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REVIEW

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BIBLIOMETRIC UPDATE ON THE SERRANIDAE FAMILY (SWAINSON, 1839) IN THE ATLANTIC OCEAN

Atualização bibliométrica da família Serranidae (Swainson, 1839) no Oceano Atlântico

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ABSTRACT

The Serranidae family's significant economic importance in the Atlantic Ocean, particularly in subtropical areas, contrasts with its ecological role as slow-growing predators, especially species that form reproductive aggregations. This contrast has led to overfishing of many species. Despite this, most studies focus primarily on the most economically important species, leaving many gaps in our understanding of the group. The aim of this article is to update the state of the scientific research of the Serranidae family in the Atlantic. We gathered data using the Scopus database with the query "TITLE-ABS-KEY (Serranidae AND Atlantic)" and filtered the results. Our findings reveal a decrease in both citation and publication rates, as well as a heavy concentration of research in the Western Atlantic, particularly in the USA. We provide an update on bibliometric data regarding scientific production, citations, international collaborations, journals, and institutions related to the Serranidae family in the Atlantic. There are significant knowledge gaps concerning species in this family, and the concentration of studies in specific areas is concerning. The threats facing groupers are numerous, and the concentration of research exacerbates the vulnerability of less-studied regions, highlighting the need for more continuous and comprehensive studies.

Keywords: Groupers, review, productivity, distribution, scientometrics.

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RESUMO

A alta importância econômica da família Serranidae no oceano Atlântico, especialmente em áreas subtropicais, entra em conflito com seu papel ecológico de predador de crescimento lento, especialmente espécies que se reproduzem em agregações, fazendo com que muitas espécies sejam sobre-pescadas. Apesar disso, a maioria dos estudos focam apenas nas espécies mais importantes economicamente, deixando muitas lacunas no conhecimento atual deste grupo. O objetivo deste artigo é atualizar o estado de conhecimentos dos estudos científicos da Família Serranidae no Atlântico. Nós coletamos dados usando a base de dados Scopus com a query "TITLE-ABS-KEY (Serranidae AND Atlantic)" e filtramos os resultados. Nossos resultados mostram um decréscimo nas taxas de citação e de publicação, assim como uma grande concentração das pesquisas no Atlântico Oeste, em especial nos EUA. Nós apresentamos uma atualização na bibliometria em relação à produção científica, citações, colaboração entre países, revistas e instituições para a família Serranidae no Atlântico. Há lacunas no conhecimento das espécies que compõem a família, bem como concentrações dos estudos em determinadas áreas. As ameaças enfrentadas pelas garoupas são numerosas, e a concentração de pesquisas agrava a vulnerabilidade de regiões menos estudadas, destacando a necessidade de estudos mais contínuos e abrangentes.

Palavras-chave: *Garoupas, revisão, produtividade, distribuição, cientometria.*

INTRODUCTION

The Serranidae (Swainson, 1839) are a family of carnivorous Osteichthyes. They are mostly solitary, sedentary, demersal, and associated with reefs, with some species forming reproductive aggregations (Bullock & Smith, 1991; FAO, 1993). With more than 570 species and 70 genera (Parenti & Randall, 2020) they are distributed between the temperate zones but with higher abundance within the tropics (FAO, 1993). It is a very diverse group size-wise, ranging between 6 cm and 2 m, with coloration and color patterns that may vary ontogenetically (Bullock & Smith, 1991). Some species have similar colors and patterns, which hampers specimen identification (FAO, 1993). Serranids are a big target for commercial, artisanal and sport fishing, mainly in tropical and subtropical zones (FAO, 1993), especially the Epinephlinae subfamily (Bleeker, 1874), popularly known as groupers (Sujatha Kandula; Shrikanya & Iswarya Deepti, 2015). This high demand associated with aggregation fishing and their slow growth make the groupers an overfished group (FAO, 1993; Sujatha Kandula; Shrikanya & Iswarya Deepti, 2015). Due to fishing sub-notification, especially in developing countries, their real stock is largely unknown (Amorim & Westmeyer, 2015). Another threat to smaller species is fishkeeping (Sujatha Kandula; Shrikanya & Iswarya Deepti, 2015).

Despite their ecological importance (Amorim & Westmeyer, 2015; FAO, 1993; Sujatha Kandula; Shrikanya & Iswarya Deepti, 2015), most scientific research is done on economically important species (Bullock & Smith, 1991). However, there are exceptions, such as checklists of local (Gasparini & Floeter, 2001; Monteiro-Neto *et al.*, 2013; Smith-Vaniz & Jelks, 2014), regional (Del Moral-Flores *et al.*, 2013; Escobar-Sierra *et al.*, 2021) or global scale (Parenti & Randall, 2020) of serranid species. Ecological studies of the invasive lionfish species in the Atlantic Ocean (Curtis *et al.*, 2017; Whitfield *et al.*, 2007), *Pterois miles* (Bennett, 1828) and *Pterois volitans* (L., 1758), often involve serranids due to their predator-prey relationship where large serranids may prey on lionfish but small or juvenile serranids are preyed upon by the lionfish (Curtis *et al.*, 2017; Morris & Akins, 2009; Chappell & Smith, 2016).

Using bibliometric methods to analyze published academic documents has become an important way to understand the state of the scientific research and the evolution of the literature, showing past and present trends and enabling predictions of future trends, as well as potentially identifying knowledge gaps and under-researched areas within a given topic

(Donthu *et al.*, 2021; Nunen *et al.*, 2018; Zhang *et al.*, 2020). The objective of this article is to give a broad update on the state of the studies on the serranid family in the Atlantic Ocean, displaying the temporal progression and current spatial status of those studies through bibliometric analysis.

MATERIAL AND METHODS

The data was obtained through the Scopus database in February of 2022 using the query "TITLE-ABS-KEY (serranidae AND atlantic)" and then filtered to remove false flags and duplicate documents. Documents from every language were included. After filtering, 167 out of 250 documents remained, of which 157 were scientific articles, six were reviews and four were conference papers; due to their high frequency and important relationships with groupers, we decided to also count the lionfish species found in those documents. The bibliometric analysis was done using the R language on the RStudio software with the bibliometrix package.

A table with all the serranid species presents in the Atlantic Ocean mentioned in the documents, their vernacular names and distribution in the Atlantic Ocean was created by screening through all documents and cataloging all serranid species mentioned. The vernacular names and distributions were gathered from the World Register of Marine Species ("WoRMS - World Register of Marine Species", 2023), FishBase ("FishBase : A Global Information System on Fishes", 2023) and articles, the conservation status and population trend were obtained through the IUCN Red List ("The IUCN Red List of threatened Species, 2023").

RESULTS

The 167 documents were published between 1976 and 2021. Out of those 46 years, 30 (65.21%) had at least one publication, and since 1999 there were at least two publications per year. All 562 authors published at most six documents (Table I), with 557 (99.11%) of them publishing between one and three documents. The vast majority of authors (88.26%) published only one document. Three authors published four documents, one published five and another published six.

Almost all documents were written in English (153, 91.62%), four were written in French with an abstract in English (Barnabe; Boulineau-Coatanea & Rene, 1976; Chaves & Bouchereau, 1999; De Haro *et al.*, 2019; Pottier & Vernoux, 2003), two were written in English with an abstract in Spanish (Freitas *et al.*, 2011; López-Rocha & Arreguín-Sánchez, 2013), one was written in Spanish and English (Pantoja Echevarría *et al.*, 2017), two were written in Spanish with an abstract in English (Flores *et al.*, 2013; Querales *et al.*, 2004), one was written in English with an abstract in French (Tuset *et al.*, 1996), and one in Portuguese with an abstract in English (Sanches; Silva & Herrera, 2018).

Table 1 – Number of authors for each number produced documents

Documents written	N. of Authors	Percentage
1	496	88.26
2	41	7.30
3	20	3.56
4	3	0.53
5	1	0.18
6	1	0.18

In total, 94 serranid and two invasive lionfish species (*Pterois miles* and *P. volitans*) were mentioned in the documents, summing 479 mentions (table II). Out of all species, 72 (75.79%) are found exclusively on the western side of the Atlantic Ocean, 12 (12.63%) only inhabit the eastern Atlantic, and 11 (11.58%) can be found on both sides. The two lionfish species were included due to their high mention frequency (18, 3.76%) and ecological relationships with serranids, especially as invasive predators. There were 20 (21.05%) species mentioned in one single document and 36

(37.89%) mentioned in five or more documents. The species with the most mentions were *Mycteroperca bonaci* (19, 3.97%), *Epinephelus adscensionis* (17, 3.55%) and *Epinephelus morio* (16, 3.34%). There were 13 mentions of five other serranid taxa: Serrranidae (7), *Serranus sp.* (2), *Hypoplectrus sp.* (2), *Epinephelus sp.* (1) and *Diplectrum spp.* (1).

The vast majority of the native species (62, 66.96%) are currently classified as Least Concern on the IUCN Red List (table II), 14 (14.89%) are Data Deficient, eight (8.51%) are Vulnerable, four (4.26%) are Not Evaluated, four (4.26%) are Near Threatened, two (2.13%) are Endangered, and one is Critically Endangered (1.06%). As for the population trends of the native species, most of them are unknown (57, 61.70%), 20 (21.28%) are decreasing, 13 (13.83%) stable, and four (4.26%) not evaluated. Regarding the two invasive species, both are classified as Least Concern; *P. miles* has an unknown population trend and *P. volitans* is increasing.

Table 2 - List of species in the studied documents, their vernaculars and distribution, in bold are the two lionfish species, CS and PT are the IUCN conservation status and population trend. The distribution is ordered north to south, a hyphen (-) indicates a contiguous distribution. Abbreviations: n: Northern, ne: Northeastern, s: Southern, se: Southeastern, AI: Ascension Island, AN: Angola, AR: Argentina, AZ: Azores, BE: Bermuda, BEL: Belize, BEN: Benin, BR: Brazil, CA: Caribbean, CAM: Cameroon, CAN: Canada, CI: Canary islands, CO: Colombia, CV: Cape Verde, FG: French, Guiana, FN: Fernando de Noronha Archipelago, GB: Guinea-Bissau, GU: Guyana, HO: Honduras, MA: Mauritania, MD: Madeira, ME: Mexico, MO: Morocco, NA: Namibia, NG: Nigeria, NI: Nicaragua, NO: Norway, PA: Panama, PT: Portugal, SA: South Africa, SH: Saint Helena, SN: Senegal, SP: Spain, SPSP: St. Peter & St. Paul Archipelago, STP: São Tomé and Príncipe, SU: Suriname, TC: Tristan da Cunha, TMV: Trindade & Martim Vaz Archipelago, UR: Uruguay, US: United States, VE: Venezuela, WS: Western Sahara, UK: United Kingdom, ↑: increasing, ↓: decreasing, —: stable, ?: unknown, NE: not evaluated

Species	Vernaculars	Western Atlantic distribution	Eastern Atlantic distribution	N	%	CS	PT
Mycteroperca bonaci	Black grouper, black rockfish	n US-s BR, CA, BE, TMV	AZ	19	3.97	NT	↓
Epinephelus adscensionis	Rock hind	n US-s BR, CA, BE, TMV	AI, SH, STP	17	3.55	LC	—
Epinephelus morio	Red grouper, deer hamlet	n US-s BR, CA, BE, TMV		16	3.34	VU	↓
Epinephelus guttatus	Red hind	n US-VE, CA, BE		15	3.13	LC	↓
Epinephelus marginatus	Dusky perch, Deusky grouper	s ME, CA, ne BR-s BR	UK , PT, AZ, CV, MD, SN-AN, SA	15	3.13	VU	↓
Epinephelus striatus	Nassau grouper, hamlet	n US-VE, FG, CA, BE		15	3.13	CR	↓
Centropristis striata	Blackfish, black sea bass	s CAN-s US, CA, VE		14	2.92	LC	—
Cephalopholis fulva	Coney	n US-VE, CA, BE, n BR-se BR		14	2.92	LC	↓
Mycteroperca microlepis	Gag grouper, gag, finescale rockfish	n US-ME, VE, ne BR, se BR		13	2.71	VU	↓
Mycteroperca interstitialis	Yellowmouth grouper, salmon rockfish, monkey	n US-GU, CA, BE, ne BR-se BR, TMV		12	2.51	VU	↓
Cephalopholis cruentata	Graysby	n US-VE, CA, BE, FN, TMV		11	2.30	LC	—
Mycteroperca venenosa	Yellowfin rockfish, yellowfin grouper, red rockfish	n US-VE, CA, BE, ne BR-UR		11	2.30	NT	↓
Epinephelus itajara	Jewfish, itajara, goliath grouper	US-VE, CA, SU-se BR	GB-n AN	10	2.09	VU	↓
Mycteroperca phenax	Scamp	n US-ME, CA, PA-VE, FG	AZ	10	2.09	DD	—
Pterois volitans	Turkeyfish, red lionfish, lionfish	n US-VE, CA, BE, FN, se BR		10	2.09	LC	↑
Hypoplectrus nigricans	Black hamlet	s US-VE, CA		9	1.88	LC	?
Hyporthodus niveatus	Snowy grouper	s CAN-s BR, CA		9	1.88	VU	↓
Mycteroperca tigris	Tiger grouper, gag rockfish	n US-VE, BE, CA, ne BR		9	1.88	DD	↓

Table 2: Continued

Species	Vernaculars	Western Atlantic distribution	Eastern Atlantic distribution	N	%		
Paranthias furcifer	Creole-fish, barber, atlantic creolefish	n US-ME, BE, CA, PA-VE, FG, ne BR-se BR	STP, AI	9	1.88	LC	—
Hyporthodus nigritus	Warsaw grouper	n US-BEL, CA, VE-FG, s BR		8	1.67	NT	?
Hypoplectrus puella	Butter hamlet, bared hamlet	n US-VE, CA, BE		8	1.67	LC	?
Pterois miles	Devil firefish	n US, VE		8	1.67	LC	?
Diplectrum formosum	Sand seabass, sand perch	n US-s BR, CA, BE		7	1.46	LC	?
Hypoplectrus unicolor	Butter hamlet	n US-VE, CA, BE		7	1.46	LC	?
Mycteroperca acutirostris	Western comb grouper, wavy-lined grouper	s US-VE, CA, s BR		7	1.46	LC	—
Rypticus saponaceus	Greater soapfish	n US-VE, CA, BE ne BR-s BR, FN, SPSP, TMV	SN-NA, SH, AI, CV	7	1.46	LC	?
Dules auriga		se BR-AR, TMV		6	1.25	NE	NE
Hypoplectrus chlorurus		s US-VE, CA		6	1.25	LC	?
Hyporthodus flavolimbatus	Yellowedge grouper	n US-FG, s BR		6	1.25	VU	↓
Serranus tigrinus	Harlequin bass	n US-VE, CA		6	1.25	LC	?
Dermatolepis inermis	Marbled grouper	n US-GU, CA, ne BR, se BR		5	1.04	DD	↓
Diplectrum radiale		n US-s BR, CA		5	1.04	LC	?
Hypoplectrus aberrans	Yellowbelly hamlet	s US, CA, BEL-VE		5	1.04	LC	?
Hyporthodus mystacinus	Misty grouper, John paw	n US-SU, CA		5	1.04	LC	?
Serranus atricauda	Blacktail comber		AZ, MD, CI	5	1.04	DD	↓
Serranus baldwini	Lantern bass	n US-VE, CA, SU, BR		5	1.04	LC	?
Acanthistius brasilianus	Argentine seabass	ne BR- s AR		4	0.84	DD	?
Alphestes afer	Mutton hamlet	n US- s US, BE, CA, NI-CO, ne BR-se BR		4	0.84	LC	—
Cephalopholis taeniops			CI, CV, SN-NA	4	0.84	LC	—
Epinephelus aeneus	White grouper	s US, CA, HO	MD, WS-NA, STP	4	0.84	NT	↓
Epinephelus drummondhayi	Speckled hind, guinea chick hamlet	n US-HO		4	0.84	DD	↓
Gonioplectrus hispanus	Spanish flag	n US-ME, CA, CO, VE, ne BR-se BR		4	0.84	LC	?
Hypoplectrus guttavarius	Shy hamlet	s US-VE, CA		4	0.84	LC	?
Hypoplectrus indigo	Indigo hamlet	s US, CA, HO, PA, VE		4	0.84	LC	?
Pseudogramma gregoryi	Reef bass	n US-VE, CA		4	0.84	LC	?
Serranus atrobranchus	Blackear bass	n US-s BR, CA		4	0.84	LC	?
Serranus cabrilla	Comber		UK-n NA, s SA, MD, AZ, CI, CV, STP, TC	4	0.84	LC	—
Serranus flaviventris		n US, CA, BEL-VE, BR		4	0.84	LC	?
Serranus scriba	Painted comber	s CAN-n US	UK-FR, SP-SN	4	0.84	LC	—
Acanthistius patachonicus		AR		3	0.63	DD	↓
Cephalopholis nigri			SN-NA, STP	3	0.63	LC	?
Hypoplectrus gemma	Blue hamlet	s US, CA		3	0.63	LC	?
Hypoplectrus gummigutta		s US, CA		3	0.63	LC	?
Liopropoma carmabi	Candy basslet	s US-VE, CA		3	0.63	LC	?

‘

Table 2: Continued

Species	Vernaculars	Western Atlantic distribution	Eastern Atlantic distribution	N	%		
Liopropoma rubre	Peppermint basslet peppermint bass	s US-VE, CA		3	0.63	LC	?
Pronotogrammus martinicensis	Roughtongue bass	n US-n BR, CA, BE, se BR-s BR, FN		3	0.63	LC	?
Rypticus subbifrenatus	Spotted soapfish	n US-VE, CA, ne BR	CAM, STP	3	0.63	LC	?
Serranus phoebe	Tattler	n US-n BR, CA, BE, se BR		3	0.63	LC	?
Anthias anthias	Swallowtail seaperch, marine goldsifh		MO-NA, MD, AZ, CI, STP	2	0.42	LC	—
Centropristis ocyurus	Bank sea bass	n US-ME, VE		2	0.42	LC	?
Epinephelus costae	Goldblotch grouper		SN, NA	2	0.42	DD	?
Hypoplectrus providencianus		NI		2	0.42	LC	?
Hypoplectrus randallorum		s US, HO, NI		2	0.42	LC	?
Hyporthodus haifensis	Haifa grouper		MO-s AN	2	0.42	LC	?
Mycteroperca fusca			SN, AZ, CI	2	0.42	VU	↓
Mycteroperca rubra	Mottled grouper, comb grouper	s US, ME, CA, VE, ne BR-s BR	AZ, CI, MA, BEN, NA	2	0.42	LC	?
Parasphyraenops incisus		n US, CA, ne BR		2	0.42	LC	?
Rypticus bistrispinus	Freckled soapfish	n US-se BR, CA, BE		2	0.42	LC	?
Rypticus carpenteri		s US, HO, NI, CA		2	0.42	LC	?
Schultzea beta	School bass	n US-VE, CA		2	0.42	LC	?
Serranus annularis	Orangeback bass	n US-VE, CA, FG, n BR		2	0.42	LC	?
Serranus chionaraia	Snow bass	s US, HO-VE, CA, n BR		2	0.42	LC	?
Serranus hepatus			FR, PT, CV	2	0.42	LC	?
Serranus papilionaceus			CI	2	0.42	LC	—
Serranus subligarius	Belted sandfish	n US-ME, CA, PA		2	0.42	LC	?
Serranus tortugarum	Chalk bass	s US-CO, CA		2	0.42	LC	?
Diplectrum bivittatum	Dwarf sand perch	n US-GF, ne BR, CA		1	0.21	LC	—
Epinephelus caninus	Dogtooth grouper		CI, SN-AN	1	0.21	DD	?
Epinephelus fasciatus	Golden grouper, blacktip grouper		MA-AN, CV	1	0.21	LC	?
Hypoplectrus castroaguirrei		ME		1	0.21	EN	?
Hypoplectrus maya		BEL		1	0.21	EN	↓
Hypoplectrus atlahua		s US, HO, NI		1	0.21	DD	?
Liopropoma aberrans		n US, CA, VE, SU		1	0.21	LC	?
Liopropoma mowbrayi	Cave basslet, cave bass	ME-VE, CA		1	0.21	LC	?
Liopropoma olneyi		CA		1	0.21	DD	?
Liopropoma santi		CA		1	0.21	DD	?
Meganthias carpenteri			NG	1	0.21	DD	?
Mycteroperca cidi		s US, CO, VE, SU		1	0.21	DD	?
Odontanthias cauoh		SPSP		1	0.21	NE	NE
Paralabrax dewegeri		CA, VE-n BR		1	0.21	LC	?
Rypticus maculatus	Whitespotted soapfish	n US-ME		1	0.21	LC	?
Rypticus randalli		n US-se BR, CA, SPSP		1	0.21	LC	?
Serranus aliceae		se BR		1	0.21	NE	NE
Serranus luciopercanus		ME, VE, CA		1	0.21	LC	?

Table 2: Continued

Species	Vernaculars	Western Atlantic distribution	Eastern Atlantic distribution	N	%		
Serranus tabacarius	Tobaccofish	n US-VE, CA		1	0.21	LC	?
Tosanoides aphrodite		SPSP		1	0.21	NE	NE
Total sum				47 9	100		

About half (83, 49.70%) of the documents focused on serranids of any taxonomic rank. Out of those *Centropristis striata* was the most studied (table III), being the focus of eight documents, followed by Hypoplectrus (7 documents), then Serranidae (6), and *Epinephelus guttatus* (5); the two lionfishes were the main subject of seven documents in total.

The theme of the studies of *Centropristis striata* were: ontogeny (3), diet (1), fecundity (1), fishing (1), genetics (1), vertical movement (1); for Hypoplectrus they were: speciation (5), effects of a hurricane (1), taxonomic review (1); for the lionfishes: feeding (4), abundance (1), ecology (1), phylogeography (1); for Serranidae: conservation (2), effects of hurricanes (1), mercury poisoning (1), taxonomic review (1); for *Epinephelus guttatus*: reproductive aggregations (3), fishing (1), ontogeny (1).

Table 3 – Top ten serranid taxa appearing as the focus of the studied documents, and the two lionfish species

Taxon	**Documents**
Centropristis striata	8
Hypoplectrus	7
Lionfishes	7
Serranidae	6
Epinephelus guttatus	5
Cephalopholis taeniops	4
Epinephelus marginatus	4
Epinephelus striatus	4
Serranus atricauda	4
Epinephelus aeneus	3
Epinephelus morio	3

Scientific production

Most of the scientific production (89.02%) was done in the 21st century (Figure 1), where at least three documents were published per year and the yearly average was seven documents. The two most prolific years (2004 and 2012) took place with ten documents being produced in each of those years. The annual growth rate was of 4.42%.

The authors with most published documents were František Moravec (6), José A. González (5), and Carole C. Baldwin, Sergio R. Floeter and Victor Tuset (4), as shown in table 4.

Figure 1 – Annual scientific production over the years of publication

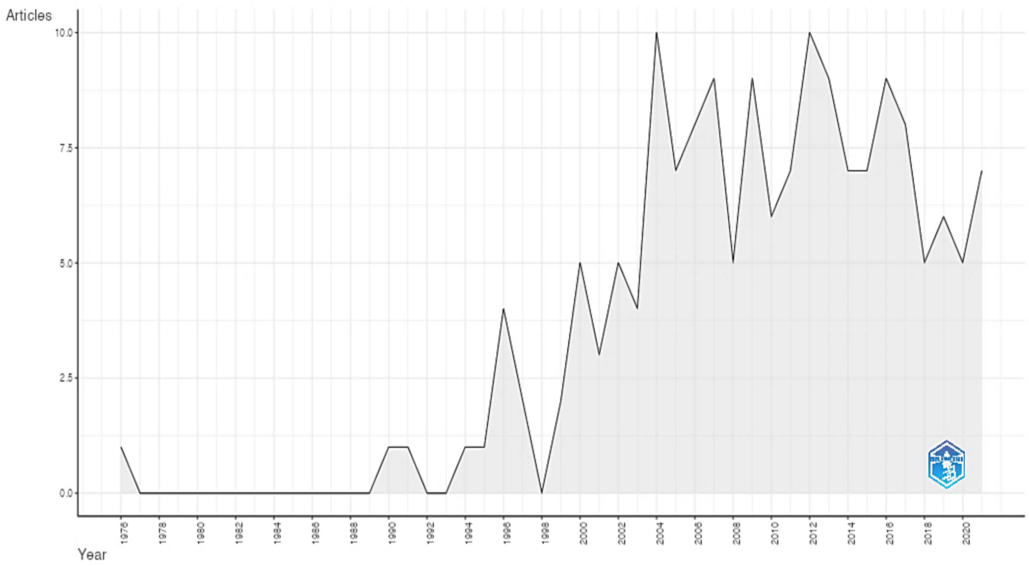


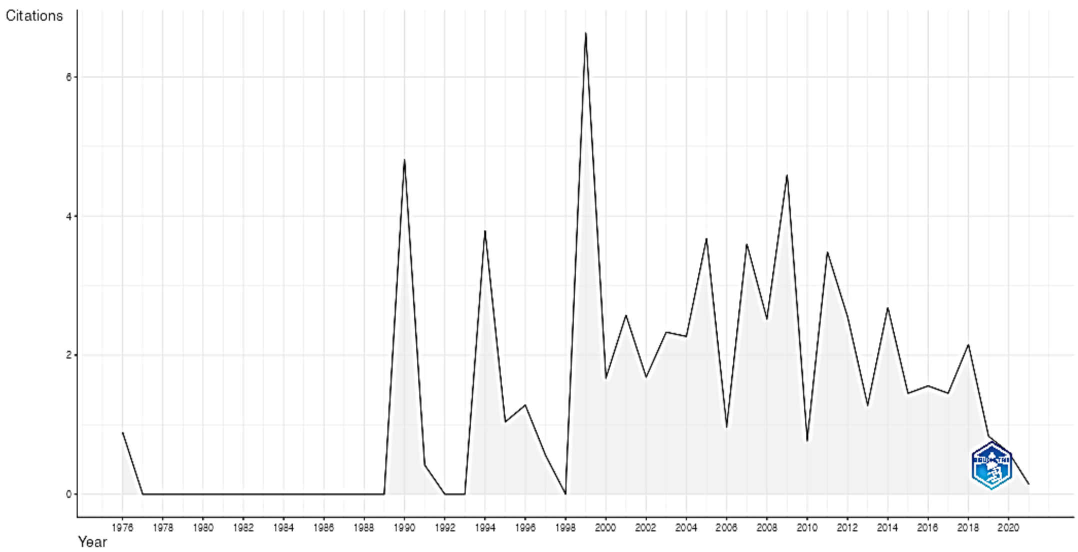
Table 4 – Top five most prolific authors

Authors	Articles	Articles Fractionalized
Moravec F	6	2.28
González JA	5	1.18
Baldwin CC	4	1.67
Floeter SR	4	0.99
Tuset VM	4	0.95

Citations

The average number of citations in years with publications ranged from 0.14 to 6.63 citations per year (Figure 2), with 1999 having the highest ratio.

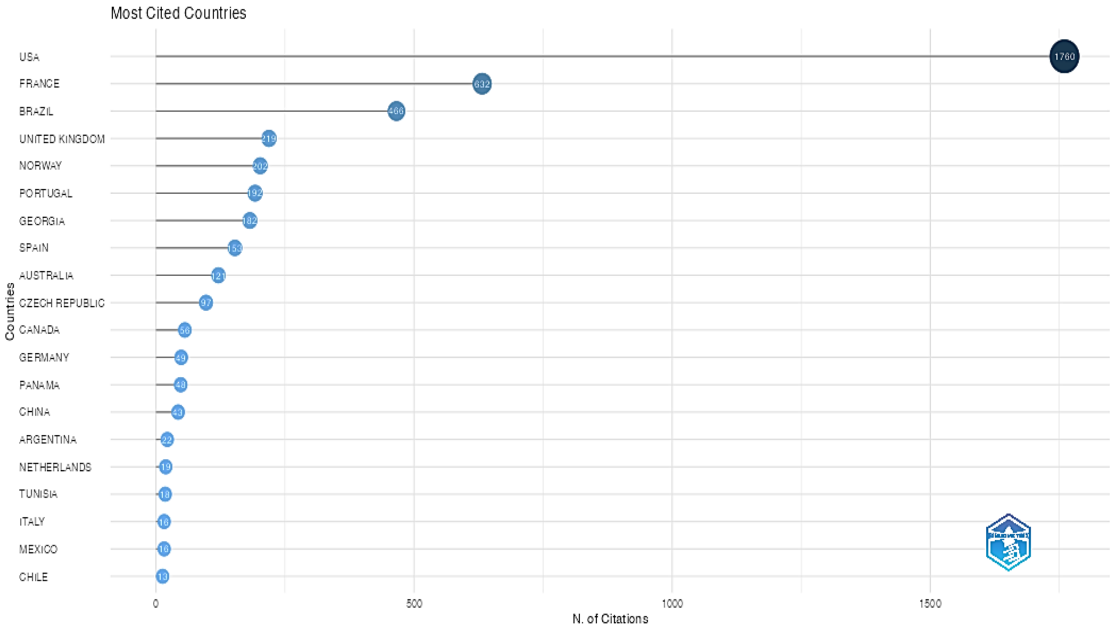
Figure 2 – Average article citation per year



In total all documents were cited 4,773 times. Out of all the countries, the United States has the highest total number of citations (1760), representing 40.44% of all citations, more than doubling second in rank France (632, 14.52%), Brazil was the third most cited country with 466 (10.71%)

citations (Figure 3); the top five most cited countries represent 75.34% of all citations. The countries with the highest and lowest average article citation were Norway (101) and Venezuela (4), respectively.

Figure 3 - Number of citations per country of publication



There were 14 uncited documents, 12 of those were published between 2017-2021, one in 2005 and another in 2007. The most cited publications were Roméo *et al.* (1999), Morris Jr. & Akins (2009), and Baroiller *et al.* (2009), with 279, 239 and 193 citations respectively (Table 5). The top ten most cited documents corresponded to 35.58% of all citations.

Out of the 20 most cited papers only three focused on groupers (Nemeth, 2005; Sadovy; Rosario & Román, 1994; and Nemeth et al., 2007), specifically focusing on the reproductive aggregations of the red hind (*Epinephelus guttatus*). There were also three articles focused on the lionfish's diet and abundancy (Morris & Akins, 2009; Whitfield et al., 2007; and Muñoz; Currin & Whitfield, 2011). The other 16 papers were ecological studies of habitats or multiple species, on topics like heavy metal concentration in fishes (Roméo et al., 1999), effects of artisanal fishing (Hawkins & Roberts, 2004), or the genetic structure of fish populations (Bowen & Avise, 1990).

Table 5 – Top 20 most cited documents by total citation

Paper	Total Citations	TC per Year	Normalized TC
Roméo *et al.*, 1999	279	11.63	1.83
Morris & Akins, 2009	239	17.07	4.01
Baroiller; d'Cotta & Saillant, 2009	193	13.79	3.23
Magnadottir *et al.*, 2005	178	9.89	2.85
Hawkins & Roberts, 2004	171	9.00	4.19
Bowen & Avise, 1990	154	4.67	1.00
Nemeth, 2005	133	7.39	2.13
Whitfield *et al.*, 2007	132	8.25	2.45
Santos *et al.*, 2002	113	5.38	3.36
Sadovy; Rosario & Román, 1994	106	3.66	1.00
Heyman & Kjerfve, 2008	103	6.87	2.93

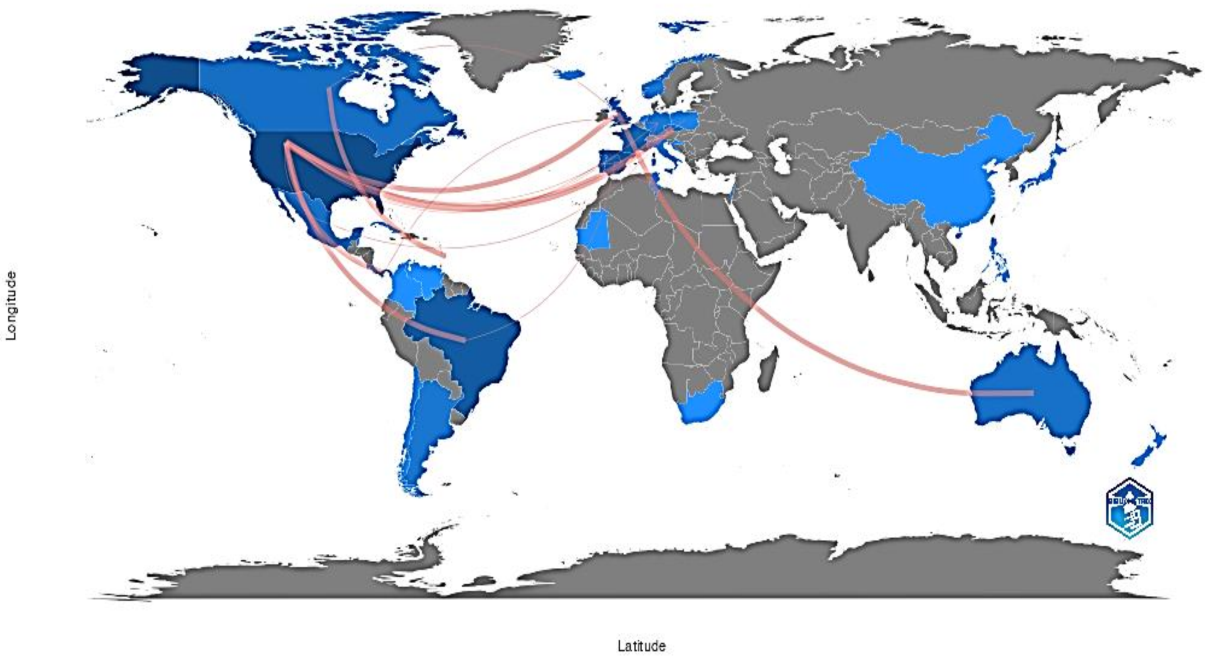
Table 2: Continued

Paper	Total Citations	TC per Year	Normalized TC
Seaman, 2007	100	6.25	1.86
Gasparini & Floeter, 2001	92	4.18	1.70
Muñoz; Currin & Whitfield, 2011	90	7.50	2.35
Szedlmayer & Able, 1996	87	3.22	2.62
Nemeth *et al.*, 2007	82	5.13	1.52
Feitoza; Rosa & Rocha, 2005	80	4.44	1.28
Weigt *et al.*, 2012	76	6.91	2.98
Mumby *et al.*, 2012	75	6.82	2.94

International collaboration

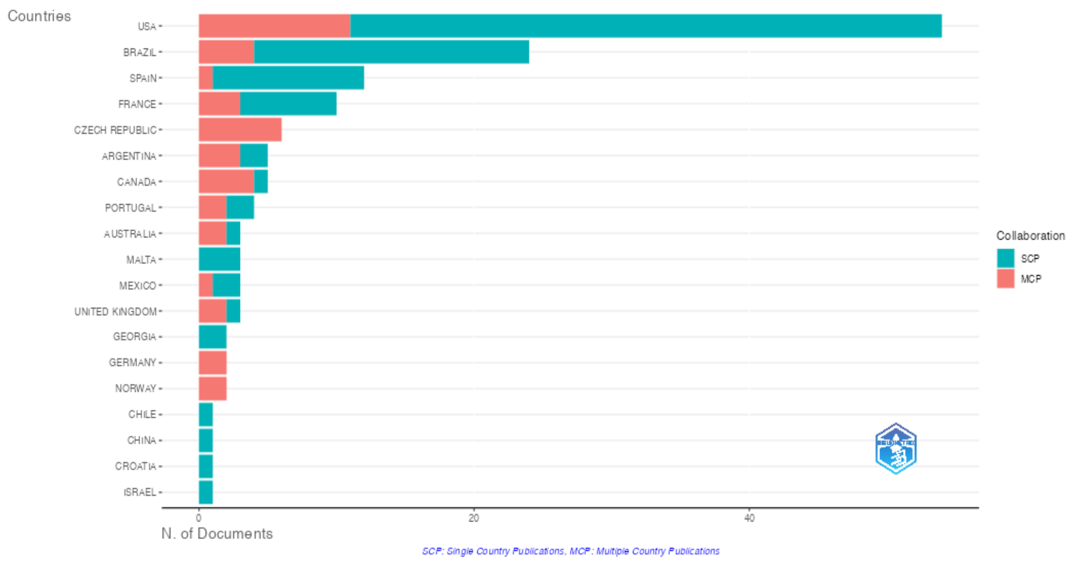
There were 29 countries collaborating among themselves, summing a total 77 collaborations (Figure 4). The USA was the most co-productive country. having collaborated 31 times between 17 countries, followed by Australia with 11 collaborations between nine countries, and the United Kingdom and Brazil with 12 and ten collaborations, respectively, between seven countries.

Figure 4 - Collaboration map of publishing countries on a gradient scale, darker colors means more collaborations



In total, 24 countries from all continents had a respective corresponding author in document publications (Figure 5). The USA had the most with 54 corresponding authors, followed by Brazil (24) and Spain (12), and 17 documents had no identified corresponding author country. There were eight countries that published at least four documents, while 16 countries published up to three documents. Excluding unidentified countries of origin, nine countries had only documents with a single country participation and five only had multiple country participation.

Figure 5 – Number of documents published per corresponding author country of origin. SCP is the number of documents with a single country participation and MCP is the number of documents with multiple country participation



Journals

The documents were published in 93 different journals. The majority (67.74%) of journals published a single document, while five (5.38%) published at least five documents. The Marine Ecology Progress Series (9, 9.68%) was the most prolific publisher, followed by the Journal of Fish Biology (7, 7.53%) and the Bulletin of Marine Science and the Journal of Parasitology (6, 6.45%) (Table 6).

Table 6 – Top 20 most prolific journals

Sources	Articles	Percent
Marine Ecology Progress Series	9	9.68
Journal of Fish Biology	7	7.53
Bulletin of Marine Science	6	6.45
Journal of Parasitology	6	6.45
Zootaxa	5	5.38
Acta Ichthyologica et Piscatoria	4	4.30
Aquaculture	4	4.30
Cybium	4	4.30
Environmental Biology of Fishes	4	4.30
Fisheries Research	4	4.30
Marine Biology	4	4.30
Zookeys	4	4.30
Copeia	3	3.23
Fishery Bulletin	3	3.23
Molecular Ecology	3	3.23
Scientia Marina	3	3.23
Acta Parasitologica	2	2.15
Biological Invasions	2	2.15
Caribbean Journal of Science	2	2.15

‘

Institutions

Out of the 272 institutions present in our data, 208 (76.47%) participated in only one document, while 11 participated in at least five (1.84%). The Fish and Wildlife Research Institute (14, 5.15%) had the most appearances, the Southeast Fisheries Science Center (8, 2.94%) followed in second place, and the Institute of Parasitology, University of Florida and University of Miami (7, 2.57%) in third (table VII). All of the top ten most prolific institutions are located on the western side of the Atlantic Ocean, the top seven all being from the USA, the 8th place from Panama and the 9th and 10th from Brazil. Out of the top 20 most prolific institutions, 18 institutions are from the western side of the Atlantic Ocean and represent 34.92% of all publications, and two are from Spain.

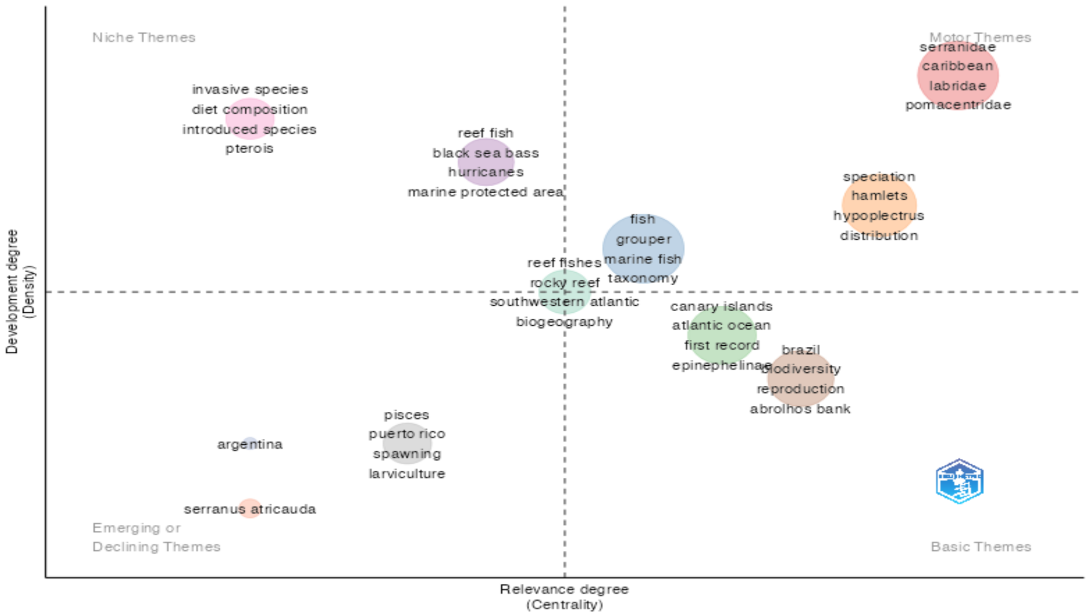
Table 7 – Top 20 most prolific institutions

Affiliation	**Articles**	**Percent**
Fish and Wildlife Research Institute	14	5.15
Southeast Fisheries Science Center	8	2.94
Institute of Parasitology	7	2.57
University of Florida	7	2.57
University of Miami	7	2.57
Smithsonian Institution	6	2.21
Northeast Fisheries Science Center	5	1.84
Smithsonian Tropical Research Institute	5	1.84
Universidade Federal do Espírito Santo	5	1.84
Universidade Federal do Rio de Janeiro	5	1.84
University of Puerto Rico	5	1.84
Mcgill University	4	1.47
Universidade de Vigo	4	1.47
Universidade Federal da Paraíba	4	1.47
University of The Virgin Islands	4	1.47
Auburn University	3	1.10
California Academy of Sciences	3	1.10
Instituto Canario de Ciencias Marinas	3	1.10
Universidad de Antofagasta	3	1.10

Thematics

The most popular keyword chosen by authors were ‘serranidae’ (24), ‘caribbean’ (9), ‘fish’ (9), ‘canary islands’, ‘grouper’ (6), ‘reef fish’ (6) and ‘speciation’ (6). The keyword groupings formed nine clusters led by ‘serranidae’, ‘fish’, ‘canary islands’, ‘reef fish’, ‘speciation’, ‘brazil’, ‘invasive species’, ‘reef fishes’, ‘serranus atricauda’ and ‘argentina, as shown in figure 6.

Figure 6 - Cluster aggrupation of author's keywords by their development (y axis) and relevance (x axis), the bigger the circle the more documents it contains



DISCUSSION

More species were mentioned at least five times (37.89%) than only once (21.05%). The more popular species have bigger distribution and often more than one common name, whereas most of the species mentioned only once have a small distribution and no common name. This is more likely a consequence of the less popular species being smaller and having little to no economic value, thus, they are less studied and/or spotted, but their actual range is probably much bigger, with the exception of those exclusive to isolated oceanic islands.

As expected, considering the very broad search query, serranids were not the focus of most studies but rather appeared in them incidentally not only due to their high diversity and widespread range but also due to the size of the larger species, which makes spotting and identifying them easier. This means that despite most of the bigger species appearing recurrently in the literature, they are not on the spotlight for research, and instead a few taxa are studied for mostly distinct reason such as the recent speciation process of the Hypoplectrus genus or *E. guttatus*' reproductive aggregations.

Serranids not being the main target of studies is also shown in the keyword clusters and is exemplified in the 20 most cited articles, those results also happen because of broader spectrum studies like the ecology of a region or area (such as countries (Lee & Ostrowski, 2001; Vallès; Kramer & Hunte, 2008), islands (Sazima *et al.*, 2007; Triay-Portella *et al.*, 2015) or reefs (Bejarano; Mumby & Sotheran, 2011; Heyman & Kjerfve, 2008)) and fauna checklists (Escobar-Sierra *et al.*, 2021; Gasparini & Floeter, 2001; Monteiro-Neto *et al.*, 2013; Smith-Vaniz & Jelks, 2014) will often include serranids. Groupers also frequently appear in the literature as hosts for parasites (Çelik; Korun & Gökoğlu, 2020; Chaabane *et al.*, 2016; Costa *et al.*, 2013; Moravec & Bakenhaster, 2010, 2012). Conversely due to the Serranidae family's high diversity and often cryptic nature there are many registries for new species (Baldwin & Robertson, 2014; Baldwin & Weigt, 2012; Carvalho Filho; Macena & Nunes, 2016; Aderson Jr, 2006; Wirtz & Schliewen, 2012) and new records of distribution of groupers (Bañón *et al.*, 2017; Pimentel *et al.*, 2019; Sithole; Heemstra & Mwale, 2021). This shows that groupers can be more tangentially studied than be a directly targeted group. One topic where this is especially true is the lionfish invasion in the western Atlantic because of the predator-prey and competitor relationship of the two groups, where they compete for food and bigger serranids may pray on lionfish but smaller species or younger individuals are preyed upon (Curtis *et al.*, 2017; Morris & Akins, 2009; Chappell & Smith, 2016), meaning groupers will often appear in ecology studies of lionfish. We expect an increase in such cases as the lionfish keep increasing their range in the western Atlantic, already appearing south of the Amazon River plume in Brazil (Ferreira *et al.*, 2015; Luiz *et al.*, 2021; Soares *et al.*, 2022).

The USA appears as the most relevant country regarding studies about the serranid family in the Atlantic Ocean in aspects such as production, citation and collaboration with other countries, meanwhile other important locations, such as the African continent and the Caribbean region; have little research credited to them. This polarization is a crucial problem for the serranid family, given their mainly sub-tropical distribution and lack of consistent data on the status of most of their species (Amorim & Westmeyer, 2015). A broader distribution of scientific studies is needed to have a more informed outlook of the current health of serranid species alongside their conservation status and existing fishing stock.

It is possible that the fluctuation in citation numbers may indicate higher or lower numbers in published documents a few years into the future, even when considering new articles tend to get less citations due to their recency, which would help explain how the declining publication rate that began on the early 2010's may be influenced by the fall of the citation rate which started on the late 2000's and still going. Considering the high number of authors with few publications regarding this topic, the low continuity in research may also be a factor of the increase in research done in the early 2010's associated with a drop in citation rates. It is also worth noting that this family's back-and-forth taxonomical classification history (Parenti & Randall, 2020) may have excluded many documents from our search query, as authors may have classified, for example, *Rypticus maculatus* as a Gramitidae rather than a Serranidae making it impossible to appear in our search results.

CONCLUSION

This work presented an update on the bibliometry regarding scientific production, citations, country collaborations, journals and institutions for the Serranidae family in the Atlantic Ocean.

There is currently a big gap of research on groupers on each side of the Atlantic Ocean, where the western side, in particular the USA, concentrates most of the studies. Also, about half of the documents focused on members of the family, meaning the group is often not the main research target and when this happens bigger species will appear more often due to their sheer size making them more conspicuous.

Despite both the ecological and economic importance, and the knowledge gaps in academia regarding this group, our results show a decrease in citations and publications after a peak, in the late 2000's and early 2010's respectively. Very few countries represent the great majority of all published material, this is worrisome, especially considering the large amount of countries that share the Atlantic Ocean, because the threats to the serranids (mainly overfishing) are not local or regional but widespread throughout their habitat range. Altogether, 87.10% of all journals and 94.49% of all institutions published three or less documents, showing a low continuity in the research which potentially hinders the production of long-term studies in comparison to sporadic ones, leaving us with an opaquer view of the whole family.

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