

Preface

Studies on extant and fossils astricypeids (Echinoidea Clypeasteroidea)

Paolo Stara

Centro Studi di Storia Naturale del Mediterraneo, c/o Museo di Storia Naturale Aquilegia, Via Italia 63 Cagliari-Pirri and Geomuseo Monte Arci, Masullas, Oristano, Sardinia, Italy; e-mail: paolostara@yahoo.it

Received 25.06.2013; accepted 30.05.2014; printed 30.06.2014

In: Paolo Stara (ed.). Studies on some astricypeids (Echinoidea Clypeasteroidea), pp. 225–358

This monographic volume is the result of the need to clarify the diagnostic characters that really distinguish species and genera belonging to this interesting family of clypeasteroids.

In particular, during the research on the Oligo-Miocene species of *Amphiope* L. Agassiz, 1840 present in numerous outcrops of Sardinia (Stara et al., 2012; Stara & Borghi, 2014) have been reported several difficulties in specific distinction, when was using only the set of morphological and morphometric data normally used in the past (see Philippe, 1998).

As already observed by Durham (1955), almost all of the authors prior to his monograph on clypeasteroids were limited to the description of a few morphological and/or morphometric data, such as length, width and height of the test, petal-length and distance stoma or periproct from the anterior or posterior margin; all data disconnected from the plate pattern of the shell and often described by adjectives.

This practice, unfortunately, left many uncertainties, as is clear from the discussion that lasted for over a century (see Stara & D. Fois, 2014, and references therein). In fact much has been discussed on several morphotypes belonging to the

genus *Amphiope* rather than *Echinodiscus* Leske, 1778, only on the basis of shape of their lunules.

The discussion, in fact, concerned about the usefulness of the shape of the two posterior lunules (ellipsoidal elongated along the axis of the rear ambulacra, or rounded to ellipsoidal transverse to the rear ambulacra) in the diagnostic applied to the systematic.

Philippe (1998), studying the *Amphiope* populations from the Rhône Basin of South-Eastern France, and highlighting the great variability of shape and size of the lunules in the examined individuals, placed in synonymy with *Amphiope bioculata* des Moulins, 1837, all nominal species previously established in its and in other peri-Mediterranean regions (except *Amphiope boulei* Cottreau, 1914).

To make matters worse, at the current state of historical research, several specimens used by the authors as type-species, are nowhere to be found, poorly defined and with stratigraphic data absent if not conflicting (for *Amphiope*, for example, see des Moulins, 1835–37; L. Agassiz, 1838–41; Cottreau, 1914, Philippe, 1998).

The generic distinction, however, is made easy since Durham (1955) published the plate patterns

of two specimens that have been a type-function, widely diffused by Smith & Kroh (2011) and used by various authors, such as eg. Jansen & Mooi, 2011.

As admitted by Philippe (1998), given the many uncertainties arose because of the supposed wide variability of lunules in *Amphiope*, it would be necessary to examine some sample of extant *Echinodiscus*, the genus closer to *Amphiope*. From this correct observation we started to plan the work that led to the publication of this monograph.

One of the main tools used in this study was the examination of the plate pattern and internal structure; to determine the usefulness and reliability were examined more than 100 samples of *Amphiope* from different Sardinian's sites, including more than 40 samples from a single locality (*A. lovisatoi* Cotteau, 1895) (Stara et al., 2012; Stara & Borghi, 2014) and more than 60 extant and fossils "*Echinodiscus*" from many other locality (Stara & Sanciu; Stara & M. Fois, 2014).

In particular, we have examined the plate pattern by more than 30 samples of "*Echinodiscus cf. auritus*" (Stara & M. Fois, 2014) from Mangili, Province of Tulear (Madagascar). Of these, the plates are numbered and have performed the necessary checks of the stability of the encountered characters.

The result of the research summarized in this monographic volume has exceeded all expectations and has allowed us to develop the tools to be used for generic and specific distinction of echinoids belonging to this family.

Meanwhile, it became clear that the variability of the lunules was not the real problem, since Stara & Borghi e Stara & Sanciu (2014) were able to differentiate between different species (some of them with a very high variability of lunules) of Sardinia and many other locations.

Overcoming these issues is also fundamental to achieve one of our main goals: to understand what were the relationships that these populations have had with the congeners of other regions of the Proto Western Mediterranean (Stara & Rizzo, 2013; Stara & Rizzo, 2014).

Now we can propose, as a main tool for description of recent and fossils echinoids, analysis of the plate pattern of the test and in particular those of the oral interambulacrum 5 and oral / aboral ambulacra I and IV.

In the case of fossils from different geological epochs, with the same plate pattern, is also proposed the analysis of the internal structure, since that, as observed by Stara & Borghi (2014) with the elapse of geological times, the structure shows significant changes.

The trend shown by the sample of Sardinia (over 100 specimens of *Amphiope*) indicates a progressive reduction of the plates number and a lightening of the structure of the internal supports system.

The introduction of simple indices used for the recognition of the shape (Shape Index) and the size of lunules (Width Index) in *Amphiope*, as done by Stara & Sanciu (2014), for example, allowed to further differentiate groups of populations apparently similar. The use of other data before overlooked such as the measure within the ambitus of the interambulacrum 5 (Width at Ambitus) and the overall length of petalodium (Petalodium Length) facilitated further discrimination between genera and species. Finally, when the number of samples available makes it possible, can not miss the statistical analysis, as is done by Stara & Borghi (2014).

Other characters, such as the difference in the shape and size of pedicellaria are certainly important in supporting the distinction between species and varieties, but never separately from the analysis of the characters previously underlined. The use of these tools has made possible the distinction of two new genera and two new species within the family *Astriclypeidae* Stefanini, 1912, and has allowed us to lay the basis for the recognition of further differentiation.

It was possible to achieve this work, thanks to the availability of the web. The rapid access to relevant documents, before traceable only in few and far libraries; the ability to instantly contact other researchers around the world and to get such important information in real time; the possibility of obtaining original photos of animals and places in which examine the characteristics otherwise unreachable and geographic data such as, eg., topography, vegetation type, type of coasts, altitude of the mountains, has made it possible to multiply a hundredfold the potential at our disposal. And has certainly facilitated the realization of this work.

Summary

Stara P. - Preface. Studies on extant and fossils astriclypeids (Echinoidea Clypeasteroidea): 225–228

Stara P. & Fois D. - Dispute about *Echinodiscus* Leske, 1778 and *Amphiope* Agassiz, 1840 (Echinoidea Astriclypeidae): 229–232

Stara P. & Rizzo R. - Paleogeography and diffusion of astriclypeids (Echinoidea Clypeasteroidea) from Proto-Mediterranean basins: 233–244

Stara P. & Borghi E. - The echinoid genus *Amphiope* L. Agassiz, 1840 (Echinoidea Astriclypeidae) in the Miocene of Sardinia: 245–268

Stara P. & Fois M. - Analysis on a sample of *Echinodiscus* cf. *auritus* Leske, 1778 (Echinoidea, Clypeasteroidea): 269–290

Stara P. & Sanci L. - Analysis of some astriclypeids (Echinoidea Clypeasteroidea): 291–358

ACKNOWLEDGEMENTS

A heartfelt thanks to Enrico Borghi, of the Società di Scienze Naturali of Reggio Emilia, for the support given to the overall success of this volume. Thanks to the reviewers and in particular to Andreas Kroh, of the Naturhistorisches Museum of Vienna, for the advice dished out in compilation of the work of *Amphiope* and for the patient revision that has allowed all of us to achieve unexpected results. I also thank on behalf of the entire workgroup, institutions (museums and research centers) that have allowed and encouraged this research by allowing access to their fine collections or use of your important data on their collections or specimens: Museo di Paleontologia "D. Lovisato", Dipartimento di Chimica e Geologia and Dipartimento di Biologia animale ed Ecologia, University of Cagliari; Museo Comunale di Storia Naturale "G. Doria" in Genoa, and Dipartimento del Territorio e delle sue Risorse, University of Genoa; NHMUK, London; Natural History Museum of Denmark (Zoology), Copenhagen; PMBC of Phuket (Thailand).

REFERENCES

Agassiz L., 1841. Monographie d'échinodermes vivants et fossiles. Échinites. Famille des Clypéasteroïdes. Seconde Monographie. Des Scutelles. Neuchâtel: 149 pp.

Barbera C. & Tavernier A., 1989. Il Miocene dei dintorni di Baselice (Benevento) significato paleoecologico e paleogeografico. Atti 3° Simposio di Ecologia e Paleocologia delle comunità bentoniche. Taormina, 12–16 ottobre 1985. I. de Geronimo (Ed.). 745–757.

Comaschi Caria I., 1972. Gli echinidi del Miocene della Sardegna, Stabilimento Tipografico Edizioni Fossataro S.p.A. Ed., Cagliari, 95 pp.

Cottreau J., 1914. Les échinides néogènes du Bassin méditerranéen. Annales de l'Institut Océanographique, Monaco, 6: 1–193.

des Moulins C., 1837. Troisième Mémoire sur les échinides. Synonymie général. Actes Société Linnéenne, Bordeaux: 9: 45–364.

Durham J.W., 1955. Classification of clypeasteroid echinoids. University of California Publications in Geological Sciences, 31: 73–198.

Jansen N & Mooi R., 2011. The Astriclypeidae: Phylogenetics of Indo-Pacific, super-flat, holey sand dollars. Meeting abstract in: Society for Integrative and Comparative Biology, 2011 Annual Meeting. Salt Lake City, UT, USA.

Smith A.B. & Kroh A., 2011. The Echinoid Directory. World Wide Web electronic publication. <http://www.nhm.ac.uk/scienceprojects/echinoids> (accessed September 2013).

Stara P., Rizzo R., Sanci L. & Fois D., 2012. Note di geologia e paleoecologia relative ad alcuni siti ad *Amphiope* (Echinoidea: Clypeasteroidea) in Sardegna, Parva Naturalia (2010–2011), 9: 121–171.

Stara P. & Rizzo R., 2013. Diffusion of *Amphiope* Agassiz, 1840 (Astriclypeidae, Clypeasteroidea) from the Western proto-Mediterranean Sea, towards the Eastern Neotethys, XIII Giornate di Paleontologia. Perugia, May 23–25, 2013, Riassunti: 119–120, sessione poster.

Stara P. & Borghi E., 2014. The echinoid genus *Amphiope* L. Agassiz, 1840 (Echinoidea Astriclypeidae) in the Oligo-Miocene of Sardinia (Italy). In: Paolo Stara (ed.). Studies on some astriclypeids (Echinoidea Clypeasteroidea), pp. 225–358. Biodiversity Journal, 5: 245–268.

Stara P. & Fois D., 2014. Dispute about *Echinodiscus* Leske, 1778 and *Amphiope* L. Agassiz, 1840 (Echinoidea Astriclypeidae). In: Paolo Stara (ed.). Studies on some astriclypeids (Echinoidea Clypeasteroidea), pp. 225–358. Biodiversity Journal, 5: 229–232.

Stara P. & Fois M. 2014. Analysis on a sample of *Echinodiscus* cf. *auritus* Leske, 1778 (Echinoidea Clypeasteroidea). In: Paolo Stara (ed.). Studies on some astriclypeids (Echinoidea Clypeasteroidea), pp. 225–358. Biodiversity Journal, 5: 269–290.

Stara P. & Rizzo R., 2014. Paleogeography and diffusion of astricypeids (Echinoidea Clypeasteroidea) from Proto-Mediterranean basins. In: Paolo Stara (ed.). Studies on some astricypeids (Echinoidea Clypeasteroidea), pp.

225–358. Biodiversity Journal, 5: 233–244.

Philippe M., 1998. Les échinides miocènes du Bassin du Rhône: révision systématique. Nouvelles Archives du Muséum d'Histoire Naturelle de Lyon, 36: 3–241, 249–441.