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RESEARCH NOTE

Evaluation of visible implants elastomer tags in juveniles of red octopus *Octopus maya*

Evaluación de implantes visibles de elastómero en juveniles de pulpo rojo *Octopus maya*

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Abstract.- In this work, the effects of visible implant elastomer (VIE) tags on survival and body growth rate on juvenile red octopus *Octopus maya* from the Yucatan Peninsula were tested under controlled conditions. Juveniles with an average weight of 1.14 g were not affected by VIE within 30 days, so this methodology is suggested as a useful tool to study the life cycle aspects of this important fishery species.

Key words: *Octopus maya*, tagging, visible implants elastomer

INTRODUCTION

Mexico is one of the three primary octopus producers worldwide. The Yucatan Peninsula, composed by Campeche, Yucatan, and Quintana Roo, has the largest catches, with more than 90% of the national production (SIAP 2019) and almost 100% of the catches in the Gulf of Mexico. This fishery is of great importance because it offers a lot of direct and indirect jobs in the region (DOF 2018)[1]. The two most captured species are the red octopus *Octopus maya* Voss & Solís, 1966 that accounts for 74% of the catches and the common octopus *O. vulgaris* Cuvier, 1797. Between 2,065 and 14,780 tons of red octopuses were caught in Campeche during the 1998-2019 period, whose information was obtained from the Fisheries and Aquaculture Information System (SIPESCA[2]) of the National Commission of Aquaculture and Fisheries (CONAPESCA). The fishery, which is managed by a Fisheries Management Plan (FMP) and with a catch quota during the fishing season (August to December) (DOF 2014)[3] has reached its maximum sustainable yield (MSY) (DOF 2018)[1]. Due to the socio-economic importance of this fishery, it is essential to have a broader understanding of the red octopus population dynamics to achieve sustainable management. One way to monitor the population movements, migrations, behavior, age, individual growth rate, recruitment, mortality, and abundance is the use of marks in specimens (McFarlane *et al.* 1990, Barry *et al.* 2011). A diverse number of marking techniques have been used on cephalopods, such as chemical (Ikeda *et al.* 1999, 2003), electronic (Mather *et al.* 1985, Anderson & Babcock 1999, Scheel *et al.* 2007), external (Hartwick *et al.* 1984, Robinson & Hartwick 1986, Nagasawa *et al.* 1991, Mereu *et al.* 2015) and subcutaneous plastic marks (Nagasawa *et al.* 1991, Replinger & Wood 2007). The subcutaneous implant marks, specifically the visible implant elastomer (VIE) has been used successfully in the giant octopus of the North Pacific (*Enteroctopus dofleini* Wülker, 1910) (Brewer & Norcross 2012, 2013), in the oval squid (*Sepioteuthis lessoniana* Lesson, 1830) (Ikeda *et al.* 2009) and the Caribbean reef squid (*S. sepioidea* Blainville, 1823) (Replinger & Wood 2007). VIE tag could be the solution to study the different aspects of the life history and behavior of red octopus. Previously, in the Yucatan Peninsula external marks (T-bar anchor tags and circular plastic tags) were tested on young individuals of red octopus, with no success, and for these reasons the main objective of this study is to evaluate the effect of VIE tags on survival and body growth rate of red octopus juveniles.

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[2]Sistema de Información de Pesca y Acuacultura, Comisión Nacional de Acuacultura y Pesca, Secretaría de Agricultura y Desarrollo Rural, Gobierno de México, Mazatlán. <https://sipesca.conapesca.gob.mx/>
[3]DOF. 2014. Acuerdo por el que se da a conocer el Plan de Manejo Pesquero de pulpo (*O. maya* y *O. vulgaris*) del Golfo de México y Mar Caribe. Diario Oficial de la Federación, Gobierno de México. <http://dof.gob.mx/nota_detalle.php?codigo=5338727&fecha=28/03/2014>

Materials and methods

Using the fishing gear locally known as "jimba" that consists of a rod with several lines with live crabs (*Callinectes* spp.) as bite, three ovigerous red octopus females about to spawn were collected by the octopus fleet fishery near to Champoton, Campeche (19°21'N, 90°45'W). The collected individuals were maintained in aquariums until spawning occurred, and the eggs hatched. Then, 360 juveniles were randomly selected for the experiment, each with an average weight of 1.14 g (SD= 0.35 g), to prove the effectiveness of VIE for two life history indicators (survival and body growth rate). According to previous studies for tagging experiment in cephalopods (Ikeda *et al.* 2009), each organism was anesthetized, submerging them in a seawater solution with 1% ethanol for a minute. The experimental design consisted of three treatments with 120 juveniles in each one of them. The first treatment comprised of organisms with VIE marks, made with a subcutaneous injection between the eyes (Fig. 1). The second treatment, known as the positive control, was composed of individuals with a saline solution injection, and the third treatment, known as the negative control, made of organisms without any mark or injection.

The organisms in each treatment were exposed to the same conditions of seawater for 30 days in recipients of 60 L. The abiotic parameters were taken daily with an average temperature of 26.69 °C (SD= 1.22 °C), dissolved oxygen of 7.49 mg L^{-1} (SD= 0.46 mg L^{-1}), pH of 8.08 (SD= 0.04), salinity of 35 and dissolved ammonium of 0.20 mg L^{-1}. All organisms had the same diet, using daily the *ad libitum* method with preys commonly consumed in their natural environment as amphipods, gastropods and fresh crab meat (Rosas *et al.* 2008). At the beginning, after 20 days and at 30 days (end of the experiment), the number of octopuses was counted, each individual was weighted with an analytical scale (± 0.01 g), and the VIE mark was verified by the presence of orange color between the eyes. Survival was estimated as the proportion (%) of organisms alive after 20 days and 30 days with respect to the initial number of organisms within each treatment. Body growth rate (*BGR*) was estimated according to the difference between the final (W_f) and initial weight (W_i) of each treatment during the number of days of the experiment in g day^{-1}. Previously, the normality and homogeneity of variance of *BGR* and survival data was evaluated using Shapiro-Wilk (*W*) and Levene's tests, respectively. Later, to determine if there were differences in the survival and the body growth rate between treatments, a one-way ANOVA was used, with *R*-cran 4.0.0 software.

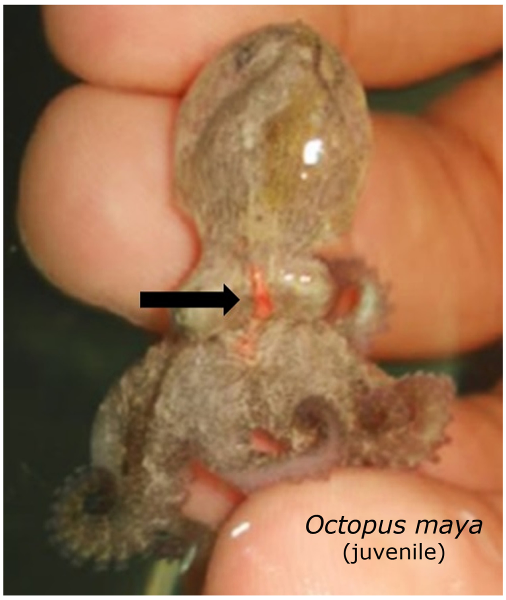

Figure 1. Visible implant elastomer tag (orange mark between eyes - black arrow) in a juvenile of *Octopus maya* / Marca de implante visible de elastómero (marca anaranjada entre los ojos - flecha negra) en un individuo juvenil de *Octopus maya*

Results and discussion

From the initial 360 red octopus juveniles, 68.6% (n= 247) and 51.1% (n= 184) survived after 20 and 30 days of experiment, respectively. At the end, the survival of negative control was 49.2%, 51.7% for positive control, and 52.5% for VIE treatment (Table 1). All organisms that survived VIE treatment had the characteristic orange mark between the eyes, which meant that they fully assimilated the elastomer. Data had a normal distribution (W= 0.93; P = 0.34), were homoscedastic (P = 0.98), and there was no evidence of significant differences between treatments (F= 0.101; P = 0.42). Therefore, there is not enough evidence to prove the effect of VIE in octopus survival. Body growth rate data had a normal distribution (W= 0.93; P = 0.42) and were homoscedastic (P = 0.19), with a mean of 0.06 g day^{-1} (grams per day) (SD= 0.03). Negative control body growth rate was 0.06 g day^{-1} (Table 1, Fig. 2), positive control had a value of 0.07 g day^{-1}, and VIE with an amount of 0.06 g day^{-1}. There was no evidence of a significant difference between treatments concerning body growth rate (F= 0.15; P = 0.87). These results suggest that the use of VIE in *O. maya* for experimental and population studies is feasible

Table 1. Body growth and survival rates by treatment for juvenile individuals of *Octopus maya* / Tasa de crecimiento corporal y supervivencia por tratamiento para los individuos juveniles de *Octopus maya*

Treatment	Body growth rate (g day^{-1})				Survival (%)
	Min	Max	Mean	SD	
VIE	0.02	0.11	0.06	0.04	52.5
Positive control	0.03	0.14	0.07	0.05	51.7
Negative control	0.05	0.06	0.06	0.01	49.2

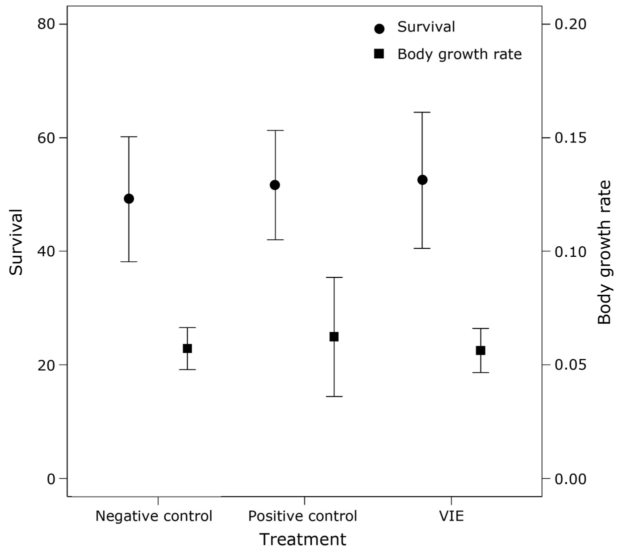

Figure 2. Survival (%) and body growth rate (g day^{-1}) by treatment for juveniles of *Octopus maya*. The black circle and square represent the mean and bars the standard deviation / Superviviencia (%) y tasa de crecimiento corporal (g día^{-1}) por tratamiento para los juveniles de *Octopus maya*. El círculo y cuadrado negro representan la media y las barras la desviación estándar

since they do not have adverse effects on survival and body growth rate, as observed at other cephalopods species (Zeeh & Wood 2009). VIE usage has successfully increased in recent years to study ecology, population dynamics, and behavior in different taxa. For example, vertebrates, invertebrates and decapods crustacean (Godin *et al.* 1996), echinoderms (Martinez *et al.* 2013), arachnids (Chapin 2011), insects (Moffatt 2013), cephalopods (Replinger & Wood 2007, Ikeda *et al.* 2009, Brewer & Norcross 2012), amphibians (Sapsford *et al.* 2015), cichlids (Schuett *et al.* 2017) and reptiles (Major *et al.* 2020). Other works have evaluated the performance of VIE on survival and growth of different species (Replinger & Wood 2007, Ikeda *et al.* 2009, Brewer & Norcross 2012), with similar results to the reported in this study. Therefore, VIE is a useful tool to study this ecological and fishing important species. Using VIE it is possible to study the productivity and other aspects of his life history.

Due to its socio-economic importance, the red octopus's fishery in the Yucatan Peninsula is one of the most regulated fisheries in the region. Among the management tools, there is an FMP (DOF 2014)[3], a Mexican Official Norm (DOF 2016)[4], and a chart of its stock status in the National Fisheries Chart (DOF 2018)[1]. These tools aim to achieve sustainability through the use of a catch quota, minimum size, temporally closed season, and specifications in the fishing gear. However, this fishery has reached its MSY (DOF 2018)[1], making it necessary to have a better understanding of its life history parameters, demography, movements, migration, recruitment, and productivity to have a better understanding of the population dynamics; this could be possible with a marking program in the wild (Fuentes *et al.* 2006). Also, and due to the worldwide commercial interest in this fishery, some institutions have developed aquaculture technology and carried out research programs to release red octopus individuals into the wild, mainly for restocking purposes; VIE marks could be a useful tool to monitor the performance and success of these kinds of programs.

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