Brazilian Journal of Biology
ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

https://doi.org/10.1590/1519-6984.208863
Original Article

Spatial distribution in marine invertebrates in rocky shore of Araucania Region (38° S, Chile)

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Received: July 20, 2018 – Accepted: February 13, 2019 – Distributed: May 31, 2020
(With 2 figures)

Abstract

The rocky shores in Chile have a wide invertebrate species diversity, that include species with marked abundances in determined regions. The aim of the present study is to analyse the spatial distribution pattern in different marine invertebrate species in rocky shore of Araucania region, considering if these species have random, uniform or associated patterns, and extrapolate if these patterns have Poisson, binomial or negative binomial distribution respectively. The results revealed the presence mainly of gastropods molluscs that would graze on benthic algae, these species have mainly aggregated pattern that has a robust negative binomial distribution pattern. The obtained results agree with observations for marine benthic fauna that mentioned the presence of aggregated pattern, has negative binomial distribution. Other ecological topics about spatial distribution were discussed.

Keywords: mollusks, rocky shore, intertidal, negative binomial distribution.

Distribuição espacial em invertebrados marinhos na costa rochosa da região de Araucanía (38° S, Chile)

Resumo

As costas rochosas no Chile têm uma ampla diversidade de espécies de invertebrados, que incluem espécies com abundância marcada em determinadas regiões. O objetivo do presente estudo é analisar o padrão de distribuição espacial em diferentes espécies de invertebrados marinhos na costa rochosa da região de Araucanía, considerando se essas espécies possuem padrões aleatórios, uniformes ou associados, e extrapolar se esses padrões possuem distribuição binomial de Poisson, binomial ou negativa. respectivamente. Os resultados revelaram a presença principalmente de moluscos gastrópodes que pastam em algas bentônicas, estas espécies têm principalmente agregado padrão que tem um padrão robusto de distribuição binomial negativa, padrão agregado de grupos, e a fauna de água doce que apresenta distribuição binomial negativa. Outros tópicos ecológicos sobre distribuição espacial foram discutidos.

Palavras-chave: moluscos, costões rochosos, intertidais, distribuição binomial negativa.

1. Introduction

The rocky intertidal environments in Chilean coast is characterized by the high species diversity specifically macroalgae, invertebrates (mollusks, echinoderms, crustaceans) and fishes, that has a marked geographic distribution pattern (Santelices, 1992; Lee et al., 2008). The rocky shore is markedly exposed to waves among a wide latitudinal gradient in Chile (17-41°S), whereas in extreme southern Chile the coast is characterized by the presence of islands and inner seas with different patterns in species reported (Santelices, 1992; Camus et al., 2013; Velasquez et al., 2016).

The literature about intertidal invertebrates revealed that these species can have a gregarious behaviour, as protection against drying during low tide, or for efficient use of food resources (Rojas et al., 2000), many of these species inhabits in rocky cracks or under rocks, or macroalgae basal disks. (Santelices, 1980; Camus and Andrade, 1999; Cerda and Castilla, 2001). Also, the distribution patterns can be affected due the topography of rocky shores, involving recruitment patterns of small gastropods (Underwood, 2004). Considering these antecedents, there are interspecific competence between intertidal gastropods and monoplacophora due shelter availabilities (Aguilera and Navarrete, 2011, 2012), that can generate that some species can have diurnal or nocturnal activity (Aguilera and Navarrete, 2011)

The Araucania region, has a coast markedly exposed to wind and strong waves, with scarce rocky shores, that have difficult access, on a biogeographical view point the invertebrate species would belong to transition between typical species of central and southern Chile (Camus et al., 2013), nevertheless, the biodiversity is low in comparison to the reports for central and northern rocky coasts (Santelices, 1992). It is due probably that Araucania coast has not upwelling processes in comparison to central and northern Chilean coast, that due upwelling, can sustain abundant algae populations for sustain a complex invertebrate and fishes communities associated (Camus and Andrade, 1999). The aim of the present study is do a first descriptive analysis of marine invertebrates in rocky shore of Araucania region with the aim of determine the presence of defined spatial distribution patterns.

2. Material and Methods

The studied sites were the rocky beaches Cheuque (39°24'26.2"S; 73°13'18.8"W), Nigue (39°17'46.2"S; 73°13'24.3"W) and Casa de Piedra (38°28' 53.2"S; 73° 31'05.8"W), at Araucania region (Figure 1), these sites are exposed coast with granite rocks and with access difficult, the sites were visited in September 2017, this is due that in autumn and winter the studied sites have access difficult due weather, and in late spring and summer the sites are disturbed by touristic activities. For each site, was thrown out random (De Los Ríos and Ibañez-Arancibia, 2018), 10 * 10 cm quadrants (n = 30 for each site), considering the relative small size of considered species (Underwood, 2004; Underwood and Chapman, 2005; Ahmad et al., 2011), and it was counted and identified the species within the quadrant. The sites sampled correspond to rocky surfaces without seaweeds, located in the middle intertidal zone with presence of small intertidal pools (< 1 m^2 surface, < 0.5 m depth).

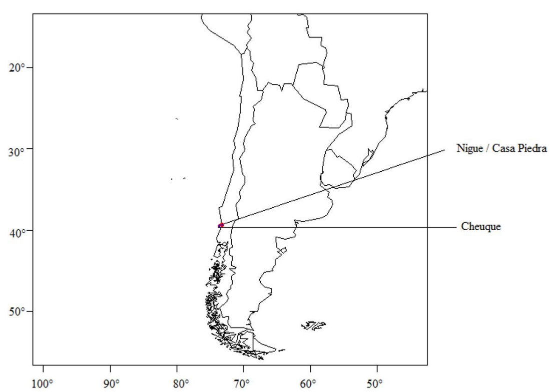

Figure 1. Map with sites included in the present site in the present [obtained with dismo R Packaje, (Hijmans et al., 2011) and software R (R Development Core Team, 2009)].

To each specie counting data, was obtained in first instance a variance mean ratio, first for determine if the specie has random if the value is 1, uniform if the value is lower than 1, or aggregated distribution, if the value is upper than 1, (Zar, 1999; Fernandes et al., 2003; De Los Ríos, 2017; De Los Ríos-Escalante and Mansilla, 2017; De Los Ríos & Ibáñez Arancibia, 2018). Once determined the spatial pattern, random, uniform or aggregated, it determined if the species have Poisson, binomial or negative binomial distribution respectively, the analysis was done manually using Excel software and literature descriptions (Zar, 1999; Fernandes et al., 2003; De Los Ríos-Escalante, 2017; De Los Ríos & Mansilla, 2017; De Los Ríos & Ibáñez Arancibia, 2018).

3. Results

The results for Cheuque and Nigue revealed that the site has numerous *Perumytilus purpuratus* populations, and the invertebrate reported were considered in rocks without *P. purpuratus*. For Nigue beach, it was considered the presence of mollusks *Acanthina crassilabrum, Prissogaster niger* and *Scurria araucana* and the tunicate *Pyura chilensis*, of these species have aggregated pattern for Nigue beach, *P. niger* for casa Piedra beach, and Nigue beach (Tables 1 and 2) and these are adjusted to negative binomial distribution (Figure 2). Whereas for Casa Piedra *S. acaucana* has uniform distribution and it has adjusted to binomial distribution model. Finally for *S. araucana* in Cheuque beach, it had random distribution and adjusted to Poisson distribution model for Cheuque beach (Tables 1 and 2, Figure 2).

Table 1. Individuals observed for quadrant and results of variance mean ratio and Chi square test for determine the negative binomial distribution for studied species at Nigue rocky beach. ("*P*" values upper than 0.05 denotes the existence of negative binomial distribution).

N	*Acanthina crassilabrum*	*Prissogaster niger*	*Scurria araucana*	*Pyura chilensis*
1	1	10	0	0
2	1	8	0	0
3	0	9	0	0
4	0	6	0	0
5	0	12	0	0
6	0	3	0	0
7	0	2	0	0
8	1	0	0	1

Table 1. Continued...

N	*Acanthina crassilabrum*	*Prissogaster niger*	*Scurria araucana*	*Pyura chilensis*
9	2	2	0	0
10	0	0	0	1
11	0	0	0	1
12	0	1	0	1
13	0	3	3	0
14	0	4	0	2
15	1	6	0	0
16	3	2	0	0
17	0	6	0	0
18	1	5	0	0
19	1	4	0	0
20	0	2	0	0
21	0	2	3	0
22	2	6	0	0
23	0	3	0	0
24	0	2	0	0
25	0	1	0	0
26	0	1	0	0
27	0	3	0	0
28	0	2	0	0
29	0	1	0	0
30	0	1	0	0
Variance/mean ratio	1.38	2.68	2.9	1.17
Chi table (α= 0.05; df: 29)	42.55	42.55	42.55	42.55
Chi observed	1.00	2.58	3.88	0.24
P	> 0.05	> 0.05	> 0.05	> 0.05

Table 2. Individuals observed for quadrant and results of variance mean ratio and Chi square test for determine the negative binomial distribution for studied species at Casa Piedra and Cheuque rocky beach. ("*P"* values upper than 0.05 denotes the existence of negative binomial distribution, Poisson or binomial distribution, see more details in results).

N	Casa Piedra			Cheuque	
1	*S. araucana*	*P. niger*	*P. chilensis*	*P. niger*	*S.araucana*
2	1	0	0	0	0
3	2	0	0	1	0
4	0	0	2	2	0
5	0	0	4	0	0
6	0	0	2	0	0
7	1	0	0	0	2
8	0	0	5	1	0
9	0	0	7	0	0
10	0	0	2	0	2
11	1	0	4	3	0
12	0	2	2	0	0
13	0	1	4	1	0
14	0	6	6	2	0
15	0	6	3	0	1
16	0	12	2	0	1
17	0	0	0	1	0
18	1	0	0	3	0
19	0	0	2	3	0
20	0	1	0	1	0
21	1	5	0	0	0
22	0	1	0	0	0
23	0	0	0	0	1
24	1	3	0	0	2

Table 2. Continued...

N	Casa Piedra			Cheuque	
25	0	2	0	0	1
26	0	0	0	1	0
27	0	1	0	0	1
28	1	2	0	0	1
29	0	3	0	0	1
30	0	6	0	0	1
Variance/mean ratio	0.90	4.25	2.84	1.58	1.00
Chi table (α= 0.05; df: 29)	42.55	42.55	42.55	42.55	42.55
Chi observed	< 0.01	0.02	2.59	0.09	2.58
P	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05

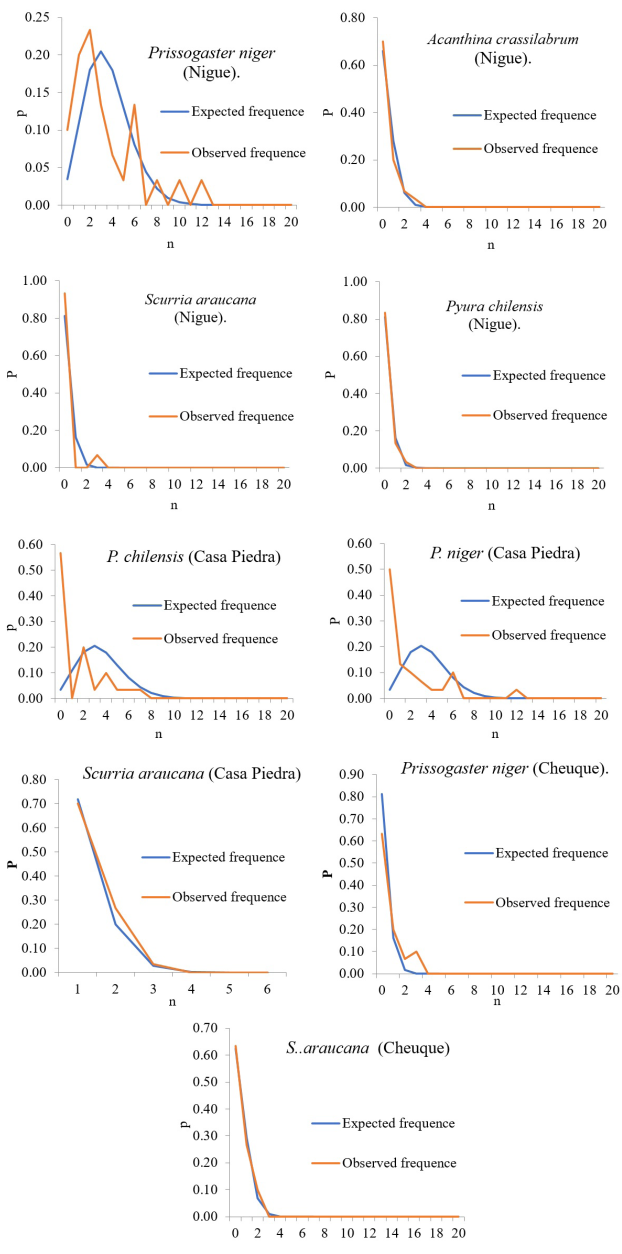

Figure 2. Results probabilistic distribution models for studied species.

4. Discussion

The results about negative binomial distribution agree with similar observations for inland water benthic invertebrates (Gray, 2005), mainly crustaceans that has a marked pattern of this probabilistic model (De Los Ríos, 2017; De los Ríos-Escalante and Mansilla, 2017; De los Ríos and Ibáñez Arancibia, 2018). Also, in recent studies, it has described the use of negative binomial distribution for intertidal environments (Philippe et al., 2016; Checon et al., 2017; Sibaja-Cordero, 2018), specifically in middle intertidal zone, in rocky shores without seaweeds, similar to sites in the present study (De los Ríos and Ibáñez Arancibia, 2018). In this context Rojas et al., (2000) studied the aggregated pattern of intertidal gastropod *Nodolittorina peruviana*, nevertheless they did not focus in interpretative equations for explain its absolute abundance, but they remark the role of aggregation behaviour for avoid dehydration during low tide. Similar description was done in the first studies on intertidal decapods (Bahamonde and López, 1969). The literature for other similar ecosystems proposed as survival strategy the joining of groups for avoid dehydration due temperature increase at low tide (Shanks et al., 2014; Mortensen and Dunphy, 2016). About the differences in spatial distribution of *S. araucana* that has uniform pattern in Casa Piedra and aggregated pattern in Cheuque and Nigue, would be probably to interspecific behaviour mediated probably by topographic differences (Underwood, 2004), that would provide shelters for optimizate the use of trophic resources (Aguilera and Navarrete, 2011, 2012).

As conclusion it suggests do more ecological studies considering the importance of the marine invertebrates in these ecosystems as important preys for littoral fishes and/or marine birds, that would understand the ecological community structure amd process in Chilean rocky shores.

Acknowledgements

The present study was founded by projects Tides Grant Foundation TRF13-03011 MECESUP UCT 0804, Technical Faculty, and the Research Direction of the Catholic University of Temuco. M.I. and S.M.A. is acknowledged for her valuable comments that helped improve the manuscript.

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