

# Matrix of Odontasteridea morphological characters, Table 3 from Janosik & Halanych (2013) (Antarctic Inverts project)

**Website:** <https://www.bco-dmo.org/dataset/671850>

**Data Type:** Cruise Results

**Version:**

**Version Date:** 2016-12-27

## Project

» [Genetic connectivity and biogeographic patterns of Antarctic benthic invertebrates](#) (Antarctic Inverts)

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## Dataset Description

This dataset was published as Table 3 from Janosik et al (2013). It contains a matrix of 29 Odontasteridea morphological characters. See Appendix 5. Morphological Character analysis of Odontasteridae, below, for detailed methodology

**Related Reference:** Janosik, A.M., and K.M. Halanych,. 2013. Seeing stars: a molecular and morphological investigation of the evolutionary history of Odontasteridae (Asteroidea) with description of a new species from the Galapagos Islands. Marine Biology.160:821-841. DOI 10.1007/s00227-012-2136-x

## Related Datasets:

[Janosik\\_2013\\_T1: Odontasteridae species collection information](#)

[Janosik\\_2013\\_T2: outgroup species and accessions](#)

## Methods & Sampling

From Janosik et al (2013):

### **Specimen collection**

*Specimens were obtained from the Division of Echinoderms, Smithsonian Institution National Museum of Natural History (USNM) in Washington, DC, the Department of Invertebrate Zoology, California Academy of Sciences (CASIZ), San Francisco, California, and the National Institute of Water and Atmospheric Research (NIWA), New Zealand (Table 1). Most specimens were dried. Antarctic species were collected during two five-week research cruises aboard the R/V Laurence M. Gould in November/December of 2004 and May/June of 2006. Images of D. clarki were provided by NIWA.*

### **Morphological data**

*Characters consist of external skeletal features and variation in accessory structures and spines. For each*

species, multiple specimens were examined with the unaided eye and by stereomicroscope. Morphological characters were scored from published descriptions, photos, and/or museum specimens. Terminology follows Lambert (2000) and Clark and Downey (1992). Table 1 provides a list of species, references containing descriptions, and museum numbers employed herein. Additionally, *Odontaster* specimens collected from around the Gala'pagos Islands were also included in morphological character analyses. Pawson and Ahearn (2000) published a report of the echinoderms collected from submersible dives using the Johnson-Sea-Link, including a new *Odontaster* species, which does not corroborate the descriptions of known species. We scored morphological characters of these specimens to quantify previously unrecognized biodiversity, but were unable to extract usable genomic DNA.

A data matrix consisting of 29 characters and 28 in-group taxa was constructed in NEXUS data editor 5.0 (Page 2001) (Table 3 in Appendix). Nine characters were scored as binary and 19 were coded as unordered multistate. Morphological characters were mapped onto the recovered molecular tree to distinguish the important external characters useful for phylogenetic analysis. Character transformations were evaluated and mapped onto the molecular tree using a parsimony approach to show all most parsimonious states at each node using Mesquite ver. 2.74 (Maddison and Maddison 2010). First, the morphological character matrix was imported and followed by the combined 16S and COI Bayesian inference. Mesquite applies stochastic models of character state change and can explicitly accommodate uncertainty in ancestral states. Characters were mapped only for species present in the molecular tree.

#### From **Appendix 5. Morphological Character analysis of Odontasteridae:**

1. Recurved spine on oral plates: 0 = absent, 1 = one spine, 2 = two spines Whether one or two recurved spines were present in the last common ancestor of Odontasteridae cannot be determined here. *Hoplaster* lacks a recurved spine, which is a lost character. *Acodontaster*, *Eurygonias*, *Odontaster* have one recurved, glassy spine per oral plate; *Diplodontias* has two recurved, glassy spines per oral plate, while the recurved, glassy spines are missing in *Diabocilla* and *Hoplaster*. Number of changes on tree (changes) = 2; Consistency Index (CI) = 1.0
2. Abactinal plates: 0 = tabulate, 1 = paxillate, 2 = highly paxillate Tabulate abactinal plates are inferred as an ancestral character, with a change occurring in *Eurygonias hyalacanthus* and *Odontaster* species. A change to highly paxillate occurs in *O. validus*. *Acodontaster* has tabulate abactinal plates. *Diplodontias* has sub-tabulate abactinal plates. *Eurygonias* has abactinal plates that are paxillar and club-shaped. *Hoplaster* has abactinal plates that are tabulate. Overall, *Odontaster* has somewhat paxillate abactinal plates, although some species tend to have a more tabulate look. Changes = 3; CI = 0.67
3. Abactinal spines per plate: 0 = (5-10), 1 = (11-15), 2 = (16-20), 3 = (21-25), 4 = (26-30), 5 = (30 and above) *Diplodontias* and *Eurygonias* have the most spines, while a change occurs in *Diplodontias singularis* from a category 5 to 4. Changes = 10; CI = 0.45
4. Abactinal spine: 0 = smooth spines, 1 = rough spines Whether the last common ancestor of *Diplodontias* had either smooth or rough abactinal spines cannot be determined. *Acodontaster*, *Eurygonias*, *Hoplaster*, and *Odontaster* share a common ancestor that likely had rough abactinal spines. Smooth or rough texture of spines on abactinal spines is not genus specific and varies greatly from species to species. Changes = 5; CI = 0.167
5. Glassy granules on abactinal plate: 0 = absent, 1 = present Glassy granules are a derived character present only in *Diplodontias miliaris*, *Diplodontias dilatatus*, *Hoplaster spinosus*, *O. aucklandensis*, *O. australis*, *O. cynthiae*. Changes = 2; CI = 0.5
6. Abactinal spine shape: 0 = granular, 1 = short, stout, 2 = short, slender, 3 = clavate, 4 = long, slender, 5 = long, slender prominent spine in middle Granular abactinal spines are inferred as the most ancestral state. A change occurs in *Eurygonias hyalacanthus*, which has short, slender spines. A change also occurs at the base of the *Odontaster* clade to clavate spines. A reversal to granular spines occurs in *O. penicillatus*. A change occurs in *O. validus* and *O. robustus* to long, slender spines. *Acodontaster* and *Diplodontias* species all have granular abactinal spines. *Diabocilla* and *Hoplaster* species have clavate or club-shaped spines, while *Eurygonias* has short, slender spines. *Odontaster* species tend to have a variation of spine shapes. Changes = 7; CI = 0.71
7. Papulae on abactinal surface: 0 = restricted to arms and central disk, not found interradially, 1 = absent from disks center and interradiial area, 2 = covering entire abactinal surface Papulae covering the entire abactinal surface are inferred as an ancestral character in *Eurygonias hyalacanthus* and *Diplodontias* species. *Odontaster* and *Acodontaster* species have papulae restricted to the arms and central disk. A reversal has occurred in *Hoplaster kupe*, which has papulae covering the entire abactinal surface. Changes = 3; CI = 0.67
8. Marginal plate border: 0 = plates form even border with abactinals, 1 = plates form slightly raised border with abactinals, 2 = plates form distinct border with abactinals The inferred ancestral character is marginal plates that form a slightly raised border with the abactinals, while a change to forming an even border occurs at the base of the *Acodontaster* and *Odontaster* clade. A character reversal to a slightly raised border occurs in *O. crassus*, *O. meridionalis*, *O. pearsei*, and *O. roseus*. *Acodontaster hodgsoni* has marginal plates that form a distinct border with the abactinal plates. Changes = 4; CI = 0.50
9. Grooves between marginal plates: 0 = grooves not distinct, 1 = deep grooves between plates *Diplodontias*

and *Eurygonias hyalacanthus* have deep grooves between plates. It is equally parsimonious that either deep grooves or grooves not distinct between marginal plates were present in the last common ancestor of *Acodontaster* and *Odontaster*. *Odontaster* species have deep grooves between marginal plates, while *Acodontaster* do not. Changes = 4; CI = 0.25

10. Marginal plate shape: 0 = wider than long, 1 = square (block-like), 2 = wedge-shaped, 3 = rectangular round Square-shaped marginal plates are inferred as ancestral, with change occurring in *Acodontaster conspicuus* and *Eurygonias hyalacanthus* to rectangular round-shaped plates. *Diplodontias miliaris*, *O. crassus*, *O. benhami*, *O. meridionalis*, *O. pearsei*, *O. penicillatus*, and *O. roseus* have plates that are wider than long. A reversal occurs in *O. validus*. Changes = 7; CI = 0.43

11. Superomarginal plates: 0 = densely covered in spines of same length, 1 = densely covered in spines getting longer toward the edge of the plate With the exception of *Hoplaster kupe*, *O. crassus*, and *O. hispidus*, all members of *Odontasteridae* have superomarginal plates densely covered in spines of the same length. *Acodontaster*, *Diplodontias*, *Eurygonias* species have superomarginal plates densely covered in spines of the same shape. *Diabocilla*, *Hoplaster*, and *Odontaster* species vary between densely covered in spines of the same shape and densely covered in spines getting longer toward the edge of the plate. Changes = 3; CI = 0.33

12. Spines on superomarginal plates: 0 = granules, 1 = spinelets Granules for spines on the superomarginal plates are inferred as the ancestral character state. A change occurs at the base of the *Odontaster* clade. Reversals occur in *Odontaster crassus*, *O. mediterraneus*, and *O. penicillatus*. *Acodontaster*, *Diplodontias*, and *Eurygonias* have granules for spines on the superomarginal plates. *Diabocilla* and *Hoplaster* have spinelets on the superomarginal plates, while *Odontaster* is varied, with some species having granules and some with spinelets. Changes = 5; CI = 0.20

13. Inferomarginal plates: 0 = densely covered in spines of the same length, 1 = densely covered in spines getting longer toward the edge of the plate With the exception of *Hoplaster kupe*, *O. crassus*, and *O. hispidus*, and *O. penicillatus*, all members of *Odontasteridae* have inferomarginal plates densely covered in spines of the same length. *Acodontaster*, *Diplodontias*, and *Eurygonias* have granules for spines on the inferomarginal plates. *Diabocilla* has spinelets on the superomarginal plates, while *Hoplaster* and *Odontaster* are varied, with some species having granules and some with spinelets. Changes = 4; CI = 0.25

14. Spines on inferomarginal plates: 0 = same as superomarginal plates, 1 = longer than superomarginal plates, 2 = granules, with one long, prominent spine toward the outside edge of the plate *Diplodontias*, *Eurygonias hyalacanthus*, and *Acodontaster* have spines on inferomarginal plates that are the same as the superomarginal plates. A change to longer spines occurs in *O. meridionalis*, *O. pearsei*, *O. penicillatus*, and *O. roseus*. *Acodontaster marginatus* has one long, prominent spine toward the outside edge of the plate. Most *Acodontaster* species have spines that are the same length as the spines on the superomarginal plates. Changes = 4; CI = 0.50

15. Glassy granules on superomarginal plates: 0 = absent, 1 = present, 2 = present only on plates toward the arm tips The presence of glassy granules on the superomarginal plates is inferred as an ancestral character found in *Diplodontias* and *Eurygonias hyalacanthus*. Absence of glassy granules occurs at the base of *Acodontaster* and *Odontaster*, with changes in *O. benhami*, *O. crassus* and *O. mediterraneus*. *Odontaster hispidus* has glassy granules present only on the plates toward the arm tips. Changes = 5; CI = 0.40

16. Glassy granules on inferomarginal plates: 0 = absent, 1 = present, 2 = present only on plates toward the arm tips The ancestral state of the glassy granules on the inferomarginal plates cannot be determined. Glassy granules are present in *hyalacanthus*, *Diplodontias dilatatus*, *D. miliaris*, *Odontaster benhami*, *O. crassus*, and *O. mediterraneus*. *Odontaster hispidus* has glassy granules, but only on the plates toward the arm tips. Changes = 6; CI = 0.33

17. Number of chevrons on actinal surface: 0 = 3, 1 = 4, 2 = 5, 3 = 6, 4 = 7. The number of chevrons present on the actinal surface is quite variable across and within all genera (character not mapped on Fig. 8)

18. Spines per plate on actinal surface: 0 = (4-9), 1 = (10-15), 2 = (16-20), 3 = (8-10 with one prominent longer spine) The number of spines per plate on the actinal surface is varied across genera and species within genera. Sixteen to twenty spines per plate on the actinal surface was inferred as the ancestral state. Changes occur at the base of the *Diplodontias miliaris* and *D. dilatatus* clade and several times throughout *Acodontaster* and *Odontaster* clades. Changes = 10; CI = 0.10

19. Glassy granules on actinal surface: 0 = absent, 1 = present *Acodontaster*, *Diabocilla*, *Diplodontias*, *Eurygonias*, and *Hoplaster* are all lacking in glassy granules on the actinal surface. Only two members of *Odontaster* have glassy granules present on the actinal surface. Changes = 1; CI = 1.0

20. Number of furrow spines: 0 = (1-2), 1 = (2-3), 2 = (3-4), 3 = (4-5) The number of furrow spines is varied across and within taxa. The majority of taxa have 2-3 furrow spines. Changes = 9; CI = 0.33

21. Furrow spine shape: 0 = smooth, cylindrical, 1 = smooth, pointy, 2 = rough, cylindrical, 3 = rough, pointy *Diplodontias* species and *E. hyalacanthus* have smooth, cylindrical furrow spines. A change to smooth, pointy spines occurs at the base of the *Acodontaster* and *Odontaster* clade. Further changes occur within the *Odontaster* and *Acodontaster* clades. Character reversal to smooth, cylindrical furrow spines occurs in *O. benhami*, *O. hispidus*, and *O. penicillatus*. Changes = 14; CI = 0.21

22. Adambulacral plate shape: 0 = rectangle, 1 = square The ancestral character state is inferred as rectangular adambulacral plates. Character state changes occur in lineages leading to *Acodontaster hodgsoni*,

*A. marginatus*, *Hoplaster kupe*, *Odontaster penicillatus*, and *O. robustus*. Changes = 5; CI = 0.20

23. Pedicellariae: 0 = absent, 1 = present All *Acodontaster*, except *A. capitatus*, have pedicellariae. *Diabocilla*, *Hoplaster*, and *Diplodontias* (except *D. singularis*) are lacking pedicellariae. *Eurygonias* and several members of *Odontaster* have pedicellariae. Type and appearance of pedicellariae are variable. Changes = 3; CI = 0.33

24. Body shape outline: 0 = pentagonal, 1 = subpentagonal, 2 = pentagonal-stellate, 3 = sub-stellate, 4 = stellate Determination of the body shape outline in the last common ancestor of *Odontasteridae* is not possible. Changes = 12; CI = 0.33

25. Interradial arc: 0 = rounded, 1 = sub-linear, 2 = linear A rounded interrarial arc is the inferred ancestral character state. All *Acodontaster* and the majority of *Diplodontias* species have rounded interrarial arcs. *Diabocilla* and *Hoplaster* have sub-linear interrarial arcs, while *Odontaster* have either rounded or sublinear interrarial arcs. *Eurygonias* has a completely linear interrarial arc. Changes = 6; CI = 0.33

26. Arm length: 0 = short, 1 = medium, 2 = elongate *Acodontaster* have elongate arms. *Diabocilla* has medium length arms, and *Diplodontias*, *Hoplaster*, and *Odontaster* have a variety of arm length, while *Eurygonias* have very short arms. Changes = 12; CI = 0.17

27. Number of apical spines per oral plate: 0 = 2, 1 = 3, 2 = 4, 3 = 5, 4 = 6 The majority of taxa have four apical spines per oral plate. Changes occur at terminal nodes within *Acodontaster* and *Diplodontias*. Several changes occur throughout the *Odontaster* clade (character not mapped)

28. Number of suboral spines per oral plate: 0 = 2, 1 = 3, 2 = 4, 3 = 5, 4 = 6? The character state of last common ancestor of *Odontasteridae* is equivocal with either two or three suboral spines per oral plate. The number of suboral spines per oral plate is variable across and within genera (character not mapped).

29. Number of marginal spines per oral plate: 0 = (2-3), 1 = (3-4), 2 = (4-5), 3 = (5-6), 4 = (6-7) The number of marginal spines per oral plate is variable across and within genera (character not mapped)

## Data Processing Description

### BCO-DMO Processing notes:

- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

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## Data Files

File
<b>Janosik_2013_T3.csv</b> (Comma Separated Values (.csv), 2.15 KB) MD5:5f2add7290ae7772002839cd268fad0a  Primary data file for dataset ID 671850

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## Parameters

Parameter	Description	Units
species	Odontasteridea species name	unitless
char_num	coded morphological characters; see metadata description section	unitless

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## Instruments

<b>Dataset-specific Instrument Name</b>	Beckman CEQ 8000 Genetic Analysis System (Beckman Coulter)
<b>Generic Instrument Name</b>	Automated DNA Sequencer
<b>Dataset-specific Description</b>	Purified products were then sequenced bidirectionally
<b>Generic Instrument Description</b>	A DNA sequencer is an instrument that determines the order of deoxynucleotides in deoxyribonucleic acid sequences.

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	Thermal Cycler
<b>Generic Instrument Description</b>	A thermal cycler or "thermocycler" is a general term for a type of laboratory apparatus, commonly used for performing polymerase chain reaction (PCR), that is capable of repeatedly altering and maintaining specific temperatures for defined periods of time. The device has a thermal block with holes where tubes with the PCR reaction mixtures can be inserted. The cycler then raises and lowers the temperature of the block in discrete, pre-programmed steps. They can also be used to facilitate other temperature-sensitive reactions, including restriction enzyme digestion or rapid diagnostics. (adapted from <a href="http://serc.carleton.edu/microbelife/research_methods/genomics/pcr.html">http://serc.carleton.edu/microbelife/research_methods/genomics/pcr.html</a> )

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## Deployments

### Halanych\_lab\_2011-16

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/671488">https://www.bco-dmo.org/deployment/671488</a>
<b>Platform</b>	Auburn University lab
<b>Start Date</b>	2011-08-01
<b>End Date</b>	2016-07-31
<b>Description</b>	Invertebrate genomics

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## Project Information

### Genetic connectivity and biogeographic patterns of Antarctic benthic invertebrates (Antarctic Inverts)

**Coverage:** Antarctica

*Extracted from the NSF award abstract:*

The research will explore the genetics, diversity, and biogeography of Antarctic marine benthic invertebrates, seeking to overturn the widely accepted suggestion that benthic fauna do not constitute a large, panmictic population. The investigators will sample adults and larvae from undersampled regions of West Antarctica that, combined with existing samples, will provide significant coverage of the western hemisphere of the Southern

Ocean. The objectives are: 1) To assess the degree of genetic connectivity (or isolation) of benthic invertebrate species in the Western Antarctic using high-resolution genetic markers. 2) To begin exploring planktonic larvae spatial and bathymetric distributions for benthic shelf invertebrates in the Bellinghausen, Amundsen and Ross Seas. 3) To continue to develop a Marine Antarctic Genetic Inventory (MAGI) that relates larval and adult forms via DNA barcoding.

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## Funding

Funding Source	Award
<a href="#">NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)</a>	<a href="#">PLR-1043745</a>
<a href="#">NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)</a>	<a href="#">PLR-1043670</a>

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