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

Contributors	Affiliation	Role
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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 interradial 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 Acodontasterspecies 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 andEurygonias hyalacanthus.Absenceof glassy granules occurs at the base of Acodontaster and Odontaster,with changes inO. 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 interradial arc is the inferred ancestral character state. All Acodontaster and the majority of Diplodontias species have rounded interradial arcs. Diabocilla and Hoplaster have sub-linear interradial arcs, while Odontaster have either rounded or sublinear interradial arcs. Eurygonias has a completely linear interradial 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
Janosik_2013_T3.csv (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

Dataset-specific Instrument Name	Beckman CEQ 8000 Genetic Analysis System (Beckman Coulter)
Generic Instrument Name	Automated DNA Sequencer
Dataset-specific Description	Purified products were then sequenced bidirectionally
Generic Instrument Description	General term for a laboratory instrument used for deciphering the order of bases in a strand of DNA. Sanger sequencers detect fluorescence from different dyes that are used to identify the A, C, G, and T extension reactions. Contemporary or Pyrosequencer methods are based on detecting the activity of DNA polymerase (a DNA synthesizing enzyme) with another chemoluminescent enzyme. Essentially, the method allows sequencing of a single strand of DNA by synthesizing the complementary strand along it, one base pair at a time, and detecting which base was actually added at each step.

Dataset-specific Instrument Name	
Generic Instrument Name	Thermal Cycler
Generic Instrument Description	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 http://serc.carleton.edu/microbelife/research_methods/genomics/pcr.html)

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Deployments

Halanych_lab_2011-16

Website	https://www.bco-dmo.org/deployment/671488
Platform	Auburn University lab
Start Date	2011-08-01
End Date	2016-07-31
Description	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
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	PLR-1043745
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