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The Occurrence of Two Lanternsharks of the Genus *Etmopterus* (Squalidae) in Taiwan

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Abstract Two forms of the lanternshark, *Etmopterus*, reported from Taiwan waters under the name *Etmopterus lucifer* were reexamined. *E. lucifer* sensu Teng (1959), Chen (1963) and Shen and Ting (1972) does not conform to the original description of *E. lucifer* Jordan et Snyder, 1902. One form described by Shen and Ting (1972) conforms to *E. splendidus* Yano, 1988, whereas another form reported by Teng (1959) and Chen (1963) agrees well with *E. molleri* (Whitley, 1939). These were identified based on a combination of the following characters: shape and length of the flank and caudal markings, position of the posterior end of flank markings, shape of the upper teeth, distributional patterns of dermal denticles on the second dorsal fin and preoral area, and length of the caudal peduncle.

Sharks of the genus *Etmopterus* are reported from northeastern and southwestern Taiwan waters, and are easily captured by bottom trawlers at depths below 200 meters. So far, over twenty nominal species of *Etmopterus* have been described from various parts of the world. Compagno (1984) recognized 17 species as valid, although he stated that several species were poorly known and of uncertain validity. Among these species, only one was reported to occur in Taiwan waters, namely, *E. lucifer* (Teng, 1959; Chen, 1963). Later, Shen et al. (1972) reported two forms of *E. lucifer* occurring in northeastern Taiwan waters (off Tahsi), based on the combination of shape of the upper teeth, length of the head and length of the caudal fin.

Yamakawa et al. (1986) suggested that six nominal species of the genus *Etmopterus*, i.e., *E. granulosus* (Günther, 1880), (=*E. baxteri* Garrick, 1957 after Tachikawa et al., 1989), *E. lucifer* Jordan et Snyder, 1902, *E. villosus* Gilbert, 1905, *E. brachyurus* Smith et Radcliffe, 1912, *E. molleri* (Whitley, 1939) and *E. bullisi* Bigelow et Schroeder, 1957, possess a peculiar arrangement of dermal denticles on the trunk and tail. They referred the six species to the "*E. lucifer* group". Yano (1988) treated *E. schmidti* as a synonym of *E. molleri* or *E. brachyurus*. Later, Yano (1988) described *E. splendidus* as a new species clearly belonging to the species complex. When examining the two types of *E. lucifer* as reported by Shen and Ting (1972), we found that form A (Fig. 2 A in Shen and Ting, 1972) did not conform to any species of the "*E. lucifer* group" given by Yamakawa et al. (1986) but agreed well with *E. splendidus* in having differently shaped flank markings.

Concerning the synonymy within "the *E. lucifer* group", Bigelow and Schroeder (1957) synonymized *E. molleri* with *E. brachyurus*. On the other hand, Garrick (1960) regarded *E. molleri* and *E. abernethyi* as synonymous with *E. lucifer*. However, Compagno (1984) recognized several differences between the holotypes of *E. lucifer* and *E. brachyurus*. Yamakawa et al. (1986) examined 311 specimens within the "*E. lucifer* group", and reexamined the holotypes and paratypes of six species, i.e., *E. lucifer*, *E. villosus*, *E. brachyurus*, *E. molleri*, *E. abernethyi* and *E. bullisi*. They suspected that some reports of the occurrence of *E. lucifer* were probably based on *E. brachyurus* and/or *E. molleri*.

The purpose of this study is to compare the two forms of *E. lucifer* sensu Shen and Ting (1972) with three other species, i.e. *E. lucifer*, *E. brachyurus*, and *E. molleri* based on specimens collected from northeastern Taiwan waters, in order to clarify the status of the two forms of *E. lucifer* sensu Shen and Ting (1972).

Materials and methods

Fifty-five specimens of the two forms of the genus *Etmopterus* were collected from northeastern Taiwan waters off Tahsi in 1988 and 1989 (Fig. 1). All specimens were caught with bottom trawlers at

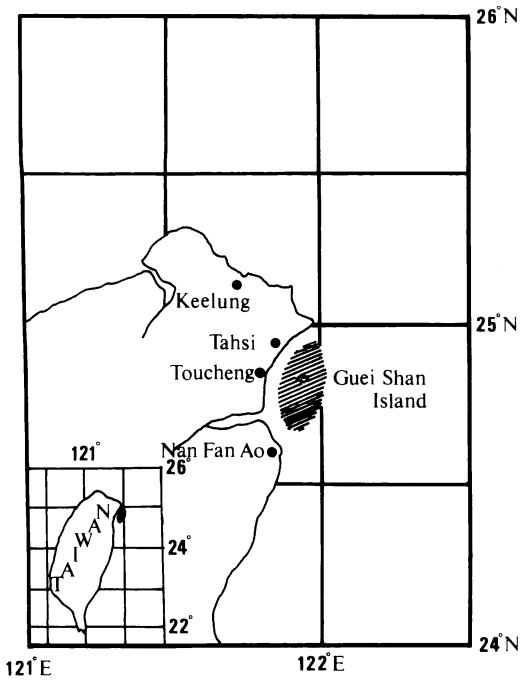

Fig. 1. Collection area of specimens examined in this study.

depths greater than 200 meters, and were examined after preservation in formalin solution. They are currently deposited at the Department of Fisheries, National Taiwan Ocean University. The specimen labelled TFRI3836, described by Teng (1959), was also reexamined. Measurements followed Yamakawa et al. (1986). The shape of the flank and caudal markings was examined. The shape of the upper teeth were studied under a binocular microscope. Dermal denticles on the trunk below the first dorsal fin, distributional pattern of dermal denticles on the preoral area, and presence or absence of dermal denticles on the second dorsal fin surface were also observed by microscope.

Results

By comparing the characters of the two forms of *E. lucifer* sensu Shen and Ting (1972) with the key to the "*E. lucifer* group" suggested by Yamakawa (1986), forms A and B (Fig. 2A in Shen and Ting, 1972) can be separated easily from *E. villosus*, *E. granulosus* and *E. bullisi*. Firstly, form A does not possess the peculiar arrangement of dermal denticles on the trunk and tail, which defines a member of the so-called "*E. lucifer* group". Secondly, dermal denticles on the head of form B are in regular longitudinal rows, this character distinguishing the species from *E. villosus* and *E. granulosus*. Although dermal denticles on the head of *E. bullisi* are also arranged in regular longitudinal rows, caudal and flank markings and distributional patterns of denticles are different between *E. bullisi* and form B. Thirdly, caudal and flank markings are indistinct in *E. bullisi* but distinct in form B, and denticles which are widely spaced in *E. bullisi* are closely spaced in form B.

Comparison of flank and caudal markings

The two forms of *Etmopterus* considered in this study and the three species of the *E. lucifer* group reported from Japanese waters, *E. molleri*, *E. brachyurus* and *E. lucifer* after Yamakawa et al. (1986) are clearly distinguishable by the combination of arrangement of flank and caudal markings (Fig. 2) and proportional dimensions (Table 1). These distinguishing features are described as follows:

Firstly, the shape of the flank marking of form A is different from other four species. The flank marking of form A is extended narrowly in the anterior part, but broadly in the posterior part of the pelvic fins. This feature is identical with that of *E. splendidus* described by Yano (1988).

Secondly, the posterior branch of the flank marking of form B is longer than that of the anterior. This character is similar to that of *E. brachyurus* and *E. molleri* (Fig. 2, Table 1, 2), but differs from *E. lucifer*.

Thirdly, the caudal marking of form B constitutes 3.7–6.4% of total length, and in *E. brachyurus* 5.0–7.0% (Table 1). Hence, form B and *E. brachyurus* can not be distinguished from one another by the length of the caudal markings alone. However, the shape of the caudal marking with a slightly rounded tip in form B is quite different from that of *E. brachyurus*. *E. brachyurus* has the caudal marking extending dorsally from the lower base of the caudal fin with a sharply pointed tip (Fig. 2).

Fourthly, the position of the posterior end of the base of the flank markings of form B is very close to or just above the origin of the second dorsal spine (Fig. 2). This character seems closer to *E. lucifer* than to *E. brachyurus* or *E. molleri* (Fig. 3 in Yamakawa, 1986).

Distance between second dorsal and upper caudal origins

The distance between the second dorsal and upper

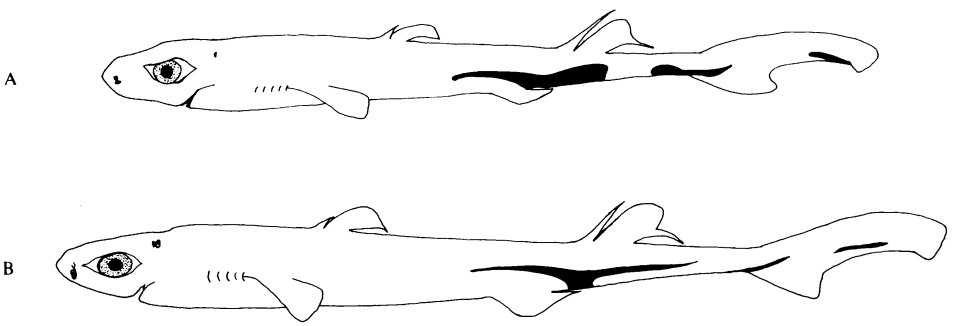

Fig. 2. Flank and caudal markings of two forms of *Etmopterus* in Taiwan. A, 127.6 mm in TL, female; B, 293.2 mm in TL, female.

caudal origins in *E. brachyurus*, *E. molleri*, and forms A and B is usually twice as long as the distance between the first dorsal and second dorsal origins, whereas the reverse is true in *E. lucifer* (Table 1; Table 3 in Yamakawa, 1986). Usually, *E. lucifer* possesses a shorter caudal peduncle, but *E. lucifer* described by Teng (1962), Chen (1963) and Shen and Ting (1972, Fig. 2B) possess a longer caudal peduncle, its distance between the second dorsal and upper caudal origin being usually longer than 14% of TL (Table 1).

Comparison of the shape of upper teeth

Shen and Ting (1972) noted that the number of lateral cusps on the upper teeth in forms A and B varied with growth. After examining the two types, we found that female specimens of form A possess two, four or six lateral cusps (14 specimens, 110.9–273.7 mm TL) and male specimens possess two or four lateral cusps (19 specimens, 100.0–217.8 mm TL), both sexes varying with growth (Fig. 3). This character seems a little different from that of *E. splendidus* Yano, 1988. Yano (1988) described the upper teeth of *E. splendidus* as having four lateral cusps (five cusps) in female specimens but six lateral cusps (seven cusps) in a male specimen. However, the specimens examined by Yano (1988) (female: 4 specimens, 247 mm, 298 mm, 178 mm, 203 mm TL; male: 1 specimen, 227 mm TL) are larger than those examined by us. As the number of lateral cusps increases with growth in the case of both *E. granulosus* (Tachikawa personal communication) and in form A, the difference in the number of lateral cusps between *E. splendidus* and form A can be regarded as being due to different growth stages. Similar changes with growth in the number of lateral cusps are also observed in both sexes in form B. The number of lateral cusps is a little different between sexes in form B. Female specimens have two or four lateral cusps, while males have two, four, six or eight lateral cusps and vary with growth. In general, two different numbers of lateral cusps (2, 4; 4, 6; ··· etc.) can be found in the same jaw in both sexes.

On the other hand, the shape of teeth is quite different between the two forms. The cusps of form A (100–280 mm TL) are rather narrow and erect, while those of form B (123–336 mm TL) are wider and slightly arched (Fig. 3). The shape of teeth did not vary between sexes in either form.

Distributional patterns of dermal denticles on the preoral area and second dorsal fin

Distributional patterns of dermal denticles on the preoral areas of forms A and B are illustrated in Fig. 3. The preoral area is covered entirely with dermal denticles in form A (33 specimens, 100–280 mm in TL), but has a patchy distribution of denticles in form B (23 specimens, 123–336 mm in TL). On examining the second dorsal fin surface of form B and TFRI3836, we found dermal denticles to be absent from this region in all specimens (Table 2). This condition occurs in *E. molleri* as described by Yamakawa et al. (1986) (Table 4 in Yamakawa, 1986).

For these reasons, form A is considered to be identical with *E. splendidus* Yano, rather than with any species in the *E. lucifer* complex.

The characteristics of form B are summarised as follows: 1) the length of the posterior branch of the flank marking is longer than that of the anterior branch; 2) the caudal marking has a slightly rounded tip; 3) the posterior end of the base of the flank marking is very close to or just above the origin of the second dorsal spine; 4) the caudal peduncle is

Table 1. Proportional dimensions in percent of total length of two forms of *Etmopterus* in Taiwan. The specimen TFRI3836 was collected by Teng in 1958.

Form		A		B		TFRI3836
Number of specimens		33		22		1
		mean	range	mean	range	
Total length (mm)		143.5	100–280	243.7	123–336	286
Snout tip to:						
eye		5.3	3.5–6.7	4.2	2.6–5.1	3.9
mouth		10.6	8.2–12.2	9.9	8.1–11.7	8.4
spiracle		13.2	11.2–15.3	12.3	10.2–14.3	10.5
1st gill opening		19.1	16.8–20.8	17.4	15.0–19.6	15.8
pectoral origin		24.4	21.6–26.5	21.7	19.6–24.1	19.7
pelvic origin	(m)	52.4	49.1–56.4	48.1	44.6–50.4	45.9
	(f)	52.8	50.3–55.4	49.9	46.9–52.2	—
1st dorsal origin	(m)	32.8	29.6–35.0	31.9	28.5–34.2	29.3
	(f)	33.4	31.9–35.6	32.7	31.4–34.7	—
2nd dorsal origin	(m)	58.8	56.0–62.9	57.6	53.5–59.9	56.7
	(f)	60.1	56.6–62.4	58.7	56.2–60.6	—
rear margin of flank marking	(m)	65.7	63.1–72.9	57.6	54.3–59.6	56.1
	(f)	64.5	52.1–69.1	58.7	56.7–62.0	—
upper caudal origin		78.5	65.3–84.4	78.6	73.2–81.3	77.4
Distance between fin bases:						
1st and 2nd dorsal	(m)	22.7	20.2–25.2	22.6	20.9–24.8	24.4
	(f)	23.4	20.4–27.3	23.0	20.4–25.7	—
2nd dorsal and caudal	(m)	14.0	9.7–15.7	15.1	12.6–15.9	15.6
	(f)	14.4	11.9–19.3	14.7	13.5–15.6	—
pectoral and pelvic	(m)	23.3	20.8–27.3	22.3	20.1–25.1	22.2
	(f)	24.9	21.6–29.2	22.9	18.4–26.2	—
pelvic and caudal	(m)	20.2	18.2–22.8	20.7	18.8–23.2	21.6
	(f)	19.7	17.4–23.9	21.3	19.9–23.6	—
Distance between origins of						
pectoral and pelvic	(m)	28.7	26.0–36.4	27.1	25.2–28.9	26.3
	(f)	30.2	26.0–38.3	28.7	24.9–32.9	—
Mouth width		8.3	6.7–10.3	7.4	6.5–8.7	—
Horizontal diameter of eye		6.9	5.2–8.8	6.6	5.5–8.3	6.0
1st dorsal fin:						
overall length		8.0	7.1–9.7	6.9	6.1–7.8	7.1
length of inner margin		4.6	3.5–5.5	4.1	3.4–4.9	4.0
height		2.3	1.8–3.2	2.8	2.0–3.6	2.9
spine length		2.9	1.7–3.6	2.8	2.4–3.9	—
2nd dorsal fin:						
overall length		10.9	9.5–12.5	10.1	8.4–11.7	9.7
length of inner margin		5.9	4.6–7.3	5.8	4.2–6.8	5.9
height		3.4	2.4–5.8	4.3	3.2–6.2	5.0
spine length		6.3	4.9–7.6	6.1	4.7–8.9	5.2
Pectoral fin:						
length of ant. margin		9.6	7.8–11.6	10.1	8.1–11.6	10.2
Pelvic fin:						
overall length		8.9	6.9–11.1	10.2	7.5–12.1	10.3
Caudal fin:						
length of upper lobe		21.7	17.9–23.8	21.5	18.0–24.8	22.3
length of lower lobe		11.6	9.5–14.6	10.2	8.5–12.1	10.1
Trunk at pectoral origin:						
width		10.6	9.0–12.2	10.3	9.7–11.7	9.1
height		9.0	6.4–10.8	8.0	6.7–9.3	8.5
Flank marking:						
length of ant. branch		9.0	4.0–11.5	10.5	8.6–12.0	11.0
length of post. branch		—	—	13.3	10.9–14.9	14.0
Caudal marking:						
length		7.7	6.3–9.5	4.9	3.7–6.4	4.2

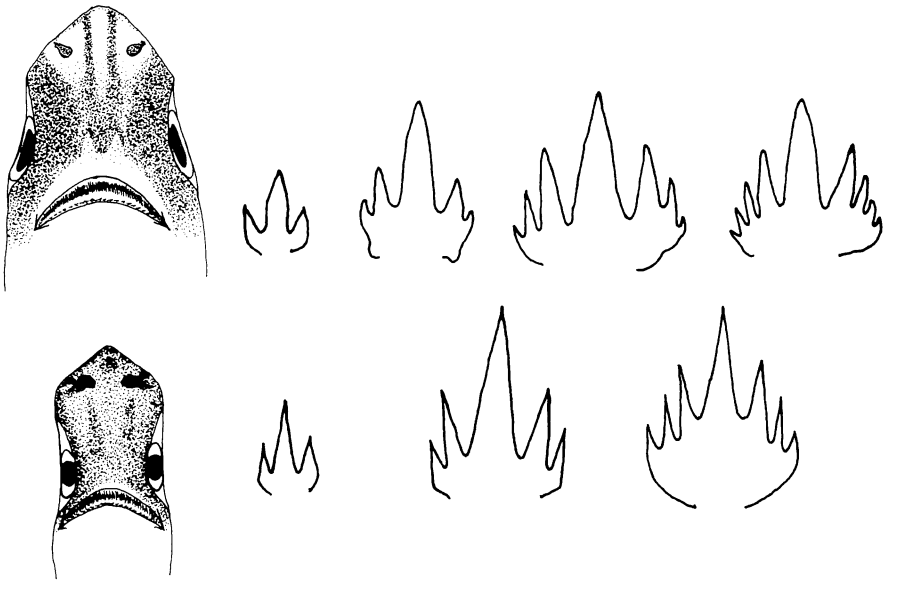

Fig. 3. Shape of teeth (×40) and distributional patterns of dermal denticles on preoral area of *E. molleri* (upper, =form B) and *E. splendidus* (lower, =form A).

longer; 5) dermal denticles are absent from the surface of the second dorsal fin. Although the position of the posterior end of the base of the flank marking is similar to that of *E. lucifer*, we conclude that form B is actually *E. molleri*, rather than *E. brachyurus* or *E. lucifer*.

Etmopterus splendidus Yano, 1988
(Fig. 4)

Etmopterus splendidus Yano, 1988: 421 (type locality: East China Sea and Java Sea).

Etmopterus lucifer (not of Jordan and Snyder, 1902): Shen and Ting, 1972: 15, Fig. 2A.

Materials. 19 male specimens (NTOU8921, 8923–24, 8926–30, 8932–33, 8935–38, 8850–51, 8854, 8860, 8863), 100.0 mm to 217.8 mm in total length (TL); 14 female specimens (NTOU8922, 8925, 8931, 8934, 8939, 8852–53, 8855–58, 8861–62, 8864), 110.9 mm to 280.2 mm TL. All specimens were collected from Tahsi in 1988 and 1989.

Diagnosis. Distance from snout tip to first dorsal spine much less than distance from the spine to upper caudal origin, and longer than distance between the two spines. Distance between first dorsal and second dorsal origins less than twice the distance between second dorsal and upper caudal origins. Dermal denticles on trunk with very small, erect, thornlike, conical crowns and arranged in regular longitudinal rows. Teeth of upper jaws with two, four or six

Table 2. Major diagnostic characters for form B and specimen TFRI3836.

Character	TFRI3836	form B
A	absent	absent
B	119.9	127.5 (109.9–161.1)
C	4.9	5.0 (3.7– 6.4)
D	97.3	100.1 (96.8–104.9)
E	40.7	60.4 (45.7– 80.3)
F (male)	21.2	20.7 (18.8– 23.2)
(female)	—	21.3 (19.8– 23.6)
G (male)	15.2	15.1 (12.6– 16.5)
(female)	—	14.7 (13.5– 15.6)

A: denticles on second dorsal fin.
B: length of posterior branch of flank marking/length of anterior branch of flank marking.
C: length of caudal marking/total length.
D: snout tip to rear margin of flank marking base / snout tip to second dorsal fin spine origin.
E: second dorsal fin height / overall length of second dorsal fin.
F: interspace between pelvic fin and lower caudal origin/total length.
G: interspace between second dorsal fin and upper caudal origin/total length.

Fig. 4. *Etmopterus slendidus* NTOU 8857, 280.2 mm TL, female.

Fig. 5. *Etmopterus molleri* NTOU 8817, 336.3 mm TL, female.

lateral cusps in females but two or four lateral cusps in males, varying with growth. Dermal denticles on dorsal surface of interorbital not arranged in longitudinal rows. Color in life purplish-black above, with inconspicuous bluish-black flank and three other bluish-black marks at base of caudal fin and along its axis, shape of flank marking narrow anterior to, but broder posterior to pelvic fins.

Etmopterus molleri (Whitley, 1939)
(Fig. 5)

Acanthidium molleri Whitley, 1939: 227 (type locality: New South Wales, Australia).

Etmopterus lucifer (not of Jordan and Snyder, 1902): Teng, 1962: 163, Fig. 41; Chen, 1963: 84, Fig. 26; Shen and Ting, 1972: 15, Fig. 2B.

Materials. 13 male specimens (NTOU8812, 8814–16, 8818–20, 8823, 8825, 8827–28, 8831–32), 133.0 mm to 333.3 mm TL, collected from Tahsi in 1988 and 1989; 9 specimens of female fish (NTOU8811, 8813, 8817, 8821–22, 8824, 8826, 8829–30), 123.4 mm to 336.3 mm TL, collected from Tahsi in 1988 and 1989; TFRI3836, 286 mm TL, male, Tung-kang, 1959.

Diagnosis. Distance from snout tip to first dorsal spine much less than distance from the spine to upper caudal origin, and about equal to distance between the two spines. Distance between first dorsal and second dorsal origins less than twice distance between second dorsal and upper caudal origins. Teeth of upper jaws with two or four lateral cusps in females and two, four, six or eight cusps in males, varying with growth. Dermal denticles on lateral trunk with very long, erect thornlike, conical crowns. Denticles on interdorsal area, dorsal surface of interorbital and laterally between second dorsal and caudal fins arranged in regular longitudinal rows. Color in life bluish above, becoming brownish gray following death; abdomen dark brown, with a longitudinal whitish band on lower body, and an inconspicuous bluish-black flank marking and three other bluish-black markings at base of caudal fin and along its axis. Length of posterior branch of flank marking longer than that of anterior branch.

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台湾産カラスザメ属の2種について

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これまでにフジクジラ (*Etmopterus lucifer*) として台湾から記載された標本を形態学的に調査した．Teng (1959), Chen (1963) および Shen and Ting (1972) の *E. lucifer* は本種の原記載とは一致しなかった．Shen and Ting (1972) の *E. lucifer* は *E. splendidus* Yano, 1988 と一致し，また Teng (1959) と Chen (1963) の *E. lucifer* は *E. molleri* (Whitley, 1939) と一致した．これら2種の形態の比較を行った．