RESEARCH ARTICLE

Contributions of the Seaflower expeditions to the knowledge of decapod crustaceans of the Archipelago of San Andrés, Providencia y Santa Catalina with new records

Aportes de las expediciones Seaflower al conocimiento de los crustáceos decápodos del archipiélago de San Andrés, Providencia y Santa Catalina con nuevos registros

DOI: https://doi.org/10.26640/22159045.2024.625 **Received:** 2024-03 -04/ **Accepted:** 2024-24-10

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CITATION:

Campos-Campos, N. H.; Dueñas-Lagos, A.; Dueñas, P. R. (2024). Contributions of the Seaflower expeditions to the knowledge of decapod crustaceans of the Archipelago of San Andrés, Providencia y Santa Catalina with new records. *CIOH Scientific Bulletin, 43*(2): 5-14. ISSN printed 0,120-0542 e ISSN online 2215-9045. DOI: https://doi.org/10.26640/22159045.2024.625

ABSTRACT

The Man and the Biosphere Program recognized the natural wealth of the Archipelago of San Andrés, Providencia y Santa Catalina, and declared it a Seaflower Biosphere Reserve in 2000; Minambiente later declared it a Marine Protected Area in 2005. Between 2017 and 2018, within the framework of the Seaflower Scientific Expeditions, crustaceans were collected from coral remains and soft bottoms. Representatives of 17 families were collected on the Serranilla Bank (SB) and Southwest Cays (SC). The results show a greater wealth in SC, with 46 species of 31 genera, while in SB only 37 species and 27 genera were recorded. In total, 67 decapod morphospecies are recorded in the two cays, contributing to knowledge with 26 new records for the Archipelago and six new ones for Colombia. With these results, the number of species for the Archipelago is 236, with an increase of 12.38%, and 16.7% of the total number of registered species. These records highlight the importance of the reserve for the Colombian Caribbean, contributing 32.3% of the species registered for Colombia.

KEYWORDS: Crustacea, Decapoda, Seaflower, biodiversity, wealth.

RESUMEN

El Programa sobre el Hombre y la biosfera reconoce la riqueza natural del archipiélago de San Andrés, Providencia y Santa Catalina y lo declara en el año 2000 Reserva de la biosfera Seaflower; posteriormente, en el 2005, esta es declarada como área marina protegida por el Ministerio de Ambiente y Desarrollo Sostenible. Entre 2017 y 2018, en el marco de las expediciones científicas Seaflower fueron recolectados crustáceos de restos coralinos y en fondos blandos. Se recolectaron representantes de 17 familias, en la isla Cayos de Serranilla (ICS) y la isla Cayos de Alburquerque (ICA). Los resultados muestran una mayor riqueza en ICA, con 46 especies de 31 géneros, mientras que en ICS solo se registraron 37 especies y 27 géneros. En total se registran 67 morfoespecies de decápodos en los dos cayos, se hace un aporte

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en el conocimiento de 26 registros nuevos para el archipiélago y seis nuevos para Colombia. Con estos resultados, el número total de especies para el archipiélago es de 236, con un incremento del 12.38 % y un 16.7 % al total de especies registradas. Estos registros resaltan la importancia de la reserva para el Caribe colombiano, aportando el 32.3 % de las especies registradas para Colombia.

Palabras clave: *Crustacea; Decapoda; Seaflower; biodiversidad; riqueza*

Introduction

Colombia has about 2,900 km^2 of coral areas, of which 1,091 km^2 comprise bottoms with high coral cover. Among the coral areas of the Colombian Caribbean, most are found around the islands, lowlands and oceanic atolls of the Archipelago of San Andrés, Providencia y Santa Catalina (77%), where the most complex and developed reefs are also observed. For this reason, the Seaflower Biosphere Reserve (SBR) was declared by the United Nations Educational, Scientific and Cultural Organization (UNESCO), in 2000, as a World Heritage Site (Abril-Howard, *et al.*, 2012). Additionally, various studies indicate that this (group of islands, keys, banks and reefs have an important richness of species and a variety of marine environments that highlight their significance as possible reservoirs of biodiversity in the Colombian Caribbean, most of which have not been studied (Díaz *et al.,* 2000; Vega *et al.*, 2015).

The lack of knowledge related to benthic communities (epifauna and macrobenthos) in the SBR is evident, therefore, it is necessary to complement the faunal inventories of shallow and deep organisms that have been carried out in the Reserve, among which the study developed by the Instituto de Investigaciones Marinas y Costeras "José Benito Vives de Andréis" (Invemar) in the Common Regime Area between Colombia and Jamaica (Invemar-ANH, 2012). Since 2015, as a comprehensive strategy for the exercise of sovereignty in the Archipelago of San Andrés, Providencia y Santa Catalina, the Presidency of the Republic of Colombia launched the Scientific Expeditions Plan In order to strengthen the management and conservation of the Biosphere Reserve. The strategy aims to increase the criterion of ecosystem unity in this protected marine area. In line with this, the Seaflower National Technical Board, led by the Colombian Ocean Commission (CCO), has focused its efforts on strengthening the generation of knowledge about the Reserve, thanks to an inter-institutional process, where different actors have contributed to scientific research, and to the coordination and execution of scientific expeditions.

Among these, it is worth highlighting the participation of the Colombian Navy (ARC), the CCO, the Government of the Department Archipelago of San Andrés, Providencia y Santa Catalina, the Corporation for the Sustainable Development of the Archipelago of San Andrés, Catalina (Coralina), and the General Maritime Directorate (Dimar), through its Caribbean Oceanographic and Hydrographic Research Center (CIOH).

Within the arthropods, Crustaceans are the most abundant arthropods after insects, and although they are predominantly aquatic organisms, they have managed to adapt and conquer the terrestrial environment. Currently, around 1,003 families, 9,522 genera and 66,914 species have been described (Ahyong *et al.*, 2011).

Coralline rocks are home to a cryptofauna that, in addition to being specific, is excavated or used for cavities. In addition, they serve as a substrate for a high number of epifaunal species that take advantage of the niche created by the macroalgae that grow in this type of substrate. This fauna in the area of influence of the Archipelago is little or not at all known.

The Decapoda are possibly the most important group within the crustaceans. More than 14,900 species have been described worldwide (Ahyong *et al.,* 2011). In the Colombian Caribbean region, more than 700 different species of decapod crustaceans have been recorded, which allows estimating the presence in that region of more than 1,000 species.

Currently, the number of species of decapod crustaceans recorded throughout the Archipelago is 210 and 24 unique records. In the chapter on crustaceans in the book 'Biodiversity of the Sea of the Seven Colors', 198 species were listed, belonging to 125 genera and 52 families (Martínez *et al*., 2016).

The purpose of these investigations was to characterize the communities of benthic decapod crustaceans associated with shallow sedimentary bottoms and the cryptofauna in calcareous rocks of the SB and SC.

Study Area

Serranilla Bank (SB) is located north of the SBR, between 15°50' and 16°'04'N, and 80°03' and 79°40' W. It is a bank that covers an area of 1,200 km^2 with the presence of small nearby cays (West Breaker, Middle Cay, East Cay and Beacon Cay). The shallow area has a carbonate shelf about 8 m deep, with bottoms composed of algae, sponges, small extensions of hard corals and some areas covered with seagrasses in the southeast sector (Abril-Howard *et al.,* 2012; CCO, 2015) (Fig. 1).

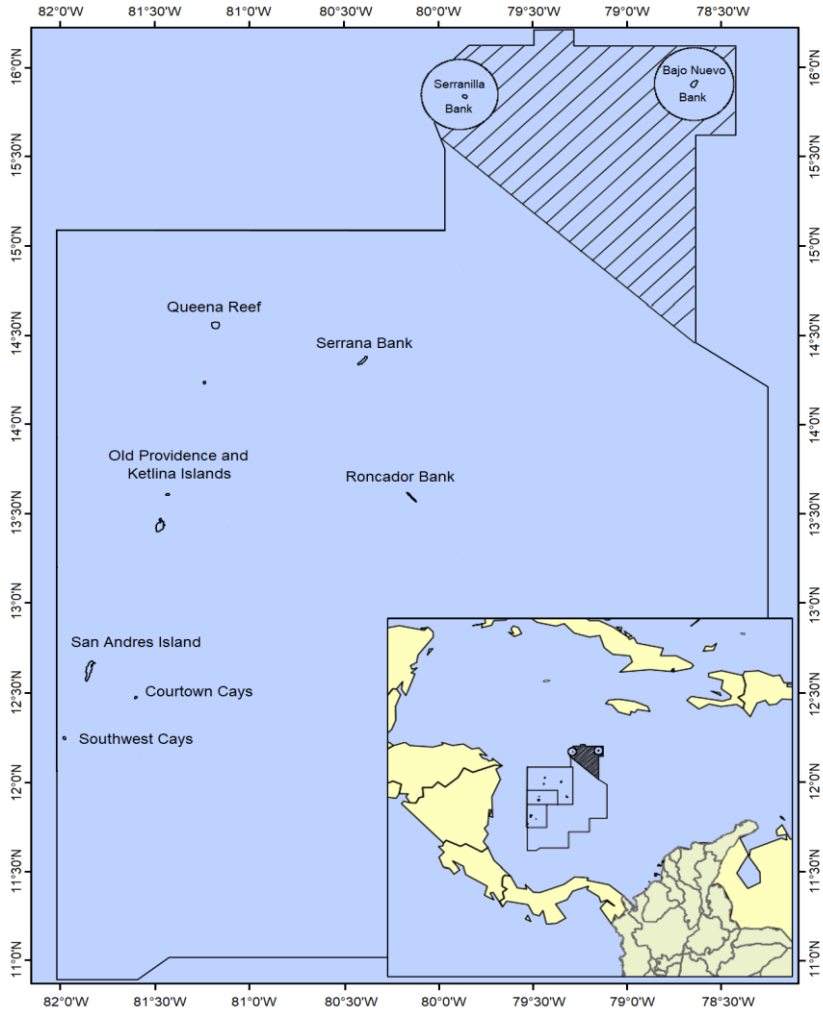

Figure 1. Location of study areas.

During the month of September 2017, the soft bottom benthic community was evaluated. Stations in the eastern sector (E11 and E12) and west (E0 to E10) of the SB (Fig. 2) were selected, samples were taken at 10.2 m and 30 m depth in the shallow zone, and one more sample was taken at 320 m at the end of the plain in the central area (E7). In turn, in the western sector of the cay, where there is no marked slope, but rather a plain approaching the limit of Colombia's jurisdiction, samples were taken in the internal zone and on the right and left margin of the plain.

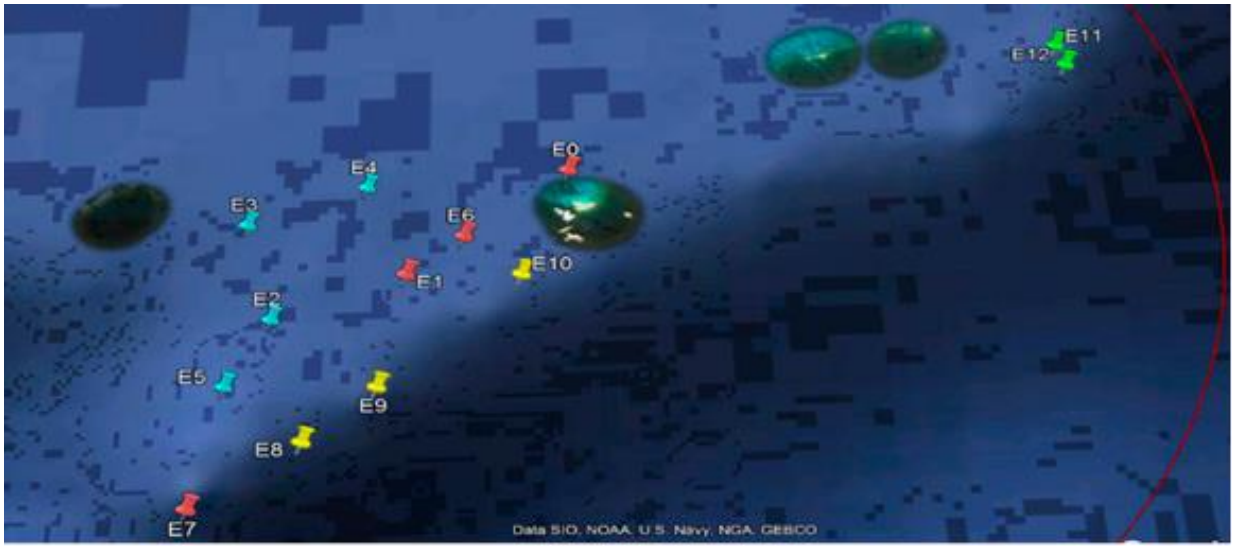

Figure 2. Serranilla Bank, location of the dredger sampling stations. (Courtesy: CCO - expedition coordination).

In September 2018, the expedition to Southwest Cays (SC) was carried out. During this outing, the research platform was not available, therefore, no sediment samples with dredge were collected and sampling was limited to the collection of crypto- and epifauna, which were carried out in the North Cay and South Cay sectors (Fig. 3).

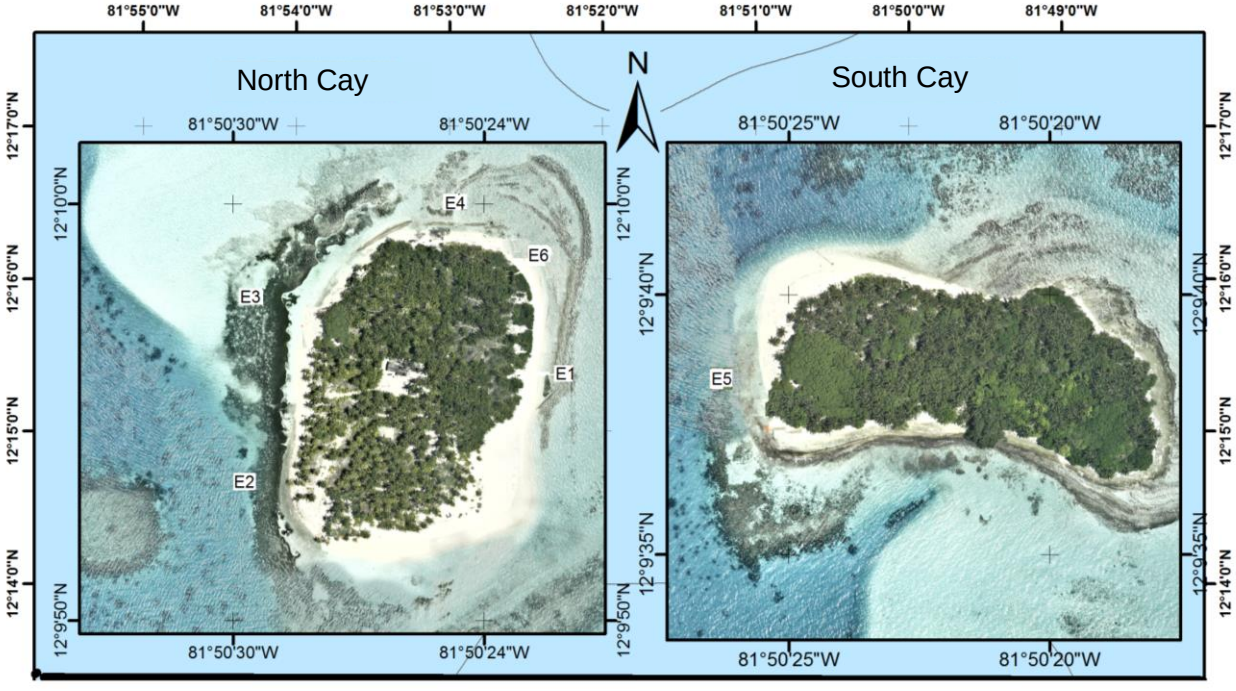

Figure 3. Southwest Cays. Location of sampling stations. (Courtesy: CCO - expedition coordination).

METHODOLOGY

In SB, sediment sample collection was carried out by means of a Chipec type dredge for the deep sample (320 m), and van Veen type for shallow samples (10 m – 30 m), until a minimum area of 0.1 m^2 was completed. On board the platform, the macrofauna was separated and the specimens were fixed in 96% alcohol. Subsequently, a preliminary wash of the sediment samples was done on a 500 µm mesh eye sieve to retain the macrofauna.

Marine benthos sediment samples were placed in plastic bags with 500 ml of magnesium chloride solution for 15-20 min. Subsequently, 500 ml of 12% formalin with borax and reactive Bengal rose were added.

At the SB, most of the stations were made up of soft substrates with a high percentage of macroalgae (collected by means of the dredge). Sampling sites (20) were chosen where coral remains accumulate, and coral stones (5 – 7) were manually extracted from them and fractured to collect crypto and epifauna.

At the SC, the collection of samples was done by free diving using two methods: *i)* on sandy bottoms with an iron framed net with an opening of 0.1 m^2, an attached mesh of 500 µm mesh eye, and with the help of a plexiglass sheet introduced between the dredge and the substrate; *ii)* 23 sites were selected for manual collection, where coral rocks (5 – 7) were extracted at each station, then, with the help of a hammer and chisel, they were fractured, the organisms were collected and deposited in plastic bags, separated into groups and fixed in 96% alcohol. Additionally, some representatives of terrestrial decapods were collected.

The samples were transported to the laboratories of the Instituto de Estudios en Ciencias del Mar (Cecimar), where they were identified and deposited in containers separated by species and sampling place. The identification was made based on the books of Rathbun (1918, 1925, 1930 and 1937) for crabs, Chace (1972) for shrimp and the 'Illustrated Guide to Decapod Crustaceans of Florida' (Abele and Kim, 1986). This activity was carried out with the help of stereoscopy. The specimens will be deposited in the reference collection of the Natural History Museum "Makurigua" of Invemar.

RESULTS

In the two cays, SB and SC, specimens from 17 families were collected. However, there are differences in terms of the number of genera and species per family. In SB, there is a clear dominance of the Mithracidae (superfamily) with seven genera and thirteen species, most of the remaining families were present with a single genus and one species. In SC, there is no clear dominance of one family; in the case of genera, the highest number is found in Xanthidae, with five, followed by Mithracidae, with four; while, in the case of species, Mithracidae is present with eight, and Xanthidae is present with only six (Fig. 4).

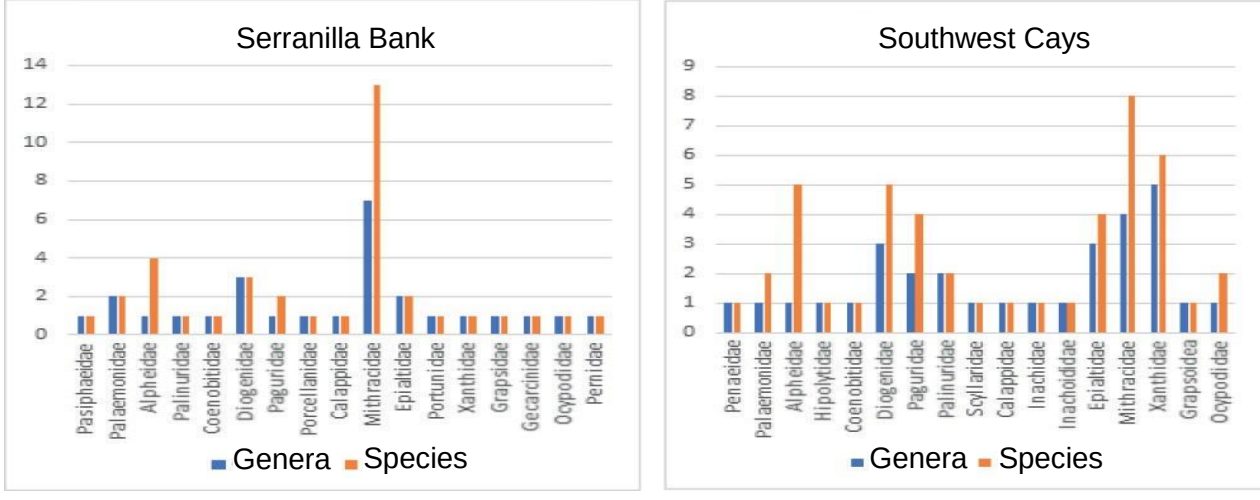

Figure 4. Number of genera and species by family of decapod crustaceans present in (A) Serranilla Bank and (B) Southwest Cays.

Table 1 lists the species present in both cays. Of the total number of species recorded (66 and one megalopa postlarvae), 35 and the megalopa were collected in the SB and 45 in the SC. Of these, six are new records for the Colombian Caribbean (N. R.). For the Archipelago, 26 species of decapods (N. R, and A. D.) are recorded for the first time; of these, only three were collected in the two sampling sites (*Paguriste puncticeps, Mithraculus cinctimanus* and *Actaea bifrons*), and a total of thirteen species of the lists are present in both cays.

Table 1 Species recorded in the Serranilla Bank (SB) and Southwest Cays (SC). A. D: Record for the Archipelago. N. R.: Record for the Colombian Caribbean. X: presence of the species.

N°.	Genus and species	SB	SC	N°.	Genus and species	SB	SC
1	*Rimapenaeus sp.*		A.D.	35	*Ericerodes gracilipes*		A.D.
2	*Anchistioides antiguensis*	A. D.		36	*Thoe puella*	A. D	X
3	*Periclimenaeus wilsoni*	N. R.		37	*Epialtus dilatatus*		N.R.
4	*Ancylomenes pedersoni*		X	38	*Epialtus sp.*	X	
5	*Leptochela carinata*	N. R.		39	*Pitho sp 1.*	X	
6	*Alpheus amblyonyx*		A.D.	40	*Pitho sp 2.*	X	
7	*Alpheus bouvieri cf.*		N.R.	41	*Pitho aculeata*		X
8	*Alpheus candei*		X	42	*Pitho lhermineri*		A.D.
9	*Alpheus heterochaelis*		X	43	*Teleophrys ruber*	X	X
10	*Alpheus normanni*		X	44	*Amphithrax hemphilli*	A. D	
11	*Alpheus nuttingi*		X	45	*Mithrax sp 1.*	X	
12	*Alpheus peasei*	X		46	*Mithrax sp 2.*		X
13	*Synalpheus brevicarpus*	N. R.		47	*Mithraculus coryphe*	X	X
14	*Synalpheus brooksi*	A. D.		48	*M. forceps*	X	
15	*Synalpheus rathbunae*	X		49	*M. sculptus*	X	X
16	*Thor floridanus*		A.D.	50	*M. cinctimanus*	A. D.	X
17	*Coenobita clypeatus*	X	X	51	*Nonala holderi*	A. D.	
18	*Clibanarius tricolor*	X	X	52	*Omalacantha bicornuta*	X	X
19	*Calcinus tibicen*	X	X	53	*O. antillensis*	A. D.	
20	*Paguristes puncticeps*	A. D.	X	54	*Macrocoeloma laevigatum*		A.D.
21	*Paguristes cadenati*		X	55	*M. subparalellum*		X
22	*Petrochirus diogenes*		X	56	*Achelous spinicarpus*	X	
23	*Pagurus brevidactylus*		X	57	*Carpilius coralinos*		X
24	*Pagurus* sp 1.	X		58	*Actaea bifrons*	A. D.	X
25	*Pagurus* sp 2.	X		59	*Platyactaea setgera*		X
26	*Phimochirus operculatus*		A.D.	60	*Williamstimpsonia denticulatus*		X
27	*Phimochirus holthuisi*		A.D.	61	*Cataleptodius floridanus*		A.D.
28	*Petrolishes galathinus*	X		62	*Pilumnus sp.*		X
29	*Panulirus argus*		X	63	*Pachygrapsus transversus*	X	
30	*Phyllamphion gundlachi*		A.D.	64	*Gecarcinus lateralis*	X	X
31	*Scyllarides aequinoctialis*		A.D.	65	*Percnon gibbesi*	X	X
32	*Cyclozodion angustum*		N.R.	66	*Ocypode quadrata*	X	X
33	*Calappa* sp. (Juv.)	X		67	Megalopa	X	
34	*Stenorhynchus seticornis*		X				

Figure 5 compares the number of shared and exclusive species. Of the 67 morphospecies present, eleven were collected at both sites, for the SB it represents the 37.14 % and for SC, 29.55 % of the species present; while 65.71% and 70.45% are present only in the SB and the SC, respectively.

Figure 5. Number of shared and exclusive species present (100%) at each of the two sampling sites.

DISCUSSION

The records of decapod crustaceans in the Archipelago of San Andrés, Providencia y Santa Catalina date back to the beginning of the last century (Rathbun, 1918, 1925, 1930 and 1937) by listing numerous species present in Old Providence, based on the material deposited in the National Museum of Natural History, Smithsonian Institution, as a product of scientific expeditions such as the Albatross and the Fish Hawk, mainly. Expeditions have also been carried out by national institutions (Werding, *et al.* 1981; Vides, *et al.* 2016).

Table 2. Number of families, genera and species recorded for the Colombian Caribbean and for the Archipelago of San Andrés, Providencia y Santa Catalina. (Modified from: Campos, et al. 2011; Martínez-Campos *et al*. 2016).

	Families	Genera	Species
Number in the Colombian Caribbean	94	315	651
Number in the Archipelago of San Andrés, Providencia y Santa Catalina	53	126	210
Percentage of presence in the Archipelago in relation to the total for the Colombian Caribbean	54.6 %	49 %	32.3 %

Recently, and with the coordination of Invemar and Coralina, the book 'Biodiversity of the Sea of the Seven Colors was published, in which the species of the main taxonomic groups were listed, including crustaceans (Vides *et al.* 2016). In the chapter on crustaceans (Martínez-Campos *et al.* 2016), 198 species belonging to 125 genera and 52 families are listed.

Taking into account these records, Table 2 compares the number of species as well as genera and families recorded by Martínez-Campos *et al*. (2016), with the number of records, including those listed in this study. Likewise, the percentage of participation by families, genera and species registered in the Archipelago was calculated, in relation to the total number of records for the Colombian Caribbean. The number of families is present in the Archipelago with more than 50% of them registered in the Colombian Caribbean, while for species they only reach 32% of the national records.

The contribution to the knowledge of species richness of this study highlights the importance of the Archipelago as a reservoir of the biodiversity of the Caribbean Sea, and it justifies the deepening of the evaluation of this richness to really know its role as a biosphere reserve.

Taking into account the records included in this study (Table 3), the contribution is significant if previous records are compared with current ones. The increase in the number of genera and species stands out, with 9.6% and 10.64%, respectively.

Table 3. Number of previous and current records of families, genera and species of decapods of the Archipelago of San Andrés, Providencia y Santa Catalina.

	Families	Genera	Species
Previous records	52	126	210
Current records	53	137	236
Increase	1.9 %	9.6 %	11.06 %

The study of the crustacean fauna in the Archipelago is equally relevant for the knowledge of crustacean biodiversity in the Colombian Caribbean. Of the 37 species listed for the SB, twelve are new records, and of those listed for the SC (46), 14 are new records for the SBR. Additionally, three species from each of the keys are new records for the Colombian Caribbean, increasing the number by six, for a total of 657 species recorded.

The six new records for the Colombian Caribbean are the shrimp *Periclimenaeus wilsoni, Leptochela carinata, Synalpheus brevicarpus* (Serranilla Bank), *Alpheus bouvieri cf.* and the crabs *Epialtus dilatatus and Calappa angusta* (Southwest Cays).

When comparing the percentage of exclusive species (Fig. 2), the SC presents a higher percentage, considering that the two keys are located one distance apart from the other. The SB is located in the north of the Archipelago, on the borders with Nicaragua, Honduras and Jamaica (Zambrano and Andrade, 2011)— according to these authors the SB is under the action of the Caribbean current that flows in a northwesterly direction, after passing through the Lesser Antilles—; while the SC is located in the southern part of the Archipelago, 37 km southwest of San Andres Island (Coralina, 2003). The behavior of the currents defines significant differences between the two cays. The SC is under the effect of the Panama-Colombia countercurrent for much of the year (Coralina-Invemar, 2012), unlike the SB, which is directly influenced by the Caribbean current. Therefore, the crustacean fauna will depend on the proximity to other ecosystems or the influence of the continental margin. In the SC, there are changing environmental conditions, due to its proximity to Central America, while in the SB the influence is clearly oceanic, with more stable conditions.

Conclusions

The results of the study of the crustacean fauna on the Southwest Cays and the Serranilla Bank demonstrate the importance that the Archipelago represents for biodiversity in the Colombian Caribbean, increasing the number of species recorded to six.

The differences in species richness between the two cays islands is directly related to the environmental conditions of each. SB is under the influence of the Caribbean current, with more stable conditions, and SC is influenced by the Panama-Colombia countercurrent, with more changing conditions.

Acknowledgements

The authors express gratitude to the organizing institutions of the expedition: the ARC, the Dimar, the CCO, the Administrative Department of Science, Technology and Innovation (Colciencias) through its Colombia BIO program, the Government of the Department Archipelago of San Andrés, Providencia y Santa Catalina, and Coralina. Likewise, our thanks to Universidad Nacional de Colombia - Sede Caribe, for the financing of the scientific personnel and equipment travels.

Funding

This research was carried out within the framework of the Seaflower expeditions coordinated by the CCO. The participation of the researchers was funded by the Universidad Nacional de Colombia - Caribbean Campus, through the projects 'Characterization of the epifauna and macrobenthos (0 m - 800 m) of the Serranilla Bank and adjacent areas' and 'Valuation of ecosystem services and biological diversity of coral reefs in the surroundings of the Southwest Cays, Seaflower Biosphere Reserve, Caribbean'.

Authors' Contribution

Conceptualization: N.H.C., A.D.L., and P.R.D.; methodology: N.H.C., A.D.L., and P.R.D.; validation: N.H.C., A.D.L., and P.R.D.; analysis: N.H. C., A. D. L y P. R. D.; research: N. H. C., A. C. D. L. y P. R. D.; resources: N. H. C., A. D. L y P. R. D.; data curation: N.H.C., A.D.L., and P.R.D.; drafting-preparation of the original draft: N. H. C., A. D. L and P. R. D; writing-revision and editing: N.H.C., A.D.L. and P.R.D.; visualization: N. H. C., A. D. L y P. R. D.; supervision: N. H. C., A.D.L. and P.R.D.; project management: N. H. C.; fundraising: N.H.C. All authors have read and accepted the published version of the manuscript.

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