Research Article

Reproductive parameters of the southern stingray *Dasyatis americana* in southern gulf of Mexico

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ABSTRACT. The southern stingray *Dasyatis americana* (Hildebrand & Schroeder, 1928) is the most landed elasmobranch by small-scale fleets in southern gulf of Mexico. However, little is known of its life history parameters in this region. In this study, a total of 900 specimens were collected from February 2006 to December 2008 to determine the reproductive parameters needed for population assessments by means of ecological risk assessments or demographic analysis. Results suggested that females of *D. americana* reproduce annually, with a gestation of 7-8 months. The reproductive cycle of females is asynchronous, with ovulation and parturition occurring throughout the year. Females and males matured at 764 and 517 mm disc width (DW_{50}) respectively. *D. americana* has one of the highest fecundity among dasyatids, from 2 to 7 embryos, with a sex ratio of embryos of 1:1. A linear relationship between maternal DW and fecundity was estimated, the larger females contain more embryos. The status of the population of *D. americana* is a cause of concern in the southern gulf of Mexico due to its high frequency of capture in artisanal fisheries and its apparently low biological productivity.

Keywords: *Dasyatis americana*, disc width at maturity, reproductive cycle, fecundity, gulf of Mexico.

Parámetros reproductivos de la raya látigo americana *Dasyatis americana* en el sur del golfo de México

RESUMEN. La raya látigo americana *Dasyatis americana* (Hildebrand & Schroeder, 1928), conocida como balá en México, es el elasmobranquio más capturado y desembarcado por flotas artesanales en el sur del golfo de México. Sin embargo, se conoce poco de sus parámetros de historia de vida en esta región. En este estudio, fueron analizados 900 ejemplares entre febrero 2006 y diciembre 2008 para determinar los parámetros reproductivos necesarios para evaluaciones poblacionales por medio de análisis demográficos o evaluaciones de riesgo ecológico. Los resultados sugieren que las hembras de *D. americana* se reproducen anualmente, con una gestación de 7-8 meses aproximadamente. El ciclo reproductivo de las hembras es asincrónico, con la ovulación y alumbramiento ocurriendo a lo largo de todo el año. Las hembras y los machos maduran a los 764 y 517 mm de ancho de disco (AD_{50}), respectivamente. *D. americana* tiene una de las fecundidades más altas entre los dasyatidos, de 2 a 7 embriones, y con una proporción de sexos de 1:1 en los embriones. Existe relación significativa lineal entre la longitud de las hembras y la fecundidad, las hembras más grandes contenían más embriones. El estado de la población de *D. americana* es motivo de preocupación en el sur del golfo de México debido a que es muy frecuente en las capturas de pesquerías artesanales y a que su productividad biológica es aparentemente baja.

Palabras clave: *Dasyatis americana*, longitud de madurez, ciclo reproductivo, fecundidad, golfo de México.

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INTRODUCTION

The southern stingray *Dasyatis americana* (Hildebrand & Schroeder, 1928) is distributed from New Jersey to Florida in United States, throughout the gulf of Mexico, Bahamas, and the Greater and Lesser Antilles, and bordering the northern coast of South America to southeastern Brazil (McEachran & de Carvalho, 2002). It inhabits shallow waters and feeds on bottom-dwelling invertebrates, mainly bivalves and worms (McEachran & de Carvalho, 2002). Although frequently captured near shore, this species is also found in estuaries and rivers (McEachran & Fechhelm, 1998). *D. americana* is abundant on sandy bottoms of the inner shelf of the gulf of Mexico (Castro-Aguirre & Espinoza-Pérez, 1996). In the western Campeche Bank, in southern gulf of Mexico, *D. americana* is the most frequently landed among elasmobranch species, with mean landings of 1.400 ton per year in the state of Campeche according to the statistics from the regional office of SAGARPA (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, 2010).

This species reaches a maximum disc width of 1520 mm (Bigelow & Schroeder, 1953). Females and males mature at 750-800 and 510 mm DW, respectively, young are 170 to 180 mm DW at birth (Bigelow & Schroeder, 1953) and fecundity range from 3 to 5 (McEachran & de Carvalho, 2002). *D. americana*, as the other dasyatid rays, display aplacental viviparity with trophonemata (Hamlett *et al.*, 1996).

Reproductive parameters estimated for *D. americana* in captivity, showed a biannual reproductive cycle, a gestation period of 4.4-7.5 months, a fecundity of 2-10 with a linear relationship with maternal disc width, size at birth 200-340 mm disc width, and 1:1 sex ratio for neonates (Henningsen, 2000). However, an annual reproductive cycle has been observed on wild specimens from Florida and Virginia waters (Grubbs *et al.*, 2006).

The determination of reproductive parameters are needed for assessment of elasmobranch populations by means of demographic analysis or ecological risk assessments due to the lack of time series of catch and fishing effort by species in Mexican official catch statistics. For example, Smith *et al.* (2008) developed age-structured demographic models for *Dasyatis dipterura* from the Mexican Pacific coast, concluding that this species has low intrinsic growth potential and limited resilience to fishing pressure.

D. americana is classed as Data Deficient by the International Union for Conservation of Nature, because the status of their populations is unknown and there is a lack of life history parameters throughout most of its range (Grubbs *et al.*, 2006). Mexican fisheries for elasmobranchs have been managed since 2007 by the Mexican Official Standard NOM-029-PESC-2006, Responsible Fisheries of Sharks and Rays, Specifications for their Use (Poder Ejecutivo Federal, 2007) and available information from the Atlantic coast of Mexico indicates that landings of batoids have been declining since the late 1990's (Poder Ejecutivo Federal, 2006), which indicates that the intrinsic growth potential of the population of *D. americana* must be assessed to determine its vulnerability to fishing pressure. Objectives of the present study were to determine the reproductive parameters for *D. americana* in the southern gulf of Mexico needed to develop, in the near future, age-structured or stage-based demographic models.

MATERIALS AND METHODS

A total of 900 specimens were examined from February 2006 to December 2008. Rays were obtained from commercial catches of the small-scale fleet from San Pedro, Tabasco, in the southern gulf of Mexico (Fig. 1). Bottom-set longlines with 60 mm shank-length tune circle hooks were the primary method of capture. The catch depth ranged from 10 to 40 m.

Disc width (DW) was measured between the tips of the widest portion of the pectoral fins (McEachran & de Carvalho, 2002). All rays were measured and examined to quantify reproductive parameters. Maturity was assessed macroscopically for both sexes. Maturity in males was assessed by the extent of clasper calcification (Clark & Von Schmidt, 1965) and testes development (Snelson *et al.*, 1988). Claspers were measured from the point of insertion at the cloaca to the tip of claspers. Males were assigned to one of two stages as follows: 1) immature, testes and claspers undeveloped; 2) mature, claspers fully developed, exceeding the posterior edge of the pelvic fins, presented hardened internal structure and, could be rotated toward the anterior part without bending (Clark & Von Schmidt, 1965), and had enlarged testes with prominent lobes (Snelson *et al.*, 1988).

Maturity in females was determined by the onset of first ovulation (Walker, 2005). Follicle diameter of the largest cohort in the ovary and the width of the left uterus were measured. In uteri, the trophonemata development, presence of uterine milk, uterine eggs and embryos were recorded. Uteri were examined to determine if embryos or uterine eggs were present. When present, the sex and DW of embryos was recorded.
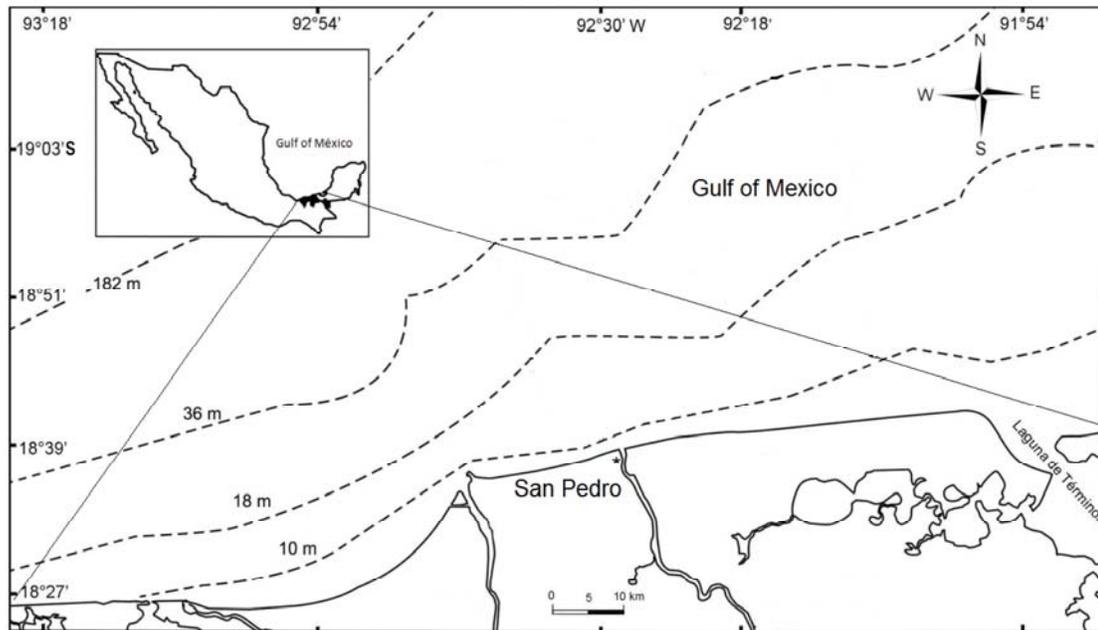
Figure 1. Location of San Pedro, Tabasco, landing site of the small-scale fleet in southern gulf of Mexico.
Figura 1. Ubicación de San Pedro, Tabasco, sitio de desembarque de la flota de pequeña escala en el sur del golfo de México.

Females were assigned to one reproductive status as follows: 1) immature, no ovarian development or if developed, there was no vitellogenic activity (follicles <25 mm diameter), uterus thin (<46 mm width) with trophonemata not well developed (<5 mm in length, thin and pale); 2) non-gravid mature, medium to large follicles (15-34 mm diameter) in the ovary, some with vitellogenic activity, wide uterus (23-47 mm), with trophonemata well developed and vascularized (>5 mm in length); 3) gravid, embryos in uterus, with medium to large follicles in the ovary (7-40 mm diameter).

Logistic models were used to estimate median disc width at maturity (DW_{50}) according to Mollet *et al.* (2000) by fitting the logistic model $Y = [1+e^{-(a+bX)}]^{-1}$ to the binary data of maturity (immature = 0, mature = 1). Because of the asynchronous nature of the reproductive cycle of females, the methods described by Braccinni *et al.* (2006) were used to determine the gestation period and the ovarian cycle. The time series of the disc width of embryos were analyzed to determine the gestation. Gravid females were assigned to one of seven categories based on the size of the embryos they carried: 1) ≤59 mm DW, 2) 60-89 mm DW, 3) 90-119 mm DW, 4) 120-149 mm DW, 5) 150-179 mm DW, 6) 180-209 mm DW and, 7) ≥210 mm DW. The length of the gestation period was determined following the growth of embryos of different classes or cohorts through the time, based on the assumption that embryos from different cohorts have the same growth pattern (Braccinni *et al.*, 2006).

To determine if ovarian cycle and gestation were concurrent or consecutive, correlation analysis was performed to assess possible relationships between follicle diameter and embryo size. The method of Braccinni *et al.* (2006) may be used to determine the ovarian cycle if the gestation and the ovarian cycle run concurrently. To estimate the ovarian cycle, the time series of the follicle diameter of gravid females was analyzed. Follicle diameter from the same subset of data selected for the gestation period analysis (seven categories of gravid females based on the size of embryos) was used to estimate the length of the ovarian cycle. The length of the ovarian cycle was determined following the growth of follicles of different classes or cohorts through the time, based on the assumption that the diameter of follicles from different cohorts has the same growth pattern (Braccinni *et al.*, 2006).

The disc width range at birth was estimated based on the disc width of the largest embryo examined and the smallest free-swimming ray recorded. To determine the fecundity, the total number of embryos was counted. The null hypothesis of a sex ratio 1:1 of embryos was tested with the chi-square procedure with Yate's correction for continuity (Zar, 1984). The relationship between maternal DW and the number of

embryos was plotted and fitted to a simple linear regression model.

RESULTS

A total of 494 females ranging from 340 to 1640 mm DW (mean = 766.5 ± 152.5) and 406 males 400-1100 mm DW (mean = 613.3 ± 69.3) were analyzed. In females, the disc width at which 50% of the population was mature was 764 mm (DW$_{50}$, 95% CI: 756-772 mm) (Fig. 2), with 288 mature and 206 immature females recorded. The smallest mature female measured 650 mm DW, had abundant uterine milk, follicles 32 mm diameter and uterus 34 mm width, and the largest immature female measured 960, had follicles 15 mm diameter and uterus 29 mm width. In males, the disc width at which 50% of the population was mature was 517 mm (DW$_{50}$, 95% CI: 510-523 mm) (Fig. 2), with 373 mature and 33 immature males recorded. The smallest mature male measured 490 mm DW (calcified claspers: 130 mm length), and the largest immature male measured 670 mm DW (partially calcified claspers: 120 mm length).

The time series of the embryos disc width (Fig. 3a) showed the asynchronous nature of the reproductive cycle of *D. americana*. The gestation lasts approximately 7-8 months. The development of embryos was traced following three cohorts through time (Figs. 4a and 4b). A first cohort could be traced from early October 2006 to late May 2007 (Fig. 4a); a second cohort from early February to late September 2008; and a third cohort from early July 2008 to late January 2009 (Fig. 4b).

The ovarian cycle could not be determined because this period does not occur concurrently with the gestation period, and the asynchronous nature of the reproductive cycle prevents it by analyzing the time series of follicle diameter of non-gravid mature females. The follicle diameter of gravid females does not show a relationship with the categories of gravid females (based on the size of the embryos they carried), as would be expected if gestation and the ovarian cycle were concurrent (Fig. 3b).

Although the correlation between the disc width of embryos and follicle diameter was significant, the degree of association is weak ($r = 0.49$, $P < 0.001$), because there exist a large variability, and only some gravid females containing full term embryos (>175 mm DW) had large follicles (Fig. 5). Therefore, the ovarian cycle and gestation were consecutive, the follicles and embryos do not develop at the same time. Apparently, however, the follicle development begins towards the end of gestation and follicles continue
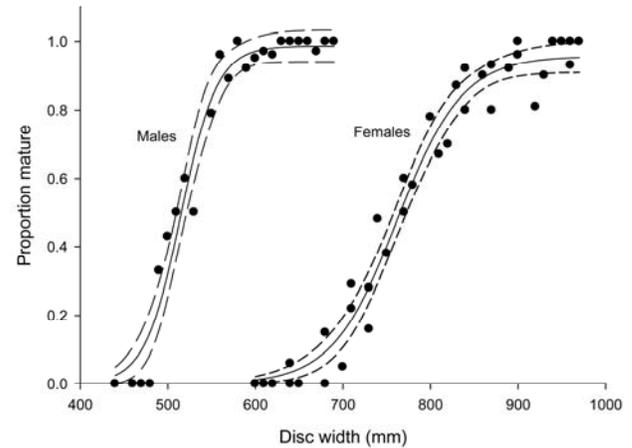

Figure 2. Female and male disc width-at-maturity ogives. Long dashed lines are 95% confidence intervals.

Figura 2. Ojivas de la longitud de madurez de hembras y machos. Las líneas punteadas son los intervalos de confianza al 95%.
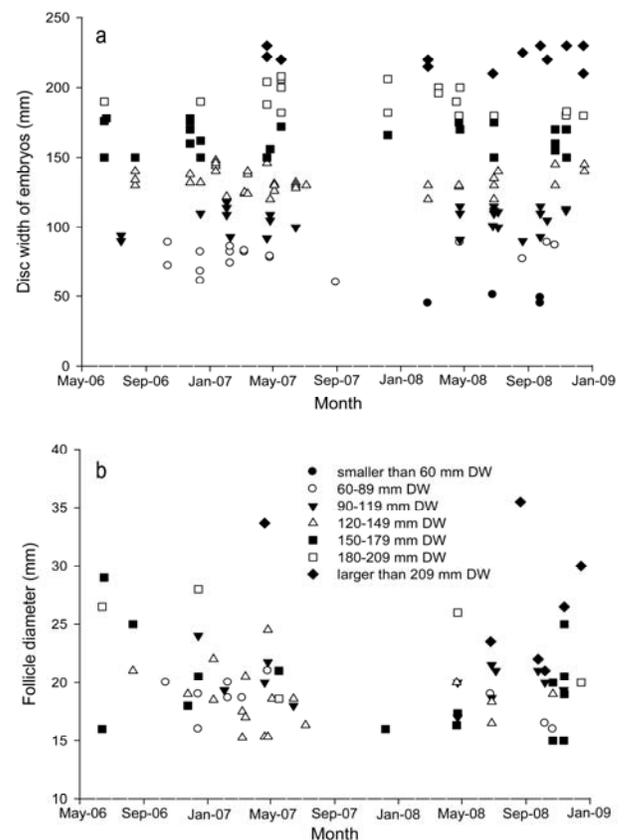

Figure 3. Time series of a) disc width of embryos and, b) average follicle diameter of gravid females of *Dasyatis americana*. Symbols descriptions apply to both graphs.

Figura 3. Series de tiempo de a) ancho del disco de los embriones, y b) el diámetro promedio de los ovocitos de hembras preñadas de *Dasyatis americana*. La descripción de los símbolos aplica para las dos gráficas.
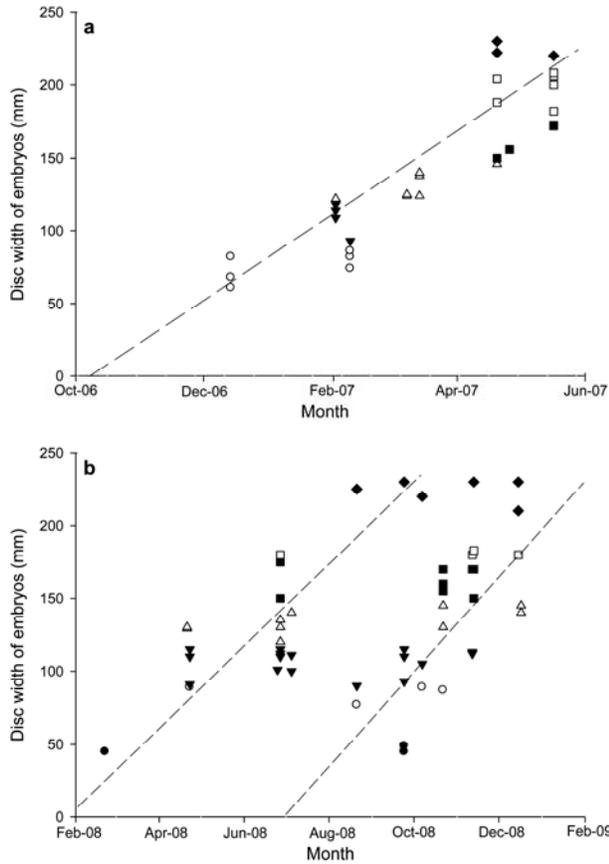
Figure 4. Time series of the growth of three cohorts of embryos (symbols descriptions in Figure 3): a) from October 2006 to May 2007, b) from February to September 2008 and from July 2008 to January 2009. Dotted lines show the cohorts of embryos.

Figura 4. Series de tiempo del crecimiento de tres cohortes de embriones (descripción de los símbolos en Figura 3): a) de octubre 2006 a mayo 2007, b) de febrero a septiembre 2008 y de julio 2008 a enero 2009. Las líneas punteadas muestran las cohortes de embriones.

growing after the 7-8 months of gestation. If it is assumed that the ovarian cycle continues several months after parturition, then it could be hypothesized that females of *D. americana* reproduce annually.

Disc width at birth was 230-340 mm. Fecundity ranged from two to seven embryos (mean = 2.5 ± 0.99). The 74.6% of gravid females carried two embryos. The most frequent number of follicles in gravid females was also two (30% of females). As the maternal DW increased, fecundity also increased (fecundity = 0.004 DW-1.41, r^2 = 0.46, $F_{1,59}$ = 46.99, P < 0.001) (Fig. 6). In total, 77 females and 79 males embryos were recorded, resulting in a sex ratio not significantly different from 1:1 (chi-square = 0.03, P > 0.05).
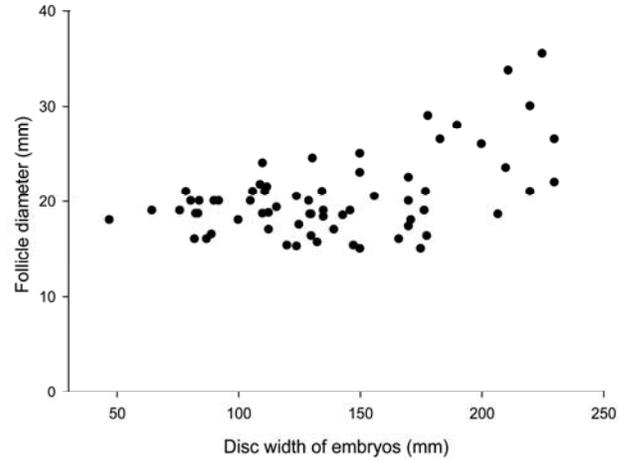

Figure 5. Correlation between the embryo disc width and the average follicle diameter (r = 0.49, P < 0.001).

Figura 5. Correlación entre el ancho de disco de los embriones y el diámetro promedio de los ovocitos (r = 0,49; P < 0.001).
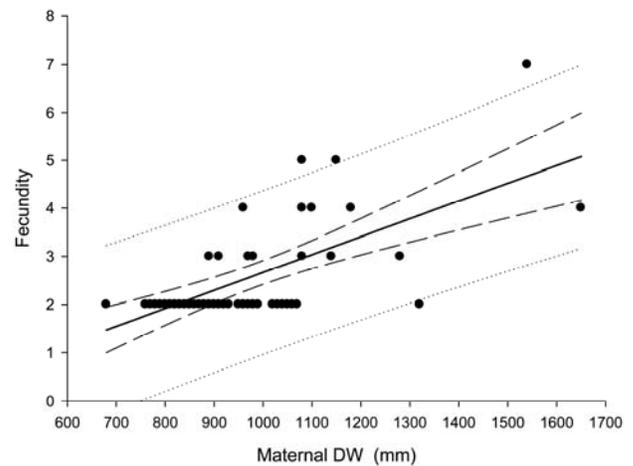

Figure 6. Relationship between maternal disc width and fecundity (fecundity = 0.004 DW-1.41; r^2 = 0.46, $F_{1,59}$ = 46.99; P < 0.001). Long dashed lines are 95% confidence intervals and dotted lines are 95% prediction intervals.

Figura 6. Relación entre el ancho de disco de las hembras y su fecundidad (fecundidad = 0,004 AD-1,41; r^2 = 0,46; $F_{1,59}$ = 46,99; P < 0,001). Las líneas punteadas largas son los intervalos de confianza al 95% y las líneas de puntos cortos son los intervalos de predicción al 95%.

DISCUSSION

Before this study, nothing was known about the reproductive parameters of *D. americana* in the gulf of Mexico. Disc width at maturity for females and males, estimated in the present study, was similar to that documented by Bigelow & Schroeder (1953) and

MacEachran & de Carvalho (2002) for specimens collected from northwestern to southwestern Atlantic, and also similar to that estimated by Henningsen & Leaf (2010) for captive specimens (Table 1). However, because it is unclear if the criteria to determine maturity used by Bigelow & Schroeder (1953) and McEachran & de Carvalho (2002) was the same of that used in the present study, we recommend that a future study that uses the same criteria to determining the disc width at maturity among regions should be carried out to test for regional differences.

Gestation periods are slightly longer in wild (7-8 months) than in captive specimens (4.4-7.5 months) (Table 1). The difference is probably associated with environmental conditions, in particular temperature. Mahon *et al*. (2004) documented that gestation in captive spotted eagle ray, *Aetobatos narinari*, is related to water temperature, being longer at lower temperatures (11-12.5 months at 19.8-29.4°C) than at higher temperatures (6-6.2 months at 28.1-30.1°C). Temperature was not provided by Henningsen (2000), however, Henningsen & Leaf (2010) indicate that temperature was maintained at 24-25°C in their study. Surface temperatures ranges between 23.9-28.7°C in the western Campeche Bank (Cuevas-Zimbrón *et al.* 2011) and are closely similar to the northern Campeche Bank where they fluctuate between 23.5-29.5°C, while bottom temperatures, in the second region, ranges between 22.9-24.5°C (Piñeiro *et al*., 2001). If the same bottom temperatures were observed in the western Campeche Bank, specimens of *D. americana* are apparently exposed to slightly lower temperatures in the wild, which could explain that gestation is longer in wild specimens. Henningsen *et al*. (2004), indicate that temperature has an effect on gestation, decreasing with an increase in temperature, such as occurs in *A. narinari* (Mahon *et al*., 2004).

Gestation ranges from 3 to 12 months in wild specimens and from 2 to 7.5 months in captive specimens of dasyatids (Table 2). *D. americana* from the southern gulf of Mexico (present study) is among dasyatids (*D. centroura*, *D. chrysonota*, *D. longa* and *D. sayi*) with gestation of 8 months or longer. In addition, *D. americana* has the longest gestation period (4.4-7.5 months) reported for captive dasyatid rays (Table 2). According to Henningsen *et al*. (2004) the temperature may have a profound effect on development. So, variation in gestation could be linked to this variable, as have been reported for captive specimens (Henningsen *et al*., 2004; Mahon *et al*., 2004). Comparisons of the differences in the length of gestation among species in wild specimens is difficult because a detailed characterization of the habitat is needed for every species.

Reproductive cycle of *D. americana* differs among wild (annual) and captive specimens (biannual). Grubbs *et al*. (2006) suggest an annual cycle of reproduction for wild specimens of *D. americana* in Florida and Virginia, eastern coast of USA. An annual cycle of reproduction has also been documented for other dasyatids, such as *D. sayi*, *D. sabina* and *D. chrysonota* (Snelson *et al*., 1989; Johnson & Snelson, 1996; Ebert & Cowley, 2008). The biannual reproductive cycle for wild specimens has been suggested for two species only, *D. marianae* and *D. guttata* (Yokota & Lessa, 2007), and for captive specimens, it has been determined for three species, *D. americana*, *D. kuhlii* and *Pteroplatytrygon violacea* (Henningsen, 2000; Mollet *et al*., 2002; Janse & Schrama, 2009). An uncommon triannual cycle of reproduction among elasmobranchs has been suggested for *D. marmorata* in wild specimens (Capapé & Zaouali, 1995), however, the authors do not explore the possibility of an asynchronous reproductive cycle for this species, in which case, a different methodology must be used, such as the proposed by Braccinni *et al.* (2006).

Differences in the reproductive cycle between captive and wild specimens are well documented for elasmobranchs (Henningsen *et al.*, 2004). In captive animals, Henningsen *et al*. (2004) indicate that several species were observed to mate immediately following parturition, whereas a longer gap it is observed in the wild (as is the case of *D. americana*). In addition, the effect of some environmental variables (*e.g.* temperature) should be explored in future studies to explain for differences among species.

The reproductive cycle is synchronous in several dasyatid species, *D. sayi*, *D. sabina*, *D. marianae*, *D. guttata* and *D. chrysonota* (Snelson *et al*., 1989; Johnson & Snelson, 1996; Yokota & Lessa, 2007; Ebert & Cowley, 2008). The asynchronous reproductive cycle has been determined for *D. americana* (present study), *D. kuhlii*, *D. zugei*, *Himantura walga* (White & Dharmadi, 2007) and *P. violacea* (Véras *et al*., 2009). In sharks, females are asynchronous in some species inhabiting tropical waters, where stable environmental conditions and abundant food throughout the year allow reproduction and birth to occur year around (Castro, 2009). The species of dasyatids inhabits tropical waters, which could explain that the asynchronous reproductive cycle is very common in these elasmobranchs.

Ovarian cycle and gestation were consecutive for *D. americana* in the wild (present study) and concurrent in captive environment (Henningsen, 2000). Also, in *D. sabina* has been determined that vitellogenesis and gestation was consecutive

Table 1. Comparison of reproductive parameters among southern gulf of Mexico (present study), western Atlantic and captive specimens of the southern stingray *Dasyatis americana*.

Tabla 1. Comparación de los parámetros reproductivos entre el sur del golfo de México (presente estudio), Atlántico oeste y especímenes en cautiverio de la raya látigo americana *Dasyatis americana*.

Parameters	Southern gulf of Mexico (present study)	From Chesapeake Bay to Brazil[1,2]	Captive specimens[3,4]
DW_{50} at maturity of females (mm)	775	unknown	unknown
DW_{50} at maturity of males (mm)	517	unknown	unknown
Smallest mature female	650	750[1]	750[4]
Largest immature female	960	800[1]	800[4]
Smallest mature male	490	510[1]	480[4]
Largest immature male	670	unknown	520[4]
Gestation period (months)	8	unknown	4.4-7.5[3]
Size at birth (mm DW)	230-340	170-180[1]	200-340[3]
Fecundity	2-7	3-5[1,2]	2-10[3]
Sex ratio of embryos	1:1	unknown	1:1[3]
Maternal DW *vs* fecundity relationship	Yes	unknown	Yes[3]
Reproductive cycle	annual	unknown	Biannual[3]

(Table 2). The relationship of these periods is an important feature in the reproductive cycle. The reproductive cycle can be defined by how often a species breeds and consist of two periods: the ovarian cycle (vitellogenesis period) and gestation (Castro, 2009). The length of the reproductive cycle depends on the duration of the ovarian cycle and gestation, and whether the two periods are concurrent or consecutive. The duration of these periods depends on how the mother can sequester energy from the environment and transfer it to the developing oocytes and embryos (Castro, 2009), and the stable conditions in captivity probably allows *D. americana* to reduce the time of gestation and the simultaneous development of oocytes and embryos.

Fecundity estimated in the present study (2-7) was smaller to that documented by Henningsen (2000) of 2-10, but higher to that documented by McEachran & de Carvalho (2002) of 3-5. The relationship between fecundity and maternal disc width was linear for *D. americana* in the present study and captivity (Henningsen, 2000). A significant linear relationship has also been estimated for *D. marmorata* (Capapé & Zaouali, 1995), and non significant for *D. sabina*, *D. sayi*, *D. centroura*, *P. violacea* and *D. chrysonota* (Snelson *et al*., 1988; Snelson *et al*., 1989; Capapé, 1993; Hemida *et al*., 2003; Ebert & Cowley, 2008). This feature is important in demographic analysis, because a larger fecundity is assigned to larger females, and for management purposes the protection

of these females may have a positive effect on the population.

Fecundity in dasyatids ranges from 1 to 7 in the wild and from 1 to 10 in captivity (Table 2). *D. americana* has the highest fecundity reported among captive dasyatid rays (maximum 10), and among the highest fecundity reported in the wild for dasyatids (maximum 7). However, the average fecundity in wild specimens is very low for *D. americana* (2.5 embryos), as in other dasyatids (Table 2). Female dasyatids easily abort embryos because of stress during capture (Struhsaker, 1969; Capapé, 1993; Snelson *et al*., 1988). It was commonly observed embryos aborted over the sides of fishing boats during landing. For this reason, it is often difficult to estimate fecundity of myliobatiform rays (Smith *et al*., 2007).

In general, the reproductive parameters of dasyatid species are similar to that of shark species with low biological productivity (Walker, 1998). For example, Smith *et al*. (2008) determine that *D. dipterura* from the Mexican Pacific coast, has low intrinsic growth potential and limited resilience to fishing pressure, and several dasyatids around the world have been classed as Vulnerable or Endangered by the International Union of the Conservation of Nature, indicating that these batoids need more attention in countries where intensive fisheries exploits them directly or incidentally. In particular, the status of the population of *D. americana* is of concern in the southern gulf of Mexico because it is the most landed elasmobranch by

Table 2. The reproductive cycle, gestation period, and fecundity of wild and captive dasyatid rays.
Tabla 2. Ciclo reproductivo, periodo de gestación y fecundidad de dasyatidos de vida libre y cautiverio.

Species	Reproductive cycle	Gestation (month)	Gestation-ovarian cycle	Fecundity (mean)	Author
Dasyatis americana	annual	7-8	consecutive	2-7 (2.5)	Present study
Dasyatis americana	annual	4.4-7.5**	unknown	2-7 (4.2)	Grubbs *et al.* (2006)
*Dasyatis americana**	biannual	4.4-7.5	concurrent	2-10 (4.2)	Henningsen (2000)
Dasyatis centroura	annual?	9-11	concurrent?	4-6	Struhsaker (1969)
Dasyatis centroura	unknown	at least 4	concurrent	2-6 (2.2)	Capapé (1993)
Dasyatis chrysonota	annual	9	concurrent	1-7 (2.8)	Ebert & Cowley (2008)
Dasyatis guttata	biannual	5-6	concurrent	1	Yokota & Lessa (2007)
Dasyatis kuhlii	unknown	unknown	unknown	1	White & Dharmadi (2007)
*Dasyatis kuhlii**	biannual	4.5-5.5	concurrent	1	Janse & Schrama (2009)
Dasyatis longa	unknown	10-11	unknown	1-5	Villavicencio-Garayzar *et al.* (1994)
Dasyatis marianae	biannual	5-6	concurrent	2	Yokota & Lessa (2007)
Dasyatis marmorata	triannual?	3	concurrent	2-4 (2.9)	Capapé & Zaouali (1995)
Dasyatis sabina	annual	4-4.5	consecutive	1-4 (2.6)	Snelson *et al.* (1988)
Dasyatis sabina	annual	3.5-4	consecutive	1-3 (2.3)	Johnson & Snelson (1996)
Dasyatis sabina	annual	4	n/a	n/a	Tricas *et al.* (2000)
Dasyatis sayi	annual	12	concurrent	1-6 (3.5)	Snelson *et al.* (1989)
Dasyatis zugei	unknown	unknown	unknown	1-4 (2.1)	White & Dharmadi (2007)
*Pteroplatytrygon violacea**	biannual	2	concurrent?	2-7	Mollet *et al.* (2002)
Pteroplatytrygon violacea	biannual?	aprox. 4	concurrent	2-7	Hemida *et al.* (2003)
Pteroplatytrygon violacea	unknown	unknown	concurrent	(3.7)	Véras *et al.* (2009)
Himantura walga	unknown	unknown	unknown	1-2 (1.4)	White & Dharmadi (2007)

*captive specimens, **from the study of Henningsen (2000).

some small-scale fleets, and its reproductive parameters suggest that this dasyatid has low biological productivity and probably limited resilience to fishing pressure.

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