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Estimation of body size using morphometric relationships of head bones, pectoral fin bones and bony precaudal distance in *Raneya brasiliensis* (Kaup, 1856) (Pisces, Ophidiiformes, Ophidiidae) in Patagonian waters

Estimación de la talla utilizando relaciones morfométricas de huesos del cráneo, de la cintura escapular y de la distancia precaudal ósea en *Raneya brasiliensis* (Kaup, 1856) (Pisces, Ophidiiformes, Ophidiidae) de aguas patagónicas

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Resumen.- El ofídido *Raneya brasiliensis* (Kaup, 1856) es una especie clave en las cadenas tróficas de alto nivel del Atlántico sudoccidental. Se calcularon ecuaciones de regresión predictivas, para estimar la talla a partir del tamaño de huesos del cráneo, del cráneo, la cintura escapular y de la distancia precaudal ósea. La transformación logarítmica de las medidas originales dio los mejores ajustes para las estimaciones.

Palabras clave: Piscivoría, mamíferos marinos, aves marinas, patagonia Argentina

Abstract.-The ophidiid fish *Raneya brasiliensis* (Kaup, 1856), is a key link in the Southwestern Patagonian higher level food web. Predictive regression equations were calculated to estimate total length in this species, using head length, various head bone lengths, cleithrum length and bony precaudal length as the independent variables. Log-transformed data gave the best fits in the equations obtained.

Key words: Piscivory, marine mammals, marine birds, Argentine Patagonia

Introduction

Raneya brasiliensis is a widely distributed ophidiid fish, living in coastal waters, at depths of 40 to 150 m, in the southwestern Atlantic, from Southern Brazil, about 23°S (Carvalho Filho 1999) to South Central Patagonia, around 46°S. Although commercially unimportant, *R. brasiliensis* constitutes a key link in the food web of the South Atlantic Ocean. As an important prey item in the diet of marine mammals, marine birds and fishes, it was found as food of the southern sea lion *Otaria flavescens* (Shaw, 1800) by Koen Alonso *et al.* (2000), of the imperial cormorant *Phalacrocorax atriceps* King, 1828 by Malacalza *et al.* (1994) and Gosztonyi & Kuba (1998), of the black–necked cormorant *Phalacrocorax magellanicus* Gmelin, 1789 by Libenson (1996). Also, *R. brasiliensis* appeared in the diet of the spiny dogfish, *Squalus acanthias* Linné, 1758 (Koen Alonso *et al.* 2002) and the skate *Dipturus chilensis* (Philippi, 1892) (Koen Alonso *et al*. 2001). Felisa Sánchez[1] reports its presence under the older name *Raneya fluminensis,* as food in a variety of elasmobranchs *Callorhinchus callorhynchus* (Linné, 1758), *Squalus acanthias, Squalus mitsukurii* Jordan & Snyder, 1903, *Atlantoraja castelnaui* (Miranda Ribeiro, 1907), *Bathyraja brachyurops* (Günther, 1880), *Dipturus flavirostris* and *Sympterygia bonapartei* (Müller & Henle, 1841), as well as in the bony fishes *Dissostichus eleginoides* (Smitt, 1898) and *Genypterus* sp.

In order to help in the assessment of the quantitative contribution of *R. brasiliensis* to the diet of marine organisms, predictive regression equations of skull length, skull and pectoral girdle bones' size, and the bony precaudal length against total length were calculated.

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Materials and methods

Sixty specimens of *Raneya brasiliensis*, 131 to 303 mm in total length, obtained between October 1980 and December 1998, by bottom trawling, in the vicinity of Isla Escondida (43°43'S; 65°20'W) off Chubut Province, Argentina, at depths of 40 to 55 m, were studied (Fig. 1). The specimens, fixed in 10% formaldehyde solution and preserved in 70 ethanol, were dissected, exposing the vertebral column from the left side, and excising one of the hemichrania (suspensorium, and branchial basket) and the pectoral girdles. *In situ* staining with alizarin red solution was performed, in order to facilitate the dissections, and preserving the integrity of the bones.

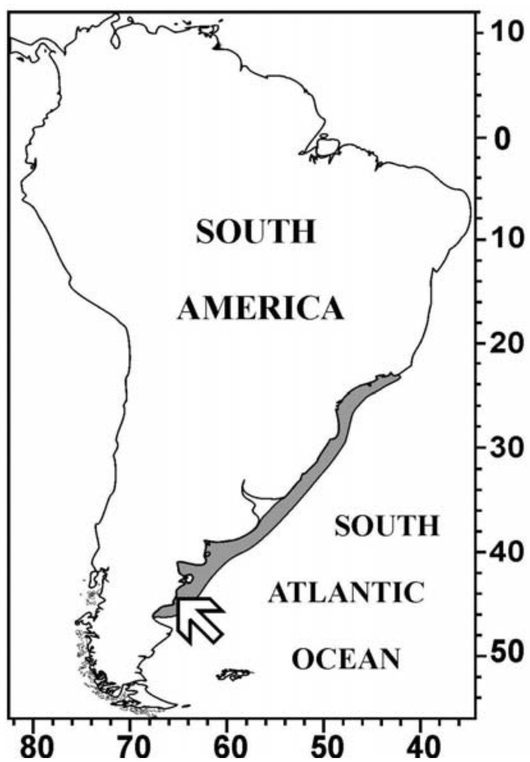

Figure 1

Distribution of *Raneya brasiliensis* in the Southwestern Atlantic Ocean (in black). The arrow indicates the sampling area

Distribución de *Raneya brasiliensis* en el Océano Atlántico Sudoccidental indicada en negro. La flecha indica la zona de recolección de los ejemplares estudiados

The bones selected for measurements were those usually appearing in stomach contents of piscivorous organisms and are diagnostic for the species, according to Gosztonyi & Kuba (1996). Measurements were taken with electronic calipers to the nearest 0.l mm according to the schemes delineated in Figs. 2 and 3 respectively. The abbreviations used are the following: VomCaud: vomero–caudal distance or bony precaudal distance, taken from the tip of the vomer to the anterior end of the first caudal vertebra (the first vertebra with a closed haemal arch); Skull: from the tip of vomer to the end of the basioccipital. Op: length of opercular. MxL: length of the maxillary; PmxL: horizontal length of the premaxillary; PmxH: height of the ascending process of the premaxillary; HyomH height of the hyomandibular; HyomL length of hyomandibular; PreopL: length of preopercular; CleiL: length of cleithrum; DenL: length of the dentary.

All measurements are standard ones except the “vomero caudal distance” (VomCaud), which we consider useful one, when the ingested fishes are partly digested, and the premaxillaries are lacking making them unsuited for total length measurement.

The normality of all the variables was proven with the Kolmogorov-Smirnov-test (as used by Watkinson & Gillis 2003)

The predictive regression equations were calculated using STATISTICA 6.0 with and without logarithmic transformations.

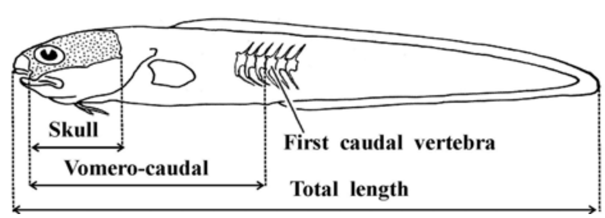

Figure 2

Schematic view of the general measurements registered

Esquema de las mediciones generales registradas

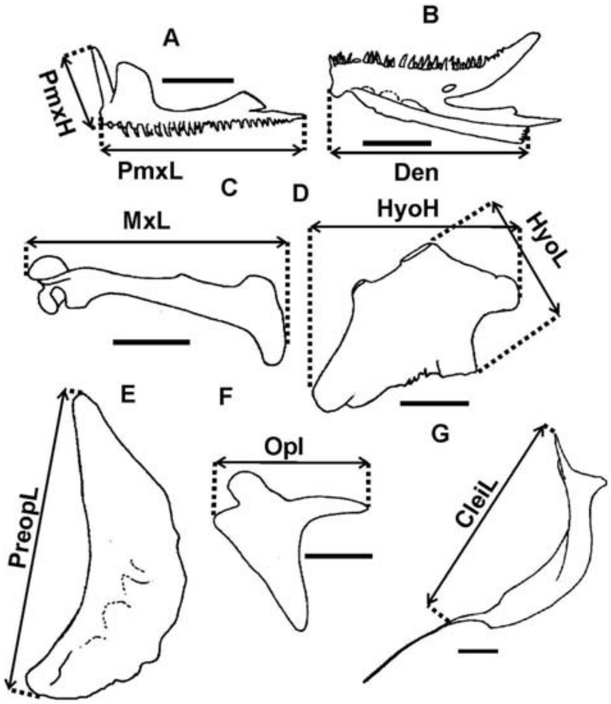

Figure 3

Schematic view of measurements on bones. A: premaxillary; B: dentary; C: maxillary; D: hyomandibular; E: preopercular; F: opercular; G: cleithrum. Scale bar= 5 mm. Abbreviations in text

Esquema de las mediciones de los huesos. A: premaxillar; B: dentario; C: maxilar; D: hiomandibular; E: preopercular; F: opercular; G: cleitro. Barra de escalar= 5 mm.
Abreviaturas en el texto

Results

Regressions of log-transformed data fitted well in most cases and the corresponding equations obtained are listed in Table 1.

Table 1

Parameters of log-transformed data predictive regression equations of skull bones, pectoral girdle bones and vomero-caudal distance against total length in *Raneya brasiliensis*. (Log Y= a+ b(Log X))

Parámetros de las ecuaciones de regresiones predictivas de datos log-transformados de medidas del cráneo, de huesos del cráneo, de huesos de la cintura escapular y de la distancia vomero-caudal *vs* la longitud total en *Raneya brasiliensis*. (Log Y= a+ b(Log X))

Variable	n	r^2	P	a	b
Log VomCaud	44	0.9890	< 0.001	0.4253 ± 0.031	0.9724 ± 0.016
Log Skull	57	0.9700	< 0.001	0.8477 ± 0.035	0.9808 ± 0.023
Log Op	52	0.9627	< 0.001	1.1405 ± 0.027	1.1401 ± 0.025
Log MxL	58	0.9496	< 0.001	1.3215 ± 0.032	1.1366 ± 0.030
Log PmxL	54	0.9559	< 0.001	1.4529 ± 0.026	1.2181 ± 0.029
Log PmxH	60	0.9493	< 0.001	1.7689 ± 0.017	1.2128 ± 0.030
Log HyomH	59	0.9493	< 0.001	1.4972 ± 0.026	1.1680 ± 0.030
Log HyomL	58	0.8781	< 0.001	1.5480 ± 0.040	1.0827 ± 0.047
Log PreopL	59	0.8979	< 0.001	1.2703 ± 0.048	1.0206 ± 0.043
Log CleiL	59	0.9492	< 0.001	1.1670 ± 0.036	1.1280 ± 0.030
Log DenL	60	0.9715	< 0.001	1.3209 ± 0.023	1.1081 ± 0.022

Discussion

The knowledge of individual lengths and weights of prey items in gut contents of piscivores is of great importance, not only to estimate the ingested biomass, but also to establish the length groups the predators are preying upon.

A direct way to quantify the ingested food is weighing the specimens contained in the stomachs of predators. This procedure can be rarely applied, due to the state of the ingested specimens, usually more or less digested, and unsuited for proper measurement. Another, and often–used procedure, is back calculating the length of the prey item using regression equations of body length (or body weight) *vs* otolith lengths. The latter technique has its drawbacks since otoliths are not only eroded by digestive fluids, negatively biasing the estimated lengths or weights, but also show great ontogenetic variations (see e. g. North *et al.* 1984) making both identifications and measurements uncertain. The limitations of using otoliths in quantitative feeding studies have been thoroughly analyzed by Jobling & Breiby (1986).

An alternative method is to use the dimensions (length or height) of skeletal elements of the preys as independent variables in the length or mass estimations. For examples, see Armstrong & Stewart (1996), Hansel *et al.* (1988) and Scharf *et al.* (1997). This procedure has advantages over the one using otoliths since: a) bones are often more reliable than otoliths in order to identify the fish they come from, especially when the otoliths are worn by digestion or when they come from juvenile specimens and, b) the errors in the length estimations are smaller, due to the larger size and hence the smaller relative error of the independent variable.

With these thoughts in mind, we decided to explore the possibility of using skull and pectoral girdle bones and specific body part measurements, to back calculate the body length of *R. brasiliensis*. As can be seen in Table 1, the regression equations obtained seem to be statistically appropriate for use. In combination with published length/mass relationships e.g. Muto *et al.* (2000), they can be used to estimate both the length and the mass of the ingested fishes.

Since most of the predators of *R. brasiliensis*, and, very specially, the marine mammals and birds, belong to the highest trophic levels, its relevance in the food chains of Patagonian waters is obvious, and we hope that the results of this research will help to better understand and eventually manage the whole ecosystem.

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