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## REMARKS ON STRATIGRAPHIC DISTRIBUTION IN THE DOLOMITES OF BENTIC CRINOIDEA RELATED TO S. CASSIANO AND HEILIGKREUZ FORMATIONS (CARNIAN, TRIASSIC)

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**Abstract** - FABRIZIO BIZZARINI - Remarks on stratigraphic distribution in the Dolomites of bentic Crinoidea related to S. Cassiano and Heiligkreuz Formations (Carnian, Triassic).

During the biostratigraphic research conducted in the 20th century in the S. Cassiano and Heiligkreuz Formations (Late Triassic, Dolomites) a significant amount of bentic Crinoidea was collected. The carnian fossil record of bentic Crinoidea is very rare in the Dolomites; however, Encrinida, Isocrinida and Millecrinida (*sensu* HAGDORN 2011a) are present. Some data of the faunistic succession of these taxa in the Carnian of the Dolomites are provided and put in relation to the age of the corresponding outcrops. The Carnian Pluvial Episode marks the transition from a community of bentic Crinoidea dominated by the Encrinida to one dominated by the Isocrinida.

**Keywords:** Bentic Crinoidea, S. Cassiano and Heiligkreuz Formations, Triassic, Dolomites.

**Riassunto** - FABRIZIO BIZZARINI - Osservazioni sulla distribuzione stratigrafica nelle Dolomiti dei crinoidi bentonici delle Formazioni di S. Cassiano e di Heiligkreuz (Carnico, Triassico).

Durante le ricerche biostratigrafiche condotte nel secolo scorso nel Carnico delle Dolomiti fu raccolta un'interessante campionatura di Crinoidi bentonici. Sulla base di questo materiale si forniscono alcuni dati sulla distribuzione stratigrafica e sulla frequenza delle specie di Encrinida, Isocrinida, Millecrinida (*sensu* HAGDORN 2011a) rinvenute nelle Formazioni di San Cassiano e di Heiligkreuz (Carnico, Triassico). Si conferma che l'Evento Pluviale Carnico segnò il passaggio da una comunità di Crinoidea dominata dagli Encrinida ad una dominata dagli Isocrinida.

**Parole chiave:** Crinoidi bentonici, Formazioni di S. Cassiano e di Heiligkreuz, Triassico, Dolomiti.

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<sup>1</sup> L'articolo è pubblicato postumo. Il prof. Fabrizio Bizzarini è improvvisamente scomparso il 10 settembre 2024. Docente di Paleontologia presso le Università degli studi di Urbino e Trieste, Conservatore per le Scienze della Terra presso il Museo Civico di Storia Naturale di Venezia, membro dei consigli scientifici delle più importanti Fondazioni e Associazioni naturalistiche italiane, Bizzarini ha collaborato con il Museo Civico di Rovereto fin dagli anni Ottanta del secolo scorso, in svariati ambiti, quali studi micro e macropaleontologici, attività didattiche e divulgative, allestimento di percorsi museali, rilevamenti paleontologici, arricchimento e riordino delle collezioni, contribuendo in modo significativo alla sua crescita culturale.

## INTRODUCTION

The biostratigraphical researches of the last century related to the Carnian age of Dolomites give us an important benthic Crinoidea collection of the S. Cassiano and Heiligkreuz Formations. Benthic crinoid remains are rare in these Formations and are based on fragmentary material, mostly columnal elements. These remains “are of limited diagnostic value and cannot be unequivocally attributed to a genus or even a species.” (HAGDORN, 2011). Partial caps and bases caps of Encrinida and Isocrinida are extremely rare and were found only in the S. Cassiano Formation.

The benthic Crinoidea distribution in the localities of the S. Cassiano and Heiligkreuz Formations was described by ZARDINI (1973) and FÜRSICH & WENDT (1977).

In FÜRSICH & WENDT (1977) the benthic crinoids represent 0,52% of fossil record in basinal assemblage *Raphistomella radians* and *Paleonucula strigillata* and only 0,14% in *Ampullina* assemblage. The percentages of benthic crinoids in reefs associations are equally low: crinoids represent 0,56% of fossil record in the assemblage of fore-reef area in Forcella Settsass - Settsass Scharte and only 0,48% in the assemblage of Alpe di Specie - Seelandalpe. FÜRSICH & WENDT (1977, 263) thus estimated the percentage of crinoids: “Crinoid ossicle and cidaroid spines were only then counted as representing more than one specimen when their number exceeded that which a single organism might have possessed.” However, the evaluation of the frequency of the crinoid species based mainly on the columnal elements is not very significant and may be more subjective than objective. For this reason, the percentages reported in figures 1, 2, 3 and 4 show only the frequency of remains in the fossil record of benthic Crinoidea without proposing any relationship between this data and the real frequency of specimens or of species in the associations examined. Therefore, my percentages in these localities are slightly different from those of FÜRSICH & WENDT (1977), but they confirm the rarity of benthic crinoids in the S. Cassiano and Heiligkreuz Formations.

The benthic Crinoidea have a wide distribution in the Carnian sedimentary successions of Dolomites, an interesting stratigraphical range (see Tab. 1) and a significant faunal turnover due to the Carnian Pluvial Episode. The Carnian Pluvial Episode (CPE) was a global climate perturbation that had a strong impact on marine Carnian ecosystems of the Dolomites. This event developed in several phases between the end of the Julico and the beginning of the Tuvalico (PRETO *et al.* 2019,

DAL CORSO *et al.* 2020). The Heiligkreuz formation in the Dolomites records the faunal turnover due to CPE. The stratigraphic successions of Alpe di Specie-Seelandalpe, Alpe di Stolla (*Cornucardia hornigi* horizon) and the Prostyliferidae horizon (*Ampullina* in FÜRSICH & WENDT 1977) of Costalares and Misurina are contemporary with the CPE. The stratigraphic successions of Rio Picol- Picol Bach, Prati di Stuares- Stuares Wiesen, Forcella Settsass- Settsass Scharte and Forcella Giau are earlier than the CPE.

## SAN CASSIANO FORMATION

### Aon subzone

Pralongia: Rio Picol - Picol Bach, Prati di Stuares - Stuares Wiesen

Benthic crinoid remains of these horizons were retrieved by bulk sampling and by quantitative surface collection. Benthic crinoids are rare almost columnal remains. Only at the bottom of stratigraphic sequence of Rio Picol - Picol Bach was found a significative quantity of crinoid remains (Fig. 1). Encrinida are dominant, were found columnal remains of *Cheilocrinus cassianus* (Laube 1864), *Zardinicrinus granulosus* (Münster 1841) and *Cassianocrinus varians* (Münster 1841) and two bases of cap: *Zardinicrinus granulosus* (Münster 1841) and *Cheilocrinus cassianus* (Laube 1864). Isocrinida are present with the species *Tyrolocrinus propinquus* (Münster 1841) and “*Isocrinus*” *venustus* (Klipstein 1845).

In upper Aon subzone of Prati di Stuares - Stuares Wiesen (16 -18 horizons in URLICHS, 1974) was found only these species of Encrinida: *Cheilocrinus cassianus* (Laube 1864), *Zardinicrinus granulosus* (Münster 1841) and *Cassianocrinus varians* (Münster 1841).

### Punta Grohmann - Passo Sella

The biostratigraphical researches conducted in the stratigraphic sequence Friederich August path - bottom of Punta Grohmann in the eighties of the last century found a marl-sandstone horizon with a significative quantity of crinoid remains. Only these two species were found *Cheilocrinus cassianus* (Laube 1864) more frequently and *Zardinicrinus granulosus* (Münster 1841) rarely.

### Lower Aonoides subzone

Forcella Giau

The basinal sequence of Forcella Giau is stratigraphically related to horizon 23 in URLICHS (1974) and the fossil record is dominated by benthic crinoids and brachio-

Tab. 1 - List of the benthic crinoids species found in relation to the locality of origin and their stratigraphic distribution.

	JULIAN					TUVALIAN
	San Cassiano Formation			Heiligkreuz Formation		
	Aon subzone	Lower Aonoides subzone	U. Aonoides subzone	Austriacum subzone		
Ord. Encrinida						
Cheilocrinus cassianus (Laube 1864)	Rio Picol, Prati di Stuores, P.ta Grohmann	F.la Settass, Sass de Stria, F.la Giau, Cianzoppè		Costalares b,	Alpe di Specie	Costalares c
Cassianocrinus varians (Mnst. 1841)	Rio Picol, Prati di Stuores	Rio Stuores, F.la Settass, F.la Giau, Cianzoppè				
Zardinicrinus granulatus (Mnst. 1841)	Rio Picol, Prati di Stuores, P.ta Grohmann	F.la Settass, Sass de Stria, F.la Giau, Cianzoppè	Boa Stoalin, Tamarin		Alpe di Specie	
Zardinicrinus tuberculatus Zardini 1973		F.la Giau				
Ord. Isocrinida						
Tyrolocrinus tyrolensis (Laube 1865)		F.la Giau, Cianzoppè	Milieres	Costalares a, b, Campo	Alpe di Specie,	Misurina, Alpe di Stolla, Costalares c
Tyrolocrinus propinquus Mnst. 1841	Rio Picol	F.la Giau				
Tyrolocrinus? candelabrum Bather 1909				Costalares a, Campo	Alpe di Specie	
Tyrolocrinus? anulatus Leonardi e Lovo 1950				Costalares a		
"Isocrinus" sassostriensis Zardini 1973		Cianzoppè, F.la Giau				
"Isocrinus" venustus (Klipstein, 1845)	Rio Picol					
Ord. Millecrinida (?)						
"Encrinus" cancellistriatus Bather 1909		F.la Giau			Alne di Specie	

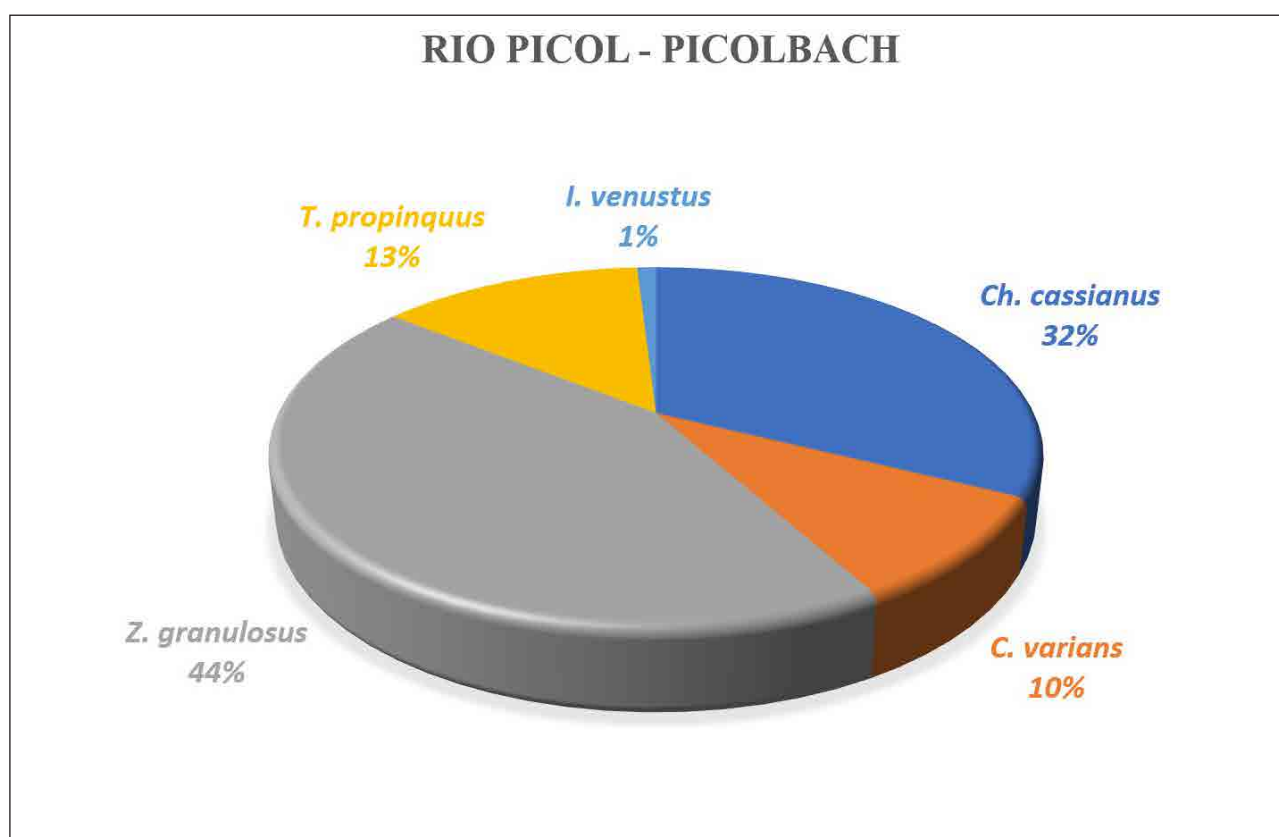


Fig. 1 - Rio Picol-Picolbach: frequency in the fossil record of benthic crinoid remains.

pods. In Forcella Giau are present columnals remains, partial caps and bases caps of Encrinida and Isocrinida and we can assume a sedimentary environment close to the living environment. Encrinida are dominant with the species: *Cheilocrinus cassianus* (Laube 1864), *Cassianocrinus varians* (Münster 1841), *Zardinicrinus granulatus* (Münster 1841) and *Zardinicrinus tuberculatus* Zardini 1973. The Millecrinida (*sensu* HAGDORN 2011a) are present with the species *"Encrinus"* *cancel-*

*listriatus* Bather 1909 and the Isocrinida with the species *Tyrolocrinus propinquus* (Münster 1841), *Tyrolocrinus tyrolensis* (Laube 1865) and *"Isocrinus"* *sassostriensis* Zardini 1973. I found partial caps of *Zardinicrinus granulatus* (Münster 1841) and *Cheilocrinus cassianus* (Laube 1864), bases caps of *Cheilocrinus cassianus* (Laube 1864), *Cassianocrinus varians* (Münster 1841) and *Zardinicrinus granulatus* (Münster 1841). ZARDINI (1973) found in Forcella Giau also *Tyrolocrinus?* *can-*

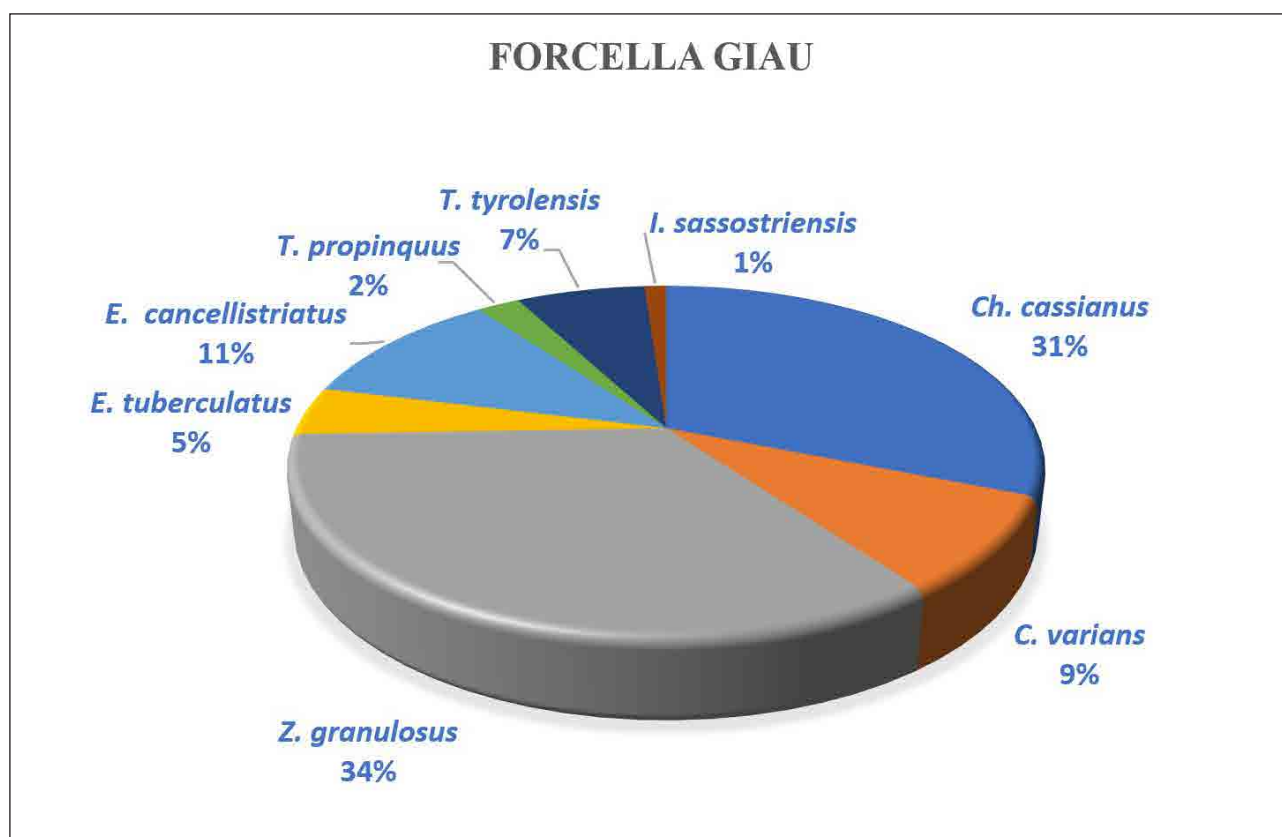


Fig. 2 - Forcella Giau: frequency in the fossil record of benthic crinoid remains.

*delabrum* Bather 1909 and HAGDORN (2011b) found a base cap of *Tyrolecrinus propinquus* (Münster 1841). The present species in Forcella Giau and their frequency in fossil records suggests that in the lower Aonoides sub-zone Encrinida were dominant and there was the first occurrence of Millecrinida (*sensu* HAGDORN 2011a) in the Carnian age of Dolomites (Fig. 2).

#### Forcella Settsass - Settsass Scharte

The examined crinoids assemblage of the Forcella Settsass - Settsass Scharte are found on top of this section, where shell beds form several thin bands of calcarenite intercalated between argillaceous and calcareous horizons are present. "The fauna of the shell beds represents an uncemented reef-dwelling fauna which was carried down from patch reef or biostromes situated at the edge of the carbonate platforms and deposited, together with detrital calcareous material, in the form of thin shelly allodapic limestone bands." (FÜRSICH & WENDT 1977). In shell beds encrusting bryozoan are common with membraniporiform zoarial habit (BIZZARINI 2022). These bryozoans live in shallow waters of the photic zone with a low sedimentation rate and high energy.

Encrinida are dominant in the crinoids assemblage of the Forcella Settsass - Settsass Scharte, the species *Zardinicrinus granulatus* (Münster 1841), *Cassianocrinus varians* (Münster 1841) and *Cheilocrinus cassianus* (Laube 1864) are found. Isocrinida are rare with only the species *Tyrolecrinus propinquus* (Münster 1841) (Fig. 3). As in the other localities, the fossil record is represented by columnals remains, with the exception of a base cap of *Zardinicrinus granulatus* (Münster 1841). The dominance of Encrinida is probably also due to the type of substrate and the high energy environment. In fore-reef associations of Sass de Stria were found columnals remains of *Cheilocrinus cassianus* (Laube 1864) e *Zardinicrinus granulatus* (Münster 1841).

#### Aonoides subzone in Ampezzo valley

##### Cianzoppè and Milieres

Columnals remains of benthic Crinoidea were found during the biostratigraphical researches in the basin sequences of Ampezzo valley. On the western side in Val Costeana were examined the basin sequences of Cianzoppè and Milieres.

Cianzoppè, just above the road leading from Cortina

## Forcella Settsass - Settsass Scharte

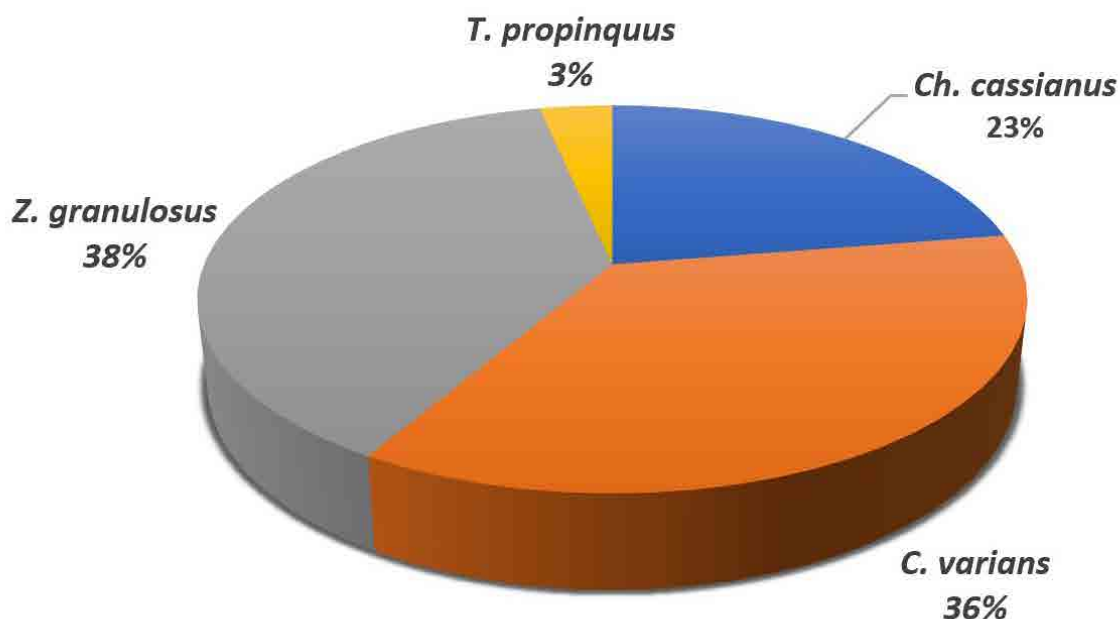


Fig. 3 - Forcella Settsass. Settsass Scharte: frequency in the fossil record of benthic crinoid remains.

d'Ampezzo to the Falzarego pass. The ammonite fauna of Cianzoppè is ascribed to the low part of Aonoides subzone (BIZZARINI 2000), in this locality were found rare columnal remains of Encrinida and Isocrinida. Encrinida are present with the species *Zardinicrinus granulosus* (Münster 1834), *Cheilocrinus cassianus* (Laube 1864) and *Cassianocrinus varians* (Münster 1841) and Isocrinida with the species *Tyrolocrinus tyrolensis* (Laube 1865) and "*Isocrinus*" *sassostriensis* Zardini 1973.

Milieres is on the southern slope of the Tofane group. In the basinal sequences of Milieres were found only columnal remains of *Tyrolocrinus tyrolensis* (Laube 1865).

Tamarin and Boa Staolin

The basinal sequences of these localities are in the meadow and woodland area between Tamarin and Lareto, in the north-eastern part of Ampezzo valley. Rare columnal remains of *Zardinicrinus granulosus* (Münster 1841), *Cassianocrinus varians* (Münster 1841) and *Tyrolocrinus tyrolensis* (Laube 1865) were found in ammonites horizon ascribed to the upper part of Aonoides subzone (BIZZARINI 2000).

## HEILIGKREUZ FORMATION

*Austriacum subzone, Sirenites horizons and early Tuvalic Campo*

The stratigraphic position of Campo is uncertain, probable low part of Austriacum subzone on the basis of the microfossils. The microfossil-samples have been made in the horizon with Porifera studied by Russo in 1981. I found in this horizon columnal remains of *Tyrolocrinus tyrolensis* (Laube 1865) and *Tyrolocrinus?* *candelabrum* Bather 1909.

Rumerlo

S. Cassiano and Heiligkreuz Formations are present in the stratigraphic sequence of Rumerlo. The biostratigraphical researches of the last century considered only the upper part of this sequence. *Megaporocidaris mariana* of Rumerlo described in Kier (1984) is found in this horizon, the crinoids described in ZARDINI (1973) are found in the lower part of this stratigraphic sequence. Only, rare columnal remains of *Tyrolocrinus propinquus* (Münster 1841) and *Cheilocrinus cassianus* (Laube 1864) are found in the upper part of this sequence.

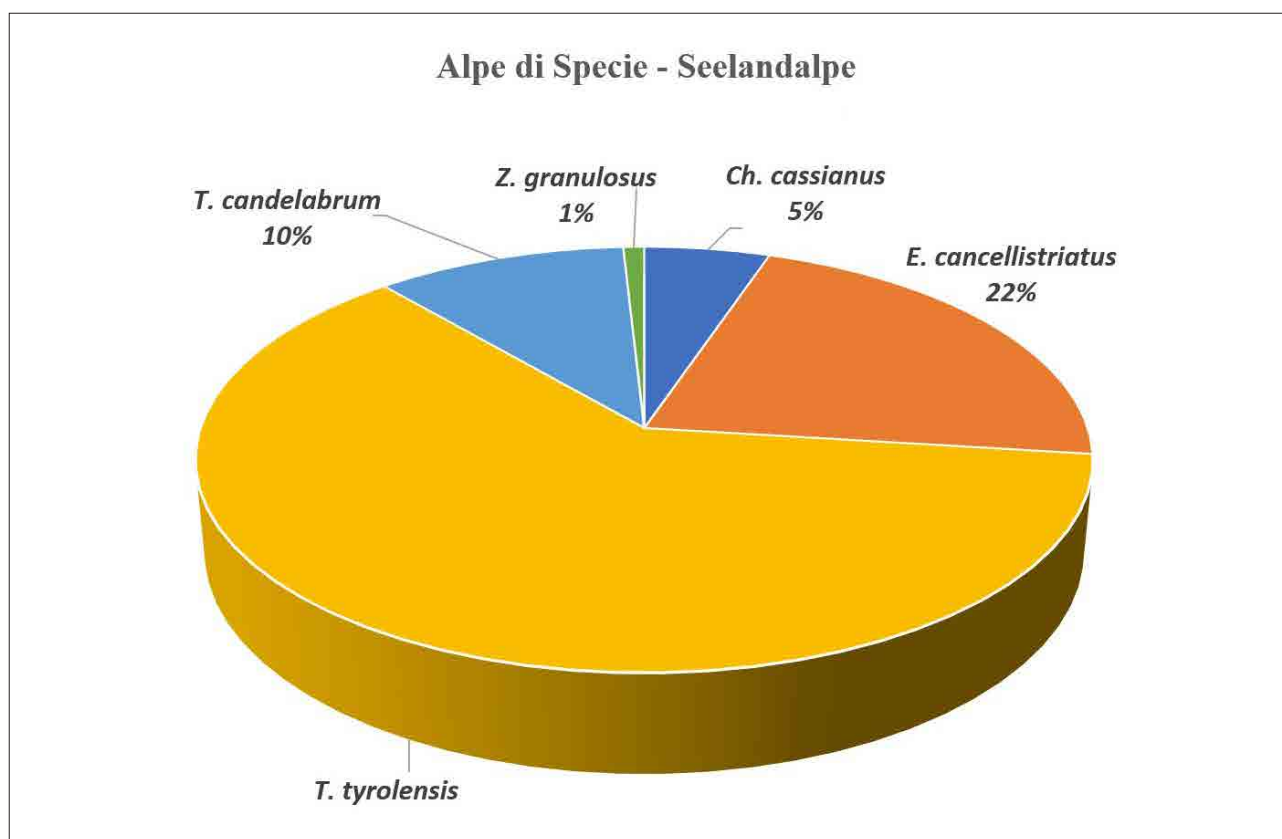


Fig. 4 - Alpe di Specie - Seelandalpe: frequency in the fossil record of benthic crinoid remains.

#### Costalares

The stratigraphic sequences of Costalares are present in the eastern part of Ampezzo valley. The fauna of these horizons were retrieved by bulk sampling and by quantitative surface collection. Costalares "a" is a calcarenite characterized by gastropods, Costalares "b" is a *Raphistomella radians*, *Myophoria harpa* and *Paleonucula strigillata* assemblage, Costalares "c" is an assemblage with Prostyliferidae (*Ampullina* in FÜRSICH & WENDT, 1977).

Benthic Crinoidea remains are very rare in Costalares a, columnals remains of *Tyrolecrinus tyrolensis* (Laube 1865) are dominated and remains of *Tyrolecrinus candelabrum* Bather 1909 and *Tyrolecrinus anulatus* Leonardi & Lovo 1950 are very rare. Columnals remains of *Tyrolecrinus tyrolensis* (Laube 1865) and *Cheilocrinus cassianus* (Laube 1864) are present also in the fossil record of Costalares b and Costalares c.

#### Alpe di Specie-Seelandalpe

Paleogeographically, the Alpe di Specie patch-reefs are interpreted as remains of bioherms which developed on the external margin of a low-profile carbonate plat-

form. Here the patch-reefs must have been formed in the photic zone, in clear, generally calm, surface waters (BIZZARINI e BRAGA 1985). Crinoidea remains for FÜRSICH e WENDT (1977) represent 0,56% of fossil record of Alpe di Specie and are present with following species *Zardinicrinus granulosus* (Münster 1834) most common species, *Cheilocrinus cassianus* (Laube 1864), "*Encrinus*" *cancellistriatus* Bather 1909, *Tyrolecrinus?* *candelabrum* Bather 1909, "*Isocrinus*" *sassostriensis* and *Isocrinus* sp. I found on Alpe di Specie a different crinoid assemblage: Isocrinida with the species *Tyrolecrinus tyrolensis* (Laube 1865) and *Tyrolecrinus?* *candelabrum* Bather 1909, that are dominant, with more than 70% of the benthic Crinoidea remains. Millecrinida (*sensu* HAGDORN 2011a) are present with the species "*Encrinus*" *cancellistriatus* Bather 1909. Encrinida remains are very rare only a few individual elements of the peduncle of *Cheilocrinus cassianus* (Laube 1864) and *Zardinicrinus granulosus* (Münster 1834) (see Fig. 4).

#### Alpe di Stolla and Misurina

Only a few individual peduncle's elements of *Tyrolecrinus tyrolensis* (Laube 1865) are found in *Cornucardia*

*hornigi* horizon of Alpe di Stolla and in Prostyliferidae horizon (*Ampullina* in FÜRSICH & WENDT 1977) along the road from Misurina to Mount Piana (BIZZARINI & LAGHI, 2005).

## CONCLUSIONS

Hagdorn (2011a) hypothesized the extinction of the order Encrinida between the aonoides and austriacum subzones and more precisely “The highest diversity was before the Mid Carnian Wet Intermezzo that caused the extinction of the order Encrinida” (HAGDORN 2011b). Also, the here reported data indicate that the order Encrinida was dominant before the Carnian Pluvial Episode, but was later replaced by the Isocrinida. The former was present but marginal before the Carnian Pluvial Episode. The order Encrinida did not become completely extinct during this climatic change, but still had some survivals like the species *Zardinicrinus granulatus* (Münster 1834) present in Alpe di Specie locality and *Cheilocrinus cassianus* (Laube 1864) present in the assemblages of Alpe di Specie, Costalares and Misurina. The Millecrinida (sensu HAGDORN 2011a) with only the species “*Encrinus*” *cancellistriatus* Bather 1909 are present before and during the Carnian Pluvial Episode with significant frequencies in the fossil record of Forcella Giau and Alpe di Specie.

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