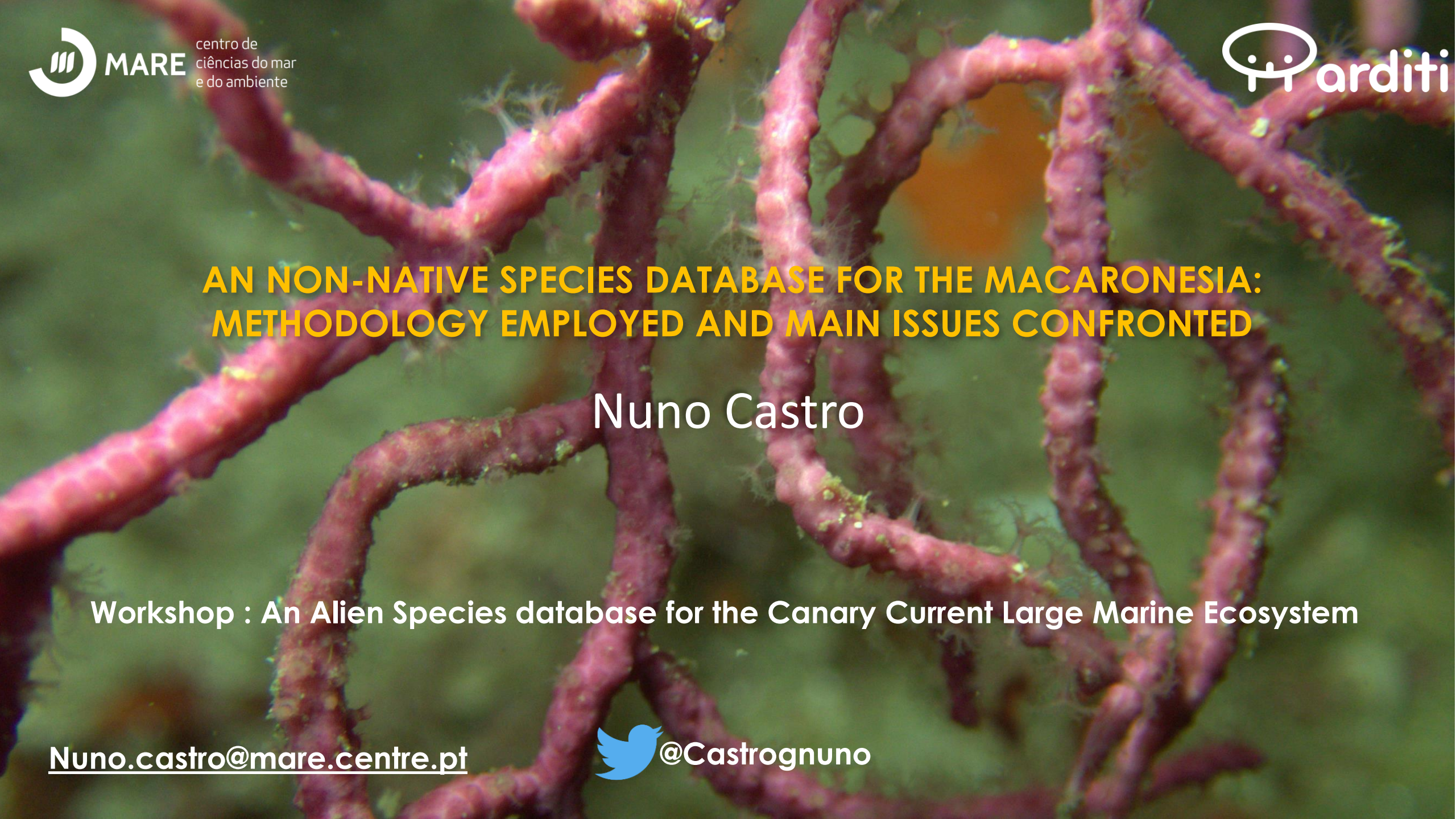


AN NON-NATIVE SPECIES DATABASE FOR THE MACARONESIA: METHODOLOGY EMPLOYED AND MAIN ISSUES CONFRONTED

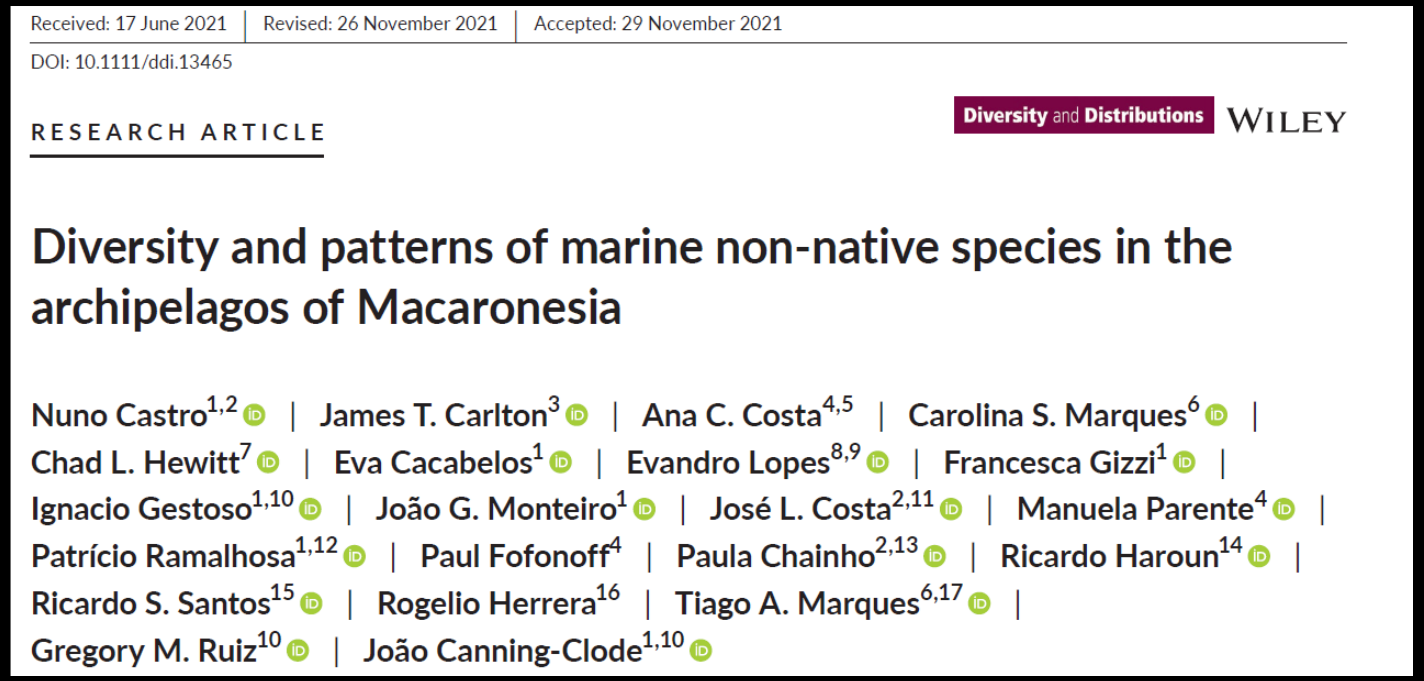
Nuno Castro

Workshop : An Alien Species database for the Canary Current Large Marine Ecosystem

Nuno.castro@mare.centre.pt

@Castrognuno

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia – Open access



Received: 17 June 2021 | Revised: 26 November 2021 | Accepted: 29 November 2021

DOI: 10.1111/ddi.13465

RESEARCH ARTICLE

Diversity and Distributions WILEY

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Nuno Castro[1,2] | James T. Carlton[3] | Ana C. Costa[4,5] | Carolina S. Marques[6] | Chad L. Hewitt[7] | Eva Cacabelos[1] | Evandro Lopes[8,9] | Francesca Gizzi[1] | Ignacio Gestoso[1,10] | João G. Monteiro[1] | José L. Costa[2,11] | Manuela Parente[4] | Patrício Ramalhosa[1,12] | Paul Fofonoff[4] | Paula Chainho[2,13] | Ricardo Haroun[14] | Ricardo S. Santos[15] | Rogelio Herrera[16] | Tiago A. Marques[6,17] | Gregory M. Ruiz[10] | João Canning-Clode[1,10]

Main objectives

- non-native species (NNS) inventory in Macaronesia
- NNS diversity patterns
- statistical modeling to explain NNS richness

Literature search (1880-2020) :

scientific papers, books, book chapters, theses and reports

Azores

KEYWORDS:

Madeira

Web of science
Scopus
Google scholar

Non-indigenous species NIS
invasive Alien Introduced
invasion non-native
Exotic

Cabo Verde

Canary Islands

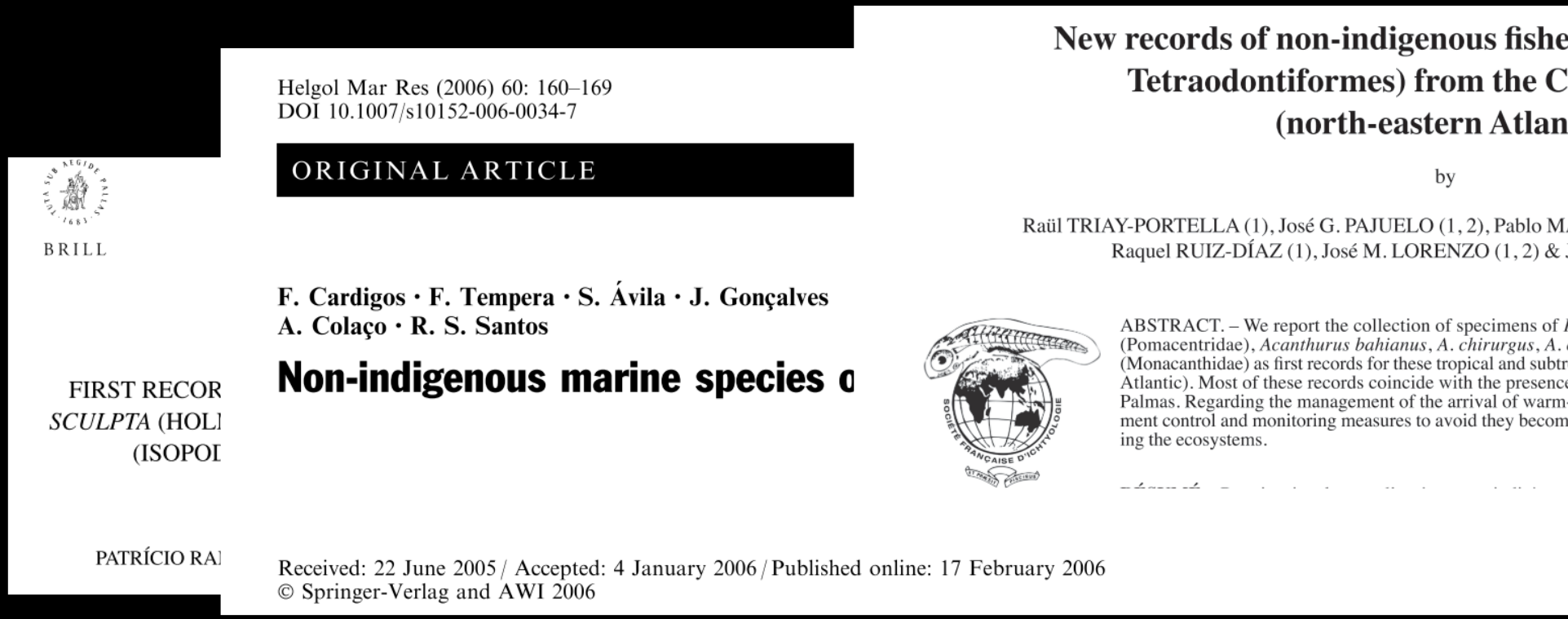
Literature search

- Focused on ecology, biology, marine biology, fisheries, biodiversity, conservation, environmental sciences, oceanography and zoology to avoid bias with medical sciences (i.e. cancer research) due to the use of the terms “invasive” and “invasion”;
- Relevant subsequent citations were also analyzed;
- For this study we removed: Marine mammals, marine birds and vascular plants and freshwater and brackish species;
- Local experts.

Species selection

Multicriteria (5) - many as possible

1 – reference in literature



BRILL

FIRST RECOR
SCULPTA (HOLI
(ISOPOI

PATRÍCIO RA

Helgol Mar Res (2006) 60: 160–169
DOI 10.1007/s10152-006-0034-7

ORIGINAL ARTICLE

F. Cardigos · F. Tempera · S. Ávila · J. Gonçalves
A. Colaço · R. S. Santos

Non-indigenous marine species o

Received: 22 June 2005 / Accepted: 4 January 2006 / Published online: 17 February 2006
© Springer-Verlag and AWI 2006

New records of non-indigenous fishes (Perciformes and Tetraodontiformes) from the Canary Islands (north-eastern Atlantic)

by

Raül TRIAY-PORTELLA (1), José G. PAJUELO (1, 2), Pablo MANENT (1), Fernando ESPINO (3), Raquel RUIZ-DÍAZ (1), José M. LORENZO (1, 2) & José A. GONZÁLEZ* (2)

ABSTRACT. – We report the collection of specimens of *Paranthias furcifer* (Serranidae), *Abudefduf hoefleri* (Pomacentridae), *Acanthurus bahianus*, *A. chirurgus*, *A. coeruleus* (Acanthuridae), and *Cantherhines pullus* (Monacanthidae) as first records for these tropical and subtropical species from the Canary Islands (north-eastern Atlantic). Most of these records coincide with the presence of oil platforms towards and within the Port of Las Palmas. Regarding the management of the arrival of warm-affinity fish species, it would be necessary to implement control and monitoring measures to avoid they become invaders, displacing indigenous species and changing the ecosystems.

Diversity and Distributions

RESEARCH ARTICLE

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Species selection

2 – found in ports and/or marinas

These marine infrastructures act as NNS hotspots (e.g. Canning-Clode et al., 2013; Marchini et al., 2015; Ferrario et al., 2017)

- we recognize that native species are also found in port facilities, and intense studies of port systems might reveal native species that are not yet reported elsewhere. However, we use multiple criteria and do not use 'only in ports' as the sole criterion by which to identify a species as NNS

Species selection

3 – Expert opinion and/or reference in marine invasions databases

- NEMESIS (Fofonoff et al., 2018);
- AquaNIS;
- Global Invasive Species Database;
- CABI – Invasive species compendium.
- European Alien Species Information Network (EASIN)

Species selection

4 – Ranges expansion species

DE GRUYTER

Carlos Sangil*, Lau
Halimeda inc
Canary Islanc
subtropical A

https://doi.org/10.1515/bot-
Received 28 November, 2017
28 February, 2018

Abstract: Extensive offshore meadows of *Halimeda incrassata* are documented for the first time in sandy bottoms of La Palma, Canary Islands. *Halimeda incrassata* forms

Rev. Aca

New records of

natural ex

Falcón, J.M.[1],

BIOLOGY

Journal of Fish Biology (2
doi:10.1111/jfb.12162, avai

New and rar
occasional

P. AFONSO*†‡, I
T. MORA

relationships and revealed that oth
species were included under the tax
findings led to a reassessment of the geographical distribu-
tion of the genus *Halimeda* section *Rhipsalis* in the tropics,
with the new species *Halimeda kanaloana* Vroom and *Hal-*

ELSEVIER

Aquatic Botany
Volume 153, February 2019, Pages 40-43

A new signal of marine tropicalization in the Macaronesia region: First record of the mesophotic macroalga *Avrainvillea canariensis* A. Gepp & E.S. Gepp in the Madeira archipelago

C. Ribeiro [a, b], A.I. Neto [c], I. Moreu [c], R. Haroun [d], P. Neves [a, b]

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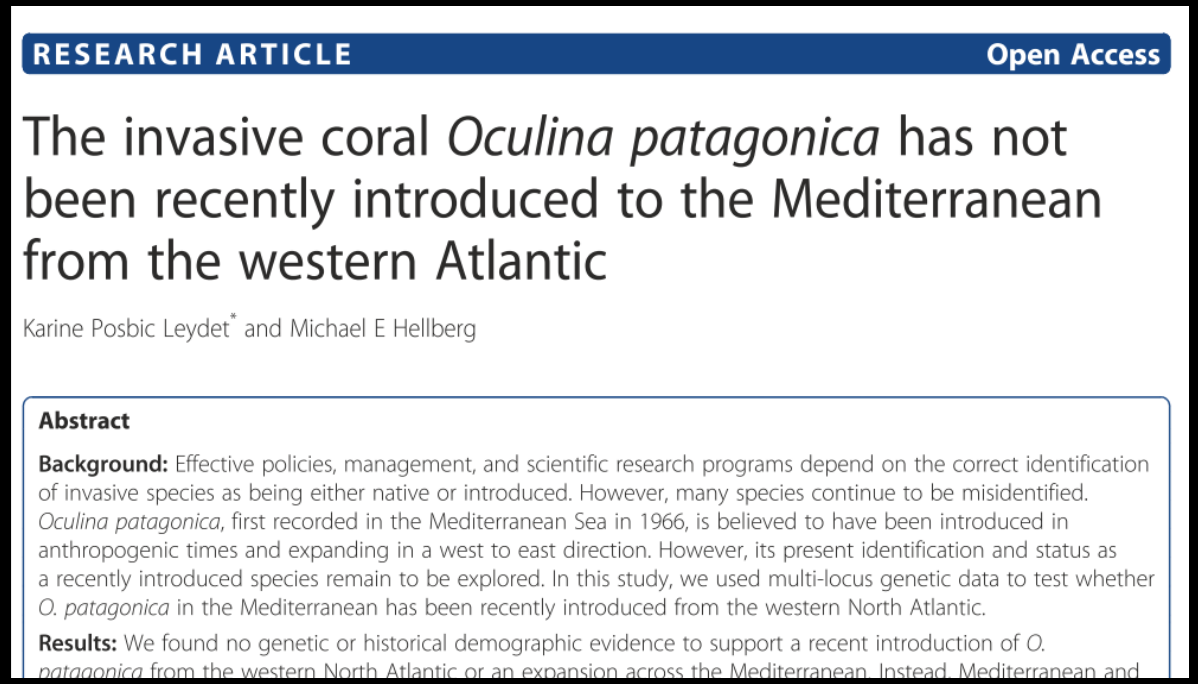
Diversity and Distributions

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Species selection

5 – Current NNS population status

Overtime some species changed their biogeographic status (e.g. Molecular evidences).



RESEARCH ARTICLE Open Access

The invasive coral *Oculina patagonica* has not been recently introduced to the Mediterranean from the western Atlantic

Karine Posbic Leydet* and Michael E Hellberg

Abstract

Background: Effective policies, management, and scientific research programs depend on the correct identification of invasive species as being either native or introduced. However, many species continue to be misidentified. *Oculina patagonica*, first recorded in the Mediterranean Sea in 1966, is believed to have been introduced in anthropogenic times and expanding in a west to east direction. However, its present identification and status as a recently introduced species remain to be explored. In this study, we used multi-locus genetic data to test whether *O. patagonica* in the Mediterranean has been recently introduced from the western North Atlantic.

Results: We found no genetic or historical demographic evidence to support a recent introduction of *O. patagonica* from the western North Atlantic or an expansion across the Mediterranean. Instead, Mediterranean and

Diversity and Distributions

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Species selection

Some species were removed:

- Sporadic records: included in the listing but removed from modelling;
- Species with doubted status (e.g. the tunicate *Botryllus schlosseri*) removed from the study.

The species list – 190 species in total 144 validated

Status (N, C, NNS, NNS/RE…)

Included in the model

Species name

Taxa

Used criteria

Year

Islands and references

	A	B	C	D	E	F	G
1	Appendix S1 - Literature search						
2							
3	Diversity and Patterns of Marine Non-Native Species in the Archipelagos of Macaronesia						
4	Nuno Castro, James T. Carlton, Ana C. Costa, Carolina Marques, Chad L. Hewitt, Eva Cacabelos, Evandro Lopes, Francesca Gizzi, Ignacio Gestoso, João G. Monteiro, José L. Costa, Manuela Parente, Patrício Rama						
5	*Corresponding author: jcanning-clode@mare.centre.pt						
6	**Please cite this paper while using any data extracted from this table**						
7							
8	List of the non-native species (NNS) detected for Macaronesia based on the comprehensive literature search conducted in the present paper. Criteria for NNS consideration is described in the Material and Meth						
9							
11	**Species**	**Taxa**	**Status**	**Criteria**	**Yea**	**ese**	**Is ds and Reference**
12	*efleri* (Steindachner, 1881)						
13	*saxatilis* (Linnaeus, 1758)	Vertebrata					N
14	*Abudefduf taurus* (Müller & Troschel, 1848)	Vertebrata					
15	*Acanthurus bahianus* Castelnau, 1855	Vertebrata					
16	*Acanthurus chirurgus* (Bloch, 1787)	Vertebrata					
17	*Acanthurus coeruleus* Bloch & Schneider, 1801	Vertebrata					
18	*Acanthurus monroviae* Steindachner, 1876	Vertebrata					
19	*Acrothamnion preissii* (Sonder) E.M.Wollaston	Macroalgae	NNS- 1st record	i	2009	1	Sa (Parente et al., 2018)
20	*Alloeocarpa loculosa* Monniot C., 1974	Tunicata	NNS- 1st record	i	1971	1	Te (Monniot C., 1974; Ca
21	*Aluterus monoceros* (Linnaeus, 1758)	Vertebrata	NNS/RE*- 1st record		1992	0	Fa (Cardigos et al. 2006 N
22	*Aluterus scriptus* (Osbeck, 1765)	Vertebrata	NNS/RE*- 1st record		1999	0	Fa (Afonso et al. 2013) N
23	*Amathia gracilis* (Leidy, 1855)	Bryozoa	NNS- 1st record	i and ii	2013-201	1	SM (Micael et al., 2019)
24	*Amathia verticillata* (delle Chiaje, 1822)	Bryozoa	NNS- 1st record	i and ii	2008	1	SJ, Te, P, Sa, Fa and SM N
25	*Amphibalanus amphitrite* (Darwin, 1854)	Arthropoda	NNS	i and ii	1887	1	Fa and SM (Gruvel, 192 N
26	*Amphibalanus eburneus* (Gould, 1841)	Arthropoda	NNS- 1st record	i and ii	1998	1	Fa and SM (Southward, 1
27	*Amphinome rostrata* (Pallas, 1766)	Polychaeta	NNS- 1st record	i	1885-191	1	Fl (David, 2017)
28	*Antiopella cristata* (Delle Chiaje, 1841)	Mollusca	NNS*- 1st record		2008	0	SM (Cordeiro et al., 201 N
29	*Antithamnion densum* (Suhr) M.A.Howe	Macroalgae	NNS- 1st record	i	2005-200	1	P (Wallenstein, 2011; Mi

Problems/solutions

Sometimes the initial search was not enough

Example: Only 1 record in Azores

Solution:

We need to verify if that species was observed in the other archipelagos :

→ Search species name + archipelago name;

→ Using NIS checklist and/or species check listing can help:

Problems/solutions

Access to references

Example:

Nobre, A., 1930. Materiais para o estudo da Fauna dos Açores. Instituto de Zoologia da Universidade dos Açores. 108pp. Instituto de Zoologia

Solution: Ask someone for the book!

http://www.livrariaesquina.com/5712.jpg

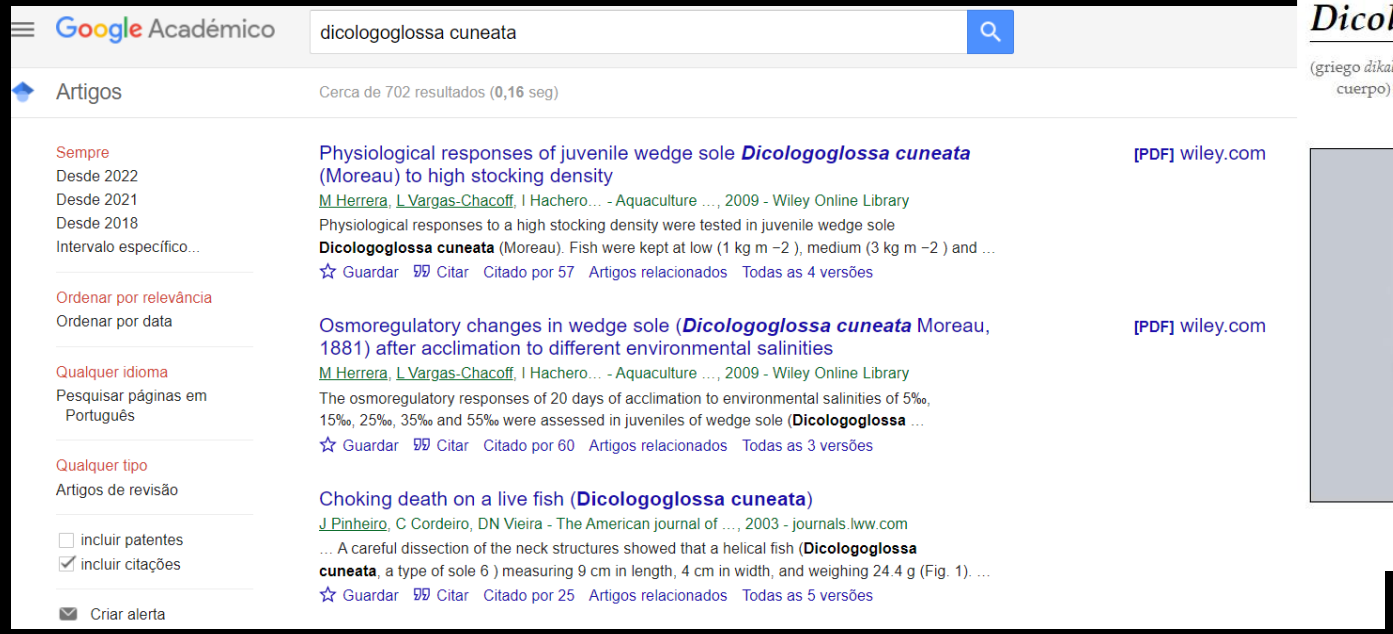
Problems/solutions

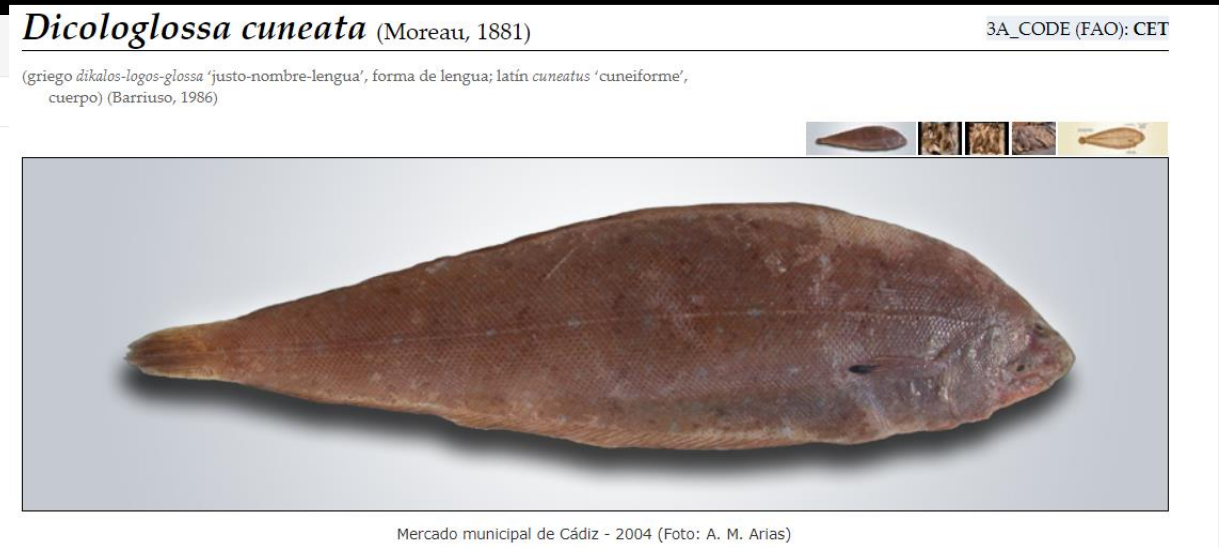
Databases or some research with typos: Dates; Locations of first record etc…

The case of *Dicologlossa cuneata* (not in the paper).

A typo over the years corrected in 2002, but the error perpetuated

Solution: Double check everthing and go to the background reference





Problems/solutions

Species names / synonyms

★ *Amathia verticillata* (delle Chiaje, 1822)

AphiaID	851581 (urn:lsid:marinespecies.org:taxname:851581)
Classification	Biota > ★ Animalia (Kingdom) > ★ Bryozoa (Phylum) > ★ Gymnolaemata (Class) > ★ Ctenost > ★ Vesicularioidea (Superfamily) > ★ Vesiculariidae (Family) > ★ *Amathia* (Genus) > ★ *Amat*
Status	accepted
Rank	Species
Parent	★ *Amathia* Lamouroux, 1812
Orig. name	★ *Hydra verticillata* Delle Chiaje, 1822
Synonymised names	☆ *Hyalosiphonia verticillatus* (Delle Chiaje, 1822) · unaccepted (synonym) ★ *Hydra verticillata* Delle Chiaje, 1822 · unaccepted (basionym) ★ *Serialaria coutinhii* Muller, 1860 · unaccepted (Subjective synonym) ★ *Zoobotryon pellucidus* Ehrenberg, 1829 · unaccepted (junior subjective synonym) ★ *Zoobotryon verticillatum* (Delle Chiaje, 1822) · unaccepted (Generic synonym)

Problems/solutions

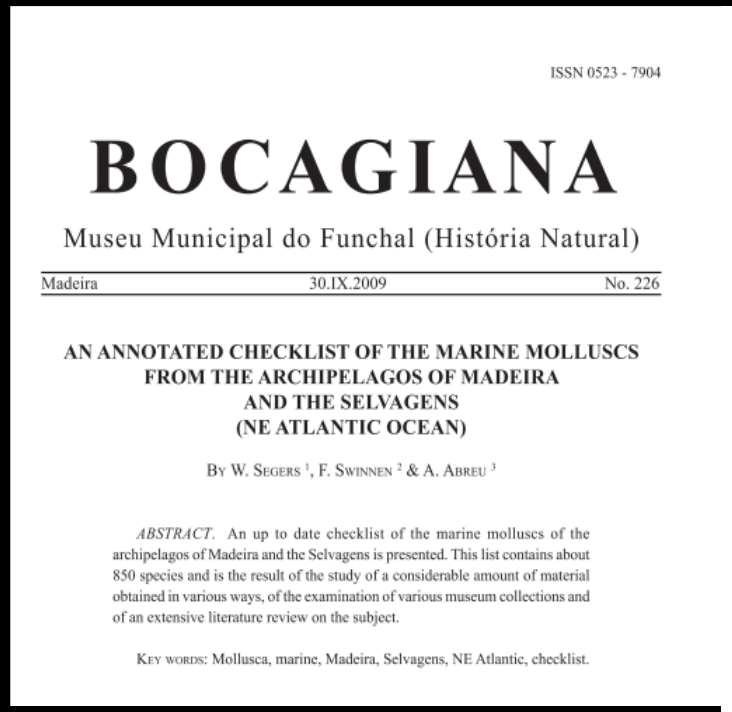
Species checklists with no information

Example:

Segers et al., 2009

850 species with no indication of location or date;

- Nightmare!
- Solution? Email the author



ISSN 0523 - 7904

BOCAGIANA

Museu Municipal do Funchal (História Natural)

Madeira 30.IX.2009 No. 226

AN ANNOTATED CHECKLIST OF THE MARINE MOLLUSCS FROM THE ARCHIPELAGOS OF MADEIRA AND THE SELVAGENS (NE ATLANTIC OCEAN)

By W. Segers [1], F. Swinnen [2] & A. Abreu [3]

ABSTRACT. An up to date checklist of the marine molluscs of the archipelagos of Madeira and the Selvagens is presented. This list contains about 850 species and is the result of the study of a considerable amount of material obtained in various ways, of the examination of various museum collections and of an extensive literature review on the subject.

Key words: Mollusca, marine, Madeira, Selvagens, NE Atlantic, checklist.

SYSTEMATICS

Class **MONOPLACOPHORA**
Order **MONOPLACOPHORIDA**
Family **NEOPILINIDAE**
Genus ***Veleropilina*** Starobogatov & Moskalev, 1987
Veleropilina zofragi (Dautzenberg & Fischer, 1896)

Class **POLYPLACOPHORA**
Order **LEPIDOPLEURIDA**
Family **LEPTOCHITONIDAE**
Genus ***Leptochiton*** Gray, 1847
Leptochiton algesirensis (Capellini, 1859)
Leptochiton cancellatus (Sowerby G.B.H., 1840)
Leptochiton odheri (Bergenhayn, 1931)
Family **HANLEYIDAE**
Genus ***Hanleya*** Gray, 1857
Hanleya hanleyi (Bean in Thorpe, 1844)
Order **CHITONIDA**
Family **ISCHNOCHITONIDAE**
Genus ***Callochiton*** Gray, 1847
Callochiton septemvalvis euplaeae (O. G. Costa, 1829)
Genus ***Lepidochitona*** Gray,1821
Lepidochitona canariense (Thiele, 1909)
Family **ACANTHOCHITONIDAE**
Genus ***Acanthochitona*** Gray, 1821
Acanthochitona crinita (Pennant, 1777)
Acanthochitona fascicularis (Linné, 1767)

Class **GASTROPODA**
SubClass **PROSOBRANCHIA**
Order **ARCHAEOGASTROPODA**
SubOrder **DOCOGLOSSA**
SuperFamily **PATELLOIDEA**
Family **PATELLIDAE**
Genus ***Patella*** Linné,1758
Patella candei candei d,Orbigny, 1840
Patella piperata Gould, 1846
Patella tenuis tenuis Gmelin, 1791
Patella ulyssiponensis gmelin, 1791
Family **ACMAEIDAE**
Genus ***Pectinodonta*** Dall,1882
Pectinodonta maxima Dautzenberg, 1925
Family **LEPETIDAE** Gray,1850
Genus ***Propilidium*** Forbes & Hanley,1849
Propilidium exiguum (Thompson W.,1844)
Family **LOTTHIDAE**
Genus ***Tectura*** Gray, 1847
Tectura virginea (Muller O. F., 1776)
SubOrder **COCCULINIFORMIA**
SuperFamily **COCCULINOIDEA**
Family **COCCULINIDAE**
Genus ***Coccopygia*** Marchall, 1892
Coccopygia **cf.** ***spinigera*** (Jeffreys, 1883)
Family **PSEUDOCOCCULLINIDAE**
Genus ***Kaiparapelta*** Marchall, 1986
Kaiparapelta askewi ***Mc Lean & Harasewych, 1995***
Genus ***Copulabyssia*** Haszprunar, 1988
Copulabyssia corrugata (Jeffreys, 1883)
Family **LEPETELLIDAE**
Genus ***Lepetella*** Verrill, 1880
Lepetella sierrai Dantart & Luque, 1994
SubOrder **NERITIMORPHA**
Family **NERITIDAE**
Genus ***Smaragdia*** Issel, 1869
Smaragdia viridis (Linné, 1758)
SubOrder **VETIGASTROPODA**
SuperFamily **FISSURELLOIDEA**
Family **FISSURELLIDAE**
Genus ***Diodora*** Gray, 1821
Diodora gibberula (Lamarck, 1822)

Diversity and Distributions

A Journal of Conservation Biogeography

RESEARCH ARTICLE

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Problems/solutions

Terminology

RE are NOT NIS?

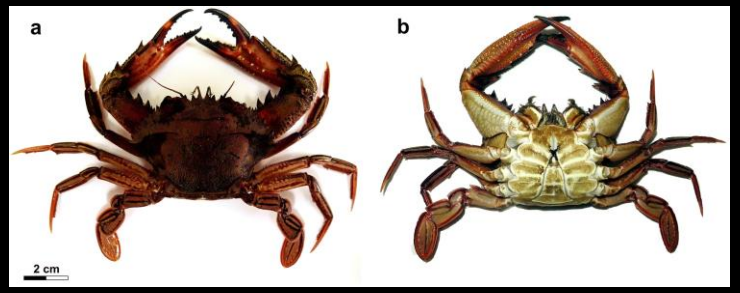
"***Non-indigenous species*** *(NIS; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range …. resulting from human activities.* ***Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS.*** *However, secondary introductions of NIS from the area(s) of their first arrival could occur without human involvement due to spread by natural means.*“
MSFD – D2 Non-indigenous species

Invasive Alien Species (IAS), are defined by TG2 as "a subset of established **NIS** which have spread, are spreading or have demonstrated their potential to spread elsewhere, **and have an adverse effect on biological diversity, ecosystem functioning, socio-economic values and/or human health in invaded regions**". MSFD – D2 Non-indigenous species


Diversity and Distributions
A Journal of Conservation Biogeography
RESEARCH ARTICLE
Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Problems/solutions

Terminology



Example – *Cronius ruber*

Range expansion species arrived to Canary Islands and Madeira – By definition cannot be NIS; but is invasive

Original Paper | Published: 31 August 2019

Cronius ruber (Lamarck, 1818) arrives to Madeira Island: a new indication of the ongoing tropicalization of the northeastern Atlantic

Susanne Schäfer, João Monteiro, Nuno Castro, Gil Rilov & João Canning-Clode

Marine Biodiversity **49**, 2699–2707 (2019) | Cite this article

420 Accesses | **9** Citations | **2** Altmetric | Metrics

applied sciences MDPI

Article

Metallic Study of the Invasive Species *Cronius ruber*—Assessment of Toxic Risk

Thabatha Thorne-Bazarra [1], Enrique Lozano-Bilbao [2], Raül Triay-Portella [3], Arturo Hardisson [1], Soraya Paz [1], Carmen Rubio-Armendariz [1], Verónica Martín [4] and Angel J. Gutiérrez [1,*]

Solution?

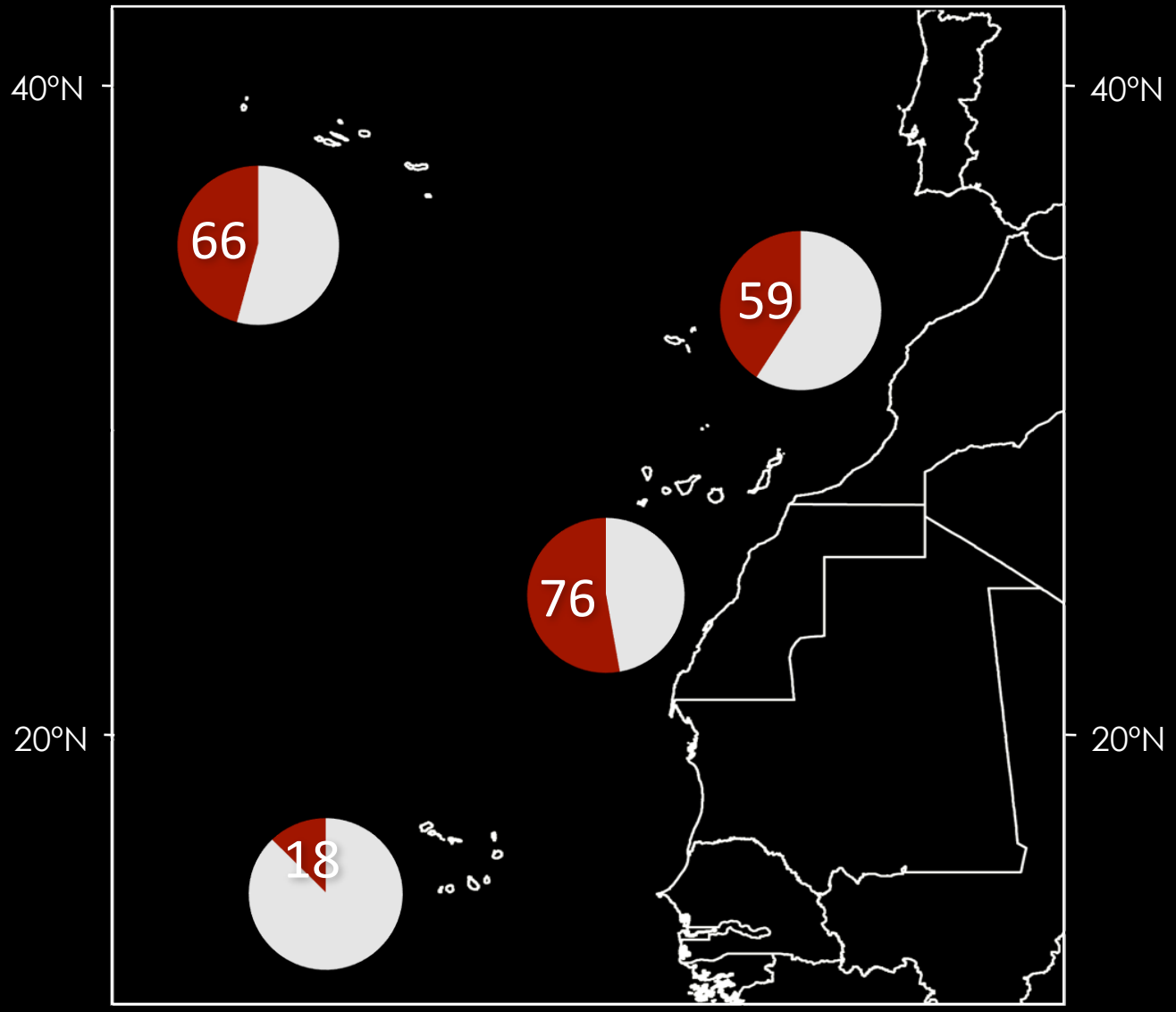

Diversity and Distributions

RESEARCH ARTICLE

Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Results of the paper

NNS richness

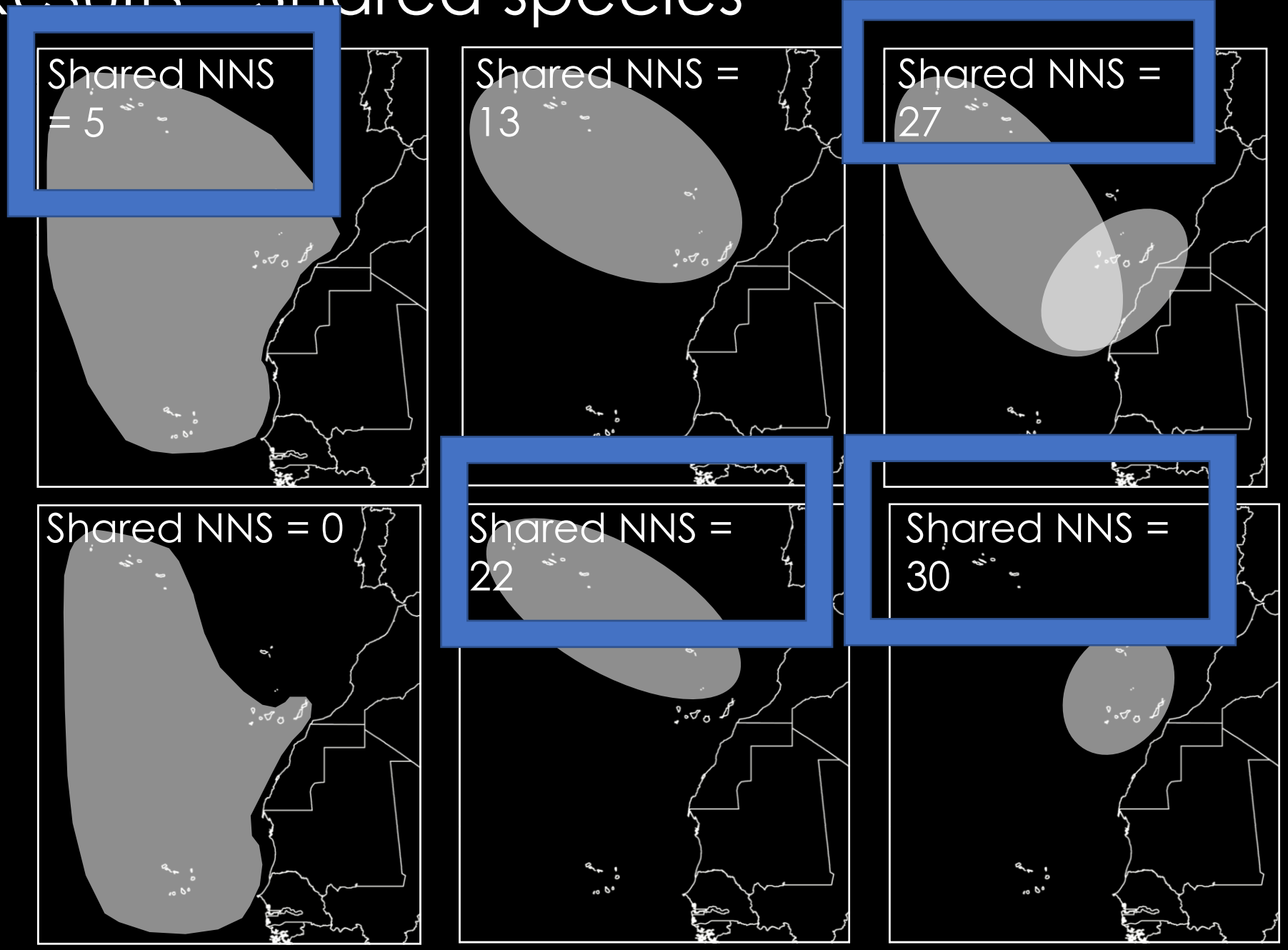


144
NNS

Castro et al., 2022


Diversity and Distributions
A Journal of Conservation Biogeography
RESEARCH ARTICLE
Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

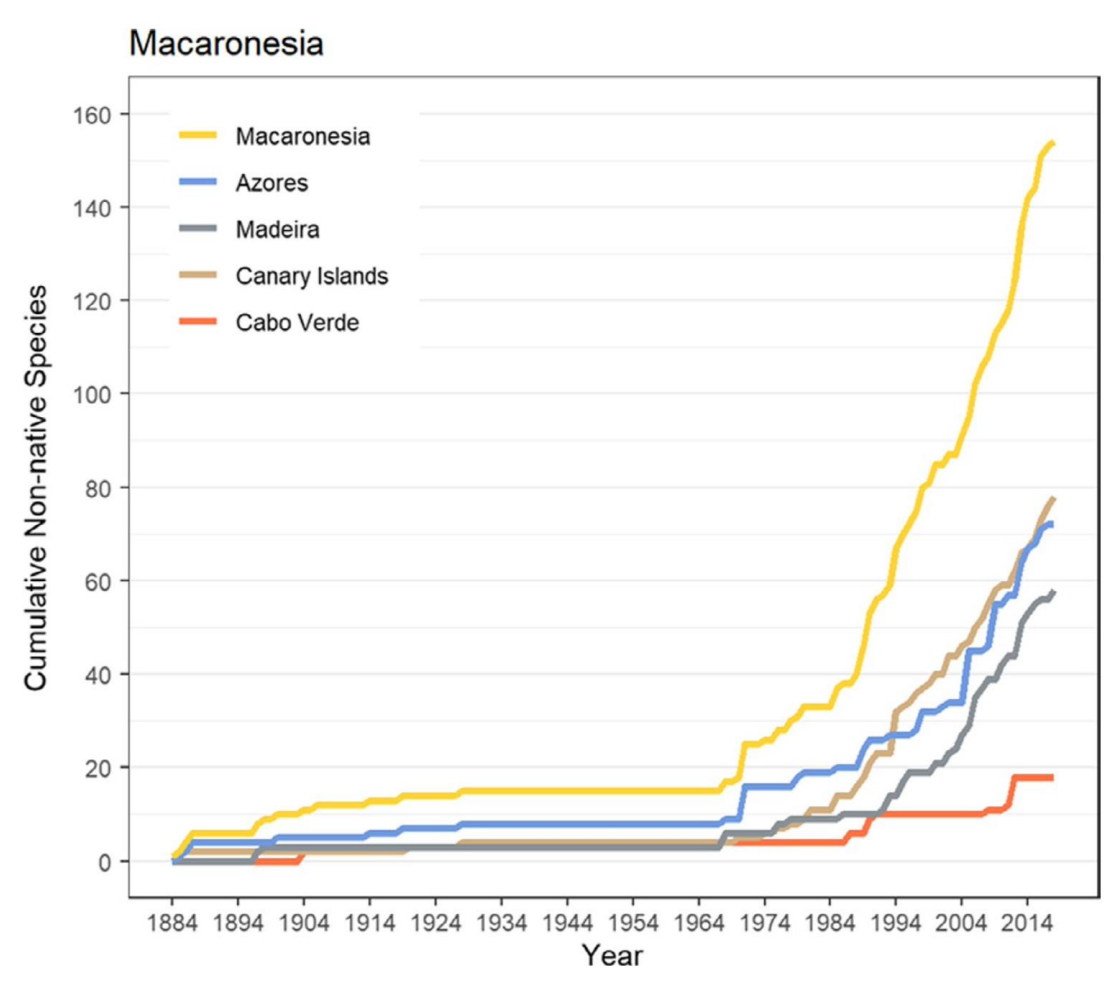
Results – Shared species



Castro et al., 2022

Results

Accumulated NNS number over time




Diversity and Distributions
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Diversity and patterns of marine non-native species in the archipelagos of Macaronesia

Castro et al., 2022

Results

Species composition

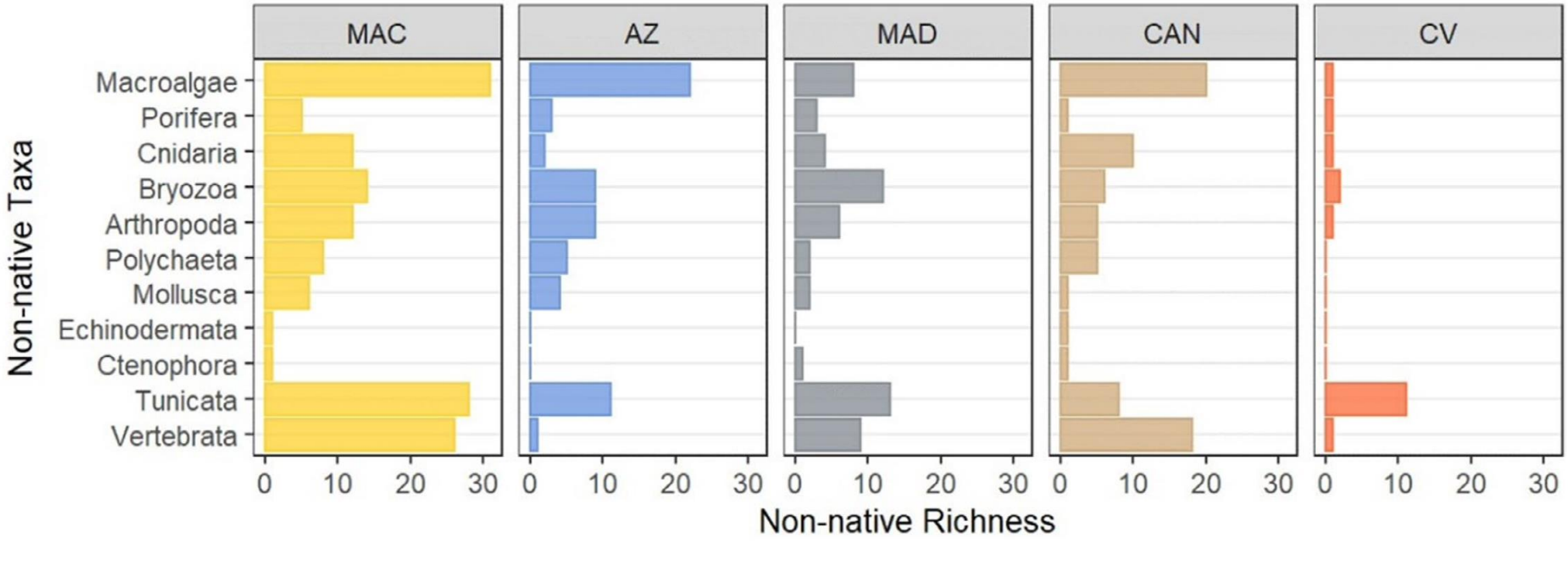

FIGURE 3 Most representative taxonomic groups for non-native species (NNS) in Macaronesia and each archipelago system (MAC—Macaronesia; AZ—Azores; MAD—Madeira; CAN—Canary Islands; CV—Cabo Verde)

Castro et al., 2022

Results

Negative Binomial GLM

TABLE 1 Estimated regression parameters, standard errors, *z*-values and *p*-values for the best Negative Binomial (NB) General Linear Model (GLM) presented regarding non-native species (NNS) richness as a function of anthropogenic, demographic and geographical variables

	Estimate	Std. error	*z* value	*p*-value
Intercept	5.458	0.7387	7.390	<.001
Mindist	−0.002	0.001	−3.849	<.001
Archipelago_codeCan	−1.562	0.382	−4.077	<.001
Archipelago_codeCV	−3.121	0.437	−7.142	<.001
Archipelago_codeMad	−1.112	0.365	−3.063	<.01
Total_marina_area	0.001	0.001	−3.589	<.001
Total_harbors_marinas	0.020	0.003	5.788	<.001

Note: The estimated value for Theta is 402 ± 3050.

Castro et al., 2022

Conclusions of the paper

- NNS > Canary Islands > Azores > Madeira > Cabo Verde
- Shared NNS – proximity, perhaps closer shipping history, and similar studied subjects (e.g. Macroalgae)
- Cabo Verde seems very distant from remaining island systems (NNS numbers and composition)
- Probably more NNS in all islands
- Search effort may play a role in these patterns

Castro et al., 2022

Guidance for An Alien Species database for the CCLME

- Describe well the terminology
- Define the impact/effect of the species (biological, economic etc).
- Try to go to the source (reference) avoiding mistakes

Thank you

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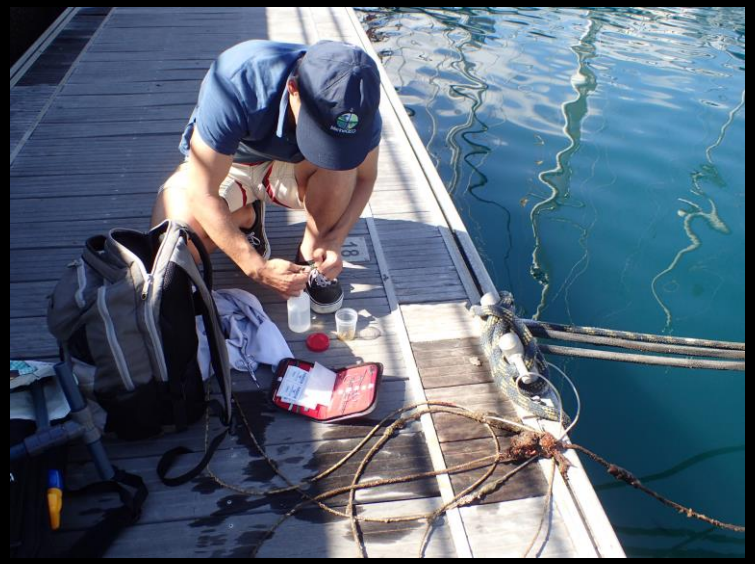
MARE centro de ciências do mar e do ambiente



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