kontinentom, jer mnogobrojni fosilni otisci su autohtoni, tako da je takva platforma bila izdignuta iznad nivoa mora, a dijelom i pod plitkim morem i nastanjena kopnenim kralježnjacima. Takve kopnene faze (emerzije) omogućile su obitavanje dinosaura u tim prostorima. Pretpostavka je, da

*It should also be emphasized that the arrangement of the oceans and continents was much different in the geologic past, and the paleogeographic position of the Istria was much more to the south than today. It is presumed that the Istrian dinosaurs originated from the African continent.*

*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, 100 million years ago). Results of geologic and sedimentologic research indicate that the*

je ta platforma bila povezana s Afričkim kontinentom (sudeći po sličnosti faune, a možda dijelom i s južnim rubom Euroazije) iako je tijekom razdoblja krede bilo i njenih povremenih izolacija (od alba do cenomana, prije oko 100 mil.g.). Mnogostruki rezultati geoloških i sedimentoloških istraživanja ukazuju na to, da se platforma u svojoj kopnenoj fazi sastojala od niza zaravnjenih otoka okruženih plimnim ravninama, kao i plitkim zaljevima i lagunama.

Dokazi postojanja dinosaura, njihova načina života, kretanja, hranjenja i sl., kako svuda po svijetu, tako i u Istri i na Brijunskom otočju vezani su uz nalaze njihovih koštanih skeleta i fragmentarno sačuvanih kostiju, te, kod nas najčešće, uz otiske njihovih stopala, bilo kao pojedinačnih otisaka ili kao staza. Na temelju takvih nalaza možemo odgonetnuti njihove osobine: četveronožnost (kvadripediju) ili dvonožnost (bipediju); hodanje oslanjanjem na cijelo stopalo ili samo na prste; oblik stopala i broj prstiju; postojanje kandži, a moguća je i procijena veličine jedinke. Iz staza "čitamo" da li je životinja trčala ili se polagano kretala, bila sama ili u krdu i sl. Prema veličini otisaka stopala procjenjujemo veličinu jedinke, a iz udaljenosti uzastopnih oti-

*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's, so that the look of our planet Earth differed from today's. 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, behaviour, 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,*

saka koje je napravila ista noga (iskorak), njenu brzinu kretanja. Procjene se temelje na omjeru između dužine iskoraka i visine kukovlja.

Otisci kretanja dinosaura vezani su za sedimentne stijene, koje najčešće nalazimo u slojevima, koji su taloženi na dubinama manjim od 3 metra i plićacima koji su dokumentirani i ostalim fosilima čiji život ukazuje na takve plićake kao npr. razne fosilne vapnenačke alge, foraminifere i drugi mikrofosilni organizmi; kao i indikativne sedimentne strukture npr. riplovi - fosilne valne brazde (slika 2). Dimenzije nadenih otisaka na području Brijunskog arhipelaga u prosjeku se kreću od oko 15 – 30-tak cm.

Dinosauri koji su se kretali po današnjem području Istre, sudeći prvenstveno po rekonstrukcijama koje se temelje na pronađenim otiscima kao i po nalazima fosilnih kostiju (podmorje Uvale Kolone JZ od mjesta Bale), a u usporedbi sa sličnom dino-faunom Afrike i Euroazije bili su, kao što je već rečeno, manjih dimenzija. Ta činjenica (ukoliko se ne radi o juvenilnim ili subadultnim primjercima) ide u prilog opće poznatoj biološkoj činjenici, da krupni primjerci nekih vrsta

*we can estimate the size of dinosaurs, whereas the distance between the sequence of footprints made by the same leg indicate 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, foraminifera and other microfossil organisms; as well as indicative sedimentary structures – ripple marks (Figure 2).*

*Dinosaurs that moved across Istrian area, judging primarily by reconstructions based on the footprints and fossil bones, (subsurface of Uvala Kolone SW from Bale) 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;*





- Slika 2: Fossilne valne brazde – riplovi, Rt Ploče (starost gornji alb: prije oko 100 mil. g.)
- *Figure 2: Fossil ripple marks, Promontory Ploče (Late Albian: about 100 Ma ago)*

životinja na izoliranim (otočnim) prostorima postaju manji tj. patuljasti i endemski i to u relativno kratkom vremenskom periodu, kao (npr. mamuti na Channel Islands, California). Ti su mamuti postali manji tijekom pleistocena u periodu od svega nekoliko tisuća godina, dok su nalazi dinosaura u Istri prisutni u slojevima čija razlika u starosti iznosi i više milijuna godina.

Biljožderni dinosauri, koji su živjeli na tom području hranili su se lišćem velikih stablašica (razne četinjače, preslice, paprati, ginkgo i ostale tadašnje gološjemenjače), dok su se mesožderni dinosauri (predatori) hranili svim što bi uspjeli uloviti, pa tako i biljoždernim dinosaurima.

Otisci kretanja dinosaura fosilno su se mogli sačuvati ukoliko su se oni kretali preko mekane podloge i na taj način ostavljali tragove. Da bi se ti tragovi mogli sačuvati, otisci trebaju biti relativno brzo pokriveni sedimentom, koji je različit od podloge u kojem su otisnuti i trebaju ostati netaknuti sve dok dijagenetski procesi ne "očvrstnu" (litificiraju) sediment i pretvore ga u konsolidiranu stijenu (u našim područjima najčešće je to vapnenac).

*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 (predators) 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 "solidified" (lithified) the sediment transforming it into consolidated sediments.*



Imajući iskustvo, da hodajući npr. po današnjim plažama u mokrom pijesku i mulju ostavljamo otiske, koje valovi ili plima, te kiše vrlo brzo unište, onda nam je jasno da vjerojatnost sačuvanja otisaka nije česta, pa su zato fosilni otisci stopala dinosaura relativno rijetki i stoga tako dragocjeni jer i predstavlja-ju autohtone nalaze.

*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.*

## Otisci stopala dinosaura na Velom Brijunu *Dinosaur footprints on Veli Brijun island*

Prve tragove kretanja dinosaura na Velom Brijunu otkrio je 1925. godine austrijski industrijalac Bachofen-Echt. Otkrivene otiske, odnosno najljepši tridaktilni (troprsti) otisak, Bachofen-Echt je pripisao rodu *Iguanodon*, no za taj otisak danas sigurno znamo da pripada ipak "nekom" mesojednom dinosauru iz skupine Theropoda. Kasnije su nalaze otisaka na Brijunima registrirali i Ante Polšak (1965), te Ivo Velić & Josip Tišljar (1987) i dr. Prva studioznija i intenzivnija paleoichnološka istraživanja (dio paleontologije koji proučava sve vidove kretanja fosilnih životinja, pa tako i dinosaura) započinju devedesetih godina prošlog stoljeća, kao rezultat općeg globalnog trenda (tzv. "dino-tracking"). Ta su istraživanja radili Talijani, posebno F.M. Dalla Vecchia i njegov tim iz Paleontološkog muzeja u Monfalconeu (Italija), kao i autori ovog teksta.

*Austrian industrial Bachofen-Echt discovered the first dinosaur traces on Veli Brijun island in 1925. Bachofen-Echt assigned the tridactyl (three-fingered) footprints to the Iguanodon genus. 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: A. Polšak (1965), I. Velić & J. Tišljar (1987), and others. First substantial and intensive paleoichnologic research (paleoichnology is a special branch of paleontology researching all forms of locomotion of fossil animals, including dinosaurs) 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 (Italy), as well as by the authors of this text.*

## Velobrijunski lokaliteti s otiscima stopala dinosaura

Na otoku Veli Brijun pronađena su četiri lokaliteta s lijepo vidljivim otiscima stopala dinosaura. Ti lokaliteti nalaze se na rtovima Pogledalo/Barban, Ploče, Kamik/Plješivac i Trstike/Debela Glava (slika 3).

## Localities with dinosaur footprints on Veli Brijun island.

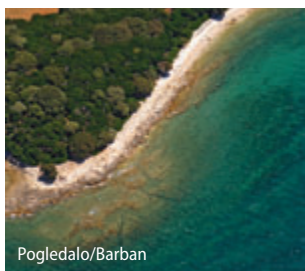
Four localities with nicely recognizable dinosaur footprints have been discovered on the island of Veli Brijun. The localities are situated on promontories Pogledalo/Barban, Ploče, Kamik/Plješivac, and Trstike/Debela Glava (Figure 3).



- Slika 3: Lokaliteti s otiscima stopala dinosaura
- Figure 3: Localities with dinosaur footprints



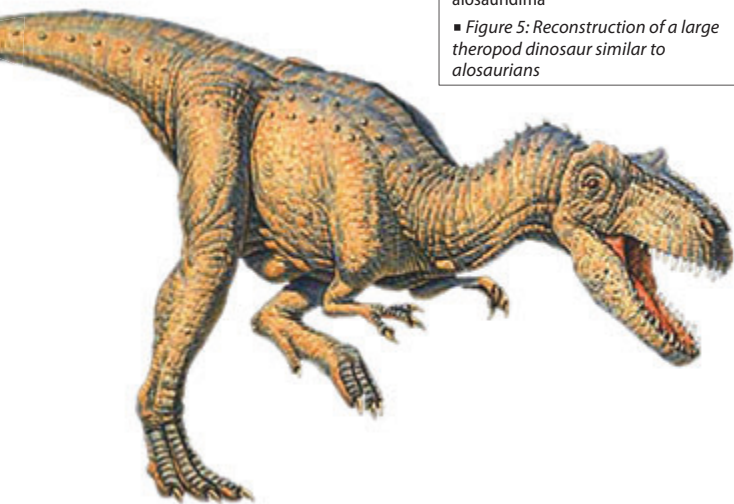
- Slika 4: Otišak teropodnog dinosaura na rtu Pogledalo/Barban (starost gornji barem: prije 130-125 mil.g.)
- *Figure 4: Footprint of a theropod dinosaur on the Pogledalo/Barban promontory (Late Baramian: 130-125 Ma ago)*



Ukupno je pronađeno preko dvjestotinjak otisaka. Na rtu Pogledalo/Barban nađen je 61 otisak krupnih dvonožnih mesojeda (slika 4). Na temelju otisaka njihova dužina je procijenjena na 7.5–8 m. Uslojeni sedimenti (uglavnom vapnenci) u kojima su sačuvani ti otisci gornjobaremske su starosti (prije 130–125 mil. g.), a ti dinosauri pretpostavljamo da su bili slični alosauridima (slika 5).

*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 (Figure 4). Based on footprint length, the length of dinosaurs has been estimated to 7.5 - 8 m. Layered sediments (mostly limestones) with dinosaur footprints are of Late Baramian age (a period 130 - 125 million years ago), and we presume that these dinosaurs were most similar to alosaurid theropods (Figure 5).*



■ Slika 5: Rekonstrukcija krupnog teropodnog dinosaura sličnog alosauridima

■ Figure 5: Reconstruction of a large theropod dinosaur similar to alosaurians



- Slika 6: Otisak teropodnog dinosaura s rta Ploče (starost gornji alb: prije oko 100 mil.g.)
- *Figure 6: Footprint of a theropod dinosaur from the Ploče promontory. (Late Albian: about 100 Ma ago)*



Ostala tri lokaliteta nalaze se u slojevitim vapnencima gornjoalbske starosti (prije oko 100 mil. god.). Na rtu Ploče nađeno je 60 otisaka malih dvonožnih mesojeda čija je dužina procijenjena na 3–4 m (slika 6) što bi najvjerojatnije upućivalo da se radi o mesožderima sličnima iz skupine Coelurosauria, koji su bili vrlo agresivni i okretni kao pravi napadači (predatori). (slika 7).

■ Slika 7: Rekonstrukcija malog teropodnog dinosaura sličnog coelosaurima

■ Figure 7: Reconstruction of a small theropod dinosaur similar to coelurosaurians



Ploče

*The remaining three localities are found in sediments of the Upper Albian stage (ca. 100 million years ago).*

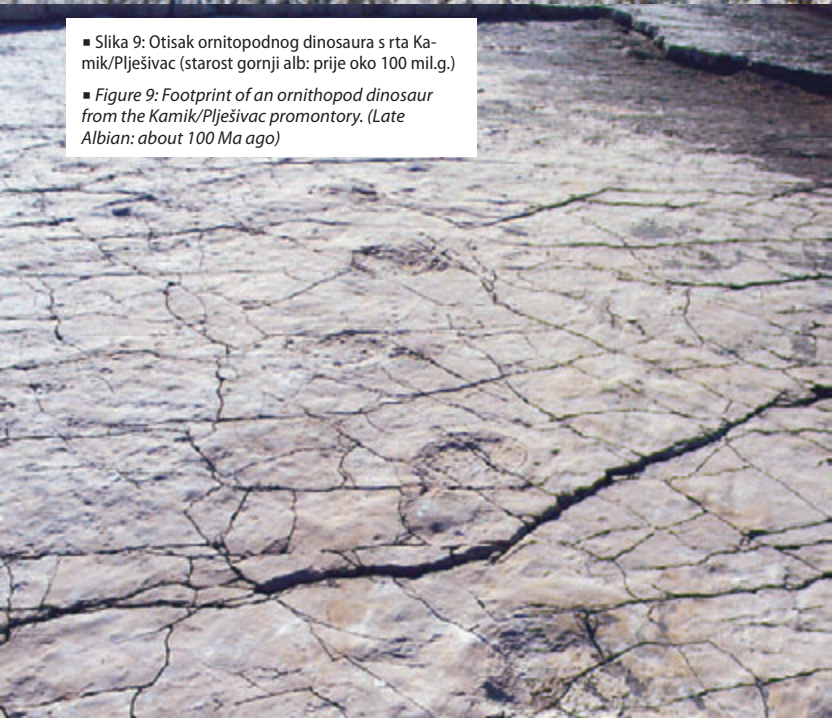
*60 footprints of small bipedal carnivore whose lengths have been estimated to 3 - 4 m (Figure 6) were found on the Ploče promontory, which would most probably indicate the fact that they were small 'coelurosaurian' carnivores, very aggressive and agile predators (Figure 7).*





■ Slika 8: Otisak teropodnog dinosaura s rta Kamik/Plješivac (starost gornji alb: prije oko 100 mil. g.)

■ *Figure 8: Footprint of a theropod dinosaur from the Kamik/Plješivac promontory. (Late Albian: about 100 Ma ago)*



■ Slika 9: Otisak ornitopodnog dinosaura s rta Kamik/Plješivac (starost gornji alb: prije oko 100 mil.g.)

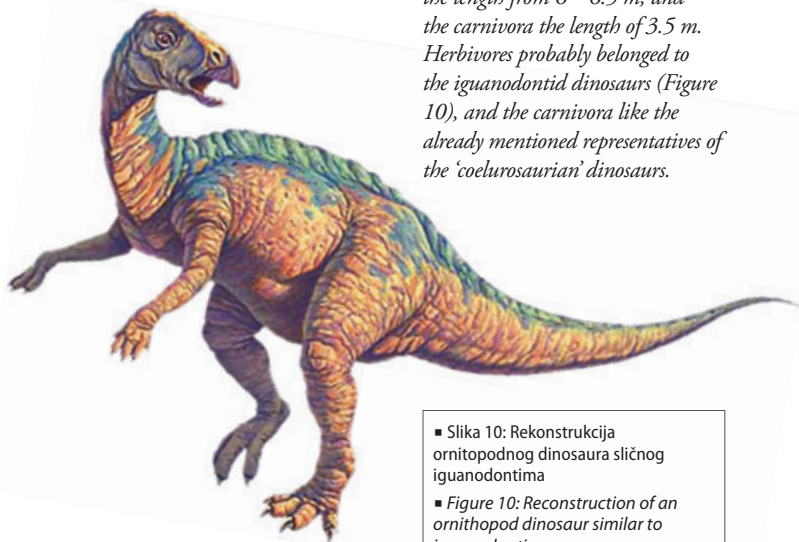
■ *Figure 9: Footprint of an ornithomimid dinosaur from the Kamik/Plješivac promontory. (Late Albian: about 100 Ma ago)*

Šezdesetak otisaka pronađeno je na rtu Kamik/Plješivac. Radi se o otiscima krupnijih dvonožnih biljojeda i malih dvonožnih mesojeda (slike 8 i 9). Dvonožni biljojedi su vjerojatno bili reda veličine 6–6.5 m, a mesojedi oko 3.5 m dužine. Biljojedi najviše nalikuju ornitopodnim dinosaurima odnosno iguanodontidima (slika 10), a mesojedi već spomenutim predstavnicima iz skupine Coelurosauria.



Kamik/Plješivac

*About sixty footprints have been found on the Kamik/Plješivac promontory. They belong to large bipedal herbivores and small bipedal carnivores (Figures 8 and 9). 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 (Figure 10), and the carnivora like the already mentioned representatives of the 'coelurosaurian' dinosaurs.*



- Slika 10: Rekonstrukcija ornitopodnog dinosaura sličnog iguanodontima
- Figure 10: Reconstruction of an ornithopod dinosaur similar to iguanodontians



■ Slika 11: Otisci sauropodnih dinosaura na rtu Trstike/ Debela Glava (starost gornji alb: prije oko 100 mil.g.)

■ *Figure 11: Footprints of the sauropod dinosaurs on the Trstike/Debela Glava promontory. (Late Albian: about 100 Ma ago)*

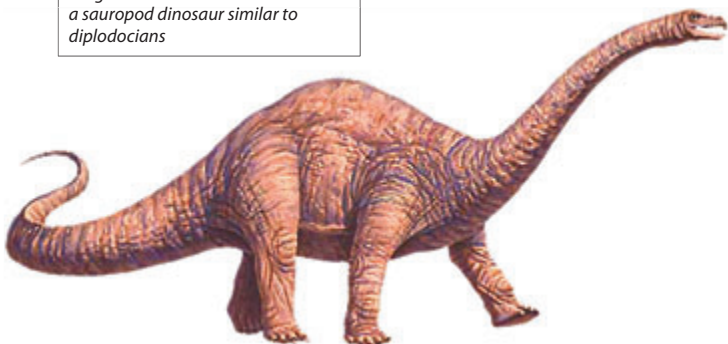


Lokalitet Trstike/Debela Glava broji oko tridesetak otisaka četveronožnih biljojednih dinosaura (slika 11). Njihove dužine procijenjene su na oko petnaestak metara, a najvjerojatnije se radi o predstavnicima skupine Sauropoda. (slika 12).

*The locality Trstike/Debela Glava has about thirty footprints of four-legged herbivorous dinosaurs (Figure 11). Their lengths have been estimated to about fifteen meters, and they were most probably representatives of the Sauropoda group (Figure 12).*

■ Slika 12: Rekonstrukcija sauropodnog dinosaura sličnog diplodokoidima

■ Figure 12: Reconstruction of a sauropod dinosaur similar to diplodocids



Pretpostavlja se da je brzina kretanja dinosaura s navedenih lokaliteta na temelju određenih parametara, za manje primjerke Sauropoda (biljojeda) iznosila od 2–2.5 km/h, (što bi odgovaralo sporom hodu), a za teropodne napadače mesoždere od 5–7, pa i do 10 km/h.

Osim na ova četiri opisana lokaliteta, pojedinačne otiske možemo vidjeti pri samom silasku s broda na glavni mol velobrijunske luke, gdje je u donešenom (alohtonom) kamenom bloku vapnenca vidljiv tridaktilni (troprsti) otisak, vjerojatno krupnog mesojeda iz skupine Theropoda (slika 13).

Osim na Velom Brijunu otiske kretanja dinosaura, kao i njihove staze možemo pronaći i na ostalim Brijunskim otocima (Vanga, Galija i dr.).

*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 (predators).*

*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 (Figure 13).*

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



- Slika 13: Otisak teropodnog dinosaura na molu u velobrijunskoj luci
- *Figure 13: Footprint of a theropod dinosaur on the pier of the port of Veli Brijun island.*



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dinosauria  
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