

# Reproductive Mode of the Tawny Nurse Shark Taken from the Yaeyama Islands, Okinawa, Japan with Comments on Individuals Lacking the Second Dorsal Fin

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## ABSTRACT

Based on observations on ovaries, egg capsules in uteri and nidamental glands, and an embryo found in a 272 cm TL female tawny nurse shark, *Nebrius concolor*, taken from the Yaeyama Islands in Okinawa, some of the reproductive aspects are described and the reproductive mode for this species is suggested to be oophagy. Individuals lacking the second dorsal fin that were found in the Yaeyama areas are described.

## INTRODUCTION

The first record of the tawny nurse shark, *Nebrius concolor*, occurring in Japanese waters was described by Yoshino et al. (1981) based on three specimen taken in the Yaeyama and Okinawa Islands. This species is wide-ranging in the Indo-West and Central Pacific region and occurs in the inshore waters of the continental and insular shelves at depths of less than one to at least 70 m (Last and Stevens, 1994; Randall, 1986; Randall et al., 1990). On October 5 and November 5 1994, six individuals of *N. concolor* were captured by longline from shallow areas of five to 20 m depth around the Yaeyama Islands. One of those individuals was pregnant and contained an embryo with an extraordinarily swollen abdomen. Three out of six individuals were found to be lacking the second dorsal fin.

This report describes some of reproductive aspects of this species based on observations on the ovaries, uteri, and the embryo and suggests that the reproduc-

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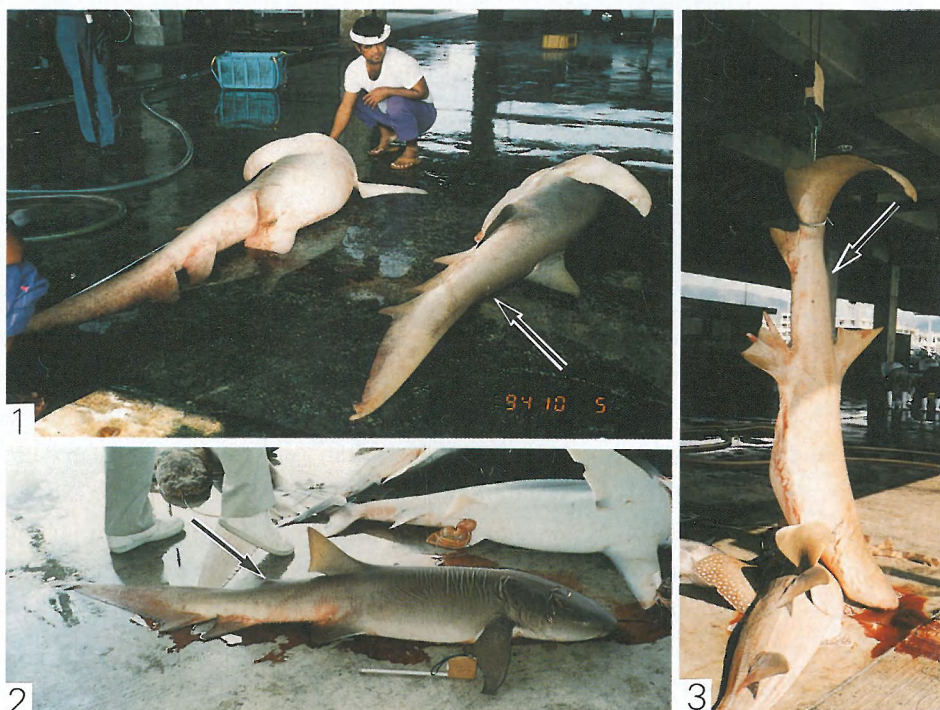
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tive mode for this species is oophagy. Descriptions of individuals that lack the second dorsal fin are given; the occurrence of these individuals in the Yaeyama areas appears to be not uncommon.

## MATERIALS AND METHODS

On October 5 1994, two female tawny nurse shark, *Nebrius concolor*, measuring 280 cm and 272 cm in total length (TL) were captured at the bottom in four to five m depth about 500 m southeast of Taketomi Island, Okinawa by local fishermen engaged in the trap net fishery (Fig. 1). One of the two female sharks was pregnant. Ovaries and uteri removed from the 272 cm TL female were brought to the laboratory for observations. This female lacked the second dorsal fin.



- Fig. 1.** Two female tawny nurse shark, *Nebrius concolor*, taken on October 5 1994. Left; 280 cm TL, Right; 272 cm TL. The right hand individual lacks the second dorsal fin. An arrow indicates the area where the second dorsal fin is normally formed.
- Fig. 2.** A female tawny nurse shark (177 cm TL), missing the second dorsal fin, taken on November 5 1994. An arrow indicates the swelling where the second dorsal fin is normally formed.
- Fig. 3.** A male tawny nurse shark (276 cm TL), missing the second dorsal fin, taken on November 5 1994. An arrow indicates the swelling where the second dorsal fin is normally formed.

On November 5 1994, two female (280 and 177 cm TL) and two male (276 and ca. 300 cm TL) *N. concolor* were captured by longline in the coastal shallow waters around Ishigaki Island. Reproductive organs of the 280 cm TL female were observed when it was dissected at the fish market. Of the four sharks, two (177 cm female and 276 cm male) lacked the second dorsal fin (Figs. 2, 3). At the fish market part of the body, on which the second dorsal fin was formed originally, was cut off transversely from these two sharks, brought to the laboratory, and frozen for X-ray observations.

Direct observations on the reproductive behavior were conducted from April 1989 through December 1989 in the Okinawa Expo Aquarium, Motobu, Okinawa. During this period two female (250 and 263 cm TL) and one male (220 cm TL) *N. concolor* were observed while in captivity.

## RESULTS

### Reproductive anatomy

#### *The ovary*

In the October 272 cm TL pregnant female, the right ovary (about 30 cm length, 25 cm width, and 8 cm thickness) was much larger in size than the left one (7 cm length, 5 cm width, and 2 cm thickness). The right ovary was densely filled with a large number of yolked oocytes of 20–23 mm diameter (Fig. 4) while a small number of non-yolked oocytes of 2–5 mm diameter were observed on the ventral surface of the left ovary (Fig. 7). Several concavities (probably, postovulatory follicles) at varying sizes of 5 to 15 mm diameter were formed on the anterior end of the right ovary (Fig. 5).

In the November 280 cm TL non-pregnant female, the right ovary appeared to have contained many more postovulatory follicles than yolked oocytes. In addition, postovulatory follicles in the November ovary were much greater in number than those in the October ovary. Like the October female, the left ovary was much smaller in size than the right one.

#### *The uterus*

In the October 272 cm TL female, numerous transversely running folds of about 2 mm height were formed regularly on the internal surface throughout the uterus (Fig. 7). Yolk material, probably an ovulated egg was observed to have flowed out from the anterior part of the left oviduct when dissected.

In the uterus of the November 280 cm TL female, numerous regularly arranged folds similar to those in the October sample were observed. No embryos or egg capsules were found in the uteri. However, both uteri were flaccid and the

November 280 cm TL female appeared to have given birth recently.

#### *The egg capsule*

An egg capsule was found in each uterus of the October 272 cm TL female. The egg of about 45 mm diameter was contained in a transparent, pale-brown, onion-shaped egg capsule measuring about 90 mm length, 50 mm width, and 25 mm thickness (Fig. 6). Each nidamental gland contained an egg capsule enclosing a single egg (Fig. 7). The egg capsule was similar in shape to that found in the uterus, but was a little smaller in size. Unlike those found in the uteri, the egg capsule in the nidamental gland was not transparent and was white in color.

#### *The embryo*

The head of an embryo was seen protruding from the cloaca of the 272 cm TL female *N. concolor* when landed at the fish market. On dissection, the embryo was found to have been contained in the left uterus. The embryo measured 59.5 cm TL and had an extraordinarily swollen abdomen (Fig. 8).

After dissecting the abdomen of the embryo, it was found that a large amount of yolk material was packed densely in the distended stomach (Fig. 9), resulting in the extraordinarily swollen abdomen. The stomach wall was very thin.

### **Reproductive behavior in captivity**

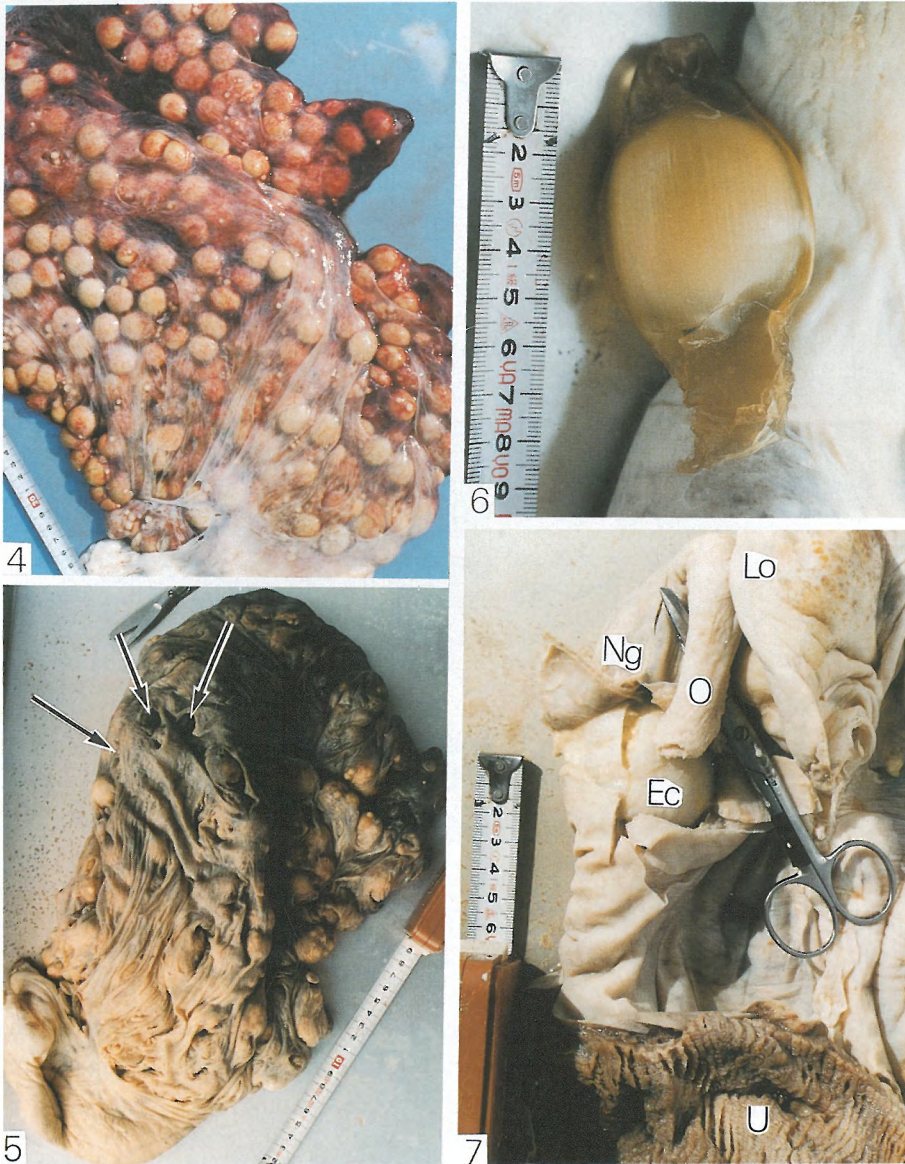
Around August of 1989, it was noticed that the abdomen of the 263 cm TL female *N. concolor* had began to swell. This female was confirmed to have laid 53 egg capsules in the tank from October 31 through December 6 1989. A yellowy brown, flattened, oval shaped egg capsule containing a single egg was 100–120 mm length and 55–65 mm width, and about 40 mm thickness (Fig. 10). Eleven egg capsules were collected for further observations. Some were kept in a tank separate from other fish. However, about a month later yolk material was noticed flowing out of the capsules and they were obviously rotting.

### **Absence of the second dorsal fin**

Of the two sharks caught on October 5 1994, the 272 cm TL female (referred to as A) was found to be lacking the second dorsal fin (Fig. 1). All other external characters were identical with those of the 280 cm TL female. However, a 59.5 cm TL embryo, found in the left uterus of A, was normal in shape and had the second dorsal fin (Fig. 8).

Of the four sharks caught on November 5 1994, a 177 cm TL female (referred to as B) and a 276 cm TL male (referred to as C) lacked the second dorsal fin (Figs. 2, 3). Unlike A, which had a smooth dorsal profile where the second dorsal fin should have been, this area was raised into a bump in B and C (Figs. 2, 3).





**Fig. 4.** Right ovary of a 272 cm TL female tawny nurse shark containing a large number of mature oocytes.

**Fig. 5.** Right ovary of a 272 cm TL female tawny nurse shark containing postovulatory follicles (arrows) of varying sizes.

**Fig. 6.** An egg capsule found in the uterus of a 272 cm TL female tawny nurse shark.

**Fig. 7.** An egg capsule found in the nidamental gland of a 272 cm female tawny nurse shark. Uterus with numerous folds on its internal surface. Ec; egg capsule, Lo; left ovary, Ng; nidamental gland, O; oviduct, U; uterus.

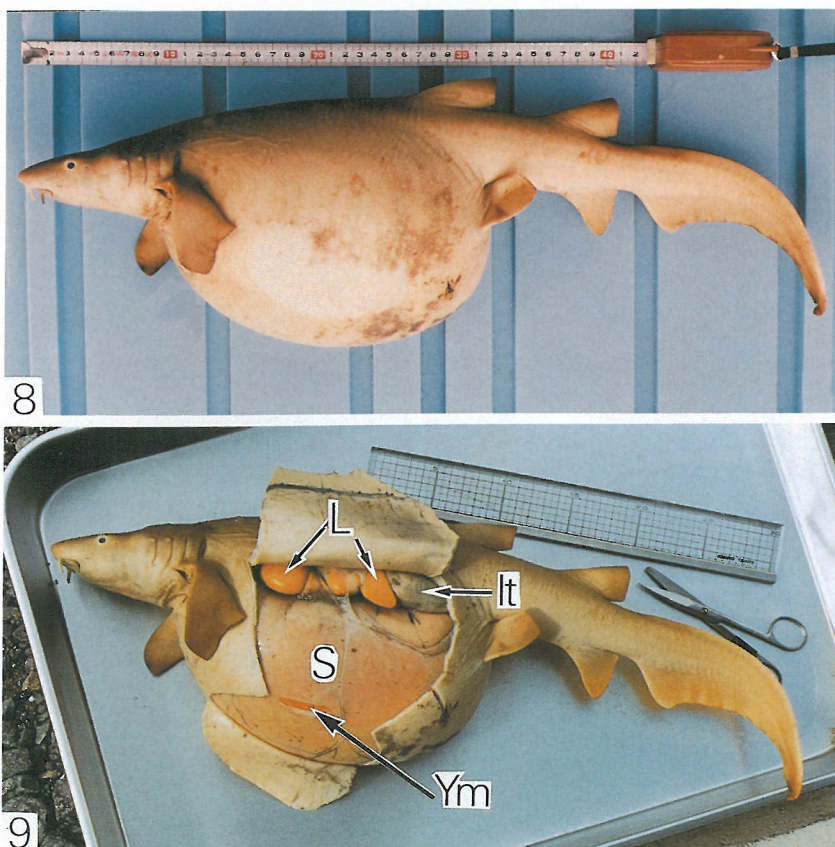


Fig. 8. An embryo of 59.5 cm TL with an extraordinarily swollen abdomen.

Fig. 9. An embryo of 59.5 cm TL with a distended stomach in which a large amount of yolk material was densely packed. It; intestine, L; liver, S; Stomach, Ym; yolk material.

The raised area in B appeared to be larger in size than in C. The raised areas in B and C appeared to be formed by tissues other than cartilage; cartilage could be seen in the anal fin of B (Fig. 11) and C in X-ray photographs.

## DISCUSSION

### Reproductive mode

The right ovary of the October 272 cm TL female had a large number of yolked oocytes of 20–23 mm diameter that appeared ready to be ovulated, as well as postovulatory follicles of varying sizes. At the same time, this female had an egg capsule containing an egg in each of the nidamental glands and uteri. The presence of mature eggs and postovulatory follicles in the ovary and an egg





**Fig. 10.** Egg capsules released in a tank by a 263 cm TL female being kept in captivity at Okinawa Expo Aquarium.

**Fig. 11.** A x-ray photograph of the raised area (indicated by an arrow) of a 177 cm TL female where the second dorsal fin would normally be. Af; anal fin.

capsule in the nidamental glands and uteri suggest that ovulation was occurring at the time that the shark was captured. The presence of a large number of mature eggs in the ovary suggests that ovulation might have continued to occur if this shark had not been captured.

The 59.5 cm TL embryo, found in the left uterus of the October 272 cm TL adult, had an extraordinarily extended stomach in which a large amount of yolk

material was densely packed. No trace of the yolk (umbilical) stalk scar was found on its abdomen and no placental connection was formed. The extended stomach of the embryo densely filled by a large amount of yolk material, an egg capsule in the nidamental glands and uteri, and possible successive ovulation indicate that the 59.5 cm TL embryo might have fed on the supply of ovulated eggs and stored ingested yolk material in its stomach, resulting in the greatly swollen abdomen (Figs. 8, 9). It is, therefore, suggested that the reproductive mode of *N. concolor* is oophagy in which the embryo obtains nourishment by feeding on the supply of ovulated eggs.

Egg capsules, released by the female tawny nurse shark kept in captivity in the aquarium were slightly larger in size than those found in the uteri of the dissected pregnant female. In each case, a single egg was contained in each egg capsule. The female shark that released the 53 egg capsules was probably not pregnant. The non-pregnant female might produce larger egg capsules, although the reason for this was not determined.

The lamniform sharks are known to include several oophagous species; *Carcharias taurus* (Springer, 1948), *Pseudocarcharias kamoharai* (Fujita, 1981), *Alopias pelagicus* (Otake and Mizue, 1981), *Isurus oxyrinchus* (Cadenat, 1956) and *Lamna nasus* (Bigelow and Schroeder, 1948). In addition to the lamniform sharks, evidence presented in this paper suggests that one orectolobid shark, *Nebrius concolor* is also oophagous.

In the literature (Compagno, 1984; Last and Stevens, 1994; Randall, 1986; Randall et al., 1990), *N. concolor* is reported to be an ovoviviparous species that retains the egg capsules until they hatch and the embryos are born. Length at birth is reported to be about 40 cm, with the number of embryos being at least four per uterus (Last and Stevens, 1994; Randall et al., 1990).

The 59.5 cm TL present embryo found in the uterus was much larger than the length at birth reported previously. The greatly extended yolk-stomach suggests that development was not complete and it is considered that length at birth for *N. concolor* is greater than 60 cm TL in the Yaeyama area.

The large difference in birth size (about 20 cm) suggested between this study and previous literature reports should be clarified by examining an entire embryonic series and determining if the difference may be due to geographical variation.

#### **Absence of second dorsal fin**

Including specimens examined in this study, seven individuals of *N. concolor* have been reported to be missing the second dorsal fin as summarized in Table 1 (Taniuchi and Yanagisawa, 1987; Teng, 1962; Yanagisawa, 1983; Yoshino et al.,



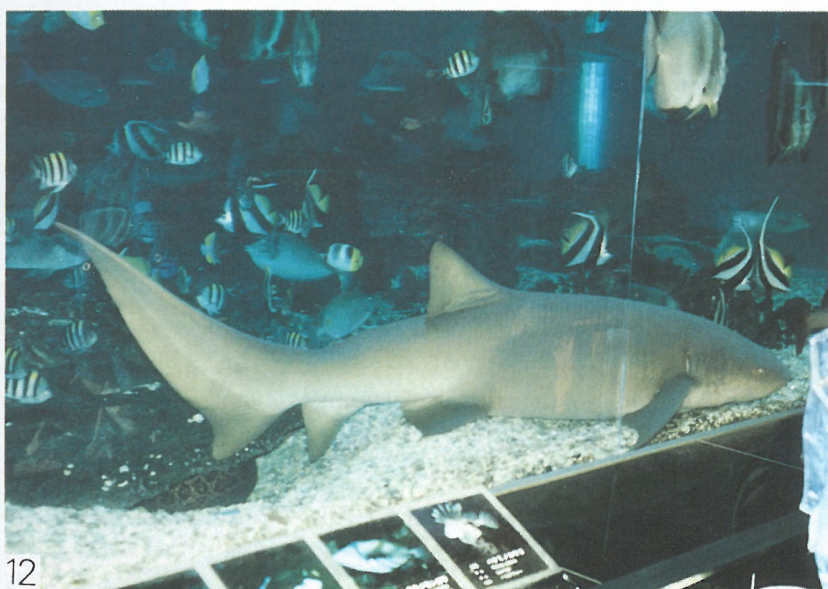
**Table 1.** Tawny nurse sharks missing the second dorsal fin

Authors	Year	Locality	TL	Sex
Teng	1956	Keelung	248 cm	Male
Yoshino et al.	1979	Ishigaki	106 cm	Female <sup>a)</sup>
Yanagisawa	1981	Wakayama	282 cm	Male
Taniuchi and Yanagisawa	1986	Wakayama	290 cm	Male <sup>b)</sup>
Present study	1994	Ishigaki	273 cm	Female
			276 cm	Male <sup>c)</sup>
			177 cm	Female <sup>c)</sup>

a) This female is now being kept at Okinawa Expo Aquarium since capture. Present total length; 265 cm (as of December 20 1994).

b) Albinism

c) Area, where the second dorsal fin is normally formed, was raised up.



**Fig. 12.** A female tawny nurse shark missing the second dorsal fin which is now being kept in captivity in the Okinawa Expo Aquarium (see Table 1).

1981). These include three females and four males, indicating that lacks of the second dorsal fin might not be caused by sexual differentiation. A 59.5 cm TL embryo had the second dorsal fin although its mother lacked the second dorsal fin. The second dorsal fin is thought to be lost during embryonic development before the young are born as no trace of this fin was visible in X-ray photographs.

At present, we do not know why this phenomenon occurs. However, the following points are of relevance; 1) the percentage occurrence of specimens

lacking the second dorsal fin, 2) does the loss of the fin occur before or after birth? If before birth, embryological and genetic studies are needed. If after birth, factors such as environmental or oceanographic conditions that may induce loss of this fin should be clarified. As Table 1 shows, the occurrence of individuals lacking the second dorsal fin is not rare in the Yaeyama areas.

In Japanese waters, *N. concolor* that were missing the second dorsal fin was first reported by Yoshino et al. in 1981. This female shark has been kept in captivity in the Okinawa Expo Aquarium for 15 years since its capture (Fig. 12). As of December 1994, this shark was 265 cm TL and had grown over 106 cm TL since it was captured in the Yaeyama area in 1979.

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## 八重山諸島から得られたオオテンジクザメの生殖様式と

### 第2背鰭を欠く個体

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#### 抄

#### 録

1994年10月5日に竹富島南東の浅海域で、2個体の雌のオオテンジクザメ、*Nebrius concolor*, (全長272, 280cm) が捕獲された。2個体の内、全長272cmの雌は妊娠しており、左の子宮に腹部が異常に肥大した全長59.5cmの胎児1個体を、左右の子宮に卵殻を1個ずつ有していた。胎児の肥大した胃は卵黄物質で充満されていた。右側の卵巣には多数の成熟卵があり、先端にはさまざまな大きさの排卵後濾胞とみえる窪みが観察された。また、左右の卵殻腺内には、不透明な白色の卵殻が1個ずつ見られ、卵殻内には1個の卵が

あった。多数の成熟卵、排卵後濾胞、卵殻腺及び子宮内の卵殻の存在から、全長272cmの雌のオオテンジクザメは10月5日の採集時には継続して排卵を行っていたことが示唆される。これらのことと胎児の腹部の状態から、オオテンジクザメの生殖様式は卵食性 (Oophagy) の可能性が高い。

1994年10, 11月に捕獲された6個体のオオテンジクザメの内、3個体が第2背鰭を欠いていた。第2背鰭を欠いた原因は不明であるが、これらの個体の出現は八重山域では、珍しいものではないといえる。