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Notes on ontogenetic color patterns in *Narcine bancroftii* (Griffith & Smith 1834) (Torpediniformes: Narcinidae)

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ABSTRACT

Fish of the genus *Narcine*, commonly known as electric rays, are characterized by the presence of depressed body, a thick tail, pectoral fins fused to the trunk, and dorsal electrical organs. Two species, *N. bancroftii* and *N. brasiliensis*, are distributed in the western Atlantic coast and the Caribbean Sea. In this study, I described the ontogenetic changes in the coloration pattern for *N. bancroftii*. The 41 specimens here analyzed come from artisanal fishery in La Ensenada de la Guardia, the ichthyological collection of the Universidad de Oriente (Isla de Margarita campus), and literature records. I observed that dorsal coloration varies greatly in this species in relation to the size of the specimen. In fact, the newborn specimens exhibit a blotch-based pattern, while large (≥ 19 cm TL) specimens showed a complex pattern of specks or terminal ocelli. These results provide a novel and important contribution to a poorly study topic in ontogeny of fish.

KEYWORDS

Elasmobranchii, Lesser electric ray, ontogenetic changes, photo identification.

Fish of the genus *Narcine*, commonly known as electric rays are widely distributed in tropical latitudes, with its greatest diversity in the tropical western Indo-pacific region. As distinctive features the electric ray species present: a dorsoventrally depressed body with pectoral fins attached to the trunk, forming and ovoid disc, a thick tail (caudal peduncle), and two electrical organs in the dorsal region of the disc (de Carvalho *et al.*, 2007; Bigelow & Schroeder, 2018).

For the Atlantic west coast and the Caribbean Sea, two species of the genus are recognized, the Lesser electric ray *Narcine bancroftii* (Griffith Smith 1834) and the Brazilian electric ray *N. brasiliensis* (Olfers, 1831). This separation is based on their different dorsal coloration, extreme geographical isolation, and tooth rows (de Carvalho, 1999; Moreno *et al.*, 2009; Last *et al.*, 2016). However, an undescribed species have been pointed out for the northern region of South America. Its dorsal coloration is different from *N. brasiliensis* and *N. bancroftii* by having numerous small brown spots or semicircles forming

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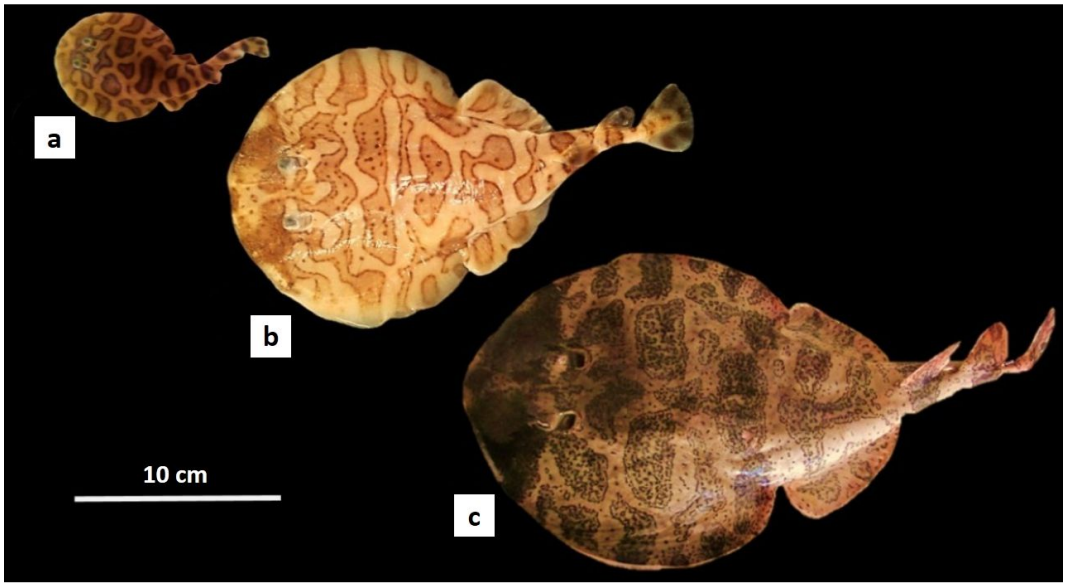

FIGURE 1 *Narcine bancroftii* dorsal pattern transition from neonate to adult form. Letters correspond to: (a) first stage; (b) second stage; (c) third stage. Scale bar: 10 cm.

large rings, small rings, and single speckles over the entire body (McEachran & de Carvalho, 2002; Garcia *et al.*, 2010; Last *et al.*, 2016). Whether it is a clinal variation (i.e., new color pattern) of any of the two species or a distinct species, remains to be described (McEachran & de Carvalho, 2002; Garcia *et al.*, 2010; Last *et al.*, 2016). Therefore, there is a need of more information and integrative analyses of both local and regional data to understand to address these points.

For 17 years it was indicated that *N. brasiliensis* inhabited Venezuelan waters (Cervigón & Alcalá, 1999; Cervigón & Ramírez, 2012), being until the publication of "Rays of the World" when *N. bancroftii* was indicated as the species occurring in the country (Last *et al.*, 2016). However, in previous years a revision of the genus for the Atlantic coast identified *N. bancroftii* for Venezuela (de Carvalho, 1999). But the lack of access to Carvalho's work at the time allowed the misidentification made by Cervigón to persist. Little is known about their populations, especially in the early stages of life. Therefore, this work aims to describe the coloration ontogenetic changes occurred in *N. bancroftii* specimens from Venezuela.

No animals were harmed to conduct this research. Twenty-two specimens were provided by the fisherman of La Ensenada de La Guardia (11°00'00.3"N - 64°01'22.5"W). In addition, 19 specimens from the ichthyological collection at the Universidad de Oriente at Isla de Margarita and photographed specimens (Cervigón & Alcalá, 1999; Cervigón & Ramírez, 2012) were examined. Due to possible overlap of characteristics such as the tooth row counts and meristic, the coloration pattern was considered to describe new forms/variations of the genus (de Carvalho, 1999). The rays were identified and later photographed following the key and terminology proposed by de Carvalho (1999) and Last *et al.* (2016). All specimens were measured, using a measuring tape, and classified into three different categories defined by their dorsal pattern and size (Fig. 1): Stage 1 (newborns) with a tail length (TL) of <13 cm; Stage 2 that correspond to individuals of 13-19 cm of TL; and the Stage 3 to specimens with >19 cm of TL (de Carvalho, 1999; Last *et al.*, 2016). Also, a visual comparison of the coloration patterns within the three stages considering the size and sex as variables was made; sex was determined by the presence or absence of claspers (de Carvalho, 1999; Last *et al.*, 2016).

The minimum body length recorded was 9.8 cm, while the maximum length recorded was 42.6 cm. The adult specimens exhibit a brown, orange, or yellow-brown background coloration, a dorsal coloration pattern consisting of a rostral blotch, which partially or entirely occupies the snout. Blotches

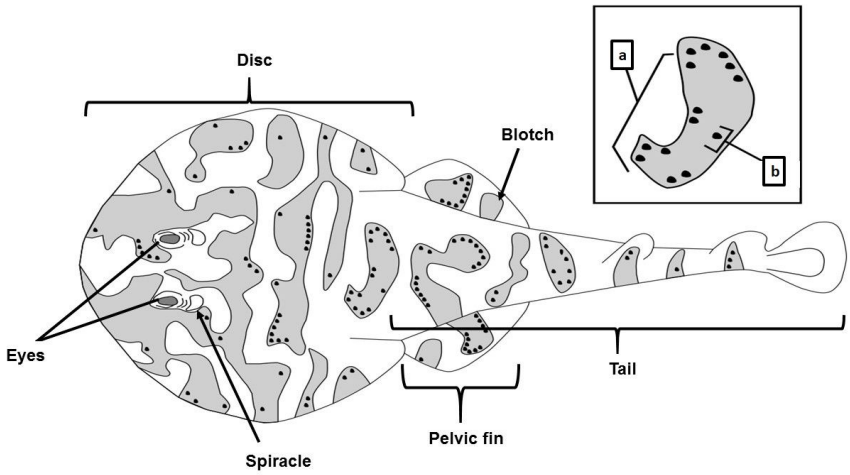

FIGURE 2 Scheme of a Lesser electric ray *Narcine bancroftii* showing the coloration pattern in stage 2; primary ocellus (a) and speckles (b) in detail

were dorsally observed in early stages (up to 13 cm total length); whereas ocelli and reticular formations were observed only in larger specimens, occupying a greater area in the anterior region of the specimen body (Fig. 2). Overall, the coloration patterns observed into the three stages analyzed were following (Fig. 1):

- **Stage 1**: A well-defined rostral blotch, with creamy brown, orange or yellow-brown background coloration, no black spots present. Body blotches are defined by broad and smooth dark brown lines.
- **Stage 2**: Dorsally creamy brown, orange, and/or yellow-brown background coloration. A well-defined rostral blotch is present. Blotches and primary ocelli are present, primary ocelli are long and stripe-like, defined by a continuous or interrupted dark brown line and black spots.
- **Stage 3**: Present a few conspicuous or light rostral blotch. Creamy brown, orange and/or yellow-brown background coloration. Ocelli lost their continuous dark brown edges becoming as terminal ocelli, which are bean-like in form with discontinuous edges enclosing dense aggregations of black speckles.

Coloration pattern characteristics of early stages and adults of the Lesser electric ray exhibit drastic changes from a simplistic blotch-based pattern to a complex speckled formation (Fig. 3). The pattern observed in large individuals of *N. bancroftii* differs from those of *N. brasiliensis* by having a dorsal pattern consisting of ocelli, these ocelli have discontinuous edges which enclose dense aggregations of black speckles (de Carvalho, 1999). Conversely, *N. brasiliensis* has irregular stripes without black spots and not-well defined edge margins. On the other hand, and despite that sexual dimorphism (based on myxopterygia and dentition criteria) it's known to occur in *Narcine* species (de Carvalho, 1999; Rolim *et al.*, 2015), our results support the idea that coloration patterns between males and females are not different.

In principle, these changes take place to benefit the species, such advantages may be associated with the environment or an ecological role (Booth, 1990), as well as to phenotypic expression of genes (Cortesi *et al.*, 2016). In the case of *N. bancroftii*, for example, the early coloration pattern may be related to the characteristic of the habitat which inhabits during this time. In fact, nursery grounds for rays of the *Narcine* genus tend to occur in muddy- turbid waters, while adults inhabit coral, rocky or sandy bottoms (Jahnke, 2010; Yokota & Lessa, 2006). From this perspective, it is possible that several morphos of species are —as in this case— overlooked in the literature. This issue remains poorly studied, but our intuitive hypothesis does not seem totally wrong. Therefore, more research is needed on these ideas.

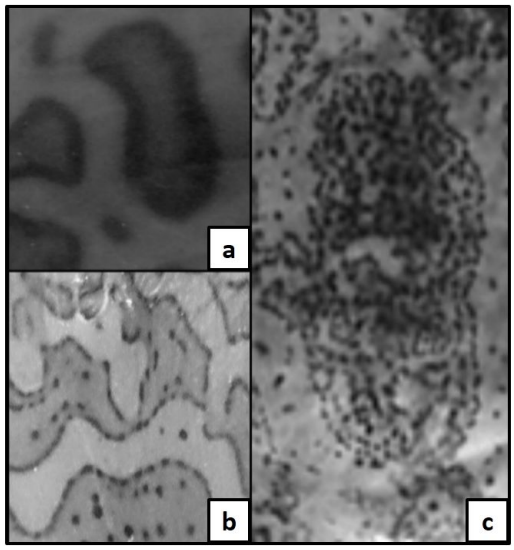

FIGURE 3 Detail of blotch in first stage (a), primary ocelli stripe alike present in second stage (b) and terminal ocelli bean alike in third stage (c).

The information provided here is important for accurate identification of species in the future, being a reference that *N. bancroftii* changes as it grows (Rainer, 2020). Something that could be happening with other species of the genus. In conclusion, regardless of the importance of ontogenetic changes in a species, detailed studies investigating the triggers and implications of the transition from one state to another remain scarce. Here, it is detailed the initial, transition, and final coloration pattern of the Lesser electric ray. Evidencing the changes that happen during the different stages of life of these animals may provide the keys to understand the different coloration pattern arrangements and their diversification process. Therefore, future cellular and physiological research are needed to explore such ideas.

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CONFLICTS OF INTEREST

The author declare no conflicts of interest.

RESUMEN

Notas sobre los cambios ontogénicos en el patrón de coloración de *Narcine bancroftii* (Griffith & Smith 1834) (Torpediniformes: Narcinidae). Los peces del género *Narcine*, comúnmente conocidos como rayas eléctricas, se caracterizan por presentar un cuerpo deprimido dorsoventralmente, pedúnculo caudal grueso, aletas pectorales fusionadas a la cabeza y órganos eléctricos en la musculatura dorsal. Dos especies, *N. bancroftii* y *N. brasiliensis*, se distribuyen en la costa del Atlántico occidental y Mar Caribe. En este trabajo se describen los cambios ontogenéticos en el patrón de coloración de *N. bancroftii*. Los 41 ejemplares examinados proceden de la pesca artesanal de La Ensenada de la Guardia, la colección ictiológica de la Universidad de Oriente (Campus la

Isla de Margarita) y de literatura. La coloración dorsal varía de acuerdo con la talla del ejemplar. Los recién nacidos poseen un patrón que consiste en manchas, mientras que ejemplares grandes (>19 cm LT), exhiben un complejo patrón de motas u ocelos terminales. Estos resultados proporcionan una contribución novedosa e importante a un poco estudiado grupo de peces.

Palabras clave: Elasmobranchii, raya eléctrica del Caribe, cambios ontogénicos, identificación fotográfica.

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