

MARINE RECORD

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# First record of *Siganus randalli* (Teleost, Siganidae) in New Caledonia, and comments on its diet

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## Abstract

**Background:** Most of the 29 Siganidae species are widely distributed through the Indo-Pacific area. In New Caledonia, these family was represented by 12 species. The present report is the first record of *Siganus randalli* in New Caledonian waters and provide information on its diet.

**Methods:** Three specimens of *Siganus randalli* were caught in shallow mangrove waters of the southern part of New Caledonia. Their stomach contents and isotopic signatures (carbon and nitrogen) were analyzed and compared to others siganids species.

**Results and conclusion:** This note provides the most southerly record of the rabbitfish *Siganus randalli*, which extends its distribution range by 1200 km southward and 1300 km southwest. The data on its diet, when compared with other co-occurring or more reef-associated siganid species, provide information on feeding processes and ecological functions associated with its mangrove habitat.

**Keywords:** Variegated rabbitfish, Diet, Stomach content, Isotope, SW pacific

**Abbreviations:** ADECAL, Agence de développement économique de la Nouvelle-Calédonie; ARR, Arrêté; C, Carbon; DENV, Direction de l'environnement; G, grams; IRI, Index of relative importance; LIVE, Laboratoire insulaire du vivant et de l'environnement; MM, millimeter; N, Nitrogen; SD, standard deviation; TL, Total length; UNC, Université de la Nouvelle-Calédonie

## Background

Most of the 29 Siganidae species are widely distributed through the Indo-Pacific area (Woodland 1990; Randall and Kulbicki 2005). Their habitats range from estuaries and mangroves to outer reefs. This local distribution is closely related to their ecological function as browsers, croppers, mixed-feeders and spongivores (Hoey et al. 2013). In New Caledonia, 12 species have been recorded, though one of them needs further verification (*S. vermiculatus*; Fricke et al. 2011). Siganid species are currently identified by color and morphology characteristics such as snout shape, color patterns, body depth and caudal fin shape (Woodland 1990; Randall and Kulbicki 2005;

Borsa et al. 2007), but similarities in these characteristics between closely related species may lead to misidentification (Randall and Kulbicki 2005).

The variegated rabbitfish *Siganus randalli* (Woodland 1990) is a little known species and the information available mostly relates to aquaculture (Collins and Nelson 1993; Brown et al. 1994; Nelson and Wilkins 1994). It lives in brackish waters of mangroves (Collins and Nelson 1993; Nelson and Wilkins 1994), as well as above sandy bottoms of coral reef flats (Woodland 1990). The species is distributed widely from Guam (Kamikawa et al. 2015) and the Philippines archipelago (Galenzoga and Quiñones 2014) to Fiji (Blaber et al. 1993).

The aim of this paper is, firstly, to record the presence of *Siganus randalli* in New Caledonia and, secondly, to provide informations on its diet through an analysis of stomach contents and stable isotope signatures. The diet

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**Fig. 1** Specimen (UNC-Y1002) of *Siganus randalli* caught during the experimental fishing session. Photo T. Moleana

data allow a better understanding of the functional role and habitat use of this species.

### Materials and methods

On 5 March 2014, three specimens of *Siganus randalli* were collected (Fig. 1) at Goro (22° 17' S; 167° 1' E), southeast of New Caledonia. All specimens were caught with a gillnet in shallow mangrove waters (0.5–1 m depth). Individual weights were measured to the nearest gram and total, fork and standard lengths and body depth were recorded to the nearest millimeter. In addition, three specimens of *Siganus lineatus* (Valenciennes, 1835) and two specimens of *Siganus fuscescens* (Houttuyn, 1782) were collected along with the three *S. randalli*, and were also analyzed for a comparison of diets.

Stomach contents were collected, weighed and preserved in a 4 % formaldehyde solution. Stomach fullness was determined using the ratio between total stomach content weight and total fish weight. Each item found in the stomachs was then identified at the lowest taxonomic level and weighed. Occurrence (F%) of items and proportions by number (N%) and by weight (W%) were monitored to estimate the Index of Relative Importance (IRI; Pinkas 1971) and express it as a percentage (%IRI) of the total IRI of the stomach content. To ascertain feeding patterns, standardized niche breadth (B; Hurlbert 1978) and niche overlap (O; Pianka 1974) were determined using %IRI of each item to take into account their

occurrence and proportion by number and weight. Following Pinnegar and Polunin (1999), carbon and nitrogen stable isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) were measured on dorsal white muscle of the jointly collected three *S. randalli*, two *S. fuscescens* and three *S. lineatus*. Other  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values obtained from siganids collected at reef sites off Noumea (22° 14' S; 166° 28' E) were also used for species and habitat comparisons (Letourneur, unpublished data for 10 *Siganus lineatus* 186–209 mm TL; 5 *S. punctatus* 200–261 mm TL; 6 *S. puellus* 170–212 mm TL).

### Results

The three *Siganus randalli* specimens exhibited the same meristic characters, body shape and color pattern as those described by Woodland (1990). Morphometric data are given in Table 1.

The stomach fullness values of *S. randalli* and *S. lineatus* caught in the mangrove was respectively  $3.35 \pm 0.67$  and  $3.42 \pm 0.57$ . By comparison, low stomach fullness values of the two *S. fuscescens* ( $0.43 \pm 0.03$ ) showed lower feeding activity in the mangrove.

The diet of the *S. randalli* comprised 15 food items (Table 2). Rhodophyta and Phaeophyta were dominant in the stomach contents, which consisted mainly of *Bostrychia* sp. (75.6 %), *Dictyota* sp. (10.7 %) and *Lomentaria* sp. (4.2 %). This trend was also apparent in terms of %W (67.2, 17.7 and 6.9 %) and hence of

**Table 1** Morphometric data of *S. randalli*, *S. lineatus* and *S. fuscescens* collected in Goro, New Caledonia

N° UNC	<i>S. randalli</i>			<i>S. lineatus</i>			<i>S. fuscescens</i>	
	Y1001	Y1002	Y1003	Y1008	Y1014	Y1019	Y1004	Y1005
Weight (g)	247.6	308.4	223.1	228.2	250.9	171.2	378.5	245
Total length (mm)	240	253	231	235	237	212	306	274
Fork length (mm)	220	235	213	217	220	197	278	246
Standard length (mm)	178	189	170	174	177	186	232	201
Body depth (mm)	95	101	90	92	92	85	100	85

**Table 2** Diet composition of *S. randalli* ( $n = 3$ ), *S. fuscescens* ( $n = 2$ ) and *S. lineatus* ( $n = 3$ ) caught in Goro, New Caledonia, and expressed in frequency of occurrence (%F), percent by number (%N) and percent by weight (%W). %IRI: Percent of Index of Relative Importance

Items prey	<i>S. randalli</i>				<i>S. lineatus</i>				<i>S. fuscescens</i>			
	F%	N%	W%	%IRI	F%	N%	W%	%IRI	F%	N%	W%	%IRI
Magnoliophyta												
<i>Halophila</i> spp.	-	-	-	-	-	-	-	-	50.0	1.0	2.8	1.5
<i>Thalassia hemprichii</i>	-	-	-	-	-	-	-	-	100.0	5.7	8.3	11.5
Rhodophyta												
<i>Amphiroa</i> sp.	-	-	-	-	-	-	-	-	50.0	42.9	55.5	40.2
<i>Bostrychia</i> sp.	100.0	75.6	67.2	74.2	100.0	49.0	44.6	62.0	-	-	-	-
<i>Centroceras</i> sp.	-	-	-	-	25.0	0.1	<0.1	<0.1	-	-	-	-
<i>Ceramiales</i> spp.	100.0	0.4	0.1	0.3	50.0	3.0	0.1	1.0	100.0	18.1	1.4	15.9
<i>Ceramium</i> spp.	-	-	-	-	50.0	0.9	0.1	0.3	-	-	-	-
<i>Gelidiella</i> sp.	-	-	-	-	-	-	-	-	50.0	17.1	18.5	14.6
<i>Gelidium</i> sp.	66.7	3.7	3.8	2.6	50.0	0.7	0.4	0.4	-	-	-	-
<i>Gracilaria</i> sp.	-	-	-	-	25.0	0.1	0.1	<0.1	-	-	-	-
<i>Hypnea</i> spp.	-	-	-	-	25.0	<0.1	0.1	<0.1	50.0	1.0	2.3	1.3
<i>Hypoglossum</i> sp.	33.3	<0.1	0.1	<0.1	-	-	-	-	-	-	-	-
<i>Lomentaria</i> sp.	100.0	4.2	6.9	5.7	100.0	4.6	6.4	7.3	-	-	-	-
<i>Polysiphonia</i> sp.	66.7	1.1	1.8	1.0	50.0	9.0	16.1	8.3	-	-	-	-
<i>Tolypocladia</i> sp.	-	-	-	-	25.0	0.3	0.1	0.1	-	-	-	-
Chlorophyta												
<i>Caulerpa verticillata</i>	66.7	0.7	0.4	0.4	75.0	3.3	1.7	2.5	-	-	-	-
<i>Chlorodesmis</i> sp.	-	-	-	-	25.0	6.0	10.7	2.8	-	-	-	-
<i>Ulva</i> sp.	-	-	-	-	-	-	-	-	50.0	4.8	0.9	2.3
Phaeophyta												
<i>Padina</i> sp.	33.3	1.5	2.0	0.6	25.0	4.2	2.3	1.1	-	-	-	-
<i>Dictyota</i> sp.	100.0	10.7	17.7	14.8	50.0	9.9	16.7	8.8	-	-	-	-
Invertebrates												
Amphipods	66.7	0.2	0.1	0.1	75.0	0.4	0.3	0.4	-	-	-	-
Ascidians	33.3	0.3	<0.1	0.1	25.0	0.1	0.1	<0.1	50.0	2.9	3.8	2.7
Copepods	-	-	-	-	75.0	0.5	<0.1	0.2	-	-	-	-
Foraminiferans	66.7	0.3	<0.1	0.1	100.0	3.1	<0.1	2.2	50.0	1.9	<0.1	0.8
Halacarids	33.3	0.5	<0.1	0.1	25.0	0.2	<0.1	<0.1	-	-	-	-
Hydrozoans	-	-	-	-	-	-	-	-	100.0	4.8	6.6	9.2
Isopods	-	-	-	-	25.0	0.1	<0.1	<0.1	-	-	-	-
Diptera larvae	-	-	-	-	25.0	0.4	<0.1	0.1	-	-	-	-
Nematods	33.3	0.5	<0.1	0.1	100.0	3.3	<0.1	2.2	-	-	-	-
Polychaetes	33.3	0.3	<0.1	0.1	75.0	0.8	<0.1	0.4	-	-	-	-

%IRI (74.2, 14.8 and 5.7 %). Consequently, niche breadth had a very low value ( $B = 0.05$ ).

*S. lineatus* consumed more food items than *S. randalli*, but a similar trend occurred with regard to dominance of Rhodophyta and Phaeophyta. In accordance with %IRI, the diet of *S. lineatus* was dominated by *Bostrychia* sp., *Dictyota* sp., *Lomentaria* sp. and *Polysiphonia* sp.

The niche breadth of this species also had a very low value ( $B = 0.07$ ).

By contrast, only 10 items were found in the diet of *S. fuscescens*, again dominated by Rhodophyta, but also by Magnoliophyta and, to a lesser extent, Chlorophyta and invertebrates. The niche breadth of this species had a higher value than *S. randalli* and *S. lineatus* ( $B = 0.37$ ).

**Table 3** Mean stable isotope ratios ( $\pm$ sd)  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of *S. randalli*, *S. lineatus* and *S. fuscescens* from mangrove, and of *S. lineatus*, *S. punctatus* and *S. puellus* from coral reef, New Caledonia

Species	Mangrove			Reef		
	N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
<i>S. fuscescens</i>	2	$-14.10 \pm 0.29$	$7.00 \pm 0.34$	-	-	-
<i>S. randalli</i>	3	$-27.95 \pm 0.68$	$5.67 \pm 0.21$	-	-	-
<i>S. lineatus</i>	3	$-26.13 \pm 1.50$	$5.57 \pm 0.23$	10	$-25.83 \pm 2.22$	$5.06 \pm 1.03$
<i>S. punctatus</i>	-	-	-	5	$-14.91 \pm 1.10$	$5.72 \pm 0.35$
<i>S. puellus</i>	-	-	-	6	$-16.42 \pm 1.97$	$6.70 \pm 1.23$

Strong niche overlap was found between *S. randalli* and *S. lineatus* ( $O = 0.99$ ), but not between *S. randalli* and *S. fuscescens* ( $O = 0.01$ ) or between *S. fuscescens* and *S. lineatus* ( $O = 0.01$ ).

*S. fuscescens* has the most  $^{13}\text{C}$ -enriched and  $^{15}\text{N}$ -enriched values, whereas *S. randalli* and *S. lineatus* from both habitats (mangrove and coral reef) exhibited quite similar values for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  (Table 3). *Siganus punctatus* and *S. puellus* had values similar to *S. fuscescens* for  $\delta^{13}\text{C}$ , but their nitrogen isotopic signatures occupied a more intermediate position between *S. fuscescens* and *S. lineatus* from mangrove.

## Discussion

The record of *Siganus randalli* from New Caledonian waters greatly extends its distribution, by approximately 1200 km southward and 1300 km southwest, compared to the closest previously recorded locations (i.e. the Solomon Islands and Fiji; Woodland 1990; Blaber et al. 1993). In view of the geographical distribution overlay (Woodland 1990) and the close phylogenetic similarities between *S. lineatus* and *S. randalli* (Borsa et al. 2007), this range extension is not surprising.

Apart from similar morphology characteristics, siganids can be separated into functional groups according to their feeding patterns. *Siganus randalli* revealed considerable differences from *S. fuscescens* in stomach content composition, a finding that explains the very low niche overlap for the two species. The close similarity found with *S. lineatus* in terms of stomach fullness, niche breadth and niche overlap suggests that *S. randalli* consumes the food resources of the mangrove in a comparable manner. Finally, the dominance of *Bostrychia* sp., a mangrove-associated algae (Zuccarello et al. 2006; Zuccarello and West 2008) in the diet of *S. randalli* highlights the importance of mangrove habitats for this species. Isotopic signatures support this view. Whereas *S. fuscescens* and *S. puellus* differ from *S. randalli* in their diets, functional groups (Debenay et al. 2011; Hoey et al. 2013) and hence their  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , the mixed feeder *S. punctatus* revealed higher  $\delta^{13}\text{C}$ , suggesting a diet of different origin. *Siganus lineatus* exhibits similar  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for both locations, suggesting that its diet

has a single habitat origin. Most notably, similarities in the isotopic ratios between *S. randalli* and *S. lineatus* indicated a comparable resource origin, utilization and assimilation by these two species. This low or even negligible food partitioning between *S. lineatus* and *S. randalli* may indicate trophic competition in the mangrove habitat. Our observations need further confirmation because of the small number of individuals examined.

## Conclusion

This note provides the most southerly record of the rabbitfish *Siganus randalli*. The data on its diet, when compared with other co-occurring or more reef-associated siganid species, provide information on feeding processes and ecological functions associated with its mangrove habitat. Several other specimens of *S. randalli* have been reported by fishermen, always in mangroves, in the northern part of New Caledonia, but individuals need to be captured to confirm these reports.

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## Availability of data and materials

*Siganus randalli* specimens are available in the fish collection of the LIVE department, Université de la Nouvelle-Calédonie, catalogued as UNC-Y1001, UNC-Y1002 and UNC-Y1003.

## Authors' contribution

TMO, LDP and YL carried out fieldwork; TMO and LDP analyzed the stomach contents; TMO and YL analyzed the isotopic signatures; TMO analyzed the data and wrote the manuscript; LDP, YL and TMe coordinated the study and corrected the draft manuscript. All authors read and approved the final manuscript.

## Competing interests

The authors declare that they have no competing interests.

## Consent for publication

Not applicable.

## Ethics approval and consent to participate

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