

## Redescription of *Paramyxine nelsoni* (Myxinidae; Myxiniformes) and Comparison with *P. yangi* from Taiwan

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(Accepted October 21, 1998)

**Shih-Chieh Kuo and Hin-Kiu Mok (1999)** Redescription of *Paramyxine nelsoni* (Myxinidae; Myxiniformes) and comparison with *P. yangi* from Taiwan. *Zoological Studies* 38(1): 89-94. The original description of the hagfish *Paramyxine nelsoni* from Taiwan waters was based solely on the holotype. The present paper provides additional data on its morphological variation. Its horizontal and vertical distributions in Taiwan waters and morphological differentiation from *P. yangi* are also presented.

**Key words:** Taxonomy, *Paramyxine nelsoni*, *Paramyxine yangi*.

Kuo et al. (1994) reported 4 new *Paramyxine* species from Taiwan: *P. nelsoni*, *P. fernholmi*, *P. sheni*, and *P. wisneri*. Of these, *P. nelsoni*, *P. yangi*, and *P. taiwanae* are similar in the gill apertures being crowded instead of arranged in straight lines. *P. nelsoni* and *P. yangi* have fewer than 6 pairs of gill pouches and gill apertures whereas *P. taiwanae* has 6 pairs of these structures. *P. nelsoni* was originally described from the holotype only. Due to the lack of additional specimens, Kuo et al. did not dissect the holotype of *P. nelsoni*. As it had 4 pairs of gill apertures, they assumed that it should also carry 4 pairs of gill pouches, and this holotype was originally described as having 4 pairs of gill pouches and apertures. The *P. nelsoni* holotype contains 35 slime pores in the trunk; this number is well below the range of the slime-pore count of *P. yangi* (Kuo et al. 1994). Since 1995, many collections have been made in the southwestern waters of Taiwan and many *P. nelsoni* specimens have been obtained. Many of the specimens that had a lower slime pore count (i.e., in the lower range of *P. nelsoni*; see below) in the trunk carried 5 pairs of gill apertures and gill pouches. Only 3 specimens with 4 pairs of gill apertures and gill pouches were found. Therefore,

we suggest that the mode of gill pouch and aperture counts for *P. nelsoni* is 5 pairs of gill pouches and gill apertures instead of 4 pairs as was described in the holotype. The holotype was recently dissected and unexpectedly found to have 5 pairs of gill pouches. The present paper describes *P. nelsoni* and *P. yangi* in order to clarify the differences.

### MATERIALS AND METHODS

Specimens of *P. nelsoni* ( $N = 309$ ) and *P. yangi* ( $N = 256$ ) from depths of about 143-250 m and 143-225 m, respectively, were collected from 26 September 1996 through 15 October 1997 in the southwestern coastal waters of Taiwan (Fig. 1). Depths of all collecting stations ranged between 82 m and 858 m. These *P. yangi* specimens were compared with those ( $N = 200$ ) collected from northeastern coastal waters. *P. nelsoni* was not captured from the latter waters.

Terminology of counts and measurements followed Fernholm and Hubbs (1981) and McMillan and Wisner (1984) (Fig. 2). Skin on the nasal region was removed to expose the nasal cartilages

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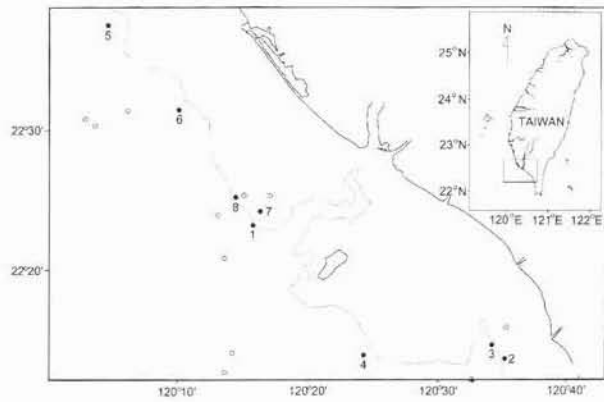
for examination. Since the cartilages of hagfish turn red after formalin fixation, no clear-and-stain preparation for the cartilages was needed. Gill pouches were counted, and egg number, and size and width of testes were recorded.

**RESULTS**

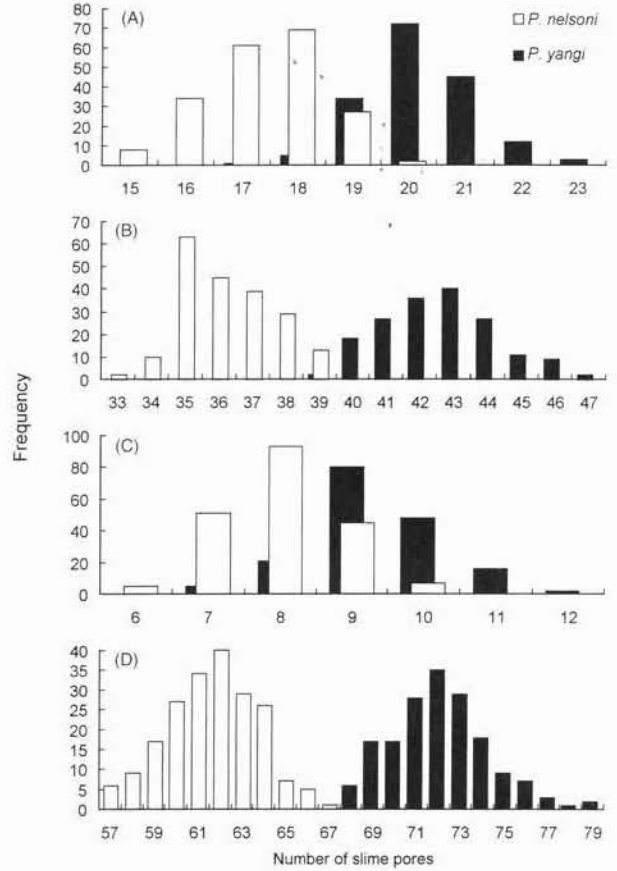
**Slime pore counts**

Numbers of slime pores in prebranchial, trunk and tail sections are independent of body length ( $R^2 < 0.01$ ). *P. yangi* has more slime pores than does *P. nelsoni* (68 to 79 vs. 57 to 67, Mann-Whitney test,  $\bar{p} < 0.001$ , Table 1) with more slime pores in the prebranchial and trunk region,

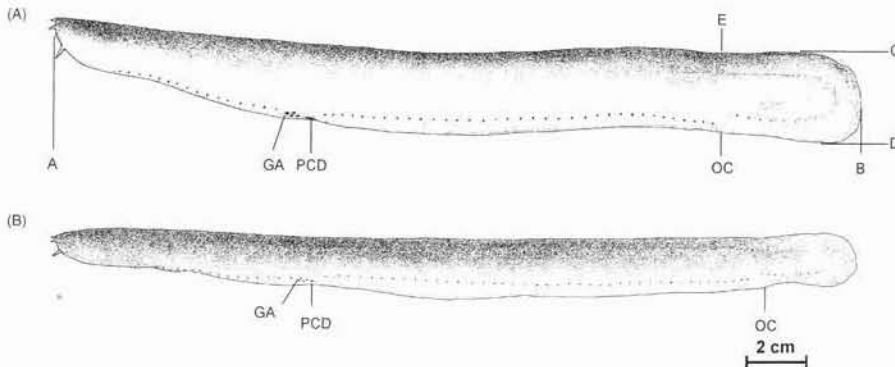
although there is slight overlapping in the counts of the prebranchial and trunk regions between these species (Fig. 3). Overlapping in slime pore count of the tail is more obvious.



**Fig. 1.** Collecting sites in southwestern waters of Taiwan. Solid circles indicate stations 1-8 as listed in Table 3 where *Paramyxine nelsoni* and *P. yangi* were captured. Open circles indicate other collection stations where no *P. nelsoni* or *P. yangi* were captured. The dotted line indicates the 200 m contour line.



**Fig. 3.** Distribution of slime pore number in *Paramyxine nelsoni* and *P. yangi*. (A), prebranchial section, (B), trunk, (C), tail, and (D), total pores.  $N = 201$  (*P. nelsoni*) and 172 (*P. yangi*).



**Fig. 2.** Outline of *Paramyxine nelsoni* (A) and *P. yangi* (B) showing regions and features used in measuring and counting. GA, gill apertures; PCD, external opening of pharyngocutaneous duct; OC, opening of cloaca. A-B, total length (TL); A-GA, prebranchial length; GA-OC, trunk length; OC-B, tail length; C-D, tail height; E-OC, cloaca height.

### Gill pouch and aperture counts

Except for 9 of the 309 *P. nelsoni* specimens examined, all carry 5 pairs of gill pouches and apertures. Of these 9 specimens, 1 has 4/5 (left side/right side) pouches and 4/5 apertures. Three specimens have 4/4 gill pouches, and 4/4 or 5/4 gill apertures. The other 5 specimens have 5/4, 4/5, 4/4, 3/5 or 5/2 gill pouches respectively, and 5 pairs

of gill apertures. Only 1 specimen has 4 pairs of apertures and pouches. All *P. yangi* ( $N = 256$ ) collected from southwestern waters have 5 pairs of gill pouches and apertures, but 1 of the 45 specimens from the northeastern waters has 4 pairs of gill pouches and gill apertures. Gill apertures on both sides are crowded (Fig. 4).

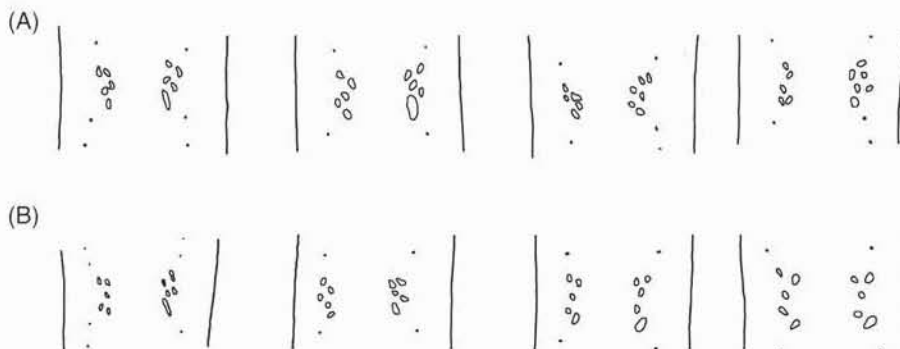
In all *P. yangi*, the last gill aperture on the left side was confluent with the pharyngocutaneous

**Table 1.** Characteristics of *Paramyxine nelsoni* and *P. yangi*

	<i>P. nelsoni</i>	<i>P. yangi</i>	
Total length (cm)	9.1-24.5	15.6-26	
Proportion to TL (mean/range) <sup>a</sup>			
Prebranchial length	0.32 (0.29-0.40)	0.31 (0.29-0.33)	$p < 0.001$
Trunk length	0.53 (0.45-0.60)	0.55 (0.51-0.58)	$p < 0.001$
Tail length	0.15 (0.09-0.18)	0.14 (0.12-0.16)	$p = 0.03$
Tail height	0.11 (0.09-0.13)	0.08 (0.07-0.10)	$p < 0.001$
Cloaca height	0.10 (0.07-0.11)	0.07 (0.06-0.08)	$p < 0.001$
Gill region width	0.05 (0.04-0.07)	0.04 (0.03-0.06)	$p < 0.001$
Sample size	43	40	
Slime pore number (median/range) <sup>b</sup>			
Prebranchial	18 (14-20)	20 (17-23)	$p < 0.001$
Trunk	33 (35-39)	43 (39-47)	$p < 0.001$
Tail	8 (6-10)	9 (7-12)	$p < 0.001$
Total	62 (57-67)	72 (68-79)	$p < 0.001$
Sample size	201	172	
Unicuspid count (median/range) <sup>b</sup>			
Fused cusps	3/2	3/2	
Anterior set/posterior set			
Cusps			
Anterior set	6 (5-8)	7 (6-8)	$p = 0.005$
Posterior set	6 (5-7)	6 (6-8)	$p < 0.001$
Sample size	43	41	
Nasal ring count (median/range) <sup>b</sup>	9 (8-10)	10 (9-11)	$p < 0.001$
Sample size	43	40	$p < 0.001$

<sup>a</sup>t-test.

<sup>b</sup>Mann-Whitney test.



**Fig. 4.** Variation in arrangement of gill apertures in (A), *Paramyxine nelsoni* and (B), *P. yangi*.

duct which is larger than the gill apertures, whereas confluency of these apertures did not occur in all of the *P. nelsoni* specimens examined (Fig. 4).

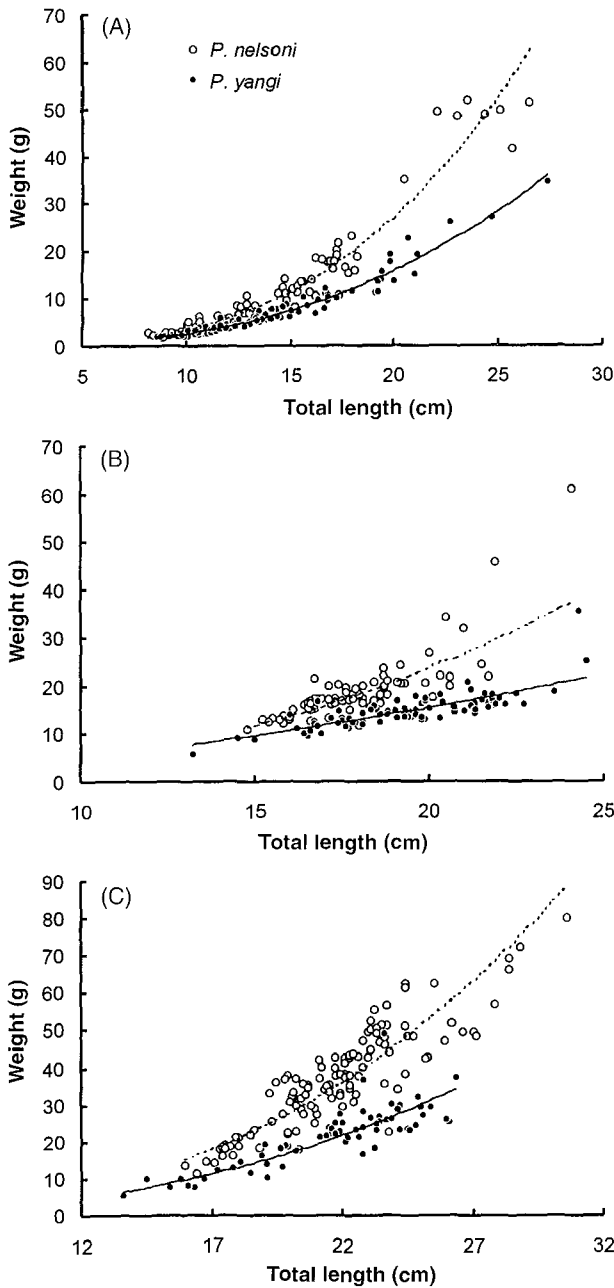
**Dentition formula**

Tooth formulas of the left cuspid set in *P. nelsoni* and *P. yangi* are 5~8+3/2+5~7 and 6~8+3/2+6~8, respectively. Statistically, cusp numbers of

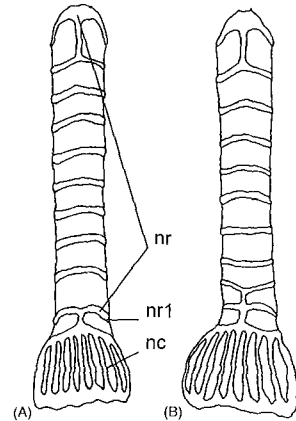
*P. nelsoni* in both anterior and posterior sets are lower than those of *P. yangi* (Table 1).

**Body proportion**

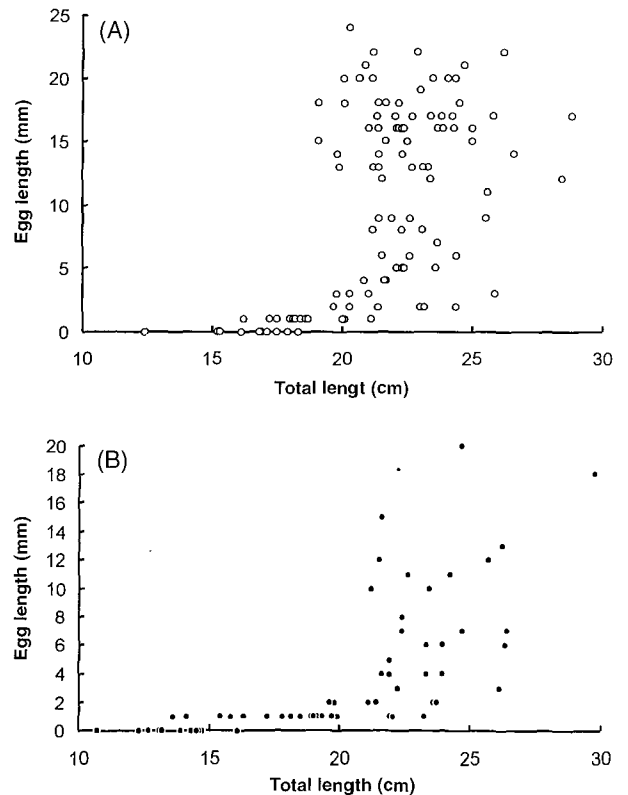
Proportions (in % of TL) of prebranchial, trunk and tail length to total length differ between *P.*



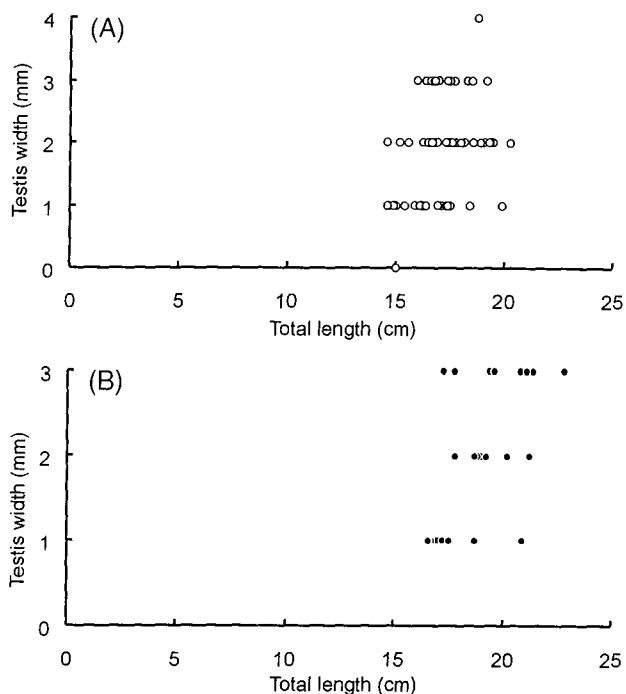
**Fig. 5.** Relationship of length and weight in *Paramyxine nelsoni* and *P. yangi*. (A), sex unknown, (B), male, (C), female.



**Fig. 6.** Dorsal view of nasal skeleton of (A), some *Paramyxine nelsoni* and (B), *P. yangi* and some *P. nelsoni*. nc, nasal capsule; nr, nasal ring; nr1, 1st nasal ring.



**Fig. 7.** Relationship of total length to egg length. (A), *Paramyxine nelsoni*, (B), *P. yangi*.



**Fig. 8.** Relationship of total length to testis width. (A), *Paramyxine nelsoni*, (B), *P. yangi*.

*nelsoni* and *P. yangi* (Table 1). Tail height is obviously greater in *P. nelsoni* (mean 0.11; range 0.09-0.13) than in *P. yangi* (mean 0.08; range 0.07-0.10), as it also is in cloaca height (mean 0.10; range 0.07-0.11 vs. mean 0.07; range 0.06-0.08; Table 1).

### Body length and weight relationship

*P. nelsoni* and *P. yangi* differ in their body length-weight relationship. *P. nelsoni* in both males, females, and the individuals whose sex couldn't be identified have higher body weights compared to *P. yangi* with similar body lengths (Fig. 5; Table 2). Body lengths of these specimens ranged between 15.6 and 26.0 cm for *P. nelsoni* and 9.1 and 24.5 cm for *P. yangi*.

### Nasal skeletal morphology

The nasal skeleton can be divided into 2 parts, the nasal capsule and the nasal rings (Fig. 6). The former is composed of 9 longitudinal cartilages bounded by 2 transverse cartilages. Nasal rings

**Table 2.** Relationship of weight and length in *Paramyxine nelsoni* and *P. yangi*

	Species			
	<i>P. nelsoni</i>		<i>P. yangi</i>	
All individuals	$Y = 0.0040 X^{2.935}$	$R^2 = 0.951$	$Y = 0.0068 X^{2.596}$	$R^2 = 0.944$
Sex unknown	$Y = 0.0038 X^{2.957}$	$R^2 = 0.950$	$Y = 0.0067 X^{2.593}$	$R^2 = 0.941$
Male	$Y = 0.0152 X^{2.452}$	$R^2 = 0.678$	$Y = 0.1118 X^{1.644}$	$R^2 = 0.687$
Female	$Y = 0.0084 X^{2.707}$	$R^2 = 0.792$	$Y = 0.0084 X^{2.542}$	$R^2 = 0.832$

X = total length; Y = body weight.

**Table 3.** Locality and depth of collecting stations and date of collections for *Paramyxine nelsoni* and *P. yangi*

Date	Station	Lat. (N)	Long. (E)	Depth (m)	Species	
					<i>P. nelsoni</i>	<i>P. yangi</i>
1996 Sept. 25	1	22°23'30"	120°16'04"	190	26	
Nov. 04	2	22°14'09"	120°35'39"	143	228	72
1997 Mar. 07	3	22°10'40"	120°36'43"	213		34
Apr. 14	4	22°14'25"	120°24'44"	226		98
May 19	5	22°37'30"	120°05'29"	243		9
July 18	6	22°31'40"	120°10'01"	250		4
Sept. 13	7	22°24'11"	120°16'36"	145	26	
Oct. 15	8	22°25'14"	120°14'17"	225	5	26

are semi-circular transverse cartilages. The number of nasal rings may vary within and among species.

In all *P. yangi* the nasal capsule was continuous with the 1st and 2nd nasal rings (Fig. 6B). The same character state was manifested in 43 of 58 *P. nelsoni* specimens examined. In the other 15 specimens the nasal capsule was continuous with only the 1st nasal ring (Fig. 6A). Nasal ring counts for *P. nelsoni* and *P. yangi* are 8-10 and 9-11, respectively (Table 1).

### Maturity and gonad characteristics

In 277 *P. nelsoni* and 256 *P. yangi*, no hermaphroditism was noted. The sex ratio (male/female ratio estimated on the basis of only those whose sex could be identified) were 1.36 and 0.68, respectively. Both species can be sexed at lengths longer than 15 cm although some immature females whose total length was 10-15 cm carried small eggs (< 3 mm). Testis could only be found in individuals longer than 15 cm (Figs. 7, 8). Mature females contain eggs of variable sizes. They may carry a group of more than 100 eggs smaller than 3 mm, and a group longer than 4 mm. Maximum number of eggs in the largest size group was 15 in *P. nelsoni* and 9 in *P. yangi*. The minimum total length of *P. nelsoni* and *P. yangi* in which the eggs reached at least 4 mm were 19 cm and 21 cm, respectively (Fig. 7). The maximum egg length in *P. nelsoni* was 24 mm and 20 mm in *P. yangi*.

### Distribution

*P. nelsoni*, has been collected only from southwestern Taiwan waters (4 of 18 stations, Table 3). However, *P. yangi* has been collected at 1 of 4 stations in northeastern waters (24° 46'54"N, 121°54'06"E) and at 6 of 18 stations in southwestern waters of Taiwan (Table 3). The depth range of all collecting stations was 82 m to 858 m. Depth ranges of *P. nelsoni* and *P. yangi* were 143~225 m and 143~250 m, respectively. Neither species has been collected below 250 m nor above 143 m.

**Acknowledgments:** We thank the crews of the R/V Ocean Research III of National Sun Yat-sen University for helping us in collecting the hagfish. The research was supported by a National Science Council grant (NSC 86-2611-B-110-008) to HKM. We also thank Dr. R.L. Wisner of the Scripps Institution of Oceanography, University of California for comments on the manuscript.

### REFERENCES

- Fernholm B, CL Hubbs. 1981. Western Atlantic hagfishes of the genus *Eptatretus* (Myxinidae) with description of two new species. *Fish. Bull.* **79**: 69-83.
- Kuo CH, KF Huang, HK Mok. 1994. Hagfishes of Taiwan (I): A taxonomic revision with description of four new *Paramyxine* species. *Zool. Stud.* **33**: 126-139.
- McMillan CB, RL Wisner. 1984. Three new species of seven gilled hagfishes (Myxinidae, *Eptatretus*) from the Pacific Ocean. *Proc. California Acad. Sci.* **43**: 249-267.

## 臺灣產之紐氏副盲鰻（盲鰻科：盲鰻目）之重新描述及與楊氏副盲鰻之比較

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早期臺灣產之紐氏副盲鰻 (*Paramyxine nelsoni*) 的形態描述來自於僅有的一尾模式標本。本文將對紐氏副盲鰻之垂直及水平分布、形態變異以及與楊氏副盲鰻 (*Paramyxine yangi*) 之間的差異提供補充描述。

**關鍵詞：**分類，紐氏副盲鰻，楊氏副盲鰻。

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