THEROPOD FOOTPRINTS IN THE CRETACEOUS
ADRIATIC-DINARIC CARBONATE PLATFORM
(ITALY AND CROATIA)

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ABSTRACT: Theropod footprints are known in ten sites of late Hauterivian/early Barremian (1), late Barremian (1), late Albian (5) and late Cenomanian (3) age on the Adriatic-Dinaric carbonate platform (Italy and Croatia). Most of the footprints belongs to small- to medium-size individuals; large ones are known in the upper Hauterivian-upper Barremian sites and are much rarer in upper Albian ones. Small- to medium-size theropods are associated with small sauropods in the late Albian and perhaps in late Cenomanian. Most of the footprint-bearing beds are marine carbonates exposed to subaereal desiccation in tidal or lagoon settings. Data suggest that theropods were just passing through these environments. The Adriatic-Dinaric carbonate platform is a special case of an intraoceanic, or at best very far away from any continental area, carbonate platform with a local dinosaur fauna.

INTRODUCTION

The Adriatic-Dinaric carbonate platform is a fossil carbonate platform of Jurassic-Cretaceous age. It was involved in Alpine-Dinaric orogeny and at present it crops out mainly in NE Italy (Pre-Alps, Karst), SW Slovenia (Karst, Istria), W Croatia (Istria, Dinarids), W Bosnia and Montenegro (Dinarids).

Sites with dinosaur fossils are found in Cretaceous limestones exposed along the western coast of the Istrian peninsula (Croatia), in Istrian islands, in the Italian Karst (Trieste) and in a block quarried in the Cansiglio Plateau (NE Italy) (for references see DALLA VECCHIA, 1997 and DALLA VECCHIA & TARLÃO, 1995). Footprints probably made by theropods are present in most of these sites (Fig. 1).

The detailed study of the Istrian sites from paleoichnologic, stratigraphic and sedimentologic point of view is in progress by the part of the writer, I. Vlahovic, S. Venturini, G. Tunis and A. Tarlao.

Since the Istrian region is bilingual (Croatian and Italian), I report two names (when existing) for each locality.

METHODOLOGICAL ASPECTS

Cretaceous tridactyl dinosaur footprints are generally attributed to theropod or ornithopod dinosaurs. Features characterizing footprints supposed to have been impressed by theropod dinosaurs (e.g. belonging to bipedal tracks, presence of claw marks, elongate and narrow digit prints, etc.) are reported in the main paleoichnological works (HAUBOLD, 1971; LOCKLEY, 1991; THULBORN, 1990) and in several papers dealing with local ichnoassociations (e.g. LEONARDI, 1984; PITTMAN, 1989).

Following these features most of the tridactyl, mesaxonic footprints, often organized in bipedal tracks found in the Cretaceous limestones of Adriatic-Dinaric carbonate platform are here considered to be theropod footprints.

Footprints in a track rarely have the same size: I report for each trackway just one value of L which corresponds to the media of the lengths or the length of the best preserved print. I consider small-size theropods those with L<15 cm, middle-size those with 15< L<25 cm and large when L>25 cm.

The estimation of V has been based on the equation by ALEXANDER (1976); h has been calculated by ALEXANDER (1976) method and by the allometric equations of THULBORN (1989). AWS was calculated by equation 10.6 in THULBORN (1990). Following THULBORN (1990: 260) the dinosaurs were considered running when SL/h>2.9.

PALEOGEOGRAPHICAL SETTING

The Adriatic-Dinaric carbonate platform was a roughly N-S elongated structure bordered W, E and N by marine basinal areas (i.e. Ionian basin, Bosnian Basin, Tolmin trough, etc.) (see for example, CATI, SARTORIO & VENTURINI, 1989; ZAPPA-TERRA, 1990). As a carbonate platform it is
Dinaric carbonate platform was completely separated from continental areas, dominated by siliciclastic fluvial-lacustrine sedimentation. However, the affinity with the associations of foraminifers of Northern Africa, suggests a strict connection with the African-Arabian continent during Hauterivian-Barremian (CHERCHI & SCHROEDER, 1973). There is a general agreement that it was separated from the Arabian-African plate by the opening of the Eastern Mediterranean Ocean during Early Aptian.

DATA

UPPER HAUTERIVIAN/LOWER BARREMIAN

Sarone, Cansiglio Plateau, Pordenone province, NE Italy.

A limestone block with a large (L=36 cm) theropod footprint preserved as positive hiporelief, was discovered in the pier of Ravenna (Fig. 1(1), 2A, 3A). Also a sauropod manual print is preserved along with the theropod footprint (DALLA VECCHIA, in press). The block comes from a quarry open in the Cretaceous limestones of the southern flank of the Cansiglio Plateau, northern point of the Adriatic platform (DALLA VECCHIA & VENTURINI, 1995). The infilling is a wackestone with foraminifers and ostracods while the stratigraphical section from which the block comes is composed mainly of mudstones with ostracods and desiccation structures, and pedogenetic breccias, sometimes with black pebbles.

Kolone, Bale/Valle, SW Istria, Croatia.

This locality preserves dinosaur bone remains in carbonate lacustrine sediments (DINI, TUNIS & VENTURINI, 1998; TUNIS, ŠPARICA & VENTURINI, 1994). It is a rich outcrop which unfortunately lies below the present sea level. For this reason only a limited number of specimens, (about 200) mostly fragmentary, were collected. Most of the identifiable bones belong to small to large-size titanosaursiform, diplodociform and, perhaps, camarasaaurid sauropods (DALLA VECCHIA, 1994, 1998). Only recently a tooth and an ungual phalanx belonging to small theropods were discovered. The tooth is a shed crown 12.5 mm long, resembling those of the velociraptorine dromeosaurids (see CURRIE, RIGBY & SLOAN, 1990), because it is laterally compressed, elongate and recurved, and denticles of the distal carina are decidedly larger than the mesial ones. In fact, in the upper part of the tooth there are six denticles per mm on the distal carina and eight denticles per mm on the mesial carina ("dentine size difference index" of RAUHUT & WERNER (1995) is therefore 1.33). However, the preserved denticles do not point apically like those of the teeth of velociraptorine dromeosaurids. The very small (8.75 mm long) ungual pha-
Fig. 2 - Theropod footprints. A - Sarone, Cansiglio Plateau (NE Italy), upper Hauterivian-lower Barremian. B - Pogledalo/Salsa Promontory, Main Brijuni/Brioni island (SW Istria), upper Barremian. C - Puntizela/Puntesella (SW Istria), upper Albian. D - Ploče II, Main Brijuni/Brioni island (SW Istria), upper Albian, cast. All scale bars in centimetres. (Continued).
Fig. 2 (continued) - Theropod footprints. E - Kamnik II, Main Brijuni/Britoni island (SW Istria), upper Albian, cast. F - Cervar/Cervera I (Central-W Istria), upper Albian, cast. G - Cervar/Cervera II (Central-W Istria), upper Albian. H - Mirna/Quieto river mouth (central-W Istria) upper Albian. All scale bars in centimetres. (Continued).
Fig. 2 (continued) - Theropod footprints. I - Fenoliga Islet (S Istria), upper Cenomanian, cast. J - Grakalovac (SW Istria), upper Cenomanian, cast. K - Lovrečica/S. Lorenzo di Daila (N Istria), upper Cenomanian. L - Lovrečica/S. Lorenzo di Daila (N Istria), upper Cenomanian, cast. All scale bars in centimetres.
lanx is narrow, low, elongate and pointed, not very much recurved; the ventral margin of the proximal ungual blade is flat whereas that of the distal ungual blade is blunt; the groove crosses diagonally the phalanx ending dorsally well before its point. The proximal part is not deep, the articular facet does not exceed the ungual blade in height and the articular surface occupies most of the articular facet. The specimen shows some resemblance with the ornithomimid manual phalanges because of its overall morphology and the presence of a relatively small flexor tubercle displaced somewhat distally (see OSMOŁSKA & BARSBOLD, 1990; RAUHUT & WERNER, 1995) but belongs to a chicken-size individual.

There is a groove between the main body of the phalanx and the flexor tubercle, which could indicate an incomplete fusion of the two and suggests that the individual was immature, as also indicated by small size. These specimens, at present under the care of the municipality of Bale/Valle, are the only theropod bones recorded up to now from the Istrian region.

**UPPER BARREMIAN**

*Pogledalos/ Salsa Promontory, Main Brijuni/ Brioni Island, SW Istria.*

In this site there are only large tridactyl footprints on a single bed surface exposed on the shore as an elongated band (Fig. 1(2), 2B, 3B). The state of preservation is not good. Five short tracks, seven couples and 19 single isolated prints, for a total of about 60 footprints are recognizable. L=24-45 cm; size distribution is shown in Figure 5. The substrate was a "fenestral micrite" overlain by stromatolites and "pelletlal limestones" with ripple marks indicating an intertidal environment (VELIČ & TIŠLJAR, 1987; Fig. 4).

**UPPER ALBIAN**

*Puntizela/Puntesella, Fazana/Fasana; SW Istria.*

This site presents two footprint-bearing surfaces placed at different stratigraphic levels (Fig. 1(3)). Level II is placed few metres above level I.

Level II has a track with five poorly preserved footprints (in the best preserved L=17.5 cm). The printed bed is a pelletlal mudstone-wackstone with rare ostracods; the stratigraphic section presents high energy bands of grainstone with gastropod shells.

Level I preserves a segment of a track with four footprints but only three preserved (in the best one L=20 cm; Fig. 2C, 3C). The printed bed is a mudstone-wackestone with rare ostracods and foraminifers; mud cracks are present on the surface.

**Ploče Promontory ("Rocca Kapp" of BACHOFEN- ECHT, 1925), Main Brijuni/ Brioni Island, SW Istria.**

In this site there are two printed surfaces (I, lower, and II, upper) at the top of two superimposed layers (Fig. 1(4), 2D, 3D). The site was described by the paleontochnological point of view by BACHOFEN-ECHT (1925) who wrongly attributed the footprints to Iguanodon MANTELL. After the description by the German paleontologist some footprints were taken away. For example, none of the large tridactyl footprints reported by him is now present in the outcrop. Five slabs with a footprint each are stored in a house of the port of the island which was once a museum. They testify the presence of relatively large theropods (L=40 cm and ~32 cm) but give no other information.

The narrow surface of level I presents two tracks and a couple, for a total of 12 footprints; L=13.5 cm, 21 cm and 21.5 cm.

In the level II there are 12 tracks, two couples and five single isolated footprints, for a total of about 60 preserved footprints; L=14-26 cm. Larger footprints (two tracks?) are considered to come from this horizon.

The footprint-bearing level I is a wackestone with foraminifers, small gastropods and desiccation structures. Level II is a packstone-grainstone with foraminifers and gastropods; the printed surface shows mud cracks. High energy accumulations of gastropod shells and ripple marks are present in the stratigraphic section (Fig. 4).

**Kamnik/Pljesivac Promontory, Main Brijuni/ Brioni Island, SW Istria.**

In this outcrop (Fig. 1(5)) there are two track-bear surfaces at the top of superimposed beds but only the upper one presents footprints ascribable to theropods (Fig. 2E, 3E-F) while the lower one has just a medium-size ornithopod trackway.

There are four theropod tracks, with badly preserved footprints, for a total of about 70 footprints. L=15.5-17.5 cm.

The footprint-bearing level is a mudstone-wackestone with foraminifers and ostracods. The layer below presents ripple marks (Fig. 4).

**Cervera/Cervar, Camping Solaris, Punta del Dente, NW Istria.**

In this site there are two separated footprint-bearing surfaces which could be different horizons (DALLA VECCHIA, 1994, 1996; DALLA VECCHIA & TARLAO, 1995) (Fig. 1(7); 2F-G, 3G-H). One is exposed along the shore (level I), the other (level II),
Fig. 3 - Drawings of some theropod footprints from the Cretaceous Adriatic-Dinaric Carbonate Platform. A - Sarone, Cansiglio Plateau (NE Italy), upper Hauterivian-lower Barremian (see Fig. 2A). B - Pogledalo/Salsa Promontory, Main Brijuni/Brioni island (SW Istria), upper Barremian, taken from the cast (see Fig. 2B). C - Punizela/Puntesella (SW Istria), upper Albian, (see Fig. 2C). D - Ploče II, Main Brijuni/Brioni island (SW Istria), upper Albian, taken from the cast (see Fig. 2D). E - Kamnik II, Main Brijuni/Brioni island (SW Istria), upper Albian, taken from the cast (see Fig. 2E). F - Kamnik II, Main Brijuni/Brioni island (SW Istria), upper Albian, taken from the cast. G - Červar/Červera I (Central-W Istria), upper Albian, taken from the cast (see Fig. 2F). H - Červar/Červera II (Central-W Istria), upper Albian, taken from the cast (see Fig. 2G). I - Mirna/Queto river mouth (central-W Istria) upper Albian, (see Fig. 2H). J - Fenoliga Islet (S Istria), upper Cenomanian, taken from the cast (see Fig. 2I). K - Grakalovac (SW Istria), upper Cenomanian, taken from the cast (see Fig. 2J). L - Grakalovac (SW Istria), upper Cenomanian, taken from the cast. M - Lovrečica/S. Lorenzo di Daila (N Istria), upper Cenomanian, taken from the cast (see Fig. 2K). N - Lovrečica/S. Lorenzo di Daila (N Istria), upper Cenomanian, taken from the cast (see Fig. 2L). Drawn to scale; scale bar = 5 cm.
much wider (33x13 m), is placed few tens of meters inland, and is the bed of an abandoned large quarry.

In the level I there are 12 tracks, five couples of footprints and 14 single isolated footprints, for a total of about 60 footprints. L = 16.5-24 cm. Probably there are also footprints of small-size sauropods. The footprint-bearing level is a pelletal wackestone with ostracods, foraminifera and desiccation structures; in the stratigraphic sequence there are some levels with large mud-cracks.

In level II there are many tracks and tens of single isolated footprints. The study of this material is just beginning. L range seems to be approximately the same of level I. Many small-sized sauropod footprints are present too (DALLA VECCHIA, 1994, 1996). The printed layer is a mudstone with ostracods and rare foraminifers; the surface shows mud-cracking.

**Mirna/Quieto river mouth, NW Istria.**

This outcrop preserved some tracks impressed by tridactyl, medium-size biped dinosaurs, very probably theropods (Fig. 1(6), 2H, 3I). Unfortunately, it was nearly completely destroyed by fossil collectors after 1977 (DALLA VECCHIA, TARLAO & TUNIS, 1993).

Two single footprints in private collections (L = 21 and 22.5 cm), a possible theropod footprint (L = 21 cm) and an uncomplete couple very badly preserved in situ, are described in DALLA VECCHIA, TARLAO & TUNIS (1993). The footprint-bearing level is a wackestone-packstone with foraminifera. Subtidal to supratidal environments are represented in the thin stratigraphic section (ibidem).

Size distribution of the late Albian theropod footprints (excluded level II of Ćrvar/Cervera) is reported in Figure 6.

**UPPER CENOMANIAN**

**Fenoliga ISlet, S Istria.**

The footprint-bearing surface (about 28x14 m) is exposed along the shore and footprints are very badly preserved (Figs. 1(8), 2I, 3J). There are three possibly theropod tracks for a total of about 55 footprints. L = 17 cm, 17.5 cm and 21.5 cm. Also many non-theropod footprints and a non-theropod long track is preserved in this site. The trackmaker of the latter was identified by LEGHISSA & LEONARDI (1990) as a small sauropod. Tracks are preserved on a wackestone with bioclasts (fragments of rudist shell), foraminifera and desiccation structures.

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**Fig. 4** - Stratigraphical column of the Lower Cretaceous carbonates of the Main Brijuni/Brioni Island with the footprint-bearing levels. 

- **A** - Stromatolite. 
- **B** - Pelmicrite/pelisparite. 
- **C** - Biomicrite with Salpingoporella. 
- **D** - Peritidal and desiccation breccia. 
- **E** - Ripple marks. 
- **F** - Biointrasparsite with gastropods. 
- **G** - Oncolite / mircite alternation. 
- **H** - Oncolite and mircite with Requienia. 
- **I** - Emersion breccias. 
- **J** - Mud pebbles conglomerate. 
- **K** - Mircite/fenestral micrite. 
- **L** - Oointrasparite. 
- **M** - Rudist coquina. 
- **N** - Beds and lenses of late diagenetic dolomite. 
- **O** - Desiccation cracks. The footprint symbol indicates the position and number of the footprint-bearing levels. After VELIČ & TISLJAR (1987), modified.
Grakalovac Promontory, Premantura/Promontore, S Istria.

The printed surface is exposed along the shore in the upper part of a cliff as a narrow and few metres long band (Fig. 1(9), 2J, 3K-L). Three tracks and a single footprint are preserved for a total of 13 footprints. L=15-25 cm. The printed layer is a bioturbated wackestone-packstone with foraminifers, in a stratigraphical sequence with rudist limestone beds and mounds.

Lovrečica/S. Lorenzo di Daila, Umag/Umago, NW Istria.

In this site there is a single footprint-bearing surface exposed along the shore as a 20 m long band (Fig. 1(10), 2K-L, 3M-N). The state of preservation of the specimens is not good. There are five tracks, seven probable tracks, three couples and four single isolated footprints, for a total of 58 footprints. L=14.5-25.6 cm. The printed bed is a microbreccia with abundant matrix with foraminifers and desiccation structures; it is intercalated among rudist limestone beds. It is probably a storm layer.

Size distribution of the late Cenomanian theropod footprints is reported in Figure 7.

INTERPRETATIONS

Even if at present the study of the Istrian footprints is far from concluded, some observations can be anticipated here.

Exposed surfaces to find vertebrate fossil footprints are limited to just a narrow band exposed along the coast in Istria, to quarry beds or to quarried blocks (the case of the footprints from Cansiglio Plateau). Despite this limited sampling area we found significant evidence of dinosaurs in the northern part of the Adriatic-Dinaric platform, which has been less disturbed tectonically. This is probably just a small portion of the real dinosaur record of this region. At least during some intervals of the Cretaceous Period, the platform was inhabited by populations of dinosaurs. The emersions which permitted the presence of the dinosaurs are most probably related to tectonic events rather than eustatic sea level fluctuations even if the influence of the latters could have played a role. In fact the Apulian Promontory or Microplate during the Cretaceous times was beginning to collide with "Europe". Besides, late Albian and early Cenomanian are intervals of worldwide sea level high stand (DERCOURT, RICOU & VICRELYNCK, 1993).

All the sites with footprints are in prevailing marine carbonate sequences but with sedimentological evidence of emersion (pedogenetic breccias, karstification of carbonates, bauxites, marsh-lacustrine deposits, etc.), mainly during late Albian. Footprint-bearing beds are deposited in marine environments as tidal flats or lagoons but most of them presents evidence of subaerial exposure as mud cracks (e.g. Puntizela/Punesella I, Ploče II and Červar/Cervera II) or desiccation microstructures (e.g. Pogledalo, Ploče I, Fenoliga).

Only a population of large theropods is testified, in the single site of late Barremian age. Most of the footprint lengths are included in the interval 30-38 cm (Fig. 5) corresponding to h values ranging 120-155 cm to 152-190 cm, with a separate group of smaller footprints and some larger; M=32.25 cm. There is not a clear mean, having three small peaks for 30 cm, 35 cm and 38 cm.

Different is the situation in the upper Albian, where we have a larger sample. Large theropods are rather uncommon and middle-size individuals are prevailing (Fig. 6). In fact, most of the footprint lengths are included in the interval 16-24 cm corresponding to h values ranging 64-72 cm to 96-115 cm. The mean is 21 cm (h = 84-98 cm), M = 20.75 cm and the distribution is skewed toward smaller forms.

The late Cenomanian assemblage is composed only by middle-size individuals (Fig. 7); the mean is 21 cm, M = 19.55 cm and the distribution is skewed toward smaller forms. There are not significative size differences with the late Albian assemblage, if we exclude the total absence of large individuals. Anyway, we must keep in mind that the sample is much smaller.

At a first preliminary survey there are some different theropod ichnotaxa in the Cretaceous of Istria. This means that a certain degree of taxonomical diversity is suggested not only by different sizes but also by footprint morphology (see Fig. 2-3). Its worth to note that the one here reported is the only theropod evidence in that part of the Cretaceous world. No skeletal record of such theropod populations remains, except the tooth and the phalanx of late Hauterivian-early Barremian age.
If the carbonate platform was connected with the African-Arabian continent (at least in pre-Aptian times), the most probable source area for colonization was Africa via Middle East. No osteological record of theropods is known in the Middle East if we exclude scanty remains in the ?Cenomanian of Syria (WEISHAMPEL, 1990). Even if some fragmentary remains have been reported during last 80 years (e.g. DALLA VECCHIA, 1995; DEPERET & SAVORNIN, 1925; LAPPA'RENT, 1960; RAUHUT & WERNER, 1995; RUSSELL, 1996; STROMER, 1915, 1931, 1934), African theropods of Aptian to Cenomanian age are just beginning to be known in detail (SERENO et al., 1994, 1996). As the general rule with terrestrial vertebrates (BEHERENSMEYER, WESTERN & DECHANT-BOAZ, 1979) the remains of large theropods are much more represented in the sample than those of small to medium-size ones. This point out that the osteological record (biased by strong taphonomic control) testifies just a little part of the real dinosaur diversity. On the other side, ichnological record is not suitable for phylogenetic analyses but opens windows on real distribution and possible local and general diversity of taxa.

If the platform was intraoceanic, separate from continental regions by deep seaways since Early Jurassic, as DERCOURT, RICOU & VRIELYNCK (1993) suggest, the colonization from a source area is apparently impossible.

None of the theropods was running; the most common gait was a relatively fast walking (Kamnik, Ploče II, Puntizela/Puntesella, Červar/Cervera I, Fenoliga, Grkalovac, Lovrečica/S.Lorenzo). As a general feature, they were going straight or in a slightly undulating way, without big changes of direction, stops, or the irregular walking of an animal searching for food. The estimated V values are as a rule higher than AWS, in many cases nearly two times higher (e.g., Červar/Cervera I and Lovrečica/S.Lorenzo). This suggests that the animals were just passing through the environments where they left the prints with something like a cruising speed. It is interesting to note that the modern flightless bird Emu (Dromaius novaehollandiae (LATHAM)), which has tridactyl feet and h comparable to that of most of the Cretaceous theropods of Istra, covers great distances at a constant speed of 7km.h⁻¹ (FOLCH, 1992). Of course, this observation is not enough to say that medium-size Cretaceous theropods had a similar behaviour and, consequently, the same metabolism of the bird Emu.

In outcrops with many footprints and tracks there is a roughly bimodal distribution of directions. Main directions are more or less perpendicular (e.g. Kamnik II, Ploče II, Lovrečica/S.Lorenzo); sometimes it is apparently roughly unimodal (Grkalovac). Such preferential directions have been often interpreted as evidence of social behaviour. I think that in the cases under examination another explanation is possible. The bimodal distribution with more or less perpendicular directions reflects the typical behaviour of vertebrates reaching the shore: a direction more or less normal to the local coastline (the shortest way to reach it) and a second one parallel to (a free way with the lateral boundary of the water). The movement was in both the two verses of each main direction. The same pattern is present in theropod trackways in coastal settings of late Albian-early Cenomanian age of Israel and AVNIMELECH (1966) came to similar conclusions about the behaviour of the trackmakers.

Dinosaur body and trace fossils are known in the carbonate platforms which surrounded the Gulf of Mexico during Aptian-Cenomanian times, mainly in the lower-middle Albian but also in the Cenomanian (PITTMAN, 1989). However, the paleogeographic setting was different from that of the Adriatic-Dinaric platform. The Gulf of Mexico platforms bordered the southern part of the North American continent, and the depositional environment for most of the dinosaur fossils has been identified as the shoreline transition between continental clastic sediments and the carbonate tidal flats (PITTMAN, 1989).
Paleoichnological associations are similar, having in both cases a dominance of supposed theropods, a significative but lesser presence of sauropods and rarer ornithopods. This is in agreement with the concept of Brontopodus ichnofacies (Lockley, Hunt & Meyer, 1994).

The predominance of carnivorous dinosaurs is not so meaningful from the palaeoecological point of view if you accept my hypothesis that the animals where just passing through: they were not in their normal habitat. It is clear for some Cenomanian sites where footprints are preserved with prevailing rudist rudstones and mounds. Tidal flats, shores and similar environments are rather uncomfortable habitats for large terrestrial vertebrates; I do not know large and extant terrestrial vertebrates which use to spend most of their time in such environments. I suspect that dinosaurs lived usually few hundred of metres or few kilometres inland, where there was vegetation and fresh water but no or scarce sedimentation. Tidal flats, shores and similar muddy and wet environments were just routes and the only place where large tetrapods could leave evidence of their presence. I do not suggest that the dinosaurs were migrating along these routes: this is a possibility but cannot be demonstrated.

Some faunal differences are evident between U.S.A. sites and the Istrian ones. The large theropods are dominant in the Gulf sites (Pittman, 1989) while medium-size ones are much more common in Istria. This is particularly true if we compare the roughly coeval Albian associations. The same happens with sauropods: upper Albian sauropod footprints of Istria are comparatively very small, probably the smallest recorded in the world. I suspect that such "dwarfism" could be related to insularity, since the isolated geographical position of the carbonate platform.

CONCLUSION

Even if the Adriatic-Dinaric carbonate platform was an area of prevailing marine carbonate sedimentation, isolated or at best very far from continental areas dominated by silicoclastic deposition, theropods were relatively common. In fact, the exposed surface where footprints can be found is very small if compared with the thickness and extension of the Cretaceous shallow water carbonate sequence of the platform. In spite of this, 10 sites with theropod and other dinosaur footprints have been discovered.

During the late Hauterivien/early Barremian there is evidence of large theropods and medium-size sauropods in the northern end of the platform, while in its Istrian portion small to large-size sauropods lived together with small theropods.

In the only site of late Barremian age just large theropods are recorded.

Most of the theropod evidence has a late Albian age, with five sites with at least nine printed levels. There was the prevalence of medium-size individuals, while large ones are testified just in one outcrop (Płoče). In one site medium-size theropod footprints are associated to small sauropod footprints.

Upper Cenomanian sites present only medium-size theropods. In just one site they are associated with a possible sauropod track.

The Adriatic-Dinaric carbonate platform is a special case of an intraoceanic carbonate platform, or at best very far away from continental land, with a local dinosaur fauna. The paleogeographic and evolutionary significance of the Istrian dinosaur remains is just beginning to be investigated.

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ABBREVIATIONS

AWS - average walking speed; h - height at hip; L - footprint length; M - media; N - number of specimens; SL - stride length; V - absolute speed.

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