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BRIEF COMMUNICATION

First observations on captive hatching and incubation period of the yellow-nose skate *Dipturus chilensis* (Rajiformes: Rajidae), from the South-Eastern Pacific Ocean

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Twelve egg capsules laid in captivity by three females of *Dipturus chilensis* were incubated in the laboratory. After 252 ± 9.4 days, 10 skates successfully hatched, with a mean total length, disc length, and disc width of 17.2, 7.4, and 11.4 cm, respectively. This is the first report of captive hatching of *D. chilensis* and its corresponding incubation period.

KEYWORDS
egg capsules, egg cases, growth parameters, reproductive biology, skate embryos, skate neonates

Life-history traits are useful for informing fishery managers and conservation biologists about the capacity of a stock to withstand a given exploitation scenario (Hoenig & Gruber, 1990; Montealegre-Quijano *et al.*, 2014; Pardo *et al.*, 2018). These data are especially relevant for elasmobranchs, which are known to be less resilient to increases in mortality rates and thus, more vulnerable to overfishing (Dulvy *et al.*, 2014; Kindsvater *et al.*, 2016). Such is the case of the yellow-nose skate *Dipturus chilensis* (Guichenot 1848), which was intensively exploited along the Chilean coast until the early 2000s (Licandeo *et al.*, 2006) when a drastic decrease in landings led to a ban between 2009 and 2011 in order to restore the stocks (Vargas-Caro *et al.*, 2017). Since then, fishing regulations (i.e., capture quotas, biological bans and temporal fishing closure) have been assigned on a yearly basis. This species has undergone numerous taxonomic changes (Vargas-Caro *et al.*, 2015), being transferred from the genus *Raja* Linnaeus 1758 to *Dipturus* by McEachran & Dunn (1998), and subsequently to *Zearaja* by Last & Gledhill (2007). However, the most recent taxonomic assignment was based on three characters of clasper anatomy (i.e., broadly spatulated distal lobe, small

TABLE 1 Morphometry and incubation period of each newborn of *Dituris chilensis* that hatched successfully (n = 10)

Newborn ID	Origin	DEL	DEC	IP (days)	L_T (cm)	L_D (cm)	W_D (cm)	M (g)	Sex
CCM-16	Female 1	May 9, 2010	February 3, 2011	270	16.5	6.4	10.8	24.3	F
CCM-17	Female 1	May 9, 2010	January 24, 2011	260	17.5	7.8	11.5	23.1	F
CCM-18	Female 2	May 27, 2010	February 4, 2011	253	17.5	7.9	11.3	24.1	F
CCM-19	Female 2	May 27, 2010	February 4, 2011	253	17.5	7.0	12.0	25.0	M
CCM-20	Female 2	May 30, 2010	February 2, 2011	248	17	6.7	10.6	22.7	M
CCM-22	Female 2	June 1, 2010	February 2, 2011	246	16.9	6.9	11.1	25.5	F
CCM-23	Female 2	June 1, 2010	February 2, 2011	246	16.5	6.6	11.0	24.5	F
CCM-31	Gillnets	April 12, 2011	December 8, 2011	240	17.3	8.4	12.0	NA	F
CCM-33	Female 3	January 2, 2012	August 13, 2012	224	17.7	7.4	11.1	NA	M
CCM-34	Female 3	January 2, 2012	August 23, 2012	234	18	8.5	12.3	NA	M
Range				242–270	16.5–18	6.4–8.5	10.6–12.3	22.7–25.5	
Mean ± SD				247.4 ± 13.0	17.2 ± 0.5	7.4 ± 0.8	11.4 ± 0.6	24.2 ± 1.0	

DEC = date of eclosion; DEL = Date of egg-lying; IP = incubation period; L_{T} = total length; L_D = disc length; M = mass; W_D = disc width.

shield and lack of sentinel) and have only been observed in *D. chilensis*, *D. maugeana* and *D. nasutus*. Moreover, molecular work by Naylor *et al.* (2012a, b), Vargas-Caro *et al.* (2014, 2016), and Jeong & Lee (2016) suggests that *Zearaja* constitutes a small subclade deeply nested within the genus *Dipturus*, which, if recognized, renders the later genus paraphyletic. As a consequence, from the standpoint of stability, we have used the name *D. chilensis* here.

Despite the current amount of information available on the reproduction, demography, and other life-history traits of *D. chilensis* (Bustamante *et al.*, 2012; Concha *et al.*, 2012; Licandeo & Cerna, 2007; Licandeo *et al.*, 2006; Quiroz *et al.*, 2009, 2011), parameters crucial for determining age and growth rates such as length at hatching (L_0) or age at length zero (t_0), and asymptotic length (L_∞) still need to be estimated. Moreover, a number of authors have recommended that L_0 should be obtained empirically, in order to save one degree of freedom in the process of model fitting for fisheries stock assessment (Cailliet *et al.*, 2006; Pardo *et al.*, 2013). The aim of this study is to empirically determine size at hatching and incubation period of *D. chilensis*, so as to reduce uncertainty surrounding these biological variables in potential new studies assessing growth of this species.

Two adult females of *D. chilensis* (105.3 and 100.3 cm total length; L_T) were retained from landings of a coastal gill-net fishery off central Chile (32°57′ 25.06″S; 71°33′ 0.12″ W) on May 6, 2010. In addition, two recently laid egg capsules were removed from gillnets on April 12, 2011, and a third female (no measurements made) was captured on January 2, 2012. All specimens were maintained in a 312 L tank with a continuous flow of non-filtered sea water at 13.58 ± 1.05 °C (mean ± S.D.) and a photoperiod 12 L:12D. A total of 12 egg capsules were kept for incubation. Each was labelled and kept in separate partitions of a 70 L aquarium with the same source of sea water as used to keep adult females. Respiratory fissures and the posterior apron of each egg capsule were checked daily to evaluate progress in embryo development. Within 1 day of hatching, sex was determined, and skates were measured (cm) and weighed (M, g). Measurements of neonates were performed following Ebert (2015). Additional information on the terminology and morphology of the egg capsules included in this study can be found in Concha *et al.* (2012).

Anterior and posterior respiratory fissures of the egg capsules opened at (mean ± S.D.) 136.3 ± 8.2 and 134.4 ± 9.9 days of incubation, respectively. Ten skates successfully hatched. Neonates resembled juvenile and adult specimens in both colour and shape. Individual measurements and incubation periods for each new-born are provided in Table 1. Disc length (L_D) and disc width (W_D) were 42.6 ± 3.5% and 65.9 ± 2.4% of L_T, respectively.

In South America, direct observations on incubation period and L_0 of batoids have been reported only in *Sympterygia acuta* Garman 1877, *S. bonapartii* Müller & Henle 1841, and *Zapteryx brevirostris* (Müller & Henle 1841) (Gonzalez, 2004; Jañez & Sueiro, 2007; Oddone & Vooren, 2002). A number of authors have provided estimates but not empirical data of these and other life-history traits of *D. chilensis* (Licandeo & Cerna, 2007; Licandeo *et al.*, 2006). However, the data vary greatly among studies and across geographic regions. Our empirical findings, contribute both to the evaluation of previously estimated parameters of different growth models (Licandeo *et al.*, 2006) and serve as a reference point for assessing the conservation status of *D. chilensis* and other rajid species with similar life-history traits. Given that studies of growth rates rely heavily on the accuracy of estimates of a relatively small number of variables, recording such variables under direct observation is paramount for fishery managers. The use of empirical overestimated parameters has been strongly recommended (Cailliet *et al.*, 2006) and these are available for a number of batoids (Capapé *et al.*, 2007; Cavanagh & Damon-Randall, 2009; Kang *et al.*, 2013; Luer & Gilbert, 1985; Márquez-Farías, 2007; Parent *et al.*, 2008). However, more empirical work needs to be done to determine size at hatching and incubation period for other batoid species of South America, to aid fishery managers and conservation biologists in obtaining more precise and reliable evaluations of the conservation status of elasmobranchs overall.

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