The occurrence of the vertebrate ichnogenus *Synaptichnium* in the Anisian (Middle Triassic) of Southern Alps

Marco AVANZINI1* & Paolo MIETTO2

1Museo Tridentino di Scienze Naturali, Via Calepina 14, 38100 Trento, Italy
2Dipartimento di Geoscienze, Università di Padova, Via Giotto 1, 35137 Padova, Italy
*Corresponding author e-mail: avanzini@mtsn.tn.it

SUMMARY - The occurrence of the vertebrate ichnogenus *Synaptichnium* in the Anisian (Middle Triassic) of Southern Alps - The specimens pertaining to the ichnogenus *Synaptichnium* found in the Anisian of Southern Italian Alps are described and compared. All the recovered specimens were discovered in Pelsonian marine marginal sediments. The reported morphotypes are sufficiently diversified for excluding “track preservation variations”. So some consideration could be proposed due to different stratigraphical occurrence of the morphotypes. It seems that *S. pseudosuchoides* is characteristic of the lower part of the sedimentary succession (early Pelsonian), while *S. cf. cameronense* appears only in the upper layers (middle to late Pelsonian). The trackmakers lived closer to the water and in the lower to upper intertidal. During the time interval considered, the environmental conditions shifted to a coastal delta mouth bars to a silicoclastic tidal flats with a more marked marine influence. This environmental variation could be considered as possible responsible for the apparent change in the ichnofauna.


**Key words**: vertebrate footprints, *Synaptichnium*, Middle Triassic, Southern Alps

**Parole chiave**: orme di vertebrati, *Synaptichnium*, Triassico Medio, Alpi Meridionali

1. INTRODUCTION

The occurrence of the ichnogenus *Synaptichnium* in the Middle Triassic sedimentary units (De Zanche et al. 1993) of the Southern Italian Alps was reported for the first time by Avanzini (1999) based on findings from Pelsonian sediments of the Non Valley (Trento and Bolzano Province) (Conti et al. 2000; Avanzini et al. 2001; Nico-sia et al. 2005).

Recent research records the presence of the ichnogenus, in a short stratigraphical interval, from several ichno-sites of the eastern area of the Italian Southern Alps (Fig. 1) (Avanzini & Mietto, in press).

The aim of this paper is to provide a description of the specimens referable to this ichnogenus recorded in northern Italy. This description is based on the author’s examination and measurement of all the specimens held in the Museo Tridentino di Scienze Naturali, Trento (MTSN) and Naturmuseum Sudtirol, Bolzano/Bozen (NMS).

2. GEOLOGY AND AGE

All the specimens described come from Anisian continental to marine marginal sediments referred to the Voltargo Conglomerate and to the Recoaro Limestone (Delfra-ti et al. 2000).

The Voltargo Conglomerate is made up of conglomerates, sandstones, siltstones and claysstones mostly red in colour. The lower part of the unit consists of grey silty-micasaceous, locally nodular, bioturbated wackestones and red, green and grey quartzic micaceous fine grained sandstones. Sandstones and siltstones are commonly cross-laminated. Conglomerate beds consist of rounded centimetre-sized pebbles in a white and yellow sandy matrix.

In the upper part of the unit, grey centimetre/decimetre-thick strongly wavy to nodular grainstone beds are interbedded with grey and red grained sandstones and biolaminated silty limestones. Plant debris is abundant throughout the unit. Owing the presence of the Binodosus Subzone ammonites in...
the overlaying Recoaro Limestone and a comparison with marine etheropic sediments in Dolomites and Carnia, this 
unit is early Pelsonian in age (Cuccense Subzone).

This unit reflects a transitional continental to marine environment characterised by coastal delta mouth bars de-
posited under relatively arid conditions.

The ichnofauna comes from the middle (final low-
stand) and upper portion (trasgressive system tract) of the 
succession.

The uppermost Recoaro Limestone predominantly 
consists of nodular, bioturbated, fossil-rich packstones and 
packstones/grainstones arranged in decimetre-thick layers 
alternating with thin calcisiltite beds containing angular fi-
ned quartz.

The fauna is locally abundant and mainly made up of 
brachiopods (*Coenothyris vulgaris* (Schlotheim), *Tetractinel-
la trigonella* (Schlotheim), *Decurtella decurtata* (Girard), *Undularia scalata* (Schlotheim), cri-
noids (*Encrinus liliiformis* Lamark), echinoids, celentera-
ta. Ammonoids of the Binodosus Subzone (*Bulogites zol-
dianus* Mojsisovich) (Pelsonian) are also documented (De 

The depositional environment is referable to a carbo-
nate ramp slightly contamined by terrigenous input.

The vertebrate ichnofauna is preserved in the basal 
layers of the formation that correspond to the trasgressi-
ve system tract.

3. SISTEMATIC ICHNOLOGY

As observed by Klein & Haubold (2007) the ich-
notaxonomic situation in *Synaptichnium* Nopcsa, 1923 
is complicated by several circumstances: no type has be-
en clearly fixed thus far in the Early and Middle Triassic it 
can possibly synonymized with other ichnotaxa (i.e. *Pro-
tochirotherium* and “*Megarynchosauroides*”) (Diedrich & 
Fichter 2003; Fichter & Kunz 2004) and footprint named 
as *Synaptichnium* show a transition to “*Brachychotheri-
um*” in different extramorphological variations (Klein & 
Haubold 2004).

A revision of the ichnotaxon seems necessary (Klein 
& Haubold 2004; Demathieu & Demathieu 2004), but this 
is not the purpose of this paper.

In the following chapters we will only provide a de-
scription of the specimens referable to this ichnogenus re-
corded in the Southern Alps following the diagnosis by 
Haubold (1971) emended by King et al. (2005)

**Ichnogenus Synaptichnium** Nopcsa, 1923

*General diagnosis of the ichnogenus from Haubold (1971)
emended by King et al. (2005)*

**Manus.** Pentadactyl and relatively large (manus/pez
ratio > 0.53) with a mesaxonic structure. Manual digit III 
is the longest and digits II and IV are approximately in the 
same length. Digit V is straight and situated proximally at 
an angle of about 40° to the long axis through digit III. The 
manus narrows posteriorly and terminates in a metatarsal-
phalangeal pad to the rear of digit V. All terminal phalanges 
show distinct sharp claw casts. Digit prints exhibit promi-
nent phalangeal nodes that indicate that digits I-III proba-
bly contained 2, 3 and 4 phalanges respectively.

**Pes.** Pentadactyl, ectuxonic, larger and more elonga-
ted than the manus, generally only about 10 cm long. Di-
gits, nearly parallel, increase in length from I to IV. Digit 
V is straight and situated proximally at an angle of about 
40° to the long axis through digit III. The pes terminates 
posteriorly in a large oval metatarsal-phalangeal pad to the 
rear of digit V. All digits show sharp claw casts at the tips. 
Casts of digits exhibit prominent phalangeal nodes. This in-
dicates that digits I-III probably contained 2, 3 and 4 pha-
langes respectively.
Trackway. Pattern not yet well established (see King et al. 2005, for a complete discussion). Traditionally, the Synaptichnium trackway is described as relatively wider than that of other chirotheriids. The pace angulation observed by Peabody (1948) varies from 140° to 160°, but in the Synaptichnium priscum trackway depicted by Demathieu (1970) the pace angulation is only about 120°.

Type ichnospecies: Synaptichnium pseudosuchoides Nopcsa, 1923. Middle Triassic England.

3.1. Southern Alps ichnospecies and morphotypes

Synaptichnium pseudosuchoides (Nopcsa, 1923) (Fig. 2a)

Description

Manus. Pentadactyl and relatively large with a mesaxonic structure. Manual digit III is the longest, and digits II and IV are approximately of the same length. Digit V is straight and placed proximally at an angle of about 40° to the long axis through digit III. All terminal phalanges show distinct sharp claw casts.

The total length of the manus is 4.5 cm with a maximum width of 3.5 cm.

Pes. Pentadactyl, ectaxonic, larger and more elongated than the manus. Digits nearly parallel, increase in length from I to IV. Digit V is straight and situated proximally at an angle of about 40° to the long axis through digit III. The pes terminates posteriorly in a large oval metatarsal-phalangeal pad to the rear of digit V. All digits show sharp claw casts at the tips.

The total length is 10 cm and the maximum width is 4.9 cm.

Trackway. No trackways are known.

Referred material

(MTSN - RU 2a/b) Non Valley (Rio Urban - TN) early Pelsonian (Voltago Conglomerate), (MTSN - RU 5) Non Valley (Rio Urban - TN) early Pelsonian (Voltago Conglomerate), (MTSN - RU 5a) Non Valley (Rio Urban - TN) early Pelsonian (Voltago Conglomerate), (MTSN - RU 1a) Non Valley (Rio Urban - TN) early Pelsonian (Voltago Conglomerate), (MTSN - ULF 22) Km. 44 S.S. 243 Palade (Valle di Non - BZ) early Pelsonian (Voltago Conglomerate).

Discussion

The characteristics of the recovered tracks are typical of this ichnospecies. The presence of distinct phalangeal pads, long claws and slightly convergent digits III and IV is clearly recognisable in all the discovered tracks. S. pseudosuchoides is relatively common in the Lower and Middle Triassic of Europe (Haubold 1984; King et al. 2005).

Synaptichnium isp. 1 (Fig. 2b)

Description

Manus. 4.8 cm long and 2.3 cm wide. Digits I-IV diverge within a 60° angle. Digit I is very small, II and IV subequal, III the longest. Small sharp claws are present. Manus V is thumb-like, but straighter than the pes.

Pes. 9 cm long and 4.8 cm wide. Digit IV is at least as long as III and appears to be even longer because of the marked slant of the metatarsal/phalangeal axis. Digit I is about half the length of II, the latter slightly over half the length of III. Thus the progressive increase in length from I to III is marked. The cross axis with the long axis of the foot makes an angle of 55°. Pes digit V is long and slender. Digits I-IV tend to be parallel with each other. Narrow claws are present on digits I-IV. The phalangeal formula is 2-3-4-5. The pes is impressed more strongly on the median side.

Trackway. The trackway pattern is relatively wide, with a pace angle of about 140°. The manus and pes are turned outward.

Referred material

(MTSN - ULF 22) Km. 44 S.S. 243 Palade (Valle di Non - BZ) early Pelsonian (Voltago Conglomerate).

Discussion

The footprints are well defined. The feet of the track makers crossed the surface of firm or stiff mud leaving distinct and sharply defined footprints. Marginal ridges were weakly developed in some cases, and were limited to only one side of the shaft. The footprints preserve fine anatomical details and the impression of the skin can be recognised (Avanzini 2000). The footprint is very close to S. pseudosuchoides from which it differs in that digits III and IV are more parallel and in that the morphology of digit V is stouter and shorter. In a pedal print, the distal part of digit V shows a slender phalangeal impression that bends slightly outward. However, the tracks are very slightly impressed with a partial impression of digit V and could represent only a “track preservation variation” of S. pseudosuchoides

Synaptichnium cf. S. cameronense Peabody, 1948 (Fig. 2c)

Description

Manus. Relatively wide (2.5 cm) and 3.5 cm long. Digit I is only faintly impressed in contrast to digit group II-IV. The digits present short narrow claws. Digits III and IV are separated slightly more than the others. Digit V is relatively short and slender distally.

Pes. Long digits with rounded, marked digital pads. Digit IV is slightly longer than III and the metatarsal-pha-
The ichnogenus *Synaptichnium* in the Anisian of Southern Alps

---

**S. cameronense** using open nomenclature, is clearly distinct from the other specimens from the Southern Alps attributed to *Synaptichnium*. The strong digits, with marked pads that strengthen in the distal phalanges and their inward rotation, appear peculiar. Digit V with its well marked pad and the curved extremity also appears peculiar. The landmark analysis suggests a short, wide morphology of the pedal print, making it clearly different from other *Synaptichnium* specimens.

---

**Referred material**

(MTSN - BzBG1) Bad Gfrill (Tisens - BZ), Pelsonian (Recoaro Limestone).
rent from the other *Synaptichnium* footprints (Klein & Haubold 2003) (Fig. 3).

*S. cameronense* is a typical ichnospecies of the Anisian Moenkopy Fm. in Northern America (Peabody 1948), but is also reported in the French Muschelkalk (Demathieu & Haubold 1972, 1974; Demathieu & Gand 1981).

**Synaptichnium** isp. 2 (Fig. 2d)

**Description**

Manus. 4 cm long and 3 cm wide. Digits I-IV diverge within a 60° angle. Digit I is very small, II and IV subequal, III the longest. Small sharp claws are present. Manus V is thumb-like, but straighter than the pes.

Pes. 13 cm long and 6 cm wide. Digit IV is at least as long as III and appears to be even longer because of the marked slant of the metatarsal/phalangeal axis. Digit I is about half the length of II, the latter slightly over half the length of III. The cross axis with the long axis of the foot makes an angle of 55°. Pes digit V is long and slender, distally curved. Digits I-IV are nearly parallel to each other. Narrow, inward claws are present on digits I-IV.

**Trackway.** No trackways are known.

**Referred material**

(MTSN - BzBG15a) Bad Gfrill (Tisens - Bz) Pelso-
nian (Recoaro Limestone).

**Discussion**

The dimensions are the greatest of all the specimens recovered. These peculiar *Synaptichnium* footprints have long, straight, parallel digits. In general, it is similar to *S. diabloense* (Peabody, 1948), but it seems to differ in the lon-
ger digit V and the central position of the proximal margin of pad V. The landmark analysis underlines some similarity with *S. pseudosuchoides* from which it nevertheless differs in the morphology of digit V.

### 4. CONCLUSIONS

In the Southern Alps ichnofauna, the ichnogenus *Synaptichnium* seems confined to the Pelsonian.

The here reported morphotypes and ichnospecies are sufficiently diversified for excluding that of some authors (i.e. Diedrich 2005, 2008) consider “track preservation variations” related to extramorphological (substrate-controlled) phenomena. So, some consideration could be proposed due to different stratigraphical occurrence of the form groups.

In the sites with a multiple trampled layer (i.e. the Gampenpass - Bad Gfrill area), it seems that *S. pseudosuchoides* is characteristic of the lower part of the sedimentary succession (Early Pelsonian) while *S. cf. cameronense* appear only in the upper layers (Middle to Late Pelsonian) (Fig. 4).

It is also interesting to note an apparent progressive dimensional trend of *Synaptichnium* footprints. The early Pelsonian forms are small and slender, the late Pelsonian ones are decidedly larger (i.e. *Synaptichnium* isp. MTSN - BzBG15a, Fig 2d).

The trackmakers lived closer to the water and in the lower to upper intertidal. During the time interval considered, the environmental conditions shifted to a coastal delta mouth bars to a silicoclastic tidal flats with a more marked marine influence. This environmental variation could be considered as a possible responsible for the apparent change in the ichnofauna.

A possible alternative interpretation could be ascribed to a evolutionary developments of the locomotor apparatus of the *Synaptichnium* trackmaker (Klein and Hau- bold, 2007) with the apparent replacement by small to large specialised forms in a relatively short time interval (about 2 million years).

### ACKNOWLEDGEMENTS

We wish to sincerely thank Umberto Nicosia (Università di Roma, La Sapienza) and Caju Diedrich (Universität Osnabrück) for reviewing and improving the manuscript.

### REFERENCES


