Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9283
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v36i3.21117

# Lapillus otoliths of the *Cathorops spixii* (Spix & Agassiz, 1829) and *Genidens genidens* (Cuvier, 1829) (Actinopterygii - Ariidae)

**Barbara Maichak de Carvalho[1*], Marco Fábio Maia Corrêa[2] and Alejandra Volpedo[3]**

*Programa de Pós-graduação de Sistema Costeiro e Oceânicos, Universidade Federal do Paraná, Av. Beira-Mar, s/n, Cx. postal 61, 83255-976, Bal. Pontal do Sul, Pontal do Paraná, Paraná, Brazil. [2]Laboratório de Ictiologia, Universidade Federal do Paraná, Pontal do Paraná, Paraná, Brazil. [3]Instituto de Investigaciones en Producción Animal, Centro de Estudios Transdisciplinarios del Agua, Universidad de Buenos Aires, Buenos Aires, Argentina.*Author for correspondence. E-mail: bmaicarvalho@gmail.com*

**ABSTRACT.** The aim of this study was to analyze the morphology and morphometry of lapillus otoliths of the catfishes *Cathorops spixii* and *Genidens genidens* from the coast of Paraná State, Brazil. We used 147 lapillus from *C. spixii* and 96 from *G. genidens*, of different size classes. Otoliths were characterized with smooth margins for both species but with different shapes: oblong for *C. spixii* and oval for *G. genidens*. The morphological differentiation between the two species is in the anterior region: rounded for *C. spixii* and pointed for *G. genidens*. The t-test results for otolith measurements were: length ($t_{value}$ = -2.88; p = 0.0042), height ($t_{value}$ = -6.87; p < 0.000001), anterior angle ($t_{value}$= 9.84; p = 0.000001) and posterior angle ($t_{value}$ =0.41; p = 0.68). The results show that lapillus otoliths of *C. spixii* and *G. genidens* differ in the shape of the anterior region and in the anterior angle, which facilitate the differentiation between the two species in trophic ecology studies on ichthyophagous.

**Keywords:** estuary, morphology, morphometry, catfish.

## Otólito lapillus de *Cathorops spixii* (Spix & Agassiz, 1829) e *Genidens genidens* (Cuvier, 1829) (Actinopterygii - Ariidae).

**RESUMO.** O objetivo do presente estudo foi analisar a morfologia e morfometria dos otólitos lapillus dos bagres *Cathorops spixii* e *Genidens genidens* do litoral paranaense. Foram utilizados de 147 lapillus de *C. spixii* e 96 de *G. genidens* em distintas classes de tamanho dos peixes. Os otólitos de ambas as espécies foram caracterizados com margens lisas, diferindo no formato do otólito em oblongo para *C. spixii* e oval para o *G. genidens*. A diferenciação morfológica entre ambas as espécies é na região anterior sendo: arredondada para o *C. spixii* e pontiaguda para o *G. genidens*. Foi realizado um teste t entre as medidas do otólito das espécies sendo: comprimento do otólito ($t_{valor}$ = -2,88; p = 0,0042), maior altura do otólito ($t_{valor}$ = -6,87; p < 0,00001), ângulo anterior ($t_{valor}$= 9,84; p < 0,000001) e ângulo posterior ($t_{valor}$ =0,41; p = 0,68). Os resultados obtidos demonstram que os otólitos lapillus do *C. spixii* e do *G. genidens* diferem no formato da região anterior e no ângulo anterior facilitando a diferenciação entre as duas espécies em estudos de ecologia trófica de ictiófagos.

**Palavra-chave:** estuário, morfologia, morfometria, bagres.

## Introduction

Otoliths are endogenous calcareous structures usually made up of aragonite, and located in the inner ear of bony fish (POPPER et al., 2005). Bony fish have three otolith pairs, sagitta, lapillus and asteriscus, named according to their shape and position relative to the inner ear. They are important structures used to estimate the age of fish by counting the rings (CORREA; VIANNA, 1992; FRANCIS; CAMPANA, 2004; NIELSEN; JOHNSON, 1983). In addition, data about the environmental parameters on which fish developed are made available through carbonate composition analysis (ELSDON et al., 2008; GHOSH et al., 2007). Otoliths are also used in studies on fish stock determination (AVIGLIANO; VOLPEDO, 2013; AVIGLIANO et al., 2014; VOLPEDO; FERNANDEZ-CIRELLI, 2006).

Although the shape of otoliths changes over ontogenetic development of each species (VOLPEDO; ECHEVERRÍA, 1999), their intraspecific pattern makes it an important taxonomic tool (POPPER et al., 2005). Thus, they are useful in trophic ecology studies of ichthyophagous animals (CORREA; VIANNA, 1992; DI BENEDITTO; LIMA, 2003). Studies of biometric relationships between otolith length and fish size (length and weight) help estimate the

size of prey for ichthyophagous animals, giving greater representation to studies on marine trophic ecology (DI BENEDITTO; LIMA, 2003).

Several studies on the morphology and morphometry of the sagitta, lapillus and asteriscus otoliths have already been made (VOLPEDO; ECHEVERRÍA, 2000; BAREMORE; BETHEA 2006; CAMPANA, 2004; FURLANI et al., 2007; NAVEDA, 2001; SMALE et al., 1995; TUSET et al., 2008;). In Brazil, studies focused on the description of the sagitta otolith being: Sciaenidae (CORRÊA; VIANA, 1992), Carangidae (ABILHOA; CORREA, 1992), Gerreidae (LEMOS et al., 1992), Engraulidae and Clupeidae (LEMOS et al., 1995). The morphometry description of *Sardinella brasiliensis* was held by Rossi-Wongtschowski et al. (1982). Braga and Goiten (1985) described the morphology of *Prionontus punctatus*, the description were made by some species of Perciformes Siliprandi et al. (2014) and Di Beneditto and Lima (2003), for species *Bembrops heterurus* by Vaz-dos-Santos et al. (2007) and the description of the otolith *Coryphaena hippurus* by Duarte et al. (2008).

Studies on sagittal otolith morphometry are more numerous than descriptive studies of lapillus and asteriscus otoliths (ASSIS, 2003; ASSIS, 2005). In Siluriformes, lapillus otoliths are larger than the other pairs, differentiating them from other teleosts (FUCHS; VOLPEDO, 2009; SMALE et al., 1995). The present study aimed to describe the morphology and morphometry of the lapillus otolith of *Cathorops spixii* and *Genidens genidens* (both belonging to the family Ariidae and very abundant on the coast of Paraná State, Brazil) (BARLETTA et al., 2008; FÁVARO et al., 2005), in order to facilitate the identification of these species and the estimation of the size of fish in stomach contents of ichthyophagous animals.

## Material and methods

All of the specimens were caught (fyke net, gillnets, beach seines) in estuarine and coastal regions of the Paraná state (25°20'-25°50'S; 48°50'-48°10'W) in 2003-2004. After capture, the specimens were identified according to Menezes and Figueiredo (2000) and measured [total length (TL) (cm); weight (g)]. Lapillus otoliths were removed from the palate region through an incision in the optic capsule, washed, dried and stored in bags identified with the catalog number of each specimen (SECOR et al., 1992), deposited in the Ichthyological Collection of the Universidade Federal do Paraná. Shape, type of margin, and type of sulcus acusticus of the otolith of both species were described according to Smale et al. (1995). Otoliths were analyzed whole.

The following measurements were taken with the aid of an ocular micrometer coupled to a stereomicroscope: length of the otolith, characterized by the greatest horizontal measurement between the posterior and anterior margin of the otolith (LO), the greatest height of the otolith, measured between the dorsal and ventral margins (LHO), and the angles of the anterior and posterior regions obtained through images in the software Corel Draw X3 (COREL CORPORATION, 2005) (Figure 1).

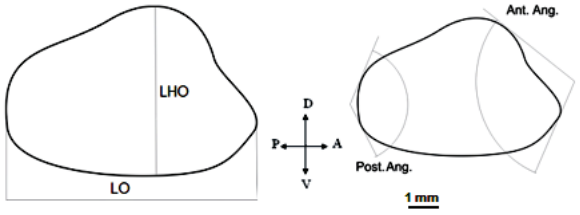


**Figure 1**. Schematic drawing of the morphological structures analyzed in the left lapillus otolith of *C. spixii* and *G. genidens*. Structures: length of the otolith (LO), greatest height of the otolith (LHO), anterior (Ant. Ang.) and posterior angles (Post. Ang.) and dorsal (D), ventral (V), posterior (P) and anterior (A) position relative to the fish.

Measurements of fish and otoliths were related through regression analysis and the models were estimated through the linear least-squares method (ZAR, 2009). The linear and exponential models were estimated between the total length (TL) and weight of fish, with the length of the otolith (LO), respectively. The t-test and discriminant analysis were used to detect significant differences between the measurements of otoliths of both species.

## Results and discussion

We used 147 lapillus of *C. spixii* and 96 of *G. genidens* with mean total length and mean total weight and standard deviation of 14.29 (± 3.27); 13.55 (±24.66) cm and 19.04 (±7.85); 73.22 (±98.99) g respectively. The frequency distribution of the total length of both species analyzed is shown in Figure 2.

In Table 1 were show the means and standard deviations of the measurements of otoliths.

The lapillus of both species was characterized by smooth margins and absent sulcus acusticus, oblong shaped for *C. spixii* and oval shaped for *G. genidens* (Figure 3). The otolith of *C. spixii* did not present sulcus acusticus, while *G. genidens* had an

indistinctive sulcus acusticus compared to other sulcus acusticus of lapillus described in the literature (FUCHS; VOLPEDO, 2009). The lapillus otolith of freshwater Siluriformes described by Fuchs and Volpedo (2009) demonstrates a diversity of shape, presence and absence of excisura and variation in the type of sulcus acusticus. In the description of some marine species lapillus family Ariidae (SMALE et al., 1995) also found a variation in the otolith shape, thickness, shape of the margins and excisura and sulcus acusticus absent. Volpedo and Echeverría (2000) conducted the description of the lapillus for *Netuma barbus* (Lacépede, 1803), which also showed sulcus acusticus and excisura absent. From the results of this and other studies, it can be assumed that the absence of sulcus acusticus and excisura in the lapillus otolith of species of the family Ariidae is a constant characteristic, different from other families of Siluriformes studied by Fuchs and Volpedo (2009).

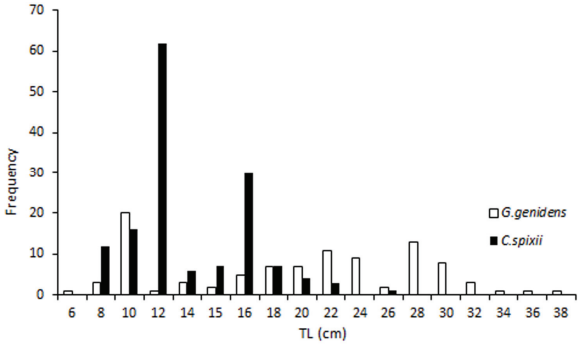


**Figure 2**. Frequency distribution of the total length of *Genidens genidens* and *Cathorops spixii*.

**Table 1**. Means and standard deviations of length of the otolith (LO), greatest height of the otolith (LHO), anterior and posterior angles of otoliths and fish total length and otolith length ratio (TL/LO).

| *Morphometric characteristics* | *C. spixii* | *G. genidens* |
|---|---|---|
| LO (cm) | 0.73 (± 0.13) | 0.80 (± 0.25) |
| LHO (cm) | 0.49 (± 0.09) | 0.62 (± 0.20) |
| Anterior angle | 134.77° (±15.70°) | 109.82° (±14.20°) |
| Posterior angle | 113.00° (±18.42°) | 109.07° (±13.33°) |
| TL/LO | 19.34 (±1.48) | 22.83 (± 3.06) |

A very clear differentiation between species is in the anterior region, where *C. spixii* presents a well-rounded protuberance and *G. genidens* presents an acute, pointed protuberance (Figure 3). All morphological characteristics described above continue during ontogenetic development in both species. Otoliths from fish between 6 and 37 cm total length (TL) were analyzed. The presence of these fish species in the stomach contents of ichthyophagous animals can be distinguished considering these characteristics.

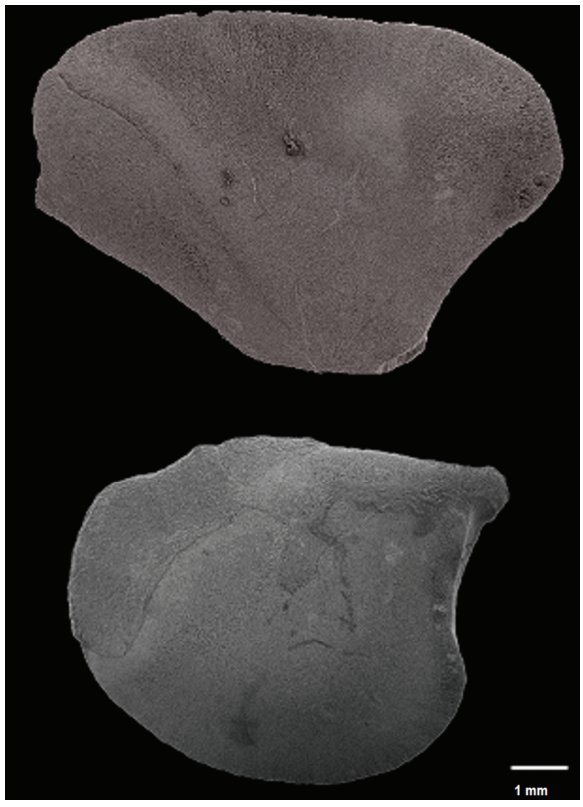


**Figure 3.** Images of lapillus of *Cathropos spixii* (top) and *Genidens geniden* (bottom). Total length (TL) of both specimens: 19 cm.

The t-test that run with values of measurements of *C. spixii* and *G. genidens* (Table 2) evidenced a difference between the measurements of the structures: LO, LHO, the anterior angle, and TL/LO, which facilitates the differentiation of the species in the stomach contents of ichthyophagous. The significant differences between these measurements may be the result of different growth rates between both species *G. genidens* is larger specimens (FROESE; PAULY, 2014).

**Table 2**. Results of the t-test with the measurements of the structures of the species: length of the otolith (LO), greatest height of the otolith (LHO), anterior and posterior angles of the otolith and fish total length and otolith length ratio (TL/LO). Significant value * < 0.05.

| *C. spixii/ G. genidens* | *t value* | *p* |
|---|---|---|
| LO (cm) | 2.92 | 0.0038* |
| LHO (cm) | 6.91 | <0.000001** |
| Anterior Angle | -9.84 | <0.000001** |
| Posterior Angle | -0.41 | 0.6812 |
| TL/LO | -11.83 | <0.000001** |

A discriminant analysis to identify significant differences as for the measured structures of both species indicated that the posterior angle is the only structure that showed no significant difference between the two species, and thus cannot be considered a structure for differentiation of otoliths (Table 3).

**Table 3**. Discriminant Analysis for the measurements of the structures of the species. Significant value * < 0.05.

| *C. spixii/ G. genidens* | *F value* | *p* |
|---|---|---|
| LO (cm) | 14.01 | 0.00028* |
| LHO (cm) | 15.42 | 0.00001* |
| Angles Anterior | 50.75 | <0.000001* |
| Angles Posterior | 3.55 | 0.06043 |
| TL/LO | 5.69 | 0.01779* |

Based on the measurements, four regression analyses were run, which enabled to determine the length and weight of prey (fish). In relation to *C. spixii*, the first equation is between TL and LO: TL = -3.93 + 24.84* LO ($p < 0.05$; $r = 0.98$ and $r^2 = 0.96$). The second is between fish weight and LO: Weight = $107*LO^{5.10}$ ($p < 0.05$; $r = 0.98$ and $r^2 = 0.96$). For *G. genidens*, the first equation is: TL = -5.68 + 30.71* LO ($p < 0.05$; $r = 0.98$ and $r^2 = 0.96$). The second is Weight = $147*LO^{3.83}$ ($p < 0.05$; $r = 0.99$ and $r^2 = 0.98$).

The lack of studies on the morphometry of the lapillus otolith of Ariidae impedes comparisons between regressions obtained by other authors for *G. genidens*. Considering *C. spixii*, a comparison to Di Beneditto and Lima (2003) is impossible, due to methodological differences, in which the regression obtained by these authors were carried out using the standard length and the otolith length, as well as the equation exponentially fitted (different from the present study).

## Conclusion

*C. spixii* and *G. genidens* have oblong and oval otoliths, respectively, with smooth margins and an absent sulcus acusticus in *C. spixii*, and less marked in *G. geniden*, not coming to form a groove. The shape of the anterior region and the anterior angle of the otolith are characteristics that facilitate the differentiation between *C. spixii* and *G. genidens*.

## Acknowledgements

The authors thank to CONICET (PIP112-20120100543CO), UBA(UBACYT 20620110100007), ANPCYT (PICT 2010-1372), Centro de Microscopia Eletrônica (UFPR) for the micrographs taken in this study; to the Fish Biology Laboratory of the Centro de Estudos do Mar for providing an ocular lens for micrometry.

## References

ABILHOA, V.; CORREA, M. F. M. Catálogos dos otólitos sagitta de Carangidae (Ostheichthys - Perciformes) do litoral do estado do Paraná, Brasil. **Nerítica**, v. 7, n. 1, p. 119-131, 1992.

ASSIS, C. A. The lagenar otoliths of teleosts: their morphology and its application in species identification, phylogeny and systematics. **Journal of Fish Biology**, v. 62, n. 6, p. 1268-1295, 2003.

ASSIS, C. A. The utricular otoliths, lapilli, of teleosts: their morphology and relevance for species identification and systematics studies. **Scientia Marina**, v. 69, n. 2, p. 259-273, 2005.

AVIGLIANO, E.; VOLPEDO, A. V. Use of otolith strontium: calcium ratio as indicator of seasonal displacements of the silverside (*Odontesthes bonariensis*) in a freshwater-marine environment. **Marine and Freshwater Research**, v. 64, n. 8, p. 1-6, 2013.

AVIGLIANO, E.; MARTINEZ, C. F. R.; VOLPEDO, A. V. Combined use of otolith microchemistry and morphometry as indicators of the habitat of the silverside (*Odontesthes bonariensis*) in a freshwater–estuarine environment. **Fisheries Research**, v. 149, n. 1, p. 55-60, 2014.

BAREMORE, I. E.; BETHEA, D. M. **A guide to otolith from fishes of the Gulf of the Mexico and Atlantic Ocean**. Panama City Laboratory National Marine Fisheries Service. Available from: <http://www.sefscpanamalab.noaa.gov>. Access on: June 22 , 2006.

BARLETTA, M.; SAINT-PAUL, U.; AMARAL, C. S.; CORRÊA, M. F. M.; GUEBERT, F.; DANTAS, D. V.; LORENZI, L. Factors affecting seasonal variations in fish assemblages at an ecocline in a tropical–subtropical mangrove fringed estuary. **Journal of Fish Biology**, v. 73, n. 6, p. 1314-1336, 2008.

BRAGA, F. M. S.; GOITEN, R. Morphologic study of the *sagitta* of the gumard (*Prionotus punctatus*) from Anchieta Island (latitud 23 33'S, longitude 45 05'W). Ubatuba, northem coast of São Paulo State, Brazil. **Naturalia**, v. 10, n. 1, p. 65-74, 1985.

CAMPANA, S. E. **Photographic atlas of fish otoliths of the northwest Atlantic Ocean**. Canadian Special Publication of Fisheries and Aquatic Sciences. Ottawa: NRC Research Press, 2004.

CORRÊA, M. F. M.; VIANA, M. S. Catálogo dos otólitos sagitta de Scianidae (Ostheichthys - Perciformes) do litoral do estado do Paraná, Brasil. **Nerítica**, v. 7, n. 3, p. 13-41, 1992.

DI BENEDITTO, A. P. M.; LIMA, N. R. W. Biometria de teleósteos da costa norte do estado do Rio de Janeiro para estudos sobre piscivoria. **Biotemas**, v. 16, n. 1, p. 135-144, 2003.

DUARTE-NETO, P.; LESSA, R.; STOSIC, B.; MORIZE, E. The use of sagittal otoliths in discriminating stocks of common dolphinfish (*Coryphaena hippurus*) of northeastern Brazil using multishape descriptors. **Journal of Marine Science**, v. 65, n. 7, p. 1144-1152, 2008.

ELSDON, T. S.; WELLS, B. K.; CAMPANA, S. E.; GILLANDERS, B. M.; JONES, C. M.; LIMBURG, K. E.; SECOR, D. H.; THORROLD, S. R.; WALTHER, B. D. Otolith chemistry to describe movements and life-history parameters of fishes: hypotheses, assumptions, limitations and inferences. **Oceanography and Marine Biology: An Anual Review**, v. 46, n. 1, p. 297-330, 2008.

FÁVARO, L. F.; FREHSE, F. A.; OLIVEIRA, R. O.; SCHWARZ, R. Reprodução do bagre amarelo *Cathorops spixii* (Agassiz) (Siluriformes, Ariidae) da Baía de Pinheiros região estuarina do litoral do Paraná, Brasil. **Revista Brasileira de Zoologia**, v. 22 n. 4, p. 1022- 1029, 2005.

FRANCIS, R. I. C.; CAMPANA, S. E. Inferring age from otolith measurements: a review and a new approach. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 61, n. 7, p. 1269-1284, 2004.

FROESE, R.; PAULY, D. **FishBase**. World Wide Web electronic publication. Available from: <http://www.fishbase.org>. Access on: Jan. 25, 2014.

FUCHS, D. V.; VOLPEDO, A. V. Morfología de Lapillus de Siluriformes Parano platenses. **Biología Acuática**, v. 26, n. 1, p. 97-108, 2009.

FURLANI, D.; GALES, R.; PEMBERTON, D. **Otoliths of common Australian temperate fish**: a photographic guide. Collingwood: CSIRO Publishing, 2007.

GHOSH, P.; EILER, J.; CAMPANA, S. E.; FEENEY, R. F. Calibration of the carbonate 'clumped isotope' paleothermometer for otoliths. **Geochimica at Cosmochimica Acta**, v. 71, n. 11, p. 2736-2744, 2007.

LEMOS, P. H. B.; CORRÊA, M. F. M.; ABILHOA, V. Catálogo dos otólitos sagitta de Gerreidae (Ostheichthys - Perciformes) do litoral do estado do Paraná, Brasil. **Neritica**, v. 7, n. 2, p. 109-117, 1992.

LEMOS, P. H. B.; CORRÊA, M. F. M.; PINHEIRO, P. C. Catálogo dos otólitos sagitta de Engraulidae (Ostheichthys - Clupeiiformes) do litoral do estado do Paraná, Brasil. **Arquivos de Biologia e Tecnologia**, v. 38, n. 3, p. 731-745, 1995.

MENEZES, N. A.; FIGUEIREDO, J. L. **Manual de peixe marinhos do sudeste do Brasil Teleostei II**. São Paulo: Museu de Zoologia, Universidade de São Paulo, 2000.

NAVEDA, I .G. G. Patrones morfológicos del otólito sagitta de algunos peces ósseos del mar peruano. **Boletin del Instituto del Mar del Peru**, v. 20, n. 1-2, p. 1-83, 2001.

NIELSEN, L. A.; JOHNSON, D. L. Fisheries techniques. **American Fisheries Society**, p. 301-324, 1983.

POPPER, A. N.; RAMCHARITAR, J.; CAMPANA, S. E. Why otoliths? Insights from inner ear physiology and fisheries biology. **Marine and Freshwater Research**, v. 56, n. 5, p. 497-504, 2005.

ROSSI-WONGTSCHOWSKI, C. L. D. B.; VAZZOLER, A. E. A. M.; BRAGA, F. M. S. Estudos sobre a estrutura, ciclo de vida e comportamento de *Sardinella brasiliensis* (Steindachner, 1879), na área entre 22°S e 28°S, Brasil: Morfologia dos otólitos. **Boletim do Instituto Oceanográfico**, v. 2, n. 31, p. 57-76, 1982.

SECOR, D. H.; DEAN, J. M.; LABAN, E. H. Otolith removal and preparation for microstructural examination, p. 19-57. In: Stevenson DK, Campana SE. Otolith microstructure examination and analysis. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 117, n. 1, p. 1-84, 1992.

SILIPRANDI, C. C.; ROSSI-WONGTSCHOWSKI, C. L. D. B.; BRENHA, M. R.; GONSALES, S. A. SANTIFICETUR, C.; VAZ-DOS-SANTOS, A. M. Atlas of marine bony fish otoliths (sagittae) of Southeastern-Southern Brazil part II: Perciformes (Carangidae, Sciaenidae, Scombridae and Serranidae). **Brazilian Journal of Oceanography**, v. 62, ed. special, p. 28-101, 2014.

SMALE, J. M.; WATSON, G.; HECHT, T. **Otolith atlas of southern African marine fishes**. Grahamstown: J. L. B Smith Institute of Ichthyology, 1995.

TUSET, V. M.; LOMBARTE, A.; ASSIS, C. A. Otolith atlas for the western Mediterranean, north and central eastern Atlantic. **Scientia Marina**, v. 72, n. S1, p. 7-198, 2008.

VAZ-DOS-SANTOS, A. M.; SANTOS-CRUZ, N. N.; ROSSI-WONGTSCHOWSKI, C. L. D. B. Sagitta otolith characterization of the squaretail duckbill *Bembrops heterurus* (Miranda-Ribeiro, 1903) (Teleostei: Percophidae) in the South-Southeast-region of Brazil. **Biokos**, v. 21, n. 2, p. 69-78, 2007.

VOLPEDO, A. V.; ECHEVERRÍA, D. D. Morfología de los otolitos sagittae de juveniles y adultos de *Micropogonias furnieri* (Desmarest, 1823) (Sciaenidae). **Thalassas**, v. 15, n. 1, p 19-24, 1999.

VOLPEDO, A. V.; ECHEVERRÍA, D. D. **Catálogo y claves de otolitos para la identificación de peces del Mar Argentino. 1**. Peces de importancia comercial. Buenos Aires: Editorial Dunken, 2000.

VOLPEDO, A. V.; FERNANDEZ-CIRELLI, A. Otolith chemical composition as a useful tool for sciaenid stock discrimination in the south – western Atlantic. **Scientia Marina**, v. 70, n. 2, p. 325-334, 2006.

ZAR, J. H. **Biostatistical analysis**. 4th ed. New Jersey: Prentice Hall, 2009.

*Received on June 10, 2013.*
*Accepted on March 12, 2014.*