

Distribution of Hagfish (Myxinidae: Myxiniformes) in Taiwan

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(Accepted April 11, 2001)

Hin-Kiu Mok and Ya-Wen Chen (2001) Distribution of hagfish (Myxinidae: Myxiniformes) in Taiwan. *Zoological Studies* 40(3): 233-239. Forty-two stations in northern, northeastern, southeastern, and southwestern waters surrounding Taiwan and 2 stations in the northern South China Sea were sampled by traps for hagfishes. Horizontal and depth distributions and numbers of specimens for 1 *Eptatretus* species, 6 *Paramyxine* species, and 3 undescribed *Myxine* species are reported. *Paramyxine yangi* exhibits a broader horizontal range than do other hagfish species in this region. Two stations in the northern part of the South China Sea were sampled; only *P. yangi* was captured at 1 of these stations. <http://www.sinica.edu.tw/zool/zoolstud/40.3/233.pdf>

Key words: *Eptatretus*, *Paramyxine*, *Myxine*, Taiwan.

In 1958, Teng reported a new hagfish species, *Paramyxine yangi*; the type specimens were collected off Kaohsiung on the southwestern coast of Taiwan (Fig. 1). Chen (1969) documented another species, *Eptatretus burgeri* in Taiwanese waters. Between 1968 and 1975, Shen and Tao put additional effort into collecting hagfish specimens that resulted in 2 new species, *P. cheni* and *P. taiwanae*, as well as additional information about the distribution of *E. burgeri* in Taiwan (Shen and Tao 1975). Their collections were all from trawl landings at Keelung, Nanfanggao, and Tachi, on the northeastern Taiwanese coast, and Tungkang in southwestern Taiwan. Depths of the trawlings, however, were not detailed enough.

Concerning the distribution of these species in Taiwan, Shen and Tao (1975) reported that (1) *E. burgeri* is only found in northeastern waters; (2) *P. taiwanae* is widely distributed from the northeast to the southwest; (3) *P. cheni* is only found from Tungkang; (4) *P. yangi* occurs in northeastern and southwestern waters.

Kuo and his colleagues chartered fishing boats to trap hagfish specimens for their study of deep-sea fishes which was published in 1994 with description of 4 new *Paramyxine* species: *P. fernholmi*, *P. nelsoni*, *P. sheni*, and *P. wisneri*. Their samplings were limited to southwestern waters and a site off

Fukang on the east coast. Coordinates of the sampling stations were not well documented.

A more intensive survey using traps aboard the research vessels *R/V Ocean Researcher II* and *R/V Ocean Researcher III*, owned by National Ocean Univ. and National Sun Yat-sen Univ., respectively, was carried out between Aug. 1996 and July 2000.

The present report documents the distribution of hagfishes and data for the numbers of species and specimens from stations in northern, northeastern, southeastern, and southwestern waters of Taiwan and the northern part of the South China Sea.

COLLECTIONS AND METHODS

Thirty cruises, each lasting 1-3 d, were launched, and 42 stations were sampled covering most coastal waters of Taiwan except for the Taiwan Strait. As the west coast of Taiwan (i.e., the Taiwan Strait) is shallow with depths less than 100 m and mostly sandy bottoms, a habitat generally not utilized by hagfish, no collecting was done in this region. The continental shelf on the east-central coast of Taiwan is very narrow (Fig. 1); no station was set there. Two stations in the northern part of the South China Sea (22°01'N, 119°01'E, 547 m; 22°07'N, 119°03'E, 567 m) were sampled (Fig. 1). Positions of the stations

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were selected at sites where the seabed is relatively flat and bottom-trawl activity is minimal. Depths of stations ranged from 90 to 872 m. Thirty to 50 white plastic cylindrical shrimp traps (diameter 16 cm, length 36 cm, in which a funnel separates the trap into 2 compartments) were deployed at each station. A fresh *Cololabis saira* (ca. 30 cm) was caged in the

rear compartment as bait. These traps were recovered from the seabed 3-15 h after deployment (i.e., bottom time). When the bottom time was long (e.g., > 8 h) for a station deeper than 500 m, some of the trapped fishes, such as synphobranchid eels, were damaged by carnivorous isopods that were also in the same trap. To avoid loss of these eel specimens,

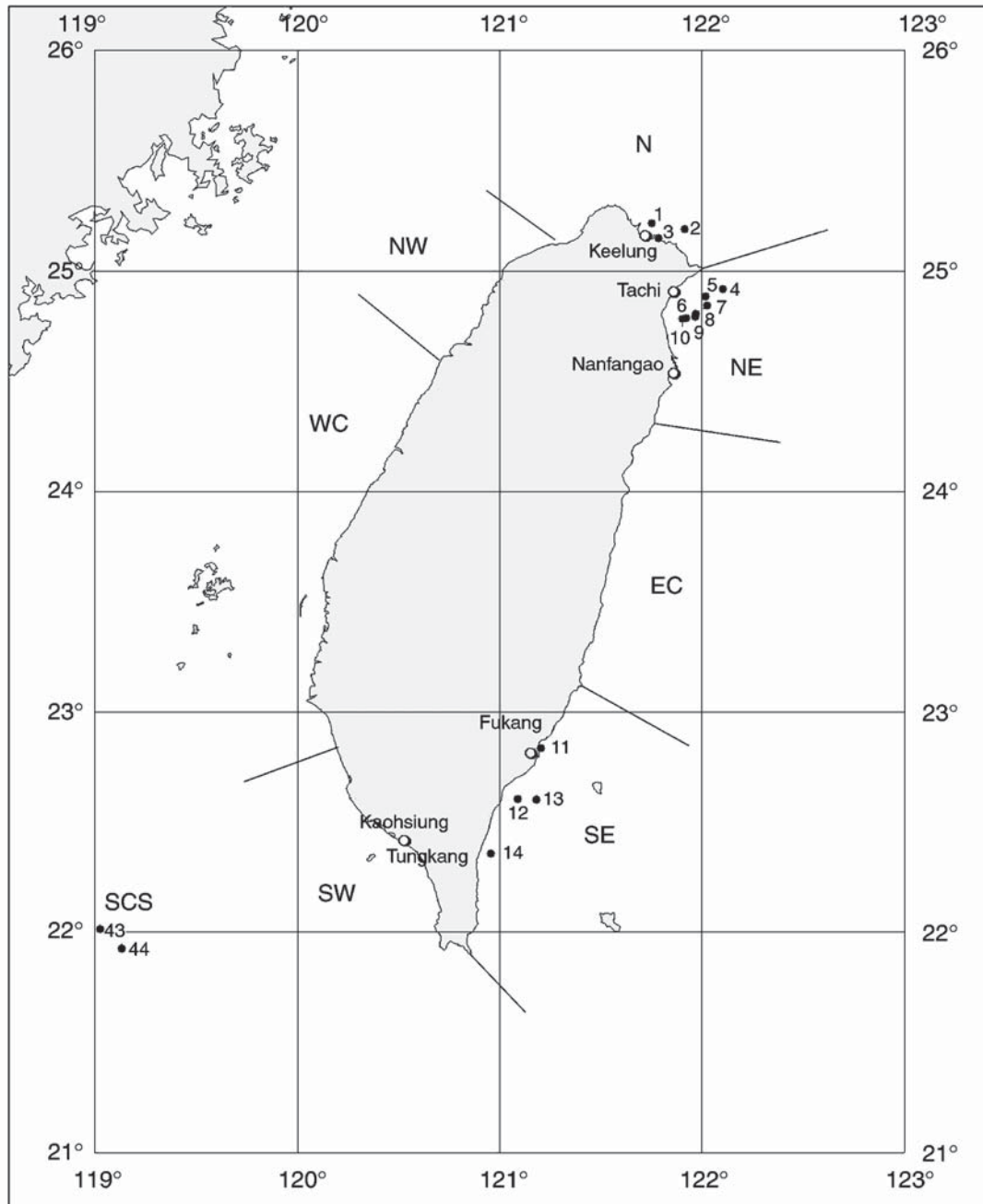


Fig. 1. Distribution of sampling stations in northern (N), northeastern (NE), and southeastern (SE) areas of Taiwanese waters and in the northern part of the South China Sea (SCS). EC: east-central coast; WC: west-central coast of Taiwan. *Eptatretus burgeri* and *Paramyxine sheni* in N; *P. taiwanae*, *P. sheni*, *P. yangi*, and *Myxine* sp. 1 in NE; *P. yangi* in SE and SCS.

Table 1. Station code, coordinates, area code, depth in meters, and numbers of specimens of species from the stations

Station no.	Date	Locality		Area code	Depth (m)	Species	No. of specimens	Range of total length (cm)
1	2000/07/15	25°13'00"N	121°44'58"E	N	90-100	<i>Eptatretus burgeri</i>	1	33.9
2	1998/10/13	25°11'24"N	121°54'44"E	N	173	<i>E. burgni</i>	1	52.0
3	1997/09/25	25°08'55"N	121°47'08"E	N	427	<i>Paramyxine sheni</i>	325	9.8-48.0
4	1997/11/20	24°55'05"N	122°06'07"E	NE	781	<i>Myxine</i> sp. 1	4	26-36.2
5	2000/07/13	24°53'07"N	122°01'08"E	NE	283	<i>P. sheni</i>	1	43.6
6	1997/09/25	24°50'43"N	122°01'25"E	NE	427	<i>P. sheni</i>	24	14.3-23.3
						<i>P. taiwanae</i>	79	9.5-28.8
7	2000/07/14	24°48'30"N	121°58'12"E	NE	263	—		
8	2000/07/13	24°47'31"N	121°57'56"E	NE	276	<i>P. sheni</i>	2	11.8-14.6
9	2000/07/14	24°47'09"N	121°55'13"E	NE	170-200	<i>P. yangi</i>	747	11.2-27.9
10	1997/09/24	24°46'53"N	121°54'05"E	NE	120	<i>P. yangi</i>	95	13-25.8
						<i>P. taiwanae</i>	74	14-30.3
						<i>P. burgeri</i>	76	13.1-29.3
11	1999/05/13	22°49'33"N	121°10'01"E	SE	219-290	—		
12	1999/05/13	22°36'16"N	121°05'19"E	SE	872-859	—		
13	1999/05/12	22°36'13"N	121°10'23"E	SE	261	<i>P. yangi</i>	1	23.5
14	1999/05/13	22°21'29"N	120°57'20"E	SE	193-227	—		
15	1999/06/14	22°38'00"N	120°05'05"E	SW	180	—		
16	1999/08/27	22°30'00"N	120°05'00"E	SW	400	<i>P. fernholmi</i>	1	9.2
17	1998/12/11	22°30'06"N	120°12'34"E	SW	205	—		
18	1997/11/25	22°29'35"N	120°03'34"E	SW	595	<i>Myxine</i> sp. 3	5	12.3-18.7
19	1998/12/12	22°29'29"N	120°06'31"E	SW	412	<i>P. fernholmi</i>	11	10.2-22.5
20	1997/12/31	22°24'25"N	120°15'51"E	SW	179	<i>P. nelsoni</i>	8	13.5-23.4
21	1997/12/18	22°24'13"N	120°13'47"E	SW	268	<i>P. cheni</i>	29	13.2-33.2
22	1999/03/11	22°24'06"N	120°13'55"E	SW	260	<i>P. cheni</i>	5	
23	1998/05/28	22°24'03"N	120°16'36"E	SW	178-186	—		
24	1996/09/25	22°23'30"N	120°16'04"E	SW	190	<i>P. yangi</i>	103	8.3-23.7
						<i>P. cheni</i>	7	9.8-42.3
25	1996/10/05	22°23'25"N	120°14'08"E	SW	384	<i>P. fernholmi</i>	122	10-28.8
26	1998/01/09	22°23'17"N	120°15'31"E	SW	225	<i>P. cheni</i>	21	24.8-71.4
27	1998/03/21	22°23'11"N	120°17'26"E	SW	151	—		
28	1998/01/09	22°23'06"N	120°15'30"E	SW	227	<i>P. cheni</i>	10	23.5-46.3
29	1998/09/25	22°23'03"N	120°16'10"E	SW	230	—		
30	1998/06/23	22°23'00"N	120°14'00"E	SW	250	—		
31	1998/11/21	22°22'55"N	120°15'01"E	SW	250	<i>P. cheni</i>	52	
32	1998/03/08	22°22'55"N	120°09'48"E	SW	585-619	<i>P. sheni</i>	38	13.5-41.6
33	1998/03/20	22°21'51"N	120°12'36"E	SW	373	—		
34	1998/01/10	22°15'34"N	120°06'56"E	SW	753	<i>Myxine</i> sp. 2	45	11-28.8
35	1997/01/15	22°15'04"N	120°33'14"E	SW	250-353	—		
36	1997/01/15	22°14'30"N	120°34'36"E	SW	317	—		
37	1997/04/14	22°14'24"N	120°24'44"E	SW	226-258	<i>P. yangi</i>	335	8.4-26.3
						<i>P. cheni</i>	22	23.5-47.3
38	1996/11/04	22°14'08"N	120°35'37"E	SW	156	<i>P. yangi</i>	70	8.8-26.2
						<i>P. cheni</i>	153	6.6-45.6
39	1996/11/05	22°14'08"N	120°35'07"E	SW	156	—		
40	1997/12/18	22°11'20"N	120°13'42"E	SW	843	<i>Myxine</i> sp. 2	119	9.3-40.6
41	1997/03/07	22°10'38"N	120°36'43"E	SW	213	<i>P. yangi</i>	23	11-25.2
						<i>P. cheni</i>	10	17.6-37.0
42	1996/12/05	22°09'32"N	120°33'04"E	SW	588	<i>P. sheni</i>	1	11.4
43	1997/06/26	22°01'00"N	119°01'00"E	SCS	547	<i>P. yangi</i>	27	12.5-18.1
44	1997/06/26	22°07'00"N	119°03'00"E	SCS	567	—		

Abbreviations of areas of Taiwan: N, northern; NE, northeastern; SE, southeastern; SW, southwestern.

SCS: South China Sea.

—: absence of hagfish specimens.

bottom time for deep stations was set at 3 h. Bottom time for shallow stations was either 3 h or longer depending on sea conditions or the workload of the cruise. All specimens recovered were frozen and later identified to species and then fixed in formalin.

RESULTS

Distribution of the 42 stations in Taiwanese waters can be sorted into 4 geographic areas: northern (3 stations), northeastern (7 stations), southeastern (4 stations), and southwestern (28 stations) (Fig. 1). Numbers of species in these areas were: two species (*Eptatretus burgeri*, *Paramyxine sheni*) in the northern area; five species (*E. burgeri*, *P. taiwanae*, *P. sheni*, *P. yangi*, and *Myxine* sp. 1) in the northeastern area; one species (*P. yangi*) in the southeastern area; and 7 species (*P. cheni*, *P. fernholmi*, *P. nelsoni*, *P. sheni*, *P. yangi*, *Myxine* sp. 2, and *Myxine* sp. 3) in the southwestern area (Table 1; Fig. 2).

Eptatretus burgeri—This species of the genus *Eptatretus* is characterized by a white mid-dorsal stripe (Shen and Tao 1975). It was the only hagfish species trapped from 2 of 3 stations in the northern area; these 2 stations were at depths of between 90 and 173 m (Table 1; Fig. 1). Only 1 specimen was recovered from each of these 2 stations.

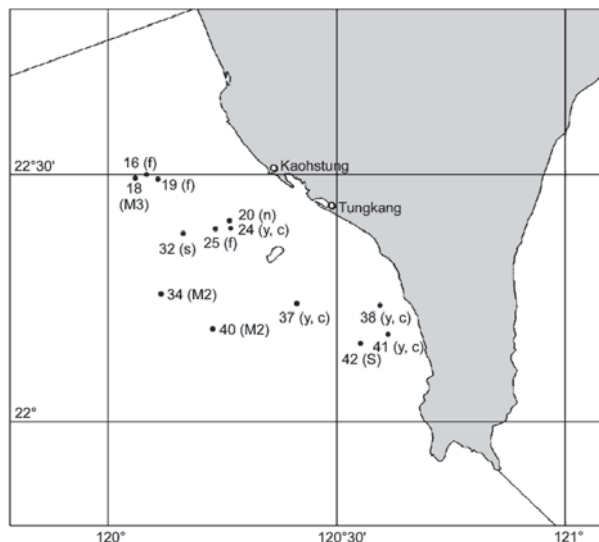


Fig. 2. Distribution of sampling stations in the southwestern waters of Taiwan where specimens of *Paramyxine cheni* (c), *P. fernholmi* (f), *P. nelsoni* (n), *P. sheni* (s), *P. yangi* (y), *Myxine* sp. 2 (M2), and *Myxine* sp. 3 (M3) were captured. The letter in parentheses is the initial letter of the species name.

Paramyxine taiwanae—This is a 6-gilled species, with gill apertures crowded and irregularly spaced (Shen and Tao 1975). This species was restricted to 2 of 7 stations in the northeastern area. Depths of these stations ranged from 120 to 427 m (Table 1; Fig. 1). Numerous specimens were recovered from these stations (Table 1). No specimen of this species was captured in other areas.

Paramyxine yangi—This is a 5-gilled species, with gill apertures crowded and irregularly spaced and a total of 68-79 slime pores (Shen and Tao 1975, Kuo and Mok 1999). It is widely distributed in both the northeastern (2 of 7 stations), southeastern (1 of 3 stations), and southwestern areas (6 of 28 stations) (Table 1; Figs. 1, 2). Most *P. yangi* live on the continental shelf; depths of occurrence ranged from 120 to 261 m (Table 1). Numerous specimens were captured from the northeastern area (Table 1). Relatively speaking, this is the most abundant hagfish species in shallower Taiwanese waters.

Paramyxine sheni—This is a 6-gilled species with 3 fused cusps in both the anterior and posterior cusp sets, and all apertures are arranged in a straight line (Kuo et al. 1994). It is distributed in the northern (1 of 3 stations), northeastern (3 of 7 stations), and southwestern areas (2 of 28 stations) (Table 1; Figs. 1, 2). *P. sheni* dwells below the continental shelf from 276 to 619 m (Table 1). The largest sample with 325 individuals was from a station in

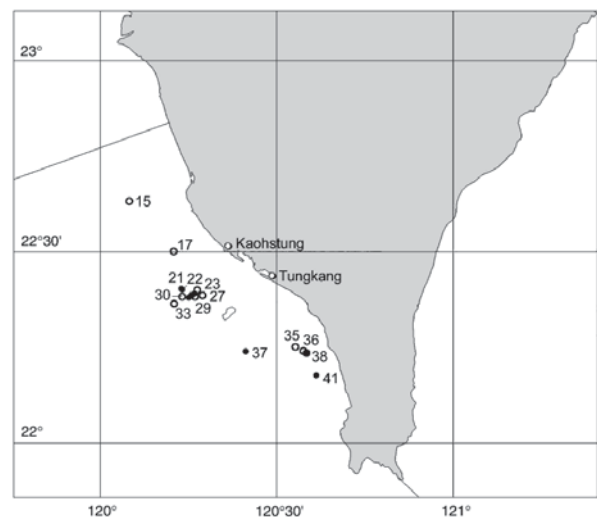


Fig. 3. Distribution of sampling stations in the southwestern waters of Taiwan where specimens of *Paramyxine cheni* were captured. No hagfish specimens were captured at the stations labelled with open circles. Numbers of stns. 21, 22, 24, 26, 28, and 31 where *P. cheni* occurred are not labelled on the map due to the close proximity of the localities.

the northern area (Table 1). The size range of specimens from that catch was broad (i.e., 9.8 to 48 cm).

Paramyxine nelsoni—This is a 5-gilled species, with gill apertures crowded and irregularly spaced and a total of 57-67 slime pores. Morphologically, it is very similar to *P. yangi*; *P. yangi* has more total slime pores and more slime pores on the trunk than does *P. nelsoni* (total pores: 68-79 vs. 57-67; trunk slime pores: 39-47 vs. 33-39) (Kuo et al. 1994, Kuo and Mok 1999). It is restricted to the southwestern area (1 of 28 stations) (Table 1; Fig. 3) on the continental shelf at 178 m.

Paramyxine cheni—*P. cheni* is a 5-gilled species with 3 fused cusps on both the anterior and posterior cusp sets (Shen and Tao 1975). This species is restricted to the southwestern area where it is broadly found from 156 to 268 m (9 of 28 stations), (Table 1; Fig. 3). From 10 to 153 individual specimens were captured at each of the stations where this species occurred (Table 1).

Paramyxine fernholmi—*P. fernholmi* is a 6-gilled species, with the external opening of the pharyngocutaneous duct and the aperture of the last left gill duct separated (Kuo et al. 1994). This species is restricted to the southwestern area (in 3 of 28 stations) (Table 1; Fig. 2) at depths of from 384 to 412 m (Table 1). Only a few specimens were captured at each of these stations (Table 1).

Myxine sp. 1—This undescribed 6- to 7-gilled species with 3- and 2-cusp multicusps on the anterior and posterior cusp sets, respectively, was collected from only 1 station at 781 m in the northeastern area (Table 1; Stn. 4 in Fig. 1).

Myxine sp. 2—This 5-gilled species, with 3- and

2-cusp multicusps on the anterior and posterior cusp sets, respectively, is currently being described by Mok (pers. obs.). All specimens were immature individuals captured at stations at depths from 753 to 843 m (Table 1) in the southwestern area (Fig. 2). This has been the major species landed at Tungfang.

Myxine sp. 3—This 6-gilled species, with a 2-cusp multicusp on both cusp sets, currently being described by Mok (pers. obs.), was captured from only 1 station at 595 m in the southwestern area (Table 1; Fig. 2). All 5 specimens were small, ranging from 123 to 187 mm in total length.

DISCUSSION

Among hagfish species previously reported from Taiwan, specimens of *Paramyxine wisneri* and *Eptatretus okinoseanus* were not captured in this survey. Kuo et al. (1994) examined a 345-mm specimen of the latter species collected from the east coast at 300 m and a 550-mm specimen from the southwestern area (22°20'N, 120°11'E) collected at 1020 m. The exact locality of the 345-mm specimen was unclear. Kuo et al. (1994) captured the 4 type specimens for *P. wisneri* from the coastal waters off Fukang (Fig. 1) on the east coast at a depth of about 200 m. No specimen of this species was obtained at the station off Fukang in this study (Table 1; Fig. 1).

Fernholm (1998) observed that, in contrast to the Japanese *Paramyxine* species (i.e., *P. atami*), all Taiwanese *Paramyxine* species are dwarf forms. Actually, only *P. taiwanae*, *P. nelsoni*, and *P. yangi*

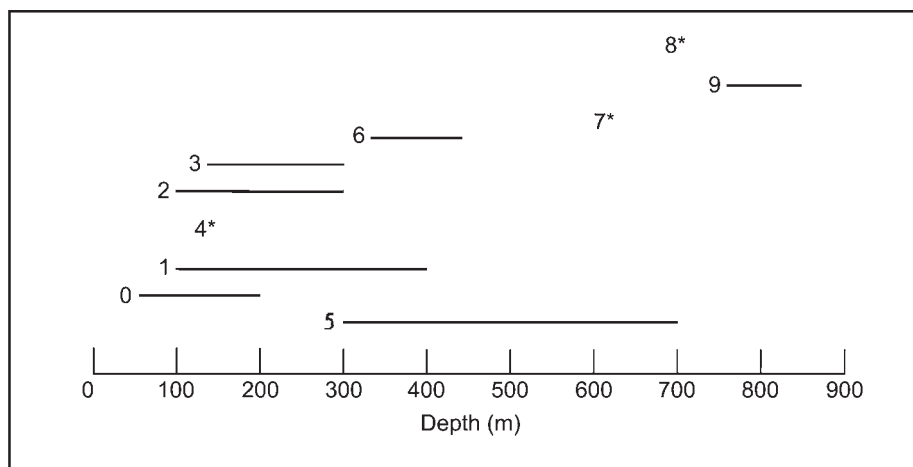


Fig. 4. Depth ranges of 10 hagfish species in Taiwanese waters. Species codes — 0: *Eptatretus burgeri*; 1: *Paramyxine taiwanae*; 2: *P. yangi*; 3: *P. cheni*; 4: *P. nelsoni*; 5: *P. sheni*; 6: *P. fernholmi*; 7: *Myxine* sp. 3; 8: *Myxine* sp. 1; 9: *Myxine* sp. 2. *the depth of the only sample for the species.

are dwarf forms; they reach maturation at a smaller size compared to other hagfish species. All of these dwarf species live mostly on the continental shelf and the upper range of the continental slope (Table 1; Fig. 4). Regarding the distribution of *P. yangi*, 27 specimens (12.5-28.1 cm) of this species were captured at 1 of the 2 stations at the northern margin of the South China Sea (22°21'N, 119°25'E at 547 m) (Fig. 1). This station extends the horizontal and depth ranges of this species.

The 14 stations where no hagfish were caught were located either (1) below the continental shelf (10 stations) (Table 1; Figs. 1, 3), and/or (2) in the northern section of the southwestern area (north of 22°23'N; 8 stations) (Table 1; Figs. 1, 3).

Horizontal distribution of the eptatretines in Taiwanese waters reveals that more species occupy the southwestern area. *E. burgeri* and *P. taiwanae* are on the northeastern coast, while *P. cheni*, *P. fernholmi*, and *P. nelsoni* are on the southwestern coast. Fewer species are on the eastern and southeastern coasts.

Figure 4 illustrates the depth ranges of 10 hagfish species. For the eptatretines, *E. burgeri* could be found in shallower waters, while *P. sheni* reached relatively deeper waters (Table 1; Fig. 3). Overlap in depths was noticed among most Taiwanese eptatretine species, i.e., *P. yangi*, *P. nelsoni*, *P. taiwanae*, *P. cheni*, and *P. fernholmi* (Fig. 3).

All specimens of *Myxine* species captured in this survey were immature, and were from depths of between 595 and 843 m. However, many large, mature specimens of *Myxine* sp. 2 were caught by fishermen at Tungkan on the southwestern coast using traps. According to these fishermen, specimens were trapped from 1000 to 1600 m. It is, therefore, possible that these mature individuals might be living in waters below the maximum sampling depths made in this survey (i.e., 843 m) (Table 1).

Only *P. sheni*-*P. taiwanae* (stn. 6), *P. yangi*-*P. cheni* (stns. 37, 38) and *P. yangi*-*P. taiwanae*-*E. burgeri* (stn. 10) were trapped in the same set of traps deployed at these respective stations (Table 1). Species in each of these stations are syntopic species (Wiley 1981). Morphologically *P. nelsoni*, *P. yangi*, and *P. taiwanae* are rather similar; all gill apertures are crowded (Kuo et al. 1994, Kuo and Mok 1999).

As not many specimens were obtained from most stations in this survey, it is reasonable to conclude that at the present time, populations of hagfish species in Taiwanese waters might be comprised of

rather small numbers of individuals (Table 1). Fishermen have complained about the prevalent decline in catches of hagfish from the southwest coast forcing them to set traps in deeper waters where catches tend to be larger in size. Stations 3 and 9 on the northeastern continental shelf (Table 1; Fig. 1) and station 37 on the southwestern continental shelf (Fig. 2) are the few stations where a larger sample of a single species (i.e., *P. sheni* or *P. yangi*) was obtained. It is known that hagfish trapping is more intense in southwestern waters, and this may partially account for the small catches in this survey from most of the southwestern stations. As most *Paramyxine* species might only occur in Taiwanese waters, the present condition of their population size is alarming. Hagfish are an important group of primitive craniates that preserve clues for unlocking the evolution of vertebrates. They are scavengers that help recycle the biomass input from the upper water column—a very important ecological role. The fact that they produce a rather low number of eggs presents a special case for fisheries management. All in all, more attention should be paid to the hagfishes in Taiwan, and immediate action should also be taken to control related fishing activities before populations drop below a sustainable level.

Acknowledgments: The authors wish to express their thanks to the officers and crews of the *R/V Ocean Researcher II* and *R/V Ocean Researcher III*; and to Y. Y. Chen, C. H. Kuo, and C. S. Kuo for their logistics help in collecting hagfish specimens. We thank Dr. S. C. Shen for reading an early draft of the manuscript. This research was supported by grants from the National Science Council of R.O.C. to Mok (NSC86-2611-B-110-008, NSC 87-2611-B-110-001, NSC88-2311-B-110-010).

REFERENCES

- Chen TF. 1969. A synopsis of the vertebrates of Taiwan. Part 1. Taipei: Taiwan Shong-Wo Book. 548 pp. (in Chinese)
- Kuo CH, KF Huang, HK Mok. 1994. Hagfishes of Taiwan (1): a taxonomic revision with description of four new *Paramyxine* species. Zool. Stud. **33**: 126-139.
- Kuo SC, HK Mok. 1999. Redescription of *Paramyxine nelsoni* (Myxinidae; Myxiniformes) and comparison with *P. yangi* from Taiwan. Zool. Stud. **38**: 89-94.
- Shen SC, HJ Tao. 1975. Systematic studies on the hagfish (Eptatretidae) in the adjacent waters around Taiwan with description of two new species. Bioscience **2**: 65-79.
- Teng HT. 1958. A new species of cyclostome, *P. yangi*, found in Taiwan. China Fish **66**: 3-6. (in Chinese)
- Wiley EO. 1981. Phylogenetics. New York: J Wiley. 439 pp.

盲鰻(盲鰻科:盲鰻目)在臺灣之分布

莫顯蕎 陳雅雯

於臺灣北部、東北部、東南部、及西南部海域 42 個採樣站和南中國海北部 2 個採樣站中以籠具捕捉盲鰻，共採獲 1 種黏盲鰻，6 種副盲鰻及 3 種未經描述的盲鰻屬魚種。本文報告其水平及垂直分布，其中以楊氏副盲鰻的水平分布最廣，本種是在南中國海北部採樣站中唯一採得的盲鰻。

關鍵詞：黏盲鰻屬，副盲鰻屬，盲鰻屬，臺灣。

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