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RESEARCH NOTE

Record of partial albino in the scalloped hammerhead *Sphyrna lewini* (Carcharhiniformes, Sphyrnidae) in the Mexican Pacific Ocean

Registro de albinismo parcial en el martillo común *Sphyrna lewini* (Carcharhiniformes, Sphyrnidae) en el océano Pacífico mexicano

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Abstract.- This study reports the capture of a partial albino scalloped hammerhead *Sphyrna lewini* in Puerto Madero, Chiapas, Mexico. The specimen was a neonate female that measured 491 mm total length and had a total weight of 800 g. This is the first report of an albino scalloped hammerhead *Sphyrna lewini* in the Pacific Ocean and the second in the world. The presence of albinism could be the result of multifactorial events, although anthropogenic stressors such as excessive fishing pressure and marine pollution might be involved.

Key words: Elasmobranch, abnormalities, Gulf of Tehuantepec, Mexico

INTRODUCTION

Coloration of each living being plays a role in basic functions such as crypsis and aposematism and even becomes an indicator of physiological and ethological functions such as sexual selection during the mating season (Protas & Pastel 2008, Hubbard *et al.* 2010). Loss of color has been suggested as one of the disadvantages that wild animals present due to the loss of crypsis, resulting in increased predation and diminished hunting abilities (Sandoval-Castillo *et al.* 2006).

Albinism is a genetically inherited condition in which melanin is absent or nonfunctional (Reum *et al.* 2008), caused by an autosomal recessive gene that affects normal pigmentation in animals (Oliveira & Foresti 1996). There are two types of albinism: a) total albinism is total absence of melanin, it involves the entire body and is characterized by the whitish body and red eyes (Sazima & Pombal 1986), and b) partial (or leucistic) albinism is phenotypically characterized by the absence of melanin in affected parts of the body or reduction of melanin in the entire body or parts of it (Lutz 2001). Albinism has been reported in at least twenty-three shark and fifteen ray species (Wakida-Kutsunoki 2015).

The scalloped hammerhead, *Sphyrna lewini* (Griffith & Smith, 1834) is considered a warm-water coastal-pelagic species (Compagno 1984) able to tolerate wide temperature ranges (23-31 °C), low salinity values including freshwater, depths up to 1,000 m, and hypoxic conditions (Castro-Aguirre *et al.* 1999, Shane 2001, Jorgensen *et al.* 2009, Hoyos-Padilla *et al.* 2014, Moore & Gates 2015, Spaet *et al.* 2017, Iqbal *et al.* 2020). It has a circumtropical distribution (Castro 1983), which in the Eastern Pacific Ocean includes southern California, from the Gulf of California to Panama, Ecuador, and northern Peru (Compagno 1984). It can be found near beaches, river deltas, estuaries, and even enters rivers (Compagno 1984, Castro-Aguirre *et al.* 1999, Iqbal *et al.* 2020). Neonates and juveniles are found in shallow water off the coast. They are viviparous placental sharks with a gestation period from 10 months to one year. Neonates are born in breeding areas that are typically shallow protected waters such as bays, inlets, or shoals. In the Mexican Pacific (MP), the reported breeding areas are found at the mouth of the Gulf of California, and on the coast of Jalisco, Michoacán, Oaxaca, and Chiapas (Campuzano-Caballero 2002, Anislado-Tolentino & Robinson-Mendoza 2001, Torres-Huerta *et al.* 2008, Bejarano-Álvarez *et al.* 2011, Alejo-Plata *et al.* 2018, Anislado-Tolentino 2018, Corgos & Rosende-Pereiro 2022). In the MP, three genetically divergent populations have been described: the North Pacific (Baja California and Baja California Sur), the Central Pacific (Nayarit-Michoacán), and the South Pacific (Oaxaca-Chiapas). Gene flow depends mainly on males, as females have more pronounced philopatry, a trait that helps them conserve energy during gestation and is also one of the factors that shape population structure (Anislado-Tolentino & Robinson-Mendoza 2001, Castillo-Olguín *et al.* 2012).

The scalloped hammerhead is one of the most important species in the catches of the artisanal fleet of different regions of the Mexican Pacific (Furlong-Estrada *et al.* 2015, Coiraton *et al.* 2017). In the Gulf of Tehuantepec, *S. lewini* is the second most captured species with 31% of the total catch. 65% of *S. lewini* catch are obtained from gillnetting for targeted finfish (Morales-Pacheco *et al.* 2016). This zone has been suggested as a birth, breeding, and nursery area for *S. lewini* (Soriano-Velásquez *et al.* 2001, Alejo-Plata *et al.* 2006).

In the last decade, the significant decline (by almost 20%) in scalloped hammerhead catch has been taken as an indirect indicator of the decline in their populations. It is also an international warning sign given their categorization as endangered species since 2010 (CITES 2022)[1], and critically endangered species in 2018 by IUCN (Rigby *et al.* 2019). In Mexico the protection work on this species began in 1996 and there are currently laws and regulations that regulate shark fishing (DOF 2004[2], 2007[3], 2018[4]). However, the recovery and resilience of hammerhead populations have not yet been assessed, and populations may still be stressed by fishing and habitat loss.

This note describes the first report of partial albinism in scalloped hammerhead shark *S. lewini* in the Pacific Ocean.

Materials and methods

An albino specimen of scalloped hammerhead *Sphyrna lewini* was found during routine shark sampling in artisanal fishing camps. The specimen was caught on June 26, 2018, at a depth of 25 m, 12.5 km off the coast of Puerto Madero, Chiapas (14°40.059”N; 92°31.677”W), using a drifting gillnets mesh with a stretched size of 3.5 inches. The specimen was collected and transported to Estación de Investigación Acuícola y Pesquera (ESIAP-Pto. Chiapas) of Instituto Nacional de Pesca y Acuacultura (INAPESCA), where it was identified using the criteria described by Compagno (1984) and McEachran & Fechhelm (1998). Morphometric data of the albino specimen were obtained. These characteristics were measured with a measuring tape, and total wet weight (W) was measured with an Ohaus® Scout® Pro 4000 (±0.1 g) analytical balance. The neonate state was estimated using the proposal of Duncan & Holland (2006), which is based on characteristics of the healing of the umbilical wound. The specimen was deposited in the fish collection of College of La Frontera Sur, Unidad San Cristóbal de las Casas (ECOSC), under the catalog number ECOSC 14763.

[1]CITES. 2022. History of CITES listing of sharks (Elasmobranchii). Convention on International Trade in Endangered Species of Wild Fauna and Flora. <https://cites.org/eng/prog/shark/history.php>

[2]DOF. 2004. Decreto por el que se reforman, adicionan y derogan diversas disposiciones del Reglamento de la Ley de Pesca. 28 de enero del 2004. Diario Oficial de la Federación, Secretaría de Gobernación, Ciudad de México. <https://dof.gob.mx/nota_detalle.php?codigo=677049&fecha=28/01/2004#gsc.tab=0>

[3]DOF. 2004. Decreto por el que se reforman, adicionan y derogan diversas disposiciones del Reglamento de la Ley de Pesca. 28 de enero del 2004. Diario Oficial de la Federación, Secretaría de Gobernación, Ciudad de México. <https://dof.gob.mx/nota_detalle.php?codigo=677049&fecha=28/01/2004#gsc.tab=0>

[4]DOF. 2018. Decreto por el que se adicionan diversas disposiciones de la Ley General de Pesca y Acuacultura Sustentables. 24 de abril del 2018. Diario Oficial de la Federación, Secretaría de Gobernación, Ciudad de México. <https://dof.gob.mx/nota_detalle.php?codigo=5520483&fecha=24/04/2018#gsc.tab=0>

Results and discussion

The material examined corresponded to a neonate female of *Sphyrna lewini* measuring 491 mm total length and weighing 800 g. Identification of the species was made according to the following observations: head is moderately expanded, width about 30% of total body length. Its anterior margin has shallow undulations that form three lobes, naris groove does not extend to the middle of the anterior margin of the head. Teeth are triangular, wavy base, smooth edges. First dorsal fin straight, not sloping backwards, its free margin never reaching the origin of the pelvic fins, second dorsal fin shorter than anal, the base of anal fin longer than the base of second dorsal, caudal peduncle with a crescent-shaped precaudal pit on the dorsal side. Main morphometric measurements and counts are presented in Table 1. Specimen was considered to have partial albinism due to the tip of the lower lobe of the caudal fin having a small black spot; all the remaining skin was white and eyes were red (Fig. 1a). In pigmented specimens, as observed in the comparison with a 600 mm TL female of approximately three months old, the upper part of the body normally varies between olive to dark gray, white ventrally, with ventral tips of the pectoral fin dark gray to black (Fig. 1b).

According to Gilbert (1967) and Ebert *et al*. (2021), *S. lewini* neonates present a light gray coloration on the back and whitish on the belly with dark marks on the tips of the fins. As they grow, they acquire a darker coloration and lose the marks on the fins. In this work, the analyzed specimen presents a whitish coloration both on the back and on the belly, with the addition that the eyes are red. Since the lower caudal lobule has a black spot it can be considered to have partial albinism (Sazima & Pombal 1986).

Currently, 31 species of sharks with albinism have been reported around the world (Table 2), however, only one report for *S. lewini* (McKenzie 1970) was known before this work. Of the five reported cases of albinism on the Mexican coast, two were elasmobranchii found in the Gulf of Tehuantepec: *Carcharhinus limbatus* (Sancho-Vazquez *et al.* 2015) and *Urotrygon nana* (Anislado-Tolentino *et al.* 2016).

Albinism and alterations in coloration have been related to exposure to heavy metals (Oliveira & Foresti 1996, Irigoyen-Arredondo *et al*. 2017), genetic alteration in melanin production (Bejarano-Álvarez & Galván-Magaña 2013), inbreeding within an isolated population (Sanabria *et al.* 2010), environmental stress, and heavy fishing pressure (Gervais *et al.* 2016, Bruckner & Coward 2018).

Table 1. Morphometric measurements (mm) of the reported *Sphyrna lewini* partial albino female (ECOSC 14763) / Medidas morfométricas (mm) del espécimen hembra de *Sphyrna lewini* reportado con albinismo parcial (ECOSC 14763)

Measurements	(mm)	Measurements	(mm)
Total length	491	Anal base	30
Fork length	371	Anal length	45
Pre-caudal length	342	Anal height	20
Inter-dorsal space	113	Ventral base	39
Pre-first dorsal length	145	Ventral height	47
Pre-second dorsal length	301	Caudal length	148
Snout length	40	Terminal caudal margin	25
Head length	131	Sub-terminal caudal margin	16
First dorsal base	50	Space between pectoral and pelvic fins	91
First dorsal length	65	Space between the vent and caudal length	98
First dorsal height	62	Eye length	15
Second dorsal base	19	Eye height	15
Second dorsal length	44	Intergill length	33
Second dorsal height	13	Pre-oral length	37
Pectoral base	28	Pre-orbital length	31
Pectoral length	47	Space between pelvic and anal fins	39
Pectoral height	52	Head width	164
Pelvic base	30		
Pelvic length	41		
Pelvic height	24		

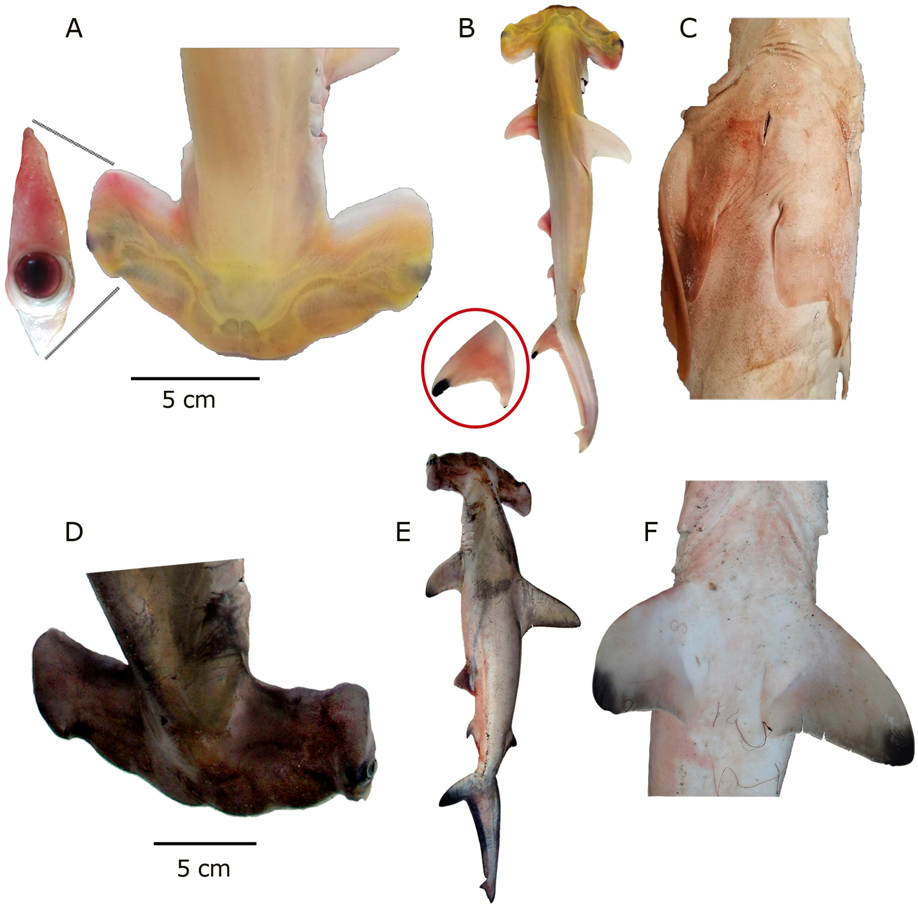

Figure 1. *Sphyrna lewini*. A) Head dorsal view of the reported partial albino female with a close-up of the right eye; B) Body dorsal view with a close-up of tail lower lobe showing a black spot; C) Pectoral area ventral view, where fresh umbilical opening is observed; D) Head dorsal view of a normal female; E) Body dorsal view of a normal female; F) Pectoral area ventral view of a normal female with black spotted fin tips and healed umbilical opening. Partial albino specimen photo by JL Hernández-Corona and normal specimen photo by V Anislado-Tolentino / *Sphyrna lewini*. A) Vista dorsal de la cabeza de la hembra albina parcial con un acercamiento al ojo derecho; B) Vista dorsal del cuerpo con un acercamiento al lóbulo inferior de la aleta caudal que muestra una mancha oscura; C) Vista ventral del área pectoral de la hembra albina donde la abertura umbilical se nota fresca; D) Vista dorsal de la cabeza de una hembra con coloración normal; E) Vista dorsal del cuerpo de una hembra con coloración normal; F) Vista ventral del área pectoral de una hembra con coloración normal, donde se notan las manchas oscuras en las puntas de las aleta y a la abertura umbilical cicatrizada. Foto de ejemplar con albinismo parcial por JL Hernández-Corona y foto del ejemplar normal por V Anislado-Tolentino

Although this is the second reported case of albinism for *S. lewini* worldwide, inbreeding must be ruled out as a cause because this is a migratory species, exchange of genetic material is unrestricted, and therefore this factor does not have weight. However, it must be considered that in the northern Pacific states, up to 95% of wetlands have been lost in the last decade, mostly affecting Baja California, Baja California Sur, Sonora and Sinaloa; central Pacific states have lost up to 50% (Landgrave & Moreno-Casasola 2012). This suggests a correlation between the decreasing populations of large coastal predators and the loss and deterioration of the coastal habitat where the breeding areas are found, being detrimental to gene transmission in the three scalloped hammerhead populations from MP. Additionally, organochlorines and polychlorinated benzyl are persistent organic pollutant compounds (OPCs) that are known to cause teratogens and carcinogens (Martínez-Villa *et al.* 2014), and have been shown to cause joint albinism with cyclopia in sea turtles (Bárcenas & Maldonado 2009). Chiapas has been reported as one of the states with the greatest problems derived from OPCs due to the presentation of persistent organic pesticides (POPs) from agriculture and the use of pesticides against malaria (Albert 1996, Ruiz-Suárez *et al.* 2014). In the coastal areas of Chiapas, a large number of POPs have been detected in sediments (Botello *et al.* 2002), as well as in the flesh of fish for human consumption (Herrera *et al.* 2013). For this reason, the high POP levels (DDT-derived heptachlorides) found by Martínez-Villa *et al.* (2014) for *S. lewini* in the Gulf of Tehuantepec might suggest a correlation with reported albinism, however, as Escobar-Sánchez *et al.* (2014) mention, this and other abiotic factors can be ruled out since the presented specimen is the only one of the litter affected.

Table 2. Reported cases of albinism and partial albinism in shark species. Species in the order suggested by Compagno (2005) and Cornejo *et al.* (2015) / Casos reportados de albinismo y albinismo parcial en especies de tiburones. Especies ordenadas de acuerdo a la propuesta de Compagno (2005) y Cornejo *et al.* (2015)

Family	Species	Albinism	Capture site	Reference
Hexanchidae	*Notorynchus cepedianus*	Partial	California, USA	Herald (1953)
	Notorynchus cepedianus	Partial	California, USA	Ebert (1975)
Squalidae	*Squalus acanthias*	Partial	Georgia, USA	Frøiland (1975)
	Squalus acanthias	Partial	Nova Scotia, Canada	Coad & Gilhen (2002)
	Squalus megalops	Total	Black Sea, Romania	Sanda & De Maddalena (2003)
Etmopteridae	*Etmopterus lucifer*	Total	New Zealand	Finucci (2020)
Somniosidae	*Centroscymnus coelolepis*	Partial	NE Atlantic	Deynat (2003)
Dalatiidae	*Dalatias licha*	Partial	Italy	Bottaro *et al.* (2005)
Squatinidae	*Squatina californica*	Total	Baja California Sur, Mexico	Escobar-Sánchez *et al*. (2014)
Hemiscylliidae	*Chiloscyllium plagiosum*	Total	USA	Clark (2002)
Orectolobidae	*Orectolobus japonicus*	Total	Japan	Iwamasa & Okano (1982)
Ginglymostomatidae	*Nebrius ferrugineus*	Total	Japan	Taniuchi & Yanagisawa (1987)
Stegostomatidae	*Stegostoma fasciatum*	Total	Indian Ocean	Nayaka (1973)
Odontaspididae	*Odontaspis ferox*	Partial	New South Wales Australia	Fergusson *et al.* (2008)
Cetorhinidae	*Cetorhinus maximus*	NA	Norway	Frøiland (1975)
Lamnidae	*Carcharodon carcharias*	Partial	South Africa	Smale & Heemstra (1997)
	Lamna nasus	Total	Norway	Frøiland (1975)
Scyliorhinidae	*Cephaloscyllium ventriosum*	Total	Baja California Sur, Mexico	Becerril-García *et al.* (2017)
	Scyliorhinus canicula	Total	Ireland	Hoare (2009)
Triakidae	*Galeorhinus galeus*	Total	English Channel	Deynat (2003)
	Hemitriakis japonica	Partial	Japan	Furuta (1985)
	Mustelus californicus	NA	Monterey Bay, USA	Herald *et al*. (1960)
	Mustelus californicus	Total	California, USA	Talent (1973)
	Mustelus californicus	Total	California, USA	Cohen (1973)
	Mustelus schmitti	Total	Brazil	Ferreira-Teixeira & Góes de Araújo (2002)
	Triakis semifasciata	Total	California, USA	Follet (1976)
Carcharhinidae	*Carcharhinus amboinensis*	Partial	Australia	McKay & Beinssen (1988)
	Carcharhinus isodon	Partial	Alabama, USA	Jones *et al.* (2006)
	Carcharhinus limbatus	Partial	Chiapas, Mexico	Sancho-Vasquez-*et al.* (2015)
	Carcharhinus melanopterus	Total	India	Manojkumar (2011)
	Carcharhinus melanopterus	Partial	Maldives Islands	Bruckner & Coward (2018)
	Carcharhinus obscurus	Total	Baja California Sur, Mexico	Bejarano-Álvarez & Galván-Magaña (2013)
	Carcharhinus plumbeus	Partial	Gulf of Gabés, Tunisia	Saïdi *et al.* (2006)
	Galeocerdo cuvier	Total	Baja California Sur, Mexico	Sandoval-Castillo *et al.* (2006)
	Galeocerdo cuvier	Total	Gulf of Mexico	Rider *et al.* (2002)
	Scoliodon laticaudus	Partial	Arabian Sea	Veena *et al.* (2011)
Sphyrnidae	*Sphyrna lewini*	Total	Georgia, USA	McKenzie (1970)
	Sphyrna lewini	Partial	Chiapas, Mexico	This work

NA= not available

Cárdenas & Franco (2021) suggest that in addition to inbreeding, hybridization and nutritional deficiencies can also cause albinism. Rodríguez-Ruíz *et al.* (2015) report that albinism in city birds is caused by anthropogenic stressors that cause congenital malformations in embryonic development. Irigoyen-Arredondo *et al.* (2018), postulate that the anthropogenic stressors affecting marine organisms can range from fishing, extensive navigation on commercial and tourist routes, industrial waste that is dumped on the coast, and loss of habitat due to human population growth on the coast, causing a failure in the genetic interconnectivity between populations. Despite the fact that for decades hammerhead fishing on the Chiapas coast have been reported as intensive (Soriano-Velásquez *et al.* 2001, Alejo-Plata *et al.* 2006), and the introduction of regulatory fishing laws in 2007 (DOF 2007)[3], there has been no evaluation of population recovery. The absence of other reports of albinism in *S. lewini* within the area or in other localities with similar levels of exploitation prevents the generalization of anthropogenic stress as the cause of albinism in the specimen. On the other hand, and in agreement with Irigoyen-Arredondo *et al.* (2018), the malformation in the *S. lewini* specimen is of multifactorial origin, which at macroscopic level will remain only as assumption, and may be clarified through genetic, nutritional and biochemical analysis of the specimens in the future.

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