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封面圖說／
黃緣步行蟲(*Epomis nigricans*)的幼蟲與成蟲皆能掠食蛙類。圖中為 3 齡幼蟲以大顎附著於黑眶蟾蜍(*Duttaphrynus melanostictus*)體表，並以其體液與組織為食。 (林春富　攝)

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Contents

Taxonomy of Chydoridae (Crustacea: Branchiopoda: Cladocera) from Taiwan

台灣產盤腸溞科(甲殼動物亞門，鰓足綱，枝角目)

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Abstract

This paper describes and illustrates 19 species of freshwater cladocerans belonging to 14 genera of the family Chydoridae collected from Taiwan in 1997 to 2006. They are consisted of 12 species that are new records to Taiwan and seven species that have been known previously. The new records are *Kurzia* longirostris Daday, 1898; *Camptocercus uncinatus* Smirnov, 1971; *Monospilus dispar* Sars, 1862; *Leydigia ciliate* (Gauthier 1939); *Oxyurella singalensis* (Daday 1898); *Karualona karua* (King 1853); *Dunhevedia crassa* King, 1853; *Ephemeroporus barroisi* (Richard 1894); *Alonella excisa* (Fischer 1854); *Pleuroxus trigonellus* (Müller 1785); *Disparalona leei* (Chien 1970); and *D. hamata* (Baird1835). The known species are *Acroperus harpae* (Baird 1835); *Alona diaphana* King, 1853; *A. rectangular* Sars, 1862; *A. costata* Sars, 1862; *A. affinis* (Leydig 1860); *A. quadrangularis* (Müller 1785); *Chydorus sphaericus* (Müller 1785). A key to the species is provided.

摘　要

台灣地區淡水枝角類分類研究，共發現 14 屬 19 種盤腸溞科(Chydoridae)物種，其中 12 種爲新紀錄種，分別是*Kurzia longirostris* Daday, 1898; *Camptocercus uncinatus* Smirnov, 1971; *Monospilus dispar* Sars, 1862; *Leydigia ciliate* (Gauthier 1939); *Oxyurella singalensis* (Daday 1898); *Karualona karua* (King 1853); *Dunhevedia crassa* King, 1853; *Ephemeroporus barroisi* (Richard 1894); *Alonella excisa* (Fischer 1854); *Pleuroxus trigonellus* (Müller 1785); *Disparalona leei* (Chien 1970); and *D. hamata* (Baird 1835). 其他 7 種爲舊有紀錄種，其分別是 *Acroperus harpae* (Baird 1835); *Alona diaphana* King, 1853; *A. rectangular* Sars, 1862; *A. costata* Sars, 1862; *A. affinis* (Leydig 1860); *A. quadrangularis* (Müller 1785); 及 *Chydorus sphaericus* (Müller 1785).

文中除敘述各種的形態特徵之外，並且具備屬和種的檢索表及外部形態的描繪。

Key words: freshwater zooplankton, Chydoridae, taxonomy, Taiwan, biodiversity

關鍵詞：淡水浮游動物、 盤腸溞科、分類學、臺灣、生物多樣性

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Introduction

Taxonomy of cladocerans (Crustacea: Branchiopoda: Cladocera) of Taiwan were studied early by Ueno (1935b, 1938a, 1938b) and Harada (1933, 1943a, 1943b). They reported 22 species for the order Cladocera with nine species in the family Chyodridae. In 1997 to 2006, we collected samples of cladocerans from inland freshwaters of Taiwan, and have reported 26 species for the families Sididae, Bosminiidae, Daphniidae, Moinidae, Ilyocryptidae, and Macrothricidae (Young and Tuo 2011). This paper reports 19 species for the family Chydoridae, the largest family of the order Cladocera (Korovchinsky 1996). Many of the chydorid cladocerans in Taiwan are less than 1 mm in body length. They are bottom dwellers in littoral areas, but occasionally planktonic. The specimens collected were mainly from shallow water areas and some from benthic substrates.

Materials and Methods

Chydorid cladocerans were collected from quite inland freshwaters throughout the island of Taiwan (Fig. 1), such as reservoirs, pools, ponds, paddy fields, ditches and sinks (Appendix 1). The reservoirs and lakes described by Chen and Wang (1997) were the key collection sites. A conical plankton net was used to collect planktonic species. It was 30 cm long with a 55-μm stretch size, and had a 15 cm wide opening and a small collection

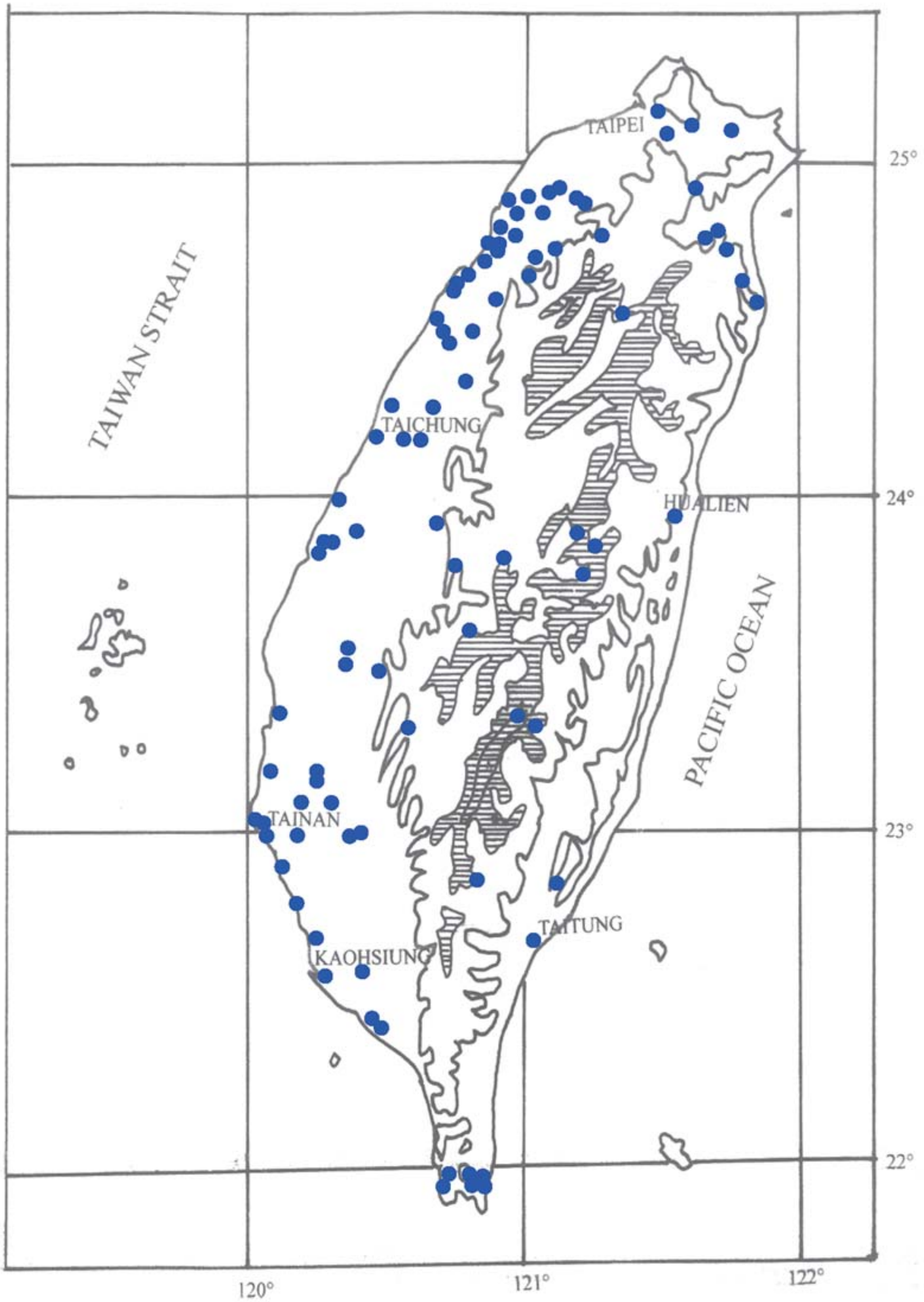

Fig. 1. Collection sites (solid circles) of Chydorid cladocerans from Taiwan.

Appendix 1. The 51 collection sites of 19 species of the family Chydoridae.

Collection sites		1 *Alona rectangula*	2 *Alona costata*	3 *Alona quadrangularis*	4 *Alona diaphana*	5 *Alona affinis*	6 *Karualona karua*	7 *Oxyurella singalensis*	8 *Monospilus dispar*	9 *Acroperus harpae*	10 *Kurzia longirostris*	11 *Alonella excisa*	12 *Camptocercus uncinatus*	13 *Leydigia ciliata*	14 *Dunhevedia crassa*	15 *Disparalona hamata*	16 *Disparalona leei*	17 *Pleuroxus trigonellus*	18 *Chydorus sphaericus*	19 *Ephemeroporus barroisi*
1. National Hsinchu University of Education (sink)	Hsinchu City		*				*												*	
2. Cemetery (garden pond)	Hsinchu City	*	*																	
3. Pao-shan reservoir	Hsinchu County																*			
4. Hsin-fong (irrigation pond No. 5)	Hsinchu County		*																*	
5. Pao-shan reservoir	Hsinchu County															*			*	
6. Bei-pu (cold spring)	Hsinchu County						*													
7. Hu-kou (fish pond 1)	Hsinchu County	*	*																	
8. Hu-kou (fish pond 2)	Hsinchu County	*																		
9. Hu-kou (fish pond 3)	Hsinchu County		*																	
10.Hu-kou (paddy irrigation ditches)	Hsinchu County	*	*								*						*		*	
11. Cin-pu (lily pond)	Hsinchu County			*										*				*		
12. E-mei (fish pond)	Hsinchu County	*																		
13.Yuan-yang-hu (high land lake)	Ilan County											*							*	
14. Shuang-lian-bei (lake)	Ilan County		*					*		*									*	*
15. Su-yao (shrimp pond)	Ilan County				*															
16. Dong-shih (irrigation ditches)	Jaiyi County				*															
17. Jhong-liao (pond)	Jaiyi County														*					
18. Lan-tan (reservoir)	Jaiyi County	*	*		*									*			*		*	
19. Min-syong (pond)	Jaiyi County													*				*		
20. Hou-long (fish pond)	Maioli County										*									
21. Min-de reservoir	Maioli County	*	*																	
22. Li-yu-tan reservoir	Maioli County		*																	
23. Zao-ciao; Long-hu-gun (fish pond)	Maioli County		*								*		*			*		*	*	

Appendix 1. The 51 collection sites of 19 species of the family Chydoridae. (Cont)

24. Zao-ciao; Long-hu-gun (garden pond)	Maioli County												*				*			
25. Zao-ciao (marsh)	Maioli County																	*		
26. Tun-siao; flyingcow ranch (garden pond)	Maioli County	*																*	*	
27. Jhu-nan township(marsh)	Maioli County	*	*															*		
28.Bai-shih-chih (high land pond)	Nantou County			*																
29. Lien-hua-chuh research center (Taiwan forestry research institute)	Nantou County																		*	
30. Tun-lu-chih (high land pond)	Nantou County																			
31. Heng-chun;Long-liuan-tan (reservoir)	Pindong County		*																	
32. Man-jhou (gang-kou creek)	Pindong County																	*		*
33. Da-guei-hu (high land lake)	Pingdong County		*																*	
34. Jia-min-hu (high land lake)	Taidong County		*	*																
35. Hsinying (water chestnut field)	Tainan County		*				*													
36. De-yan-bei (reservoir)	Tainan County		*											*						
37. Ci-gu (fish pond)	Tainan County					*														
38. Yong-kang (fish pond)	Tainan County																	*		
39. Sih-cao (milkfish pond 1)	Tainan County				*															
40. Sih-cao (milkfish pond 2)	Tainan County		*																	
41. Sih-cao (fish pond irrigation ditches)	Tainan County	*	*																	
42. National Taiwan University (garden pond)	Taipei City																		*	
43. Meng-huan-hu (pond)	Taipei City																		*	
44. Jing-long-hu (pond)	Taipei County	*	*																	
45. San-sia; tong-hou-si (creek)	Taipei County					*													*	
46. Yang-mei (fish pond)	Taoyuan County	*					*						*	*				*	*	
47. Long-tan, De-long elementary school (garden pond)	Taoyuan County		*	*					*				*			*		*	*	
48. Long-tan (fish pond)	Taoyuan County	*	*											*				*		
49. Long-tan; De-long-gong (lily pond)	Taoyuan County	*	*										*						*	
50. Long-tan-da-chi (reservoir)	Taoyuan County	*	*																	
51. Freeway Si-luo resting areas (garden pond)	Yunlin County	*																		

bucket at the cod-end. For shallow water in paddy fields and littoral zone of open water bodies, the water was stirred with a wood stick, scooped with a cup, and then filtered with the plankton net. The samples were fixed in the 5% formalin-water solution in the field, brought back to the laboratory for sorting and identifying under a stereomicroscope, and then preserved in the 70% ethanol-water solution. Appendages were dissected, mounted on microscopic slides, tinted with polyvinyl lactophenol, and then covered with a cover glass. Line drawings were made using a camera Lucida. Measurement and observation were aided by a computerized image analysis system. Average and standard deviations (SD) of body lengths were based on the measurements of 15 or more specimens. The terminology and abbreviations used in the morphological descriptions (Fig. 2) followed those of Chiang and Du (1979) and Smirnov (1996).

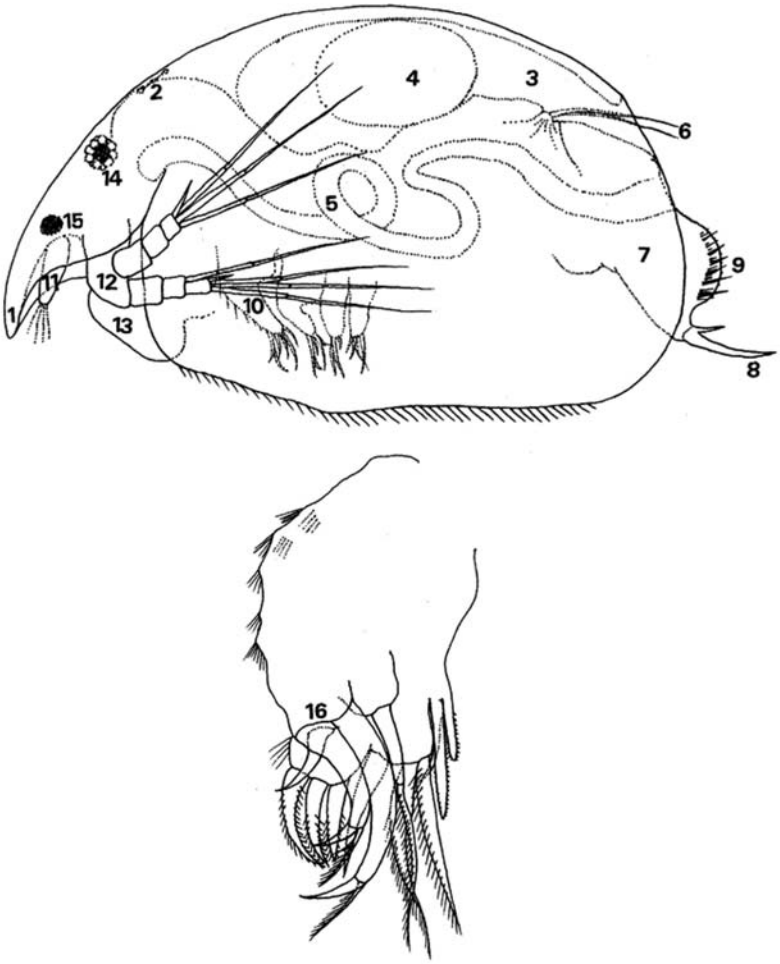

Fig. 2. General morphological descriptions of Chydoridae (1, rostrum; 2, head pores; 3, brood pounch; 4, egg; 5, gut; 6, setae natatoriae; 7, postabdomen; 8, claw; 9, anal teeth; 10, thoracic limb; 11, antennules (AI); 12, antenna (AII); 13, labral plate; 14, compound eye; 15, occellus; 16, inner distal lob (IDL) of thoracic limb I).

Results

We collected 19 species of cladocerans belonging to 14 genera of the family Chydoridae. Of them 12 species are found to be the new records to Taiwan. These were *Kurzia longirostris* Daday, 1898; *Camptocercus uncinatus* Smirnov, 1971; *Monospilus dispar* Sars, 1862; *Leydigia ciliate* (Gauthier 1939); *Oxyurella singalensis* (Daday 1898); *Karualona karua* (King 1853); *Dunhevedia crassa* King, 1853; *Ephemeroporus barroisi* (Richard 1894); *Alonella excisa* (Fischer 1854); *Pleuroxus trigonellus* (Müller 1785); *Disparalona leei* (Chien 1970); and *Disparalona hamata* (Baird 1835). They are small, mostly benthic, and inhabiting in shallow water.

A key to the genera and species of Chydoridae from Taiwan:

1a. Posterior margin of valve high, nearly to the highest part of valve; claw with 1 basal spine (*Oxyurella* with 2-3 spines) (Aloninae)..........2
1b. Posterior margin of valve low, usually not reaching the middle of the valve; claw with 2-3 basal spines (*Dunhevedia* with a spine) (Chydorinae)..........13
2a. Inner side of claw with a backward large spine in the middle..........3
2b. Inner side of claw without backward large spine in the middle..........5
3a. AI short; tip reaching middle of rostrum..........*Kurzia longirostris*
3b. AI long; tip exceeding middle or reaching near the distal end of rostrum..........4
4a. Postabdomen slender; anal spines inserted on dorsal margin (*Camptocercus*)..........*Camptocercus uncinatus*
4b. Postabdomen rectangular; anal spines inserted on lateral side near dorsal margin (*Acroperus*)..........*Acroperus harpae*
5a. Head with ocellus but no compound eye (*Monospilus*)..........*Monospilus dispar*
5b. Head with ocellus and compound eye..........6
6a. Postabdomen enlarged and semi-circular; lateral side with at least 10 bundles of larger anal spines and more than 15 bundles of smaller anal spines (*Leydigia*)..........*Leydigia ciliata*
6b. Postabdomen rod-shaped, not enlarged; lateral side with less than 10 bundles of weak anal spines..........7
7a. Claw with 2-3 basal spines (*Oxyurella*)..........*Oxyurella singalensis*
7b. Claw with a basal spine..........8
8a. Posterior corner of ventral valve with 2-3 denticles (*Karualona*)..........*Karualona karua*
8b. Posterior corner of ventral valve without denticles (*Alona*)..........9
9a. Anal spines on the dorsal margin in a bundle..........*Alona diaphana*
9b. Anal spines on the dorsal margin not in a bundle..........10
10a. Lateral anal spines stronger than dorsal anal spines..........*Alona rectangul*a
10b. Lateral anal spines weaker than dorsal anal spines..........11
11a. Posterodorsal corner of postabdomen triangular..........*Alona costata*
11b. Posterodorsal corner of postabdomen rounded..........12
12a. Inner side of basal spine on distal end of claws ciliated; dorsal with 2 major head pores......*Alona affinis*

12b. Inner side of basal spine on distal end of claws usually non-ciliated; dorsal with 3 major head pores ....*Alona quadrangularis*

13a. Postabdomen boot-shaped (*Dunhevedia*)..*Dunhevedia crassa*

13b. Postabdomen rod-shaped...14

14a. Postabdomen length less than twice of the height...15

14b. Postabdomen length more than twice of the height...16

15a. Labral plate with serration; posterior corner of ventral valve with a denticle (*Ephemeroporus*)....... ....*Ephemeroporus barroisi*

15b. Labral plate without serration; posterior corner of ventral valve smooth without denticles (*Chydorus*) ....*Chydorus sphaericus*

16a. Rostrum length less than twice of AI length (*Alonella*)..*Alonella excisa*

16b. Rostrum length more than twice of AI length..17

17a. Distal end of rostrum straight (*Pleuroxus*); posterior corner of ventral valve with 1-3 denticles...... ....*Pleuroxus trigonellus*

17b. Distal end of rostrum curved inward; posterior corner of ventral valve without denticles (*Disparalona*) 18

18a. Posterior valve slightly concave at posterodorsal corner; IDL with 3 setae, length of the shortest seta two-thirds of the longest seta..*Disparalona leei*

18b. Posterior valve not concave at posterodorsal corner; IDL of thoracic I with 2 setae, proximal seta hook-shaped..*Disparalona hamata*

Descriptions of the Species

Kurzia longirostris Daday, 1898
(Fig. 3: A~D)

Alona longirostris Daday, 1898: 34.

Pseudalona longirostris Brehm, 1933b: 34-40.

Kurzia longirostris Smirnov, 1974: 490-491; Chiang and Du, 1979: 202-203; Michael and Sharma, 1988: 217-219; Hudec, 2000: 175-176.

Female: Body lengths 0.54 - 0.69 (0.60 ± 0.05) mm [ranges (mean + SD) mm]. Preserved specimens whitish or tinted yellow in color. Body roughly square laterally; dorsal margin convex; ventral margin with setae in middle region; posterodorsal corner slightly pointed, tip of the corner slightly below level of maximum height; posteroventral corner rounded without spine. Valve surface marked with distinct longitudinal ridges crossed with weak ridges to form a square grid.

Head shield with a long rostrum. Labral plate cuneiform with pointed tip. Ocellus located anteriorly to the area between base of rostrum and AI; its diameter equivalent to a half of that of the compound eye. AI tip not extending beyond middle of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen long and narrow, slightly tapering distally, with 10-13 major marginal anal spines. Claw with a basal spine, a row of small spines on inner margin, and a backward large spine at middle.

Ephippium of female valve darker in color with the surface marked with reticular grid lines. The other structures similar to those of parthenogenetic females.

Male: Body length about 0.46 mm, smaller than females. Body structure similar to that of parthenogenetic females. A few specimens were collected.

Collection sites: Collected in April and Sepember from a rice paddy irrigation ditch in Hsinchu County (site 10) and fish ponds in Mailoi County (20, 23) (Apendix 1). Benthic or planktonic in littoral areas.

Camptocercus uncinatus Smirnov, 1971
(Fig. 3: E-G)

Camptocercus uncinatus Smirnov, 1974: 101, 535-537; 1998: 76-77.

Female: Body lengths 0.56 - 0.68 (0.610 ± 0.033) mm. Preserved specimens whitish or tinted yellow in color. Body long and oval laterally; dorsal margin archly rounded; ventral margin with setae in middle region; posterodorsal corner of valve rounded, slightly below level of maximum height; posteroventral corner rounded without spines. Valve surface marked with longitudinal ridges.

Head shield with a blunt rostrum and three main head pores. Labral plate cuneiform without marginal teeth. IDL of limb I with three digitiform lobes; proximal lobe as hard as a hook spine; two longer lobes at distal end with a plumose brush on base of distal spine. Ocellus smaller than compound eye, located anteriorly to the area between base of rostrum and AI. Tip of AI reaching near apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen long and narrow, slightly tapering distally, with 15-17 groups of marginal anal spines and a row of spine groups laterally along the margin. Claw with a basal spine, a row of small spines on inner margin, and a backward large spine in the middle.

Male: Not found.

Collection sites: Collected in January to September from Maioli country (sites 23, 24) and Taoyuan County (47, 48, 49) (Appendix 1). Benthic or planktonic in littoral areas.

Remarks: *C. uncinatus* is distinguishable from other congeners by the presence of digitiform lobes on IDL of thoracic limb I. It is easily confused with *C. rectirostris* by having similar valve shape (Tang *et al*. 1963; Chiang and Du 1979; Hann 1981; Michael and Sharma 1988).

Acroperus harpae (Baird 1835)
(Fig. 4: A~C)

Lynceus harpae Baird, 1835: 100.

Acroperus harpae Baird, 1843: 91; Ekman, 1905: 23-24; Ueno, 1930b: 446; Smirnov, 1974: 495-500; Chiang and Du, 1979: 202-203; Michael and Sharma, 1988: 189-192; Duigan, 1992: 9-10.

Female: Body lengths 0.50-0.59 (0.550 ± 0.064) mm. Preserved specimens whitish or tinted yellow in color. Body prolonged oval laterally; dorsal margin archly rounded; ventral margin with setae along middle region; posterodorsal corner rounded with 1-3 denticles, its height slightly less than the maximum height. Valve surface marked with longitudinal ridges.

Head shield with a broad but short rostrum. Labral plate cuneiform. Ocellus small, its diameter 1/2 of that of compound eye, located anteriorly to the area between the base of rostrum and AI. AI rod-shaped; tip almost reaching to tip of rostrum. Three transverse rows of setae on proximal, middle and distal parts of rostrum, respectively. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen rectangular. No marginal anal spines; 12 groups of lateral spines linearly arranged on the lateral side. Claw with a basal spine, a row of small spine-like denticles on inner margin, and a backward large spine in the middle.

Male: Not found.

Collection sites: Collected in June to July in Ilan County (site 14) (Appendix 1). Benthic or planktonic in littoral areas.

Monospilus dispar **Sars, 1862**
(Fig. 4: D, E)

Monospilus dispar Sars, 1862: 165; Ueno, 1935a: 90-91; Smirnov, 1974: 620-623; Chiang and Du, 1979: 234-235; Duigan, 1992: 32-34; Masson and Amoros, 1992: 145-148.

Female: Body length 0.31 mm. Preserved specimens white or tinted yellow in color. Body globular in lateral view; dorsal margin semicircular; setae along whole ventral margin. Posterodorsal and posteroventral corners of valve rounded and smooth. Molting incompletely; the remaining part of old valve covering the new valve surface. Each valve surface marked with circular pits as many dimples on the water surface when viewed under microscope.

Head shield with a short rostrum with pointed distal end. Labral plate cuneiform. Head with an ocellus located anterior to the area between base of rostrum and AI. Compound eye not found. AI not extending over middle of rostrum. AII setae formula: 0-0-3/0-1-3.

Postabdomen short with several linear bundles of setae along lateral side. Preanal angle prominent. Anal teeth 5-7. Claw with a large basal spine and a row of small hair-like setae on inner margin.

Male: Not found

Collection sites: A single specimen of *M. dispar* was collected in January from Taoyuan County (47) (appendix 1). Benthic or planktonic in littoral areas.

Remarks: The female *M. dispar* specimen collected had no eggs or ephippium and its valve had only two layers. The number of layers on the valve surface increased with the number of molts.

Leydigia ciliata **(Gauthier 1939)**
(Fig. 5: A-C)

Leydigia propinqua var. *ciliata* Gauthier, 1939: 168; Dumont, 1981: 99; Dumont *et al.*, 1981: 165.

Leydigia ciliata Smirnov, 1974: 557-561; Dumont *et al.*, 1984: 167-168; Chen, 1993: 14.

Female: Body lengths 0.67-0.90 (0.770 ± 0.068) mm. Preserved specimens whitish or tinted yellow in color. Body oval laterally; dorsal margin arched and slightly rounded; ventral margin with a linear row of long setae. Length of posterior valves equal to body height; posterodorsal corner distinct; posteroventral corner rounded and smooth. Valve surface marked with longitudinal lines on the dorsal part and curved lines parallel to the margin of the posteroventral corner.

Head shield with a broad and short rostrum. Labral plate broadly cuneiform; front margin with setae. Ocellus slightly larger than compound eye, located anteriorly to the area between proximal base of AI and rostrum. Tip of AI reaching apex of rostrum; front with 3 transverse groups of setae on posterior surface. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen broader than a third of body height; posteroventral margin with two notches and three oblique rows of setae on lateral side near ventral margin. Anal depression prominent; along the dorsal margin with 20-24 groups of lateral spines decreasing in size proximally. Claw with a tiny basal spine (invisible in some specimens). A row of small hair-like setae on inner margin of claw.

Male: Not found.

Collection sites: Collected in January and February from Hsinchu County (site 11), and Jaiyi County (18,19), Tainan county (36), Taoyuan county (46, 48) (Appendix 1). Benthic or planktonic in littoral areas.

***Oxyurella singalensis* (Daday 1898) Fig. 5: D, E)**

Alonopsis singalensis Daday, 1898: 43; Stingelin, 1905: 348; Brehm, 1933a: 700;

Oxyurella singalensis Rzoska, 1952: 472; Smirnov, 1974: 607-609; Chiang and Du, 1979: 233-234; Michael and Sharma, 1988: 212-214.

Female: Body lengths 0.51- 0.70 (0.580 ± 0.075) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin archly rounded; ventral margin with setae from middle to posterior end; posterodorsal corner rounded, slightly below level of maximum height; posteroventral corner rounded and smooth. Posterior valve surface marked with lines parallel to ventral margin.

Head shield with a long rostrum. Labral plate broad with smooth margin. Ocellus smaller than compound eye, located between rostrum and the proximal base of AI. Tip of AI exceeding the middle of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen slightly tapering distally; dorsal margin with 14 anal spines, the spine at the distal end small and the other 13 spines decreasing in size proximally. Lateral setae in groups arranging in a row along dorsal margin. Claw large with a slender basal spine and 1-2 additional small spines at the proximal base.

Male: Not found.

Collection sites: Collected in July from Ilan County (site 14) (Appendix 1). Benthic or planktonic in littoral areas.

***Karualona karua* (King 1853) (Fig. 6: A, B)**

Alona karua King, 1853: 260; Sars, 1916: 337-338; Stingelin, 1905: 352; Ueno, 1936: 518; Tang *et al*., 1963: 145; Chiang and Du, 1979: 215-216.

Alonella karua Sars, 1901: 59; Stingelin, 1905: 352-353; Gurney, 1916: 336.

Biapertura karua Smirnov, 1974: 587-588; 1988: 74-76; Michael and Sharma, 1988: 207-209.

Karualona karua Dumont and Silva-Briano, 2000: 61.

Female: Body length 0.35-0.43 (0.38 ± 0.02) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin archly rounded; ventral margin with setae; posterodorsal corner distinct, below level of maximum height, and about 1/3 of body height; posteroventral corner of valves distinct with 2-4 denticles. Valve surface marked with lines crossing each other in a hexagonous grid.

Head shield with a long rostrum; dorsal head with two major head pores. Labral plate broad with smooth margin. Ocellus smaller than compound eye, located posteriorly to the area between proximal base of AI and rostrum. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/0-1-3.

Postabdomen short, slightly oblong. Preanal angle small and anal teeth 7-8. Lateral setae in linear groups along dorsal margin, extending beyond the margin of postabdomen; first seta of each group large. Claw large with a small basal spine.

Male: Not found.

Collection sites: Collected in January to October from Hsinchu City (site 1), Hsinchu County (6), Taoyuan County (46) and Tainan County (35) (Appendix 1). Benthic or planktonic in littoral areas.

Alona diaphana King, 1853
(Fig. 6: C, D)

Alona diaphana King, 1853: 260; Ueno, 1938a: 130; 1938b: 167; 1938c: 286; Chiang and Du, 1979: 222-223; Brancelj, 1990: 14; Frey, 1991: 13-23.

Alona davidi Stingelin, 1905: 352; Smirnov, 1974: 451-453.

Alonella diaphana var. *punctata* Gurney, 1911: 30.

Alonella diaphana Gurney, 1927: 74; Jenkin, 1929: 248; Brehm, 1933a: 734.

Female: Body lengths 0.38-0.51 (0.450 ± 0.028) mm. Preserved specimens whitish or tinted yellow in color. Body oval laterally; dorsal margin archly rounded with a linear row of setae along almost the whole ventral margin; posterodorsal corner distinct, below the maximum height and about 1/3 of body height; posteroventral corner rounded and smooth. Valve surface smooth with no distinct markings.

Head shield with a short and pointed rostrum. Plate of labrum broad with smooth margin. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen moderately oblong with a rounded posterodorsal corner, 9-14 groups of anal teeth on dorsal margin, and 7-8 groups of lateral setae. Claw with a basal spine and a row of setae on inner margin.

Male: Not found.

Collecion sites: Collected in February to August from Ilan County (site 15), Jaiyi county (16,18) and Tainan County (39) (Appendix 1). Benthic or planktonic in littoral areas.

Alona rectangula Sars, 1862
(Fig. 6: E, F)

Alona rectangula Sars, 1862: 160; Daday, 1904: 60-61; Schiklejew, 1930: 342; Ueno, 1935c: 298; Harada, 1943a: 191; Smirnov, 1974: 425-428; Chiang and Du, 1979: 224-225; Rajapaksa and Fernando, 1982: 52, 64; Sabater, 1987: 54-55; Michael and Sharma, 1988: 171-173; Duigan, 1992: 22-24.

Alona intermedia Gurney, 1927: 72.

Female: Body lengths 0.32-0.38 (0.35 ± 0.02) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin archly rounded with a linear row of setae along almost whole ventral margin; posterodorsal corner distinct, slightly below the maximum height; posteroventral corner rounded and smooth. Posterior valve surface marked with longitudinal lines.

Head shield with a short and broad rostrum.

Labral plate broad with smooth margin. Ocellus smaller than compound eye, located in the area with an equidistance to compound eye and to proximal base of AI. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/0-1-3.

Postabdomen short and broad with a round posterodorsal corner. Preanal angle distinct; dorsal margin with 8-10 anal teeth and a linear row of 10 groups of lateral setae that are longer than marginal teeth. Claw large, base with a spine.

Male: Not found.

Collection sites: Collected in January to September from Taipei County (site 44), Taoyuan County (46, 48, 49, 50), Hsinchu city (2), Hsinchu County (7, 8, 10, 12), Maioli County (21, 26, 27), Yunlin County (51), Jaiyi County (18), and Tainan County (41) (Appendix 1). Benthic or planktonic in littoral areas.

Alona costata Sars, 1862
(Fig. 7: A, B)

Alona costata Sars, 1862: 286; Smirnov, 1974: 456-460; Frey, 1965: 160-162; Chiang and Du, 1979: 228-229; Michael and Sharma, 1988: 177-180; Duigan, 1992: 16-17.

Female: Body lengths 0.35-0.53 (0.430 ± 0.042) mm. Preserved specimens whitish or tinted yellow in color. Body oval laterally; dorsal margin slightly arched; ventral margin lined with setae; posterodorsal corner rounded, slightly below the maximum height; posteroventral corner rounded and smooth without denticles. Posterior valve surface marked with longitudinal lines.

Head shield with a short and broad rostrum. Labral plate broadly rounded with smooth margin. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong; dorsal and ventral margins almost parallel. Preanal angle distinct. Posterodorsal corner of postabdomen sharply pointed. Anal teeth 11-13; lateral side of postabdomen near the anus with a linear row of about 11 groups of setae. Claw large with a basal spine and smooth inner margin.

Male: Not found.

Collection sites: Collected in January to October from Taipei County (site 44), Taoyuan County (48, 49, 50), Hsinchu County (4, 7, 9, 10), Ilan county (14), Maioli County (21, 22, 23, 27), Jaiyi County (18), Tainan County (35, 36, 40, 41), Pingdong County (31, 33), and Taidong County (34) (Appendix 1). Benthic or planktonic in littoral areas.

Alona affinis (Leydig 1860)
(Fig. 7: C, D)

Lynceus affinis Leydig, 1860: 223.

Alona affinis Sars, 1916: 331,332; Chiang and Du, 1979: 220-221; Duigan 1992: 24-27.

Biapertura affinis Smirnov, 1974: 572-579; Michael and Sharma, 1988: 205-207.

Female: Body lengths 0.67-0.92 (0.780 ± 0.068) mm. Preserved specimens whitish or tinted yellow in color. Body oval laterally; dorsal margin arched slightly; a linear row of setae along almost whole ventral margin; posterodorsal corner rounded, slightly below level of maximum height; posteroventral corner rounded, smooth without denticles. Posterior valve surface marked with longitudinal lines.

Head shield with a short and broad rostrum; dorsal with two major head pores. Labral plate broad and rounded without teeth on margin. Ocellus diameter equal to or slightly longer than that of compound eye; located in the area between proximal base of AI and rostrum. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong, slightly dilated distally. Preanal angle distinct. Posterodorsal corner rounded. Anal teeth 10-15; lateral side with more than 15 groups of setae along dorsal margin. Claw large with one basal spine. A short row of setae at the base of basal spine.

Male: Not found.

Collection sites: Collected in July from Taipei County (site 45) and Tainan County (37) (Appendix 1). Benthic species in littoral areas.

Remarks: Fryer (1999) considers this species to be under the genus *Biapertura*, but we consider it to be under the genus *Alona*, based on the shell and postabdomen structures. Fryer's (1999) description of "*Biapertura*" merely emphasizes the head pores but neglects its similarities in the important shell and postabdomen structures to those of the genus *Alona*.

Alona quadrangularis (Müller 1785)
(Fig. 7: E, F)

Lynceus quadrangularis Müller, 1785: 72.

Alona quadrangularis Baird, 1843: 92; Ueno, 1930a: 42; Tang *et al*., 1963: 144; Smirnov, 1974: 417-419; Chiang and Du, 1979: 219-220; Michael and Sharma, 1988: 170; Duigan 1992: 23-26.

Female: Body lengths 0.36-0.51 (0.460 ± 0.068) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin arched; almost whole ventral margin with a linear row of setae; posterodorsal corner almost rounded, slightly below level of maximum height; posteroventral corner rounded with smooth margin. Posterior valve surface marked with longitudinal lines.

Head shield with a short and broad rostrum; dorsal with three major head pores. Labral plate broad and rounded with smooth margin. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. Tip of AI almost reaching apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong, slightly dilated distally. Preanal angle prominent; posterodorsal corner of the postabdomen rounded; anal teeth 15-18; lateral side with more than 10 groups of setae along dorsal margin. Claw large with a basal spine.

Male: Not found

Collection sites: Collected in January, April, and July from littoral areas of high mountain ponds in Taoyuan County (site 47), Hsinchu County (11), Nantou County (28), and Taidong County (34) (Appendix 1).

Remarks: Chiang and Du (1979) distinguish *Alona quadrangularis* from *A. affinis* based on setae on postabdomen and basal spine of claw. Duigan (1992) found that his specimens are not distinguishable between the two species by the same traits described by Chiang and Du (1979). Our samples of the two species are distinguishable by setae of postabdomen, basal spine of claw, and number of head pores.

Dunhevedia crassa King, 1853
(Fig. 8: A, B)

Dunhevedia crassa King, 1853: 261; Stingelin, 1905: 357; Sars, 1916: 343-344; Jenkin 1929: 248; Smirnov, 1966: 183; 1969: 555; 1974: 390-394; 1996: 166-167; Chiang and Du, 1979: 242-244; Michael and Sharma, 1988: 157-159.

Female: Body lengths 0.41-0.44 (0.420 ± 0.011) mm. Preserved specimens whitish or tinted yellow in color. Body oval shape laterally; anterior and posterior parts of ventral margin with setae on inner face of valve near margin; middle part of ventral margin with setae; posterodorsal corner distinct, slightly below level of maximum height; posteroventral corner with a distinct sub-terminal denticle on ventral valve.

Head shield with a short and narrow rostrum, sharply pointed terminally. Labral plate cuneiform; margin smooth, without teeth. Ocellus smaller than compound eye, located in the area between proximal base of AI and rostrum. Tip of AI reaching apex of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen boot-shaped; dorsal margin with 13-14 anal teeth; lateral side scattered with several rows of short setae. Claw with a basal spine.

Male: Not found.

Collection sites: Collected in July from Jaiyi County (17) (Appendix 1). Benthic species in littoral areas.

Ephemeroporus barroisi (Richard 1894) (Fig. 8: C-F)

Pleuroxus barroisi Richard, 1894: 375-377; Dumont *et al*., 1981: 165, 174-175.

Chydorus barroisi Sars, 1904: 636; 1916: 339-340; Stingelin, 1905: 358; Gurney, 1916: 336; Johnson, 1953: 928; Smirnov, 1974: 367-372; Chiang and Du, 1979: 257-258; Michael and Sharma, 1988: 149-151.

Alonella barroisi Schiklejew, 1930: 344-345.

Ephemeroporus barroisi Frey, 1982: 234-237, 266-267; Smirnov, 1996: 156-159.

Female: Body lengths 0.25-0.32 (0.270 ± 0.026) mm. Preserved specimens whitish or tinted yellow in color. Body almost circular in lateral view but dorsal margin semicircular. Anterior ventral margin of valve arched without setae; posterior margin of ventral valve straight with setae on inner surface; posterodorsal corner of valve rounded, halfway below level of maximum height; posteroventral angle of valve sharply pointed with a denticle. Valve surface smooth or with faint markings.

Head shield with a short and sharp rostrum. Labral plate broadly cuneiform with four denticular notches on outer margin. Ocellus smaller than compound eye, located in the area between proximal base of AI and rostrum. Tip of AI extending to middle of rostrum. Setal formula of AII: 0-0-3/0-1-3.

Postabdomen moderately oblong with distinct preanal angle; dorsal margin with two groups of anal teeth, an anterior group with three larger spines and a posterior group with seven smaller spines. Claw with two basal spines; proximal spine smaller than distal spine.

Male: Not found.

Collecion sites: Collected in April and July from Ilan County (site 14) and Pingdong County (32) (Appendix 1). Benthic species in littoral areas.

Remarks: According to Frey (1982), *E. barroisi* has a denticle on posteroventral angle of valve and denticular notches on outer margin of labral plate, and should be assigned to the genus *Ephemeroporus* rather than to the genus *Pleuroxus* (Dumont *et al*. 1981).

Chydorus sphaericus (Müller 1785) (Fig. 8: G, H)

Lynceus sphaericus Müller, 1785: 71.

Monoculus sphaericus Jurine, 1820: 157.

Chydorus sphaericus Baird, 1843: 89; Pratt, 1898: 471; Steuer, 1902: 127; Stingelin, 1905: 359; Tang *et al*., 1963: 145; Smirnov, 1974: 342-346; 1996: 101-104; Chiang and Du, 1979: 253-254; Duigan and Murray, 1987: 113-124; Michael and Sharma, 1988: 139-142; Duigan, 1992: 55-61; Brancelj, 1996: 45-59.

Female: Body lengths 0.32-0.39 (0.360 ± 0.019) mm. Preserved specimens whitish or tinted yellow in color. Body circular in lateral view; dorsal margin arched to semicircular. Posterior margin of ventral valve with setae on inner surface of shell; posterodorsal corner of valve rounded, conspicuously below level of maximum height; posteroventral corner rounded, smooth without denticles. Valve surface with lines crossing each other to form a polygon grid.

Head shield with an acute rostrum. Labral plate cuneiform; outer margin smooth. Ocellus smaller than compound eye, located in the area between proximal base of AI and rostrum. AI short, 2/3 length of rostrum; tip not extending over apex of rostrum. Setal formula of AII: 0-0-3/0-1-3.

Postabdomen short and wide. Preanal angle distinct; posterodorsal corner rounded. Dorsal margin with 8-10 anal teeth. A row of minute lateral setae lined along the posterior end. Claw with two basal spines; inner margin with a row of setae.

Male: Not found.

Collection sites: Collected in late Winter to early Spring in January to April and late Summer to Autumn in July to October from Taipei City (sites 42, 43), Taipei County (45), Taoyuan County (46,47,49), Hsinchu City (1), Hsinchu County (4, 5, 10), Ilan County (13, 14), Maioli County (23, 26), Jaiyi County (18), Nantou County (29) and Pingdong County (33) (Appendix 1). Benthic species in littoral areas but occassionally found in planktonic collections.

Alonella excisa (Fischer 1854)
(Fig. 9: A-C)

Lynceus excisus Fischer, 1854: 428.

Alonella excisa Stingelin, 1905: 355; Gurney, 1916: 336; Sars, 1916: 338-339; Ueno, 1966: 97; Smirnov, 1966: 184; 1969: 550; 1974: 317-321; 1996: 90-92; 1998: 210; Chiang and Du, 1979: 239-240; Michael and Sharma, 1988: 135-136; Duigan, 1992: 35-37; Hudec, 1998: 210.

Female: Body lengths 0.26-0.32 (0.290 ± 0.025) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin arched; a row of setae along ventral margin. Posterodorsal corner of valve distinct, conspicuously below level of maximum height; posteroventral angle distinct with a blunt process. Valve surface with many lines crossing one another to form a polygon grid, each grid having small striations inside.

Head shield with a sharp rostrum. Labral plate broad with blunt apex; outer margin smooth. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. Tip of AI reaches pass middle of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong. Preanal angle rather distinct; dorsal margin with 9-11 anal teeth; lateral side with a row of 11 setae near dorsal margin. Claw with two basal spines; proximal spine smaller.

Male: Not found.

Collection sites: Collected in September from Ilan County (site 13) (Appendix 1). Benthic species in littoral areas, sometimes found in planktonic collections.

Pleuroxus trigonellus (Müller 1785) (Fig. 9: D-F)

Lynceus trigonellus Müller, 1785: 74.

Pleuroxus trigonellus Baird, 1843: 93; Ueno, 1935b: 212; Smirnov, 1966: 177, 180, 188; 1974: 276; 1996: 38-40; Chiang and Du, 1979: 247-248; Michael and Sharma, 1988: 125-127; Duigan, 1992: 41-43; Frey, 1993: 134-135.

Female: Body lengths 0.42-0.49 (0.450 ± 0.021) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin arched; almost whole ventral margin with setae. Posterodorsal corner of valve rounded, conspicuously below level of maximum height; posteroventral corner distinct, angle with denticles varying in size and number.

Head shield with a long and narrow rostrum. Labral plate cuneiform; front margin smooth. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. AI and AII short; tip (not including setae) of AI not reaching beyond middle of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong, slightly narrowing distally; distal end deeply depressed. Preanal angle distinct; dorsal margin with 12-15 anal teeth. Claw with two basal spines; proximal spine smaller than distal spine.

Male: Not found.

Collection sites: Collected in January to April, July, and September from Taoyuan County (sites 46, 47, 48), Hsinchu County (11), Maioli County (23, 25. 26, 27), Jaiyi County (19), Tainan County (38), and Pingdong County (32) (Appendix 1). Benthic species in littoral areas.

Disparalona leei (Chien 1970) (Fig. 10: A-C)

Alona leei Chien, 1969: 67-72.

Alonella leei Chien, 1970: 536-538.

Disparalona leei Michael and Frey, 1984: 95-106; Smirnov, 1996: 79-81.

Female: Body lengths 0.38-0.42 (0.400 ± 0.021) mm. Preserved specimens whitish or tinted yellow in color. Body elongate and oval in lateral view; dorsal margin arched; almost entire ventral margin lined with setae. Posterodorsal corner of valve distinct with a shallow depression on posterior valve margin near the corner; posteroventral corner rounded and smooth without denticles. Valve surface marked with longitudinal lines crossing each other, forming a polygon grid.

Head shield with a long and sharp rostrum. Labral plate small and cuneiform; front margin smooth. IDL with three setae; length of the short seta equal about an half of that of the other two setae. Ocellus smaller than compound eye, located in the area between proximal base of AI and rostrum. Tip of AI not extending pass half of rostrum. Setal formula of AII: 0-0-3/0-1-3.

Postabdomen oblong with both dorsal and ventral margins convex. Dorsal margin with 9-11 anal teeth. Claw with two basal spines.

Male: Not found.

Collection sites: Collected in January and February from Hsinchu County (sites 3, 10), Maioli County (24), and Jaiyi County (18) (Appendix 1). Benthic species in littoral areas.

Remarks: Morphologically the valve of *D. leei* is fairly similar to that of *D. rostrata*, so that many authors have treated *D. leei* as *D. rostrata* without denticles at posteroventral corner (Tang *et al*. 1963; Smirnov 1974; Chiang and Du 1979; Idris and Fernando 1981).

***Disparalona hamata* (Baird 1835)**
(Fig. 10: D-F)

Lynceus hamatus Baird, 1835: 100.

Pleuroxus hamatus Baird, 1843: 94; Smirnov, 1974: 293-296.

Pleuroxus hamulatus Birge, 1879: 22-23; 1910: 1052; Chiang and Du, 1979: 244-246.

Alonella hamata Dumont, 1981: 105; Dumont *et al*., 1984: 164.

Alonella hamulatus Idris and Fernando, 1981: 241-242.

Alonella hamulata Zoppi *de* Roa and Vasquez, 1991: 56.

Disparalona hamata Smirnov, 1996: 81-83.

Female: Body lengths 0.42-0.55 (0.490 ± 0.037) mm. Preserved specimens whitish or tinted yellow in color. Body oval in lateral view; dorsal margin arched; almost whole ventral margin with a row of setae. Posterodorsal corner of valve rounded, conspicuously below level of maximum height; posteroventral corner rounded and smooth without denticles. Posterior valve surface marked with longitudinal lines.

Head shield with a long and narrow rostrum. Labral plate cuneiform; front margin smooth. Ocellus smaller than compound eye, located anteriorly to the area between proximal base of AI and rostrum. IDL with two setae; the proximal seta hook-shaped. Tip of AI not reaching middle of rostrum. Setal formula of AII: 0-0-3/1-1-3.

Postabdomen oblong; middle of the posterior end depressed. Preanal angle distinct; posterodorsal corner of the postabdomen rounded; dorsal margin with 12-14 anal teeth. Claw base with two basal spines.

Male: Not found.

Collection sites: Collected in January, August, and September from Taoyuan County (site 47), Hsinchu County (5), and Maioli County (23). Benthic species in littoral areas.

Acknowledgement

We thank Dr. Chang-Tai Shih for his kind assistance, systematic suggestions and encouragement.

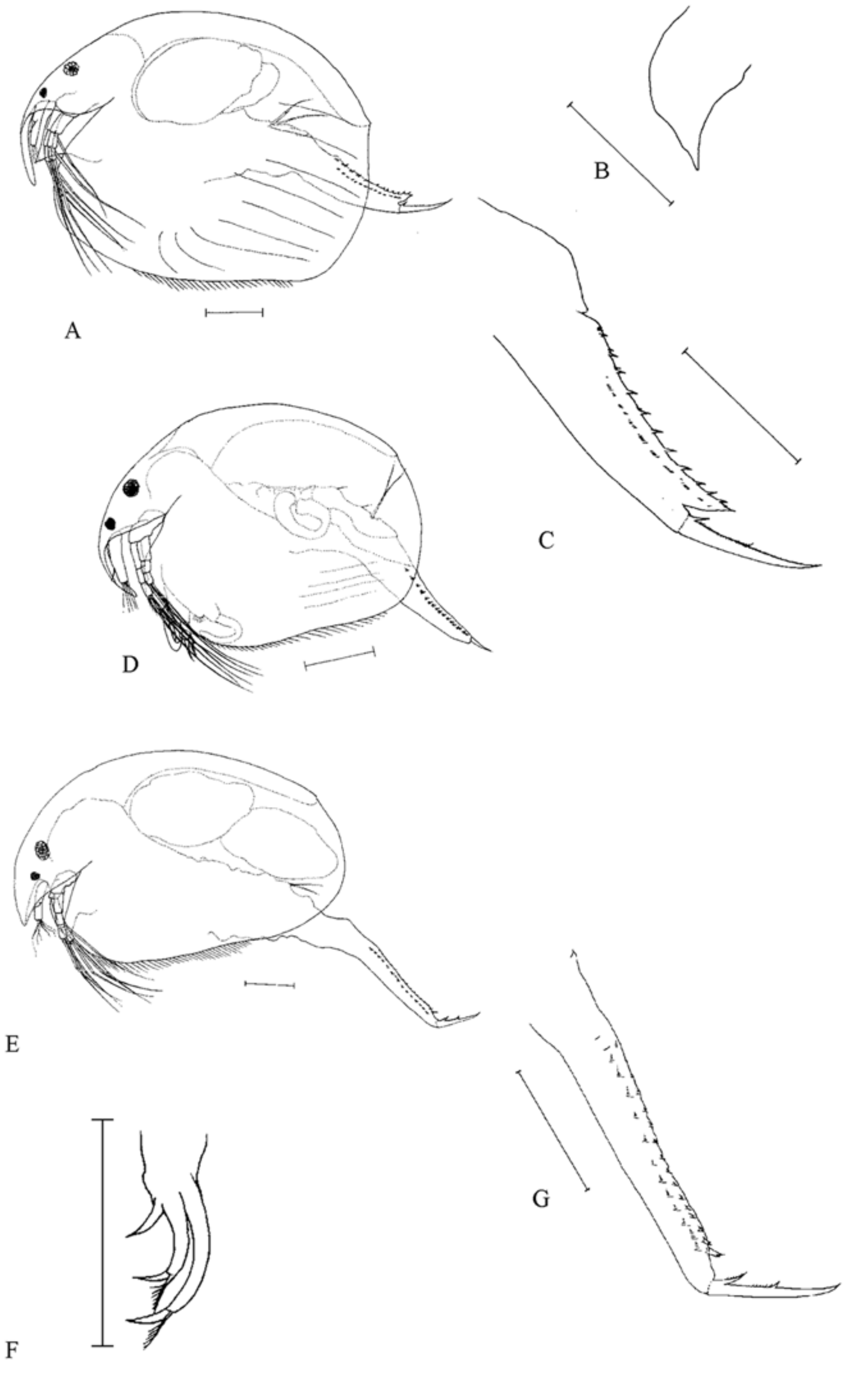

Fig. 3. *Kurzia longirostris* Daday, 1898 (adult female: A, lateral view of habitus; B, rostrum plate; C, postabdomen, and adult male: D, lateral view of habitus), and *Camptocercus uncinatus* Smirnov, 1971 (adult female: E, lateral view of habitus; F, setae on inner distal lobe of limb I; G, postabdomen) (Scale bar = 0.1 mm).

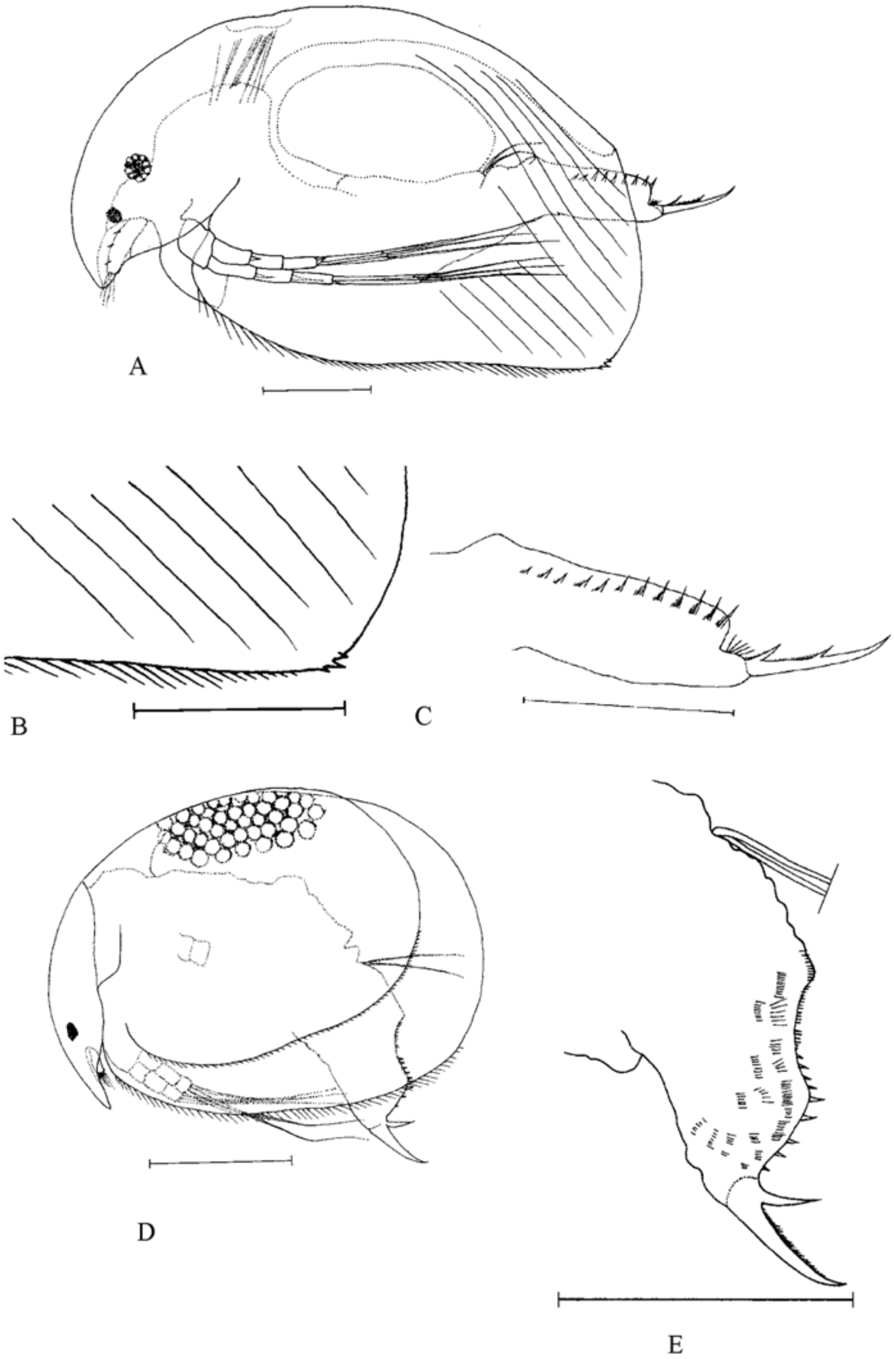

Fig. 4. *Acroperus harpae* (Baird 1835) (adult female: A, lateral view of habitus; B, posteroventral angle of valve; C, postabdomen), and *Monospilus dispar* Sars, 1862 (adult female: D, lateral view of habitus; E, postabdomen) (scale bar = 0.1 mm).

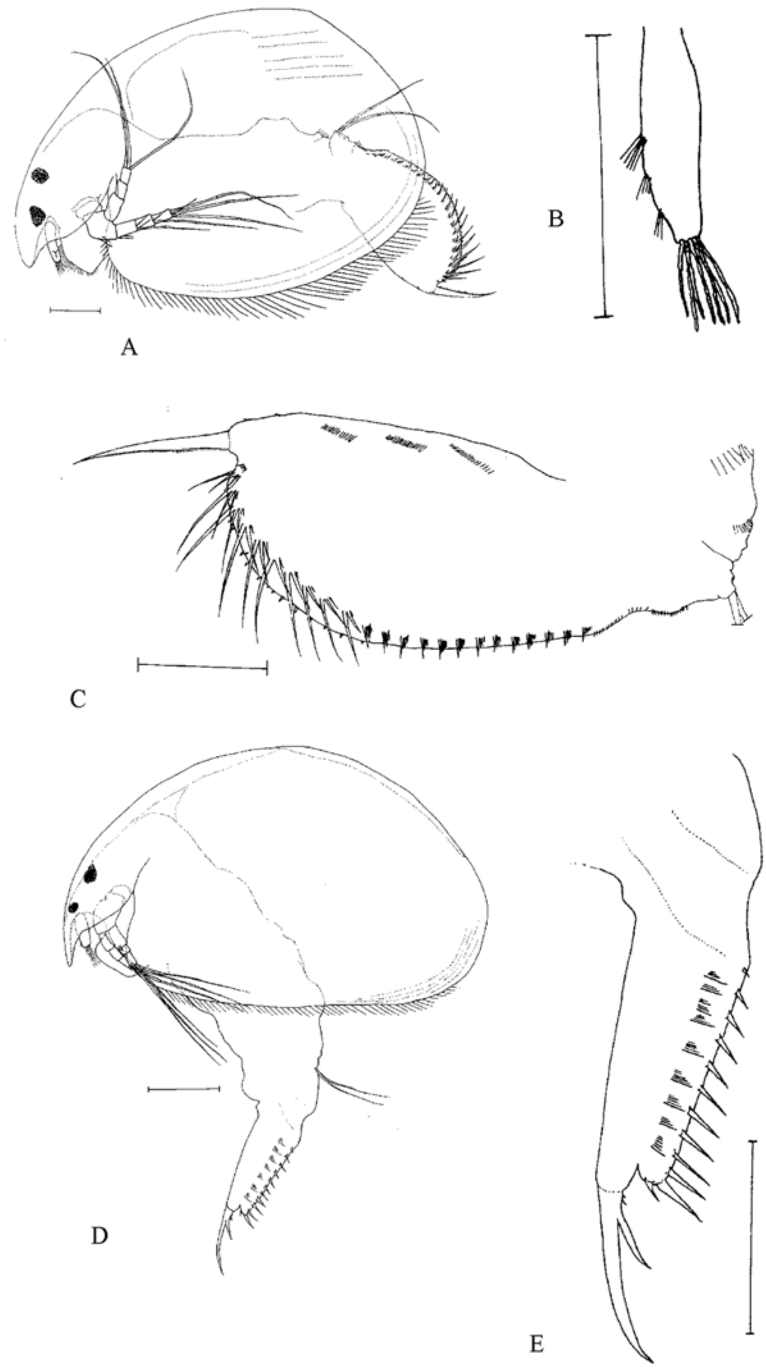

Fig. 5. *Leydigia ciliate* (Gauthier 1939) (adult female: A, lateral view of habitus; B, antennule; C, postabdomen), and *Oxyurella singalensis* (Daday 1898) (adult female: lateral view of habitus; E, postabdomen) (Scale bar = 0.1 mm).

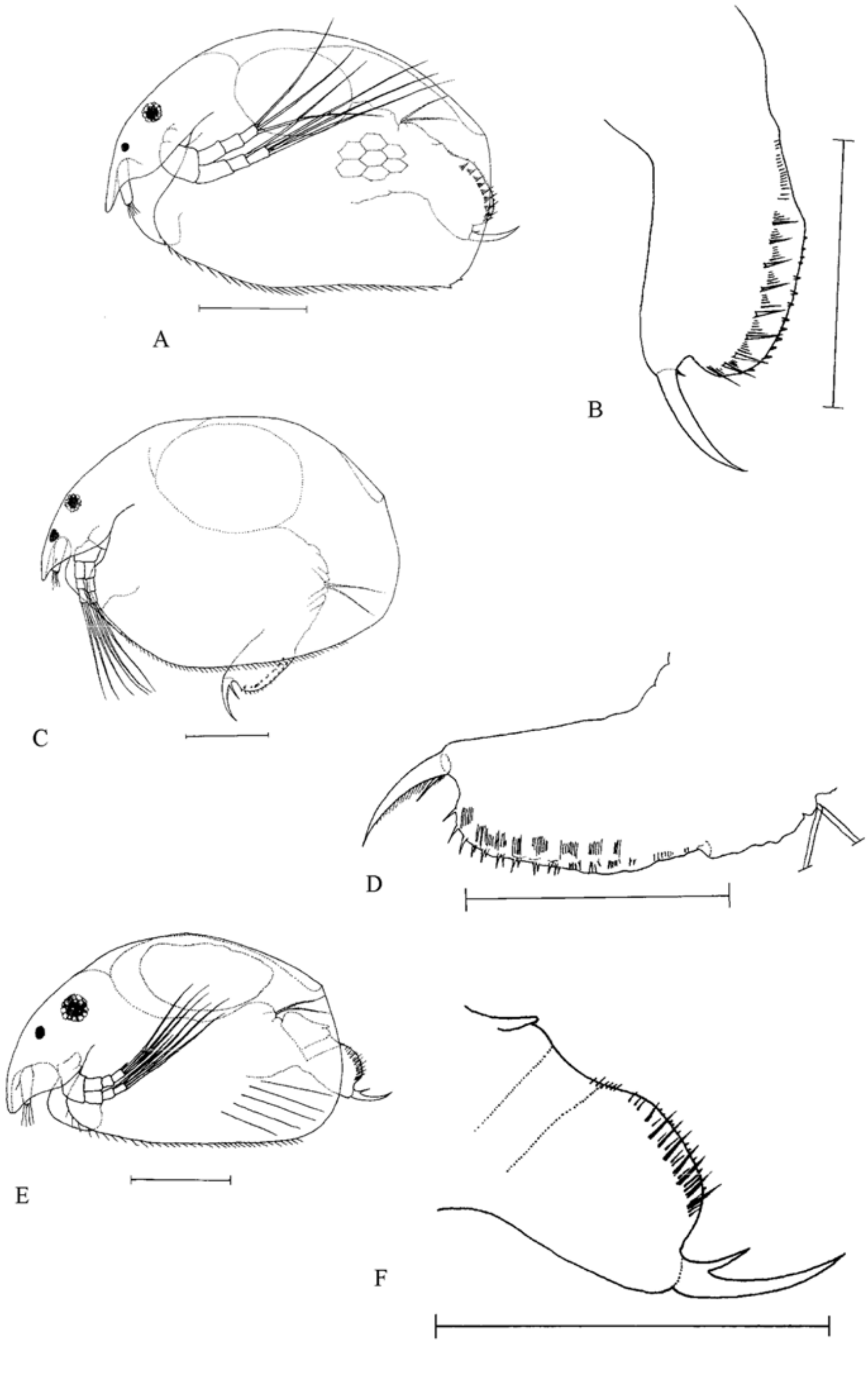

Fig. 6. *Karualona karua* (King 1853) (adult female: A, lateral view of habitus; B, postabdomen), *Alona diaphana* King, 1853 (adult female: C, lateral view of habitus ; D, postabdomen), and *Alona rectangular* Sars, 1862 (adult female: E lateral view of Habitus; F, postabdomen) (scale bar = 0.1 mm).

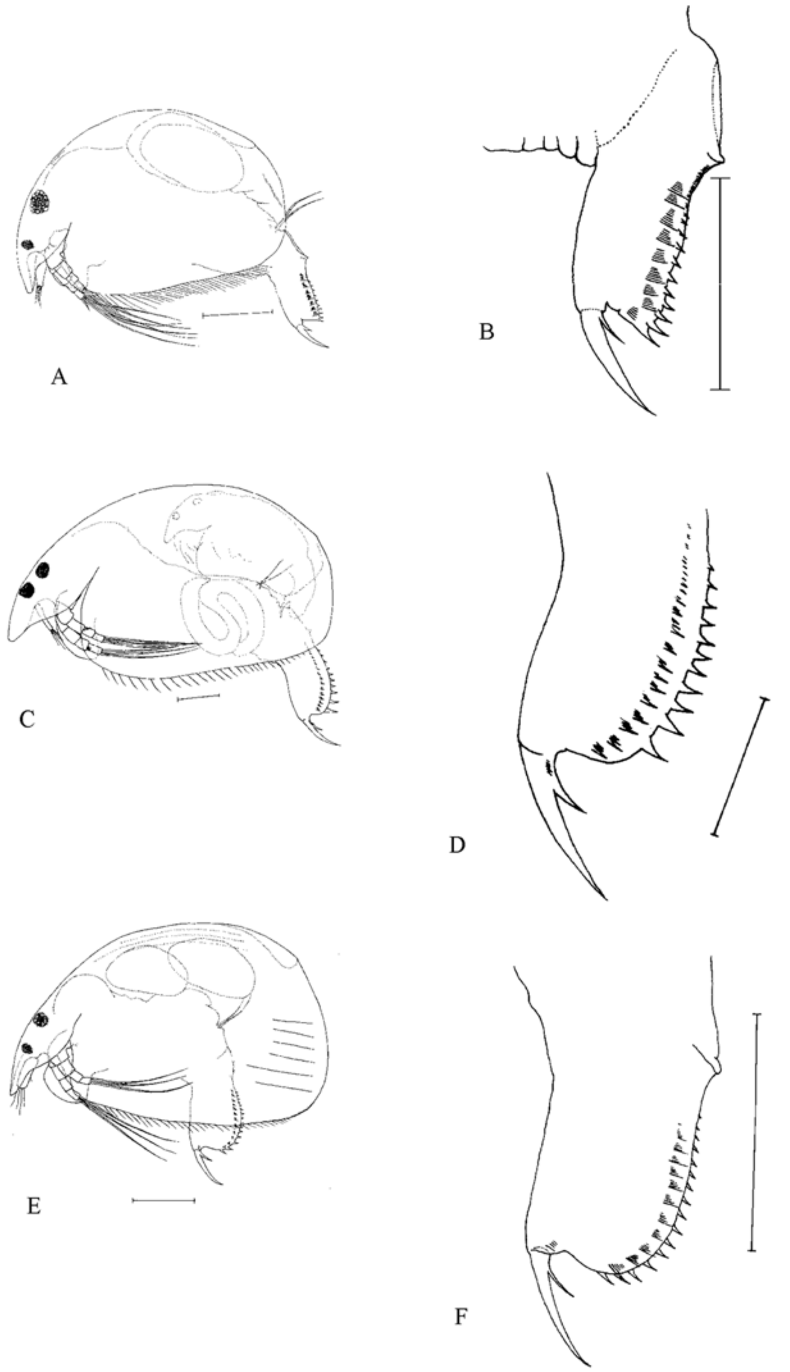

Fig. 7. *Alona costata* Sars, 1862 (adult female: A. lateral view of habitus; B, postabdomen), *Alona affinis* (Leydig 1860) (adult female: C, laeral view of habitus; D, postabdomen), and *Alona quadrangularis* (Müller 1785) (adult female: E. lateral view of habitus; F, postabdomen) (scale bar = 0.1 mm).

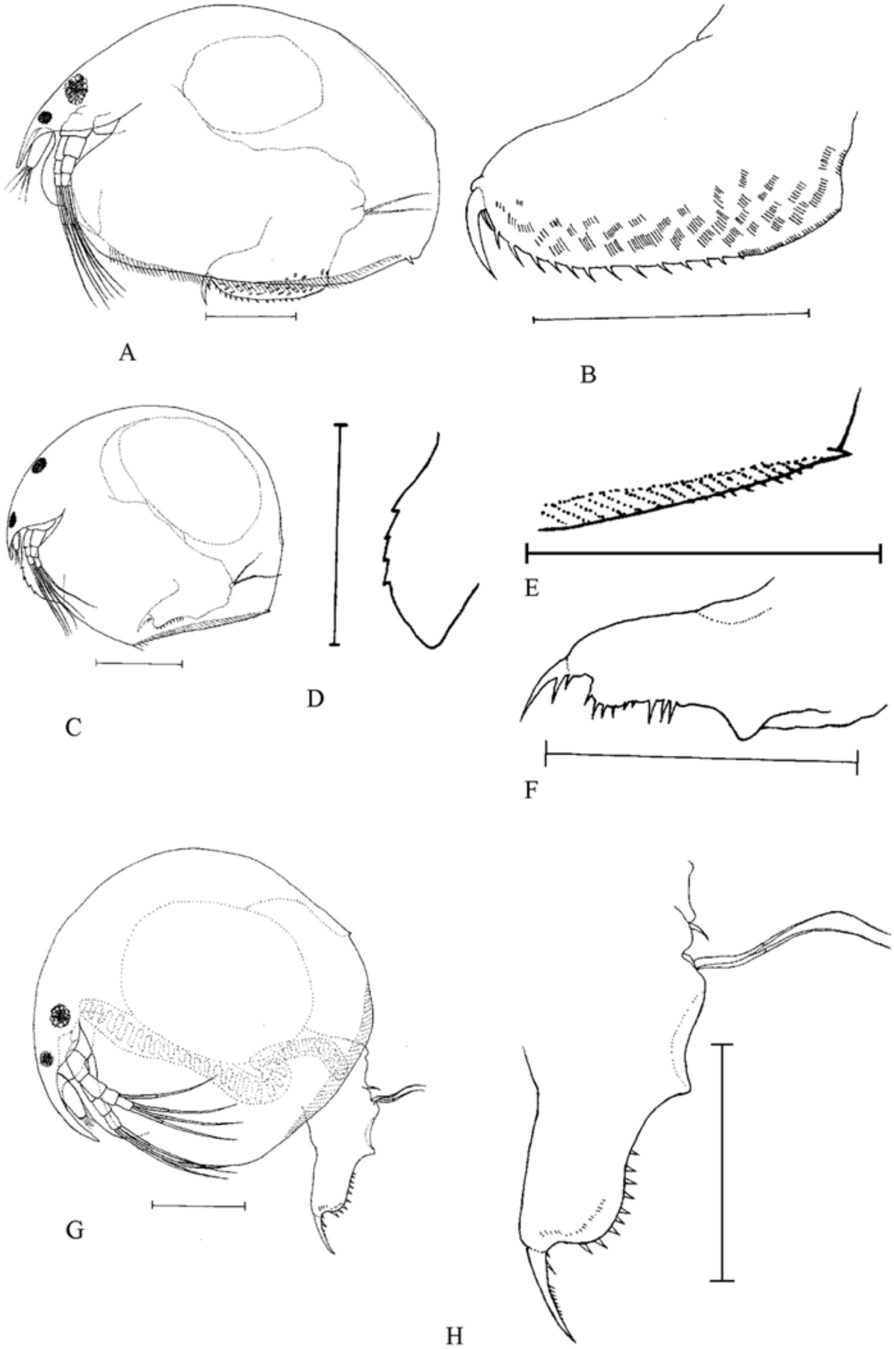

Fig. 8. *Dunhevedia crassa* King, 1853 (adult female: A, lateral view of habitus; B, postabdomen), *Ephemeroporus barroisi* (Richard 1894) (adult female: lateral view of habitus; D, labral plate; E, posteroventral angle of valve; F, postabdomen), and *Chydorus sphaericus* (Müller 1785) (adult female: lateral view of habitus; H, postabdomen) (scale bar = 0.1 mm).

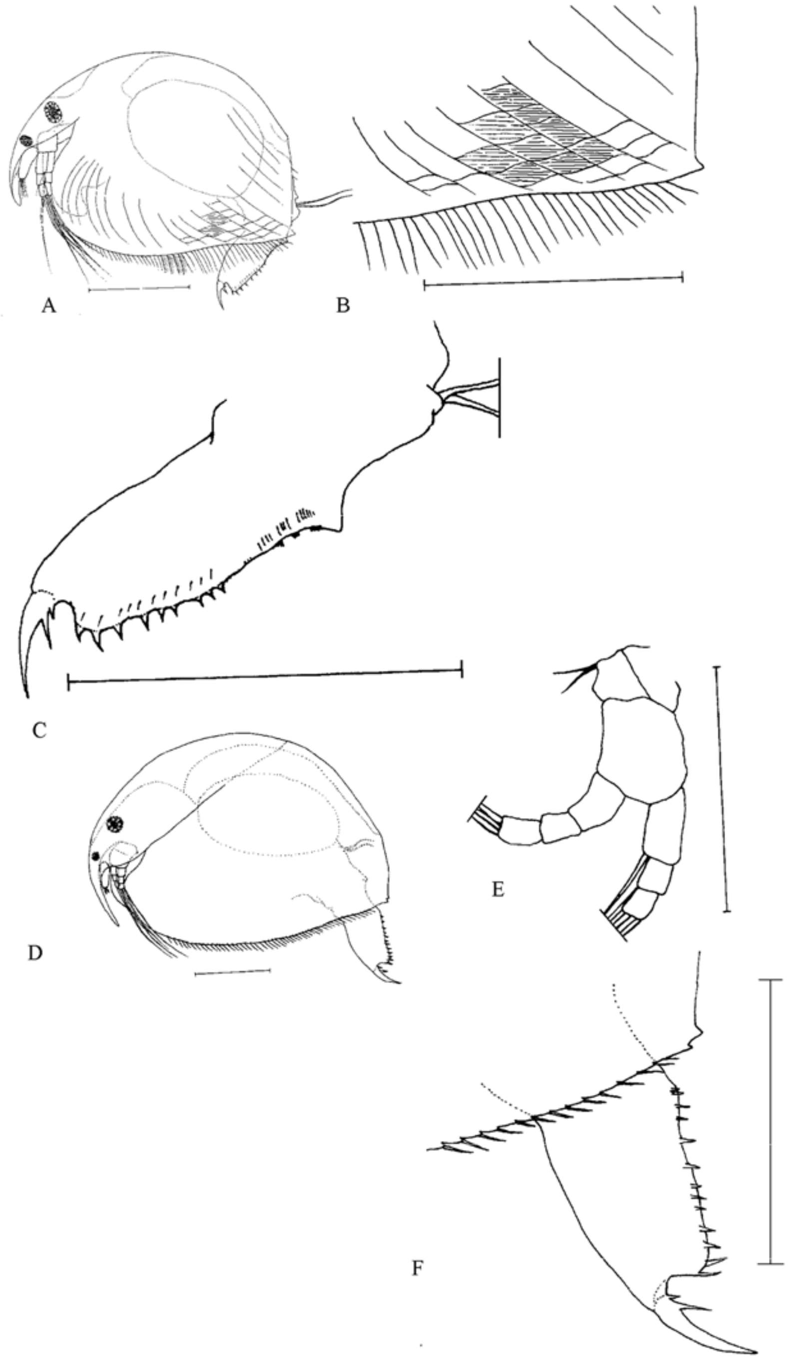

Fig. 9. *Alonella excise* (Fischer 1854) (adult female: lateral view of habitus; B, posteroventral angle of valve; C, postabdomen), and *Pleuroxus trigonellus* (Müller 1785) (adult female: lateral view of habitus; E, setae on baso-segment of AII; F, postabdomen and posteroventral angle of valve) (scale bar = 0.1 mm).

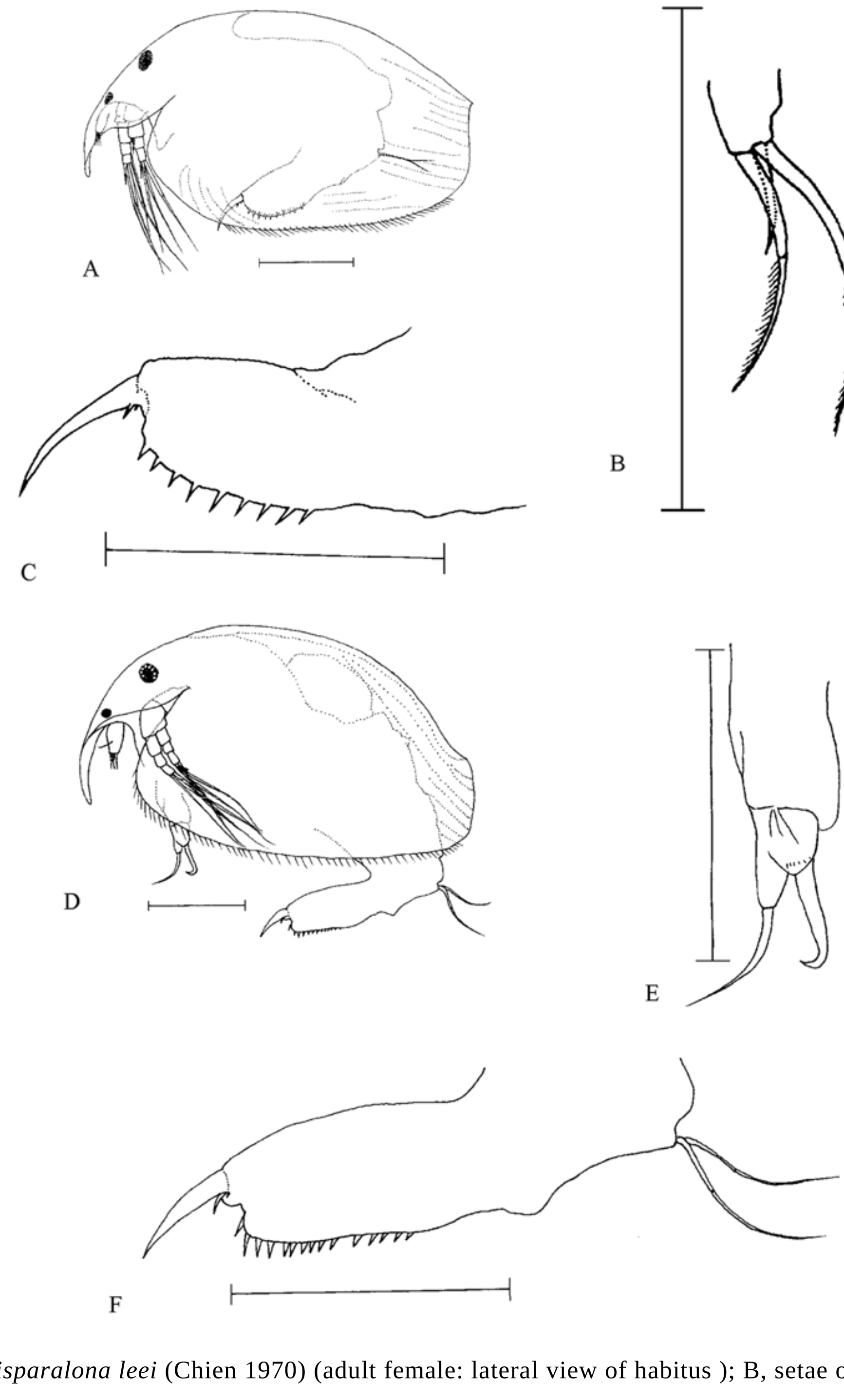

Fig. 10. *Disparalona leei* (Chien 1970) (adult female: lateral view of habitus); B, setae on inner distal lobe of limb I; C, postabdomen), and *Disparalona hamata* (Baird 1835) (adult female: lateral view of habitus; E, setae on inner distal lobe of limb I; F, postabdomen) (scale bar = 0.1 mm).

Literature Cited

Baird, W. 1835. List of Entomostraca found in Berwickshire. History of the Berwickshire Naturalists' Club, 95-100.

Baird, W. 1843. The Natural History of the British Entomostraca, No. VI. Annals and Magazine of Natural History series 1, 11: 81-95.

Birge, E. A. 1879. Notes on Cladocera. Transactions. Wisconsin Academy of Sciences, Arts and Letters 4: 77-109.

Birge, E. A. 1910. Notes on Cladocera. Transactions. Wisconsin Academy of Sciences, Arts and Letters 16: 1017-1066.

Brancelj, A. 1990. *Alona hercegovinae* n. sp. (Cladocera: Chydoridae), a blind cave-inhabiting Cladoceran from Hercegovina (Yugoslavia). Hydrobiologia 199: 7-16.

Brancelj, A. 1996. *Chydorus mutilus* Kreis, 1921- a postephippial form of *Chydorus sphaericus* (Müller 1785). Hydrobiologia 323: 45-59.

Brehm, V. 1933a. Die Cladoceren der Deutschen Limnologischen Sunda-Expedition. Archiv für Hydrobiologie-Supplement 11: 631-771.

Brehm, V. 1933b. Mitteilungen von der Wallacea-Woltereck. Mitteilung V. Zoologischer Anzeiger 104: 31-40.

Chen, S. Z. 1993. A preliminary study on genus *Leydigia* Kurz of China (Branchiopoda: Diplostraca). Acta. Zootaxonomica Sinica 18(1): 14-17. (In Chinese with English abstract)

Chen, C. T. and B. J. Wang. 1997 The lakes and reservoirs of Taiwan. Bo-Hai-Tom Press, Taipei. 504 pp. (In Chinese)

Chiang, S. C. and N. S. Du. 1979. Freshwater Cladocera. Fauna Sinica, Crustacea. Science Press Academia Sinica, Peking. 297 pp. (In Chinese)

Chien, S. M. 1969. Summer Cladocera of the Pearl River system. Master's thesis, the Mississippi State University, State College, Mississippi. 137 pp.

Chien, S. M. 1970. *Allonella fitzpatricki* sp. n. and *A. leei* sp. n.: New Cladocera from Mississippi. Transactions of the American Microscopical Society 89: 532-538.

Daday, E. 1898. Mikroskopische Susswasserthiere aus Ceylon. Természetrajzi Füzetek 21: 1-123.

Daday, E. 1904. Mikroskopische Susswasserthiere der Umgebung aus des Balaton. Zoologische Jahrbücher. Abteilung für Systematik, Geographie und Biologie der Tiere 19: 37-98.

Duigan, C. A. 1992. The ecology and distribution of the freshwater Chydoridae (Branchiopoda, Anomopoda) of Ireland, with taxonomic comments on some species. Hydrobiologia 241: 1-70.

Duigan, C. A. and D. A. Murray. 1987. A contribution to the taxonomy of *C. sphaericus* sens. lat. (Cladocera, Chydoridae). Hydrobiologia 45: 113-124.

Dumont, H. J. 1981. Cladocera and free-living Copepoda from the Fouta Djalon and adjacent mountain areas in West Africa. Hydrobiologia 85: 97-116.

Dumont, H. J., J. Pensaert and A. I. El Moghraby. 1984. Cladocera from the Sudan: Red Sea Hills, Jebel M arra and valley of the main Nile. Hydrobiologia 110: 163-169.

Dumont, H. J., J. Pensaert and I. Van de Velde. 1981. The crustacean zooplankton of Mali (West Africa). Hydrobiologia 80: 161-187.

Dumont, H. J. and M. Silva-Briano. 2000. *Karualona*. n. gen. (Anomopoda: Chydoridae), with a description of two new species, and a key to all known species. Hydrobiologia 435: 61-82.

Ekman, S. 1905. Die Phyllopoden, Cladoceren und freilebenden copepoden der nord-schwedischen Hochgebirge. Zoologische Jahrbücher, Abteilung für Systematik 21: 1-47 (Cladocera: 15-29).

Fischer, S. 1854. Abhandlung ueber einige neu oder nicht genau gekannte Arten von Daphniden und Lynceiden als Beitrag zur Fauna Russlands. Bulletin de la Société Impériale des Naturalistes de Moscou 27: 423-434.

Frey, D. G. 1965. Differentiation of *Alona costata* Sars from two related species (Cladocera, Chydoridae). Crustaceana 8(2): 159-173.

Frey, D. G. 1982. Relocation of *Chydorus barroisi* and related species (Cladocera, Chydoridae) to a new genus and description of two new species. Hydrobiologia 86: 231-269.

Frey, D. G. 1991. A new genus of alonine chydorid cladocerans from athalassic saline waters of New South Wales, Australia. Hydrobiologia 224: 11-48.

Frey, D. G. 1993. Subdivision of the genus *Pleuroxus* (Anomopoda, Chydoridae) into subgenera worldwide. Hydrobiologia 262: 133-144.

Fryer, J.G. 1999. A comment on a recent phylogenetic analysis of certain orders of the branchiopod Crustacea. Crustaceana 72(9): 1039-1050.

Gauthier, H. 1939. Contribution a l'ecologie du la faune dulcaquicole de la region du Tchad et particulierement des Branchiopodes et des Ostracodes. Bulletin de l'Institut Français d'Afrique Noire I: 110-224.

Gurney, R. 1911. On some freshwater Entomostraca from Egypt and the Soudan. Annals and Magazine of Natural History 7(8): 25-33.

Gurney, R. 1916. On some freshwater Entomostraca from Ceylon. Proceedings of the Zoological Society of London 1916: 333-343.

Gurney, R. 1927. Some Australian freshwater Entomostraca reared from dried mud. Proceedings of the Zoological Society of London 1: 59-79.

Hann, B. J. 1981. Occurrence and distribution of littoral Chydoridae (Crustacea, Cladocera) in Ontario, Canada, and taxonomic notes on some species. Canadian Journal of Zoology 59: 1465-1474.

Harada, I. 1933. Zur Biologie des Zooplankton im Zitugetutan (see Candidius). Memory Factory Science Agriculture, Taihoku Imperial University 7: 71-139.

Harada, I. 1943a. A limnological study of Lee-Yu-Tan, central Taiwan. Transaction Natural History Society of Formosa 33(238): 184-193. (In Japanese)

Harada, I. 1943b. Studien űber die Susswasserfauna Formosas VI. Das Vorkommen von *Ilyocryptus agilis* Kurz, 1878 in Formosa. Transaction of Natural History Society of Formosa 33 (238): 194-199. (In Japanese)

Hudec, I. 1998. Anomopoda (Crustacea: Branchiopoda) from some Venezuelan tepuis. Hydrobiologia 377: 205-211.

Hudec, I. 2000. Subgeneric differentiation within *Kurzia* (Crustacea: Anomopoda: Chydoridae) and a new species from Central America. Hydrobiologia 421: 165-178.

Idris, B. A. G. and C. H. Fernando.1981. Cladocera of Malaysia and Singapore with new records, redescriptions, and remarks on some species. Hydrobiologia 77: 233-256.

Jenkin, P. M. 1929. Notes on some Cladocera from the New Hebrides. Annals and Magazine of Natural History (10) 4: 246-249.

Johnson, D. S. 1953. On some Cladocera from South African muds. Annals and Magazine of Natural History 6(12): 923-928.

Jurine, L. 1820. Histoire des Monocles, qui se trouvent aux environs de Genиve. I-XVI, 1-260. (Geneva/Paris).

King, R. L. 1853. On some of the species of Daphniidae found in New South Wales. Papers & Proceedings Royal Society of Tasmania 2 (2): 243-263.

Korovchinsky, N. M. 1996. How many species of Cladocera are there? Hydrobiologia 321: 191-204.

Leydig, F. 1860. Naturgeschichte der Daphniden. Tubingen. 1-252 pp.

Masson, B. and C. Amoros. 1992. The unique headpore of *Monospilus dispar* (Cladocera, Chydoridae) is not lonesome: New record of minute lateral pores. Hydrobiologia 232: 145-148.

Michael, R. G. and D. G. Frey. 1984. Separation of *Disparalona leei* (Chien 1970) in North America from *D. rostrata* (Koch 1841) in Europe (Cladocera, Chydoridae). Hydrobiologia 114: 81-108.

Michael, R. G. and B. K. Sharma. 1988. Indian Cladocera: Fauna of India and adjacent countries. Department of Zoology, North-Eastern Hill University, Shillong 793014, Meghalaya, India. 262 pp.

Müller, O. F. 1785. Entomostraca seu Insecta testacea quae in aquis Daniae et Norvegiae reprit, descripsit et iconibus illustrativ, Lipsialet. Havniae. 134 pp.

Pratt, E. M. 1898. The Entomostraca of Lake Bassenthwaite. Annals and Magazine of Natural History 2(7): 467-476.

Rajapaksa, R. and C. H. Fernando. 1982. The Cladocera of Sri Lanka (Ceylon), with remarks on some species. Hydrobiologia 94: 49-69.

Richard, J. 1894. Cladoceres recueillis par le Dr Theod. Barrois en Palestine, en Syrie et en Egypte. Revue biologique du nord de la France, VI, 360-378.

Rzoska, J. 1952. Notes on some Cladocera from the Upper White Nile. Annals and Magazine of Natural History 5(12): 466-474.

Sabater, F. 1987. On the interstitial Cladocera of the River Ter (Catelonia, NE Spain), with a description of the male of *Alona phreatica*. Hydrobiologia 144: 51-62.

Sars, G. O. 1862. Oversight af de af ham I Omegnen af Christiania iagttagne Crustacea-Cladocera. Forhandl. Vidensk. Selsk. Christiania, 1861, 144-167; 250-302.

Sars, G. O. 1901. Contribution to the knowledge of the fresh-water Entomostraca of South America. Part I. Cladocera. Archiv for Mathematik og Naturvidenskab, Christiana 23(3): 1-102.

Sars, G. O. 1904. Pacifische Plankton-Crustaceen. Zoologische Jahrbücher, Abteilung für Systematik 19: 629-646.

Sars, G. O. 1916. The freshwater Entomostraca of Cape Province (Union of South Africa). Part I. Cladocera. Annals of the South African Museum 15: 303-351.

Schiklejew, S. M. 1930. Die Cladocerafauna der kaukasischen Hegegewasser und des Strandes des Schwarzen Meeres. Archiv für Hydrobiologie 21: 336-349.

Smirnov, N. N. 1966. *Pleuroxus* (Chydoridae): Morphology and Taxonomy. Hydrobiologia 28(2): 161-194.

Smirnov, N. N. 1969. *Alonella* and *Dunhevedia* (Chydoridae, Cladocera): Morphology of trunk limbs. Hydrobiologia 33: 547-560.

Smirnov, N. N. 1974. Fauna of the U.S.S.R. Crustacea. Volume 1, No. 2, Chydoridae.

(English translation of 1971), U.S.S.R. Academy of Science, Zoological Institute, New Ser No. 101: 644 pp.

Smirnov, N. N. 1988. Cladocera (Crustacea) from Nicaragua. Hydrobiologia 160: 63-77.

Smirnov, N. N. 1996. Cladocera: The Chydorinae and Sayciinae (Chydoridae) of the world. Guides to the identification of the microinvertebrates of the Continental Waters of the World 11. SPB Academic Publishing. 197 pp.

Smirnov, N. N. 1998. A revision of the genus *Camptocercus* (Anomopoda: Chydoridae: Aloninae). Hydrobiologia 386: 63-83.

Steuer, A. 1902. Die Entomostraken Fauna der " alten Donau" bei Wien. Zoologische Jahrbücher, Abteilung für Systematik 15: 116-139.

Stingelin, T. 1905. Untersuchungen uber die Cladocerenfauna von Hinterindien, Sumatra und Java, nebst einem Beitrage zur Cladoceren-Kenntnis der Hawaii-Inseln. Zoologische Jahrbücher, Abteilung für Systematik 21: 327-370.

Tang, T. J., C. Lee and G. F. Chen. 1963. The preliminary report of Cladocera from Por-Yang Lake. Journal of Jiangxi University (Science) 1: 141-161. (In Chinese)

Ueno, M. 1930a. Cladocerans from Alpine Lakes. Dodutsugaku-Zasschi 42(495): 38-44. (In Japanese)

Ueno, M. 1930b. Cladocera of Hokkaido lakes and ponds (I). Dodutsugaku-Zasschi 43(512): 441-450. (In Japanese)

Ueno, M. 1935a. Crustacea collected in the lakes of southern Sakhalin. Annotationes Zoologicae Japonensis15(1): 88-94.

Ueno, M. 1935b. Cladocera from Shanghai (China). Transaction of Natural History Socity of Formosa 25(142): 212-215. (In Japanese)

Ueno, M. 1935c. Inland Water Fauna of Formosa II. Cladocera (1). Transaction of Natural History Socity of Formosa 25(144): 293-299. (In Japanese)

Ueno, M. 1936. Cladocera of Lake Ngardok in Babelthaop of the Palau Islands. Annotationes Zoologicae Japonensis 15(4): 514-520.

Ueno, M. 1938a. Cladocera fauna of Formosa. Bulletin of the Biogeographical Society of Japan 8(8): 121-132.

Ueno, M. 1938b. Inland water fauna of Taiwan (Formosa). A zoogeographical sketch based chiefly on the microfauna. Bulletin of the Biogeographical Society of Japan 8(12): 161-176.

Ueno, M. 1938c. Japanese freshwater Cladocera, a zoogeographical sketch. Annotationes Zoologicae Japonensis 17: 283-294.

Ueno, M. 1966. Cladocera and Copepoda from Nepal. Japanese Journal of Zoology 26: 95-100.

Young, S.S. and Y. H. Tuo. 2011. The freshwater cladocera: Families Sididae, Bosminiidae, Daphniidae, Moinidae, Ilyocryptidae, and Macrothricidae (Crustacea: Branchiopoda) of Taiwan, with description of new species *Daphnia ueno* sp. nov. Journal National Taiwan Museum 64(1): 19-73.

Zoppi de Roa, E. and W. Vasquez. 1991. Additional Cladoceran records for Mantecal and new for Venezuela. Hydrobiologia 225: 45-62.

聚合性單寧酸對圈養台灣獼猴(*Macaca cyclopis*)消化生理之影響

Effects of Condensed Tannins on Digestive Physiology of the Captive Taiwanese Macaques (*Macaca cyclopis*)

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摘 要

植物之化學成分可能影響植食動物之消化生理，進而影響其取食模式及覓食策略，故了解動物消化生理反應與植物次級化合物(secondary compound)之相關性，是研究其覓食策略之重要基礎。本研究檢視聚合性單寧酸對台灣獼猴消化生理之影響，將有助於了解植物化學成分與其覓食策略之關係。利用在餵食食物中添加食物乾物質重 3%及 6%之白堅木(quebracho)粉末(含聚合性單寧酸達 76.5 mg/g DM)，量測受試圈養台灣獼猴(*Macaca cyclopis*)之進食量、腸道滯留時間、表面消化率等消化生理數值，以及聚合性單寧酸回收率。排遺分析所得聚合性單寧酸回收率均高於 90%，攝入較高濃度聚合性單寧酸顯著降低台灣獼猴之進食量，但對食物腸道滯留時間並無顯著影響，此外，食物之聚合性單寧酸含量對台灣獼猴之乾物質及蛋白質消化率有顯著影響。研究結

果顯示，台灣獼猴無法降解或分解聚合性單寧酸，而其消化生理受聚合性單寧酸之顯著影響，故植物所含聚合性單寧酸濃度是影響台灣獼猴覓食策略因素之一。

Abstract

Chemical components of plants may affect digestive physiology of herbivores, which in turn, set constraints on their feeding patterns and feeding strategies. Therefore, information on the effects may reveal the feeding strategies. This study was aimed to investigate the effects of condensed tannins on digestive physiology of the Taiwanese macaque (*Macaca cyclopis*) and to determine whether this secondary metabolite of plants affects its feeding strategy. Captive macaques were fed with food added with 3% and 6% Quebracho powder as the condensed tannin. We found that the recovery rate of the ingested condensed tannin was over 90%, and the ingestion significantly reduced the amount of the food intake and digestibility of its dry matter and protein. The results suggested that the digestive physiology of the Taiwanese macaque is compromised by condensed tannins in its food, and thus, this secondary compound of plants may constrain its feeding strategy.

關鍵詞：植食、單寧、消化生理、覓食策略、台灣獼猴

Key words: herbivory, tannin, digestive physiology, feeding strategy, *Macaca cyclopis*

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緒　言

在自然界中，動植物互動關係是普遍存在的，而互動之一方可能在受另一方改變而決定自己本身演化路徑，在研究植食這項動植物互動關係中，植物次級化合物對植食性動物的營養及消化生理影響是一個重要領域(Schemske and Horvitz 1988)。根據植物最佳防禦策略指出，植物爲了避免植食性動物大量取食而受損甚至死亡，演化出保護及抵抗機制來干擾動物攝取(Coley *et al*. 1985)，其中次級化合物所形成之化學防禦爲一項重要指標，植物次級化合物可以保護植物本身免於細菌及眞菌感染外，並且深切影響植食性動物營養生理及覓食行爲(Robbins 1993)。

植食性動物因植物防禦特性而無法獲取營養及能量時，除了發展出適應這些防禦機制之生態行爲外，動物之消化系統結構與生理適應的差異，可從不同植物資源來滿足能量與營養的需求(Norberg 1977; Hanya *et al*. 2007)。植物性食物提供台灣獼猴(*Macaca cyclopis*)所攝取營養與能量之大部分，所食用的植物種類超過

300 種(吳等 2002)，亦取食多個植物部位，為研究動植物間植食之互動關係的好題材。本研究探討植物次級化合物中聚合性單寧酸對台灣獼猴消化生理之影響，以了解植物化學防禦與雜食者覓食策略之關聯。

單寧酸依照化學結構可分為水解性單寧(hydrolyzed tannin)和聚合性單寧(condensed tannin)，而聚合性單寧酸在植物防禦植食上扮演重要角色。聚合性單寧酸與唾液蛋白結合會降低食物的適口性(Robbins 1993)，此外，在動物消化道內部，聚合性單寧酸還可與植物蛋白質形成複合物，抑制腸道微生物發酵而降低食物中能量之可利用性。研究指出食物乾物質重含 3%之聚合性單寧酸就會降低金昌鼠(*Mesocricetus auratus*)表面消化率及食物攝入量，同時影響消化器官及肝臟、腎臟功能，進而導致動物生長遲緩甚至死亡(Robbins 1993)。

動物因應植物防禦植食之機制反應在消化系統之構造及消化生理之適應。Lambert (1998)將靈長類之消化系統分成二大類，包括具前胃發酵(forestomach fermantation)及盲一結腸發酵(caeco-colic fermentation)功能的消化系統，具有不同消化系統的動物對所食入的植物次級化合物的生理反應不盡相同，因而有不同的覓食模式及策略。前胃發酵動物具有較大的胃室及較多於瘤胃中共生的微生物，可將單寧酸進行降解作用，改變單寧酸結構及其結合消化酶的作用，使之成為水溶性且易排泄的物質；但對盲一結腸發酵者而言，單寧酸在尚未被動物盲腸及結腸之微生物降解前，就已對動物之消化有所影響，因先與小腸內消化酵素形成複合物而被排出體外。由於前胃中之微生物發酵可以降低植物次級化合物對植食者之消化作用之影響，因此前胃發酵動物比後腸發酵動物往往更能適應含次級化合物之植物(DaSilva 1992; Wrangham and Waterman 1981)。

植食性動物因應植物次級化合物也可反應於取食及選食行為上。例如北美的草原野鼠(*Microtus pennsylvanicus*)在覓食針葉樹的枝條時，會先將枝條折斷，枝條因不再受光合作用，而減低次級化合物生成，過幾天後動物再進行取食(Roy and Bergeron 1990)。Moreno-black and Bent (1982)透過更進一步的食物化學成分分析，指出位於肯亞的安哥拉疣猴(*Colobus angolensis*)挑選食物時，會偏向單寧酸及植物鹼含量較少的植物。另一種因應植物次級化合物的覓食策略是提高食性範圍，同時攝食多種植物來降低單一植物毒素攝入的濃度，減少體內單一毒素的累積，避免因累積高濃度單一毒素而造成傷害(Baranga 1983; Burgess and Chanpman 2005)。

過去研究發現，低海拔區域之台灣獼猴以果實為主要食物來源，佔全年進食之 52~67%，但亦取食葉片、嫩莖、嫩芽、種子及花等植物部位(Su and Lee 2001; 張 1999; 尤 2000; 范 2004)。然而，研究人員亦於福山試驗林猴群研究中發現，台灣獼猴所取食的食物種類之聚合性單寧酸較未取食之植種低(未發表資料)，聚合性單寧酸對台灣獼猴消化生理之影響為何，為引發本研究之動機。因此，本研究以圈養台灣獼猴為對象，探討含不同濃度聚合性單寧酸食物對其消化生理之影響，由量測進食量、腸道滯留時間、食物表面消化率，及聚合性單寧酸之回收率，期盼了解植物次級化合物與台灣獼猴覓食策略之關聯。

材料與方法

一、研究對象

研究對象為屏東保育類野生動物收容中心 H_4 區單獨圈養之成年雄性台灣獼猴(年齡＞ 5 歲)，圈養籠舍大小為長 90 cm×寬 60 cm×高 80 cm。收容中心一天餵食猴隻二次，上午 8 點餵食多種蔬菜，下午 4 點餵食多種水果，每次餵食約 500 g 的食物，此外，每兩天提供額外補充營養之點心，如堅果、白煮蛋及獼猴專用乾

糧等，飲水爲全日供應。

本實驗取樣 15 隻成年雄性個體，分爲對照組、試驗組A及試驗組B，每組 5 隻個體(圖 1)。預備試驗期間(2010 年 9 月 10~15 日)發現台灣獼猴入睡後至隔日天亮前(5:30 AM)並不會排便，因此將觀察及收集排遺時間訂爲一天中的清晨六點至傍晚六點，實驗總天數爲 15 天，每日於下午兩點準備餵食所需的食物，一次處理兩餐的食物，用於當日下午 4 點及隔日上午 8 點。預備試驗期間亦測試研究個體對不同食物的接受度，記錄其對各種食物之取食情形，避免後續實驗因餵食動物不願取食的食物，而影響到實驗數據收集。

圖 1. 受試圈養台灣獼猴之籠舍及環境，以及食物殘渣與排遺樣本收集情形。

Fig. 1. Enclosures used in this study for Taiwanese macaques under which food residues and fecal samples were collected for chemical analysis.

二、試驗流程

於 2010 年 9 月 17 日至 10 月 1 日進行圈養台灣獼猴添加聚合性單寧酸食物餵食試驗與排遺樣本收集，共計 15 天。試驗流程分爲以下三期：第 1~2 天爲「食物適應期」，按照中心早晚各餵食一次的時間表，以當季蔬果(香蕉、香瓜、紅蘿蔔及豆薯)餵食，每次餵食量爲 500±25 g，並分析得各項食物之主要營養成分組成與總能(表 1)，及粗纖維含量。由於進行腸道滯留時間及表面消化率測量試驗時，需要餵食試驗用含高聚合性單寧酸濃度之植物粉末，故先行於每餐將巧克力醬塗抹於半片吐司上餵食猴隻，讓猴隻熟悉該食物。完成餵食後約一小時，在每個籠舍撿拾掉落於地面上之食物殘餘物並稱重，以計算該日該籠舍內個體之進食量。爲了避免食物因爲較小塊不易拿取而掉落於地面上影響進食量數據，以較大且完整的塊狀食物餵食。

表 1. 餵食受試個體之各種食物的主要營養成分與總能。

Table 1. Major nutritional contents and gross energy of food items provided to the captive Taiwanese macaques in the study.

Food item	Dry matter (g/100g DM)	Crude fat (g/100g DM)	Crude protein (g/100g DM)	Carbohydrate (g/100g DM)	Gross energy (Kcal/g DM)
Banana	22.69	0.18	5.94	83.96	3.86
Melon	12.79	5.45	14.82	60.67	4.29
Carrot	6.15	1.83	15.81	53.77	3.89
Potato	8.56	0.23	7.73	74.02	3.79
Toast*	-	12.70	14.60	69.00	-
Chocolate sauce*	-	-	-	65.79	-

* Nutrition information obtained from labels of products.

- No data available.

試驗第 3~11 天為「消化生理適應期」，開始在試驗組A個體的食物中添加佔食物乾物質重3%含高濃度聚合性單寧酸(76.5 mg/g DM)之白堅木(quebracho)粉末(約 2 g，約含聚合性單寧酸 137.7 mg)，混於巧克力醬再塗抹於吐司，於試驗組B個體的食物中添加佔食物乾物質重 6%的白堅木粉末(約 4 g，含聚合性單寧酸 275.4 mg)，每日收集排遺總量及食物殘渣，以量測進食量、排遺濕重及乾重，並紀錄排遺坨數。經餵食 6 天(本試驗進行之第 8 天)後，進行腸道滯留時間資料收集。另添加佔餵食食物乾物質重量 1~1.5%的三氧化二鉻(Cr_2O_3)粉末作為標記(顏 1985)，以巧克力醬與三氧化二鉻粉末混合均勻後塗抹於吐司上餵食猴隻。餵食三氧化二鉻粉末後，於收集排遺總量時檢視排遺是否帶有綠色的顏色，排遺若呈現綠色則指示此排遺含三氧化二鉻粉末，實驗個體食入含三氧化二鉻粉末的食物至排遺中最後出現色(三氧化二鉻所致)的時間間隔，即為台灣獼猴之食物滯留於腸道的時間，收集排遺同時並記錄每隻個體有染色排遺之數量。攝入含染色劑食物後至出現第一坨含有染色劑排遺排出的時間為食物通過時間；食物攝入後至最後一坨含有染色劑排遺排出的時間為食物在腸道滯留時間。

試驗第 12~15 天為「表面消化　試驗期」，如同「消化生理適應期」之餵食內容，依照實驗組別分別給予同前期劑量之白堅木粉末，先將吐司給予台灣獼猴完全食入後再給予其餘食物，以確保動物完全攝入所添加的實驗粉末劑量。每天收集排遺總量，為避免尿液沾染而影響排遺之氮含量，在每隻個體籠下置入波浪型板子，讓尿液沾染排遺降到最低。排遺總量採全糞收集法，秤重並記錄每隻個體的每日排糞總重量及坨數，連續取樣 3 天的排遺總量，將 3 天中所收集到的排遺混合後再取樣作為營養成分及次級化合物分析樣本(顏 1985)，並計算表面消化率及聚合性單寧酸回收率。表面消化率分別計算乾物質(dry matter)及蛋白質消化率，計算公式如下：

$$\text{乾物質消化率(\%)} = \frac{\text{取食乾物質總量} - \text{排遺乾物質總量}}{\text{取食乾物質總量}} \times 100\%$$

$$\text{粗蛋白質消化率(\%)} = \frac{\text{取食粗蛋白質總量} - \text{排遺粗蛋白質總量}}{\text{取食粗蛋白質總量}} \times 100\%$$

排遺中聚合性單寧酸之回收率計算方式如下：

$$聚合性單寧酸回收率(\%) = \frac{排遺中聚合性單寧酸總量}{取食聚合性單寧酸總量} \times 100\%$$

本實驗設計以能在最短時間達到必須資料量的收集為原則，盡可能縮短因食物改變對實驗個體造成干擾的時間，實驗中所使用之化學藥劑皆為野生動物消化生理試驗所用之標準品。三氧化二鉻(Cr_2O_3)粉末為指示劑，對動物無害且不影響動物消化生理(顏 1985)，含有聚合性單寧酸之白堅木粉末已有很多研究使用，實驗劑量是參考國外研究設計所訂定(例如：紅腹袋鼠(*Thylogale billardierii*)：McArthur *et al*. 1993、綿羊(*Ovis aries*)和美洲黑熊(*Ursus americanus*)：Robbin *et al*. 1991、灰松鼠(*Sciurus carolinensis*)：Chung-MacCoubrey *et al*. 1997)，以避免過度影響動物為原則。

三、樣本處理與化學成分分析

所餵食蔬果及排遺樣本必須先稱溼重，切碎，放入烘箱以 55 ℃烘乾 2 天，烘乾後置於室溫下回溫一天再稱重(即風乾重)，以粉碎機(Wiley mill，盈慶牌)進行磨細工作，樣本通過 20 網目篩網(網目為 5.69 mm)後，放置於塑膠封口袋密封，再置入~20 ℃冰箱貯存。分析時將每份處理後之植物樣本及排遺樣本皆均分為兩份，各別進行營養成分及次級化合物分析。

營養成分分析項目包括乾物質(dry matter, DM)、粗蛋白質(crude protein, CP)、粗脂肪(crude fat, CF)、粗纖維(crude fiber, CF)及灰分(ash)，而無氮抽出物(nitrogen-free extract, NFE；主要為可快速利用之碳水化合物)是由乾物質含量減去灰分、粗蛋白質、粗脂肪及粗纖維含量後求得。總能(gross energy, GE) (單位 kcal/g DM)是粗脂肪含量乘以 9.45、粗蛋白含量乘以 5.65，及碳水化合物含量與粗纖維含量相加後乘以 4.15 之加總求得(顏 1985)。營養成分分析方法及流程參照吳(1997)所使用分析之方法；聚合性單寧酸萃取方式採用正丁醇鹽酸法(butanol-HCl)，以丁醇－鹽酸混合鐵(ferrous sulphate heptahydrate)試劑加熱後記錄其 540 nm的吸光值，此方法參照 Hagerman (2000)。

四、統計分析

利用單因子變異數分析(One-way ANOVA)分析食物中聚合性單寧酸濃度對進食量及排遺乾、濕重之影響。並利用克－瓦二氏檢定(Kruskal-Wallis test)分析食物中聚合性單寧酸濃度對食物通過腸道時間、腸道滯留時間及排遺累積坨數之影響。對照組其中一隻個體在實驗中發生腹瀉問題，因此在排遺養本資料分析中不列入計算。因每隻受試個體排遺樣本量不足以進行所有營養成分分析，因此僅進行乾物質及粗蛋白質分析，所得資料分別計算乾物質消化率及蛋白質消化率，每隻個體之數據是取其 3 天樣本所得消化率之平均值±標準差進行分析，利用克－瓦二氏檢定分析食物中聚合性單寧酸濃度對乾物質消化率及蛋白質消化率之影響。

結　果

餵食台灣獼猴實驗期間，發現台灣獼猴進食速度相當快速，全部吃完一餐的時間不超過一小時，有些個體食用紅蘿蔔時，會將其放置在籠中，等待一段時間才會吃完。餵食實驗所需具高含量聚合性單寧酸的白堅木粉末需要以特定食物混合，方能確保所餵食的粉末量完全被攝入。一開始利用蜂蜜混合白堅木粉末塗抹於吐司來餵食，但是蜂蜜味道似乎無法蓋過白堅木苦澀的味道，因此獼猴會先嗅聞吐司後，刮除混合白堅木粉末的蜂蜜，再食入吐司。之

後選換味道較重的巧克力醬來混合白堅木粉末，獼猴刮除粉末情形不再發生。

一、食物聚合性單寧酸含量對進食量及排遺量之影響

食物中聚合性單寧酸濃度對台灣獼猴之進食量有顯著影響($F_{(2,33)}$ =15.702, P<0.05)，Tukey's HSD 事後檢定結果顯示，對照組與食用含食物乾物質重 6%白堅木粉末食物組之進食量有顯著差異(P<0.01)。對照組平均每日進食量最高，爲 939.4±68.2 g (n=5)，而食用含食物乾物質重 6%白堅木粉實驗組之進食量爲 895.8±65.5 g (n=5)。聚合性單寧酸攝入量亦顯著影響排遺乾重($F_{(2,41)}$ =3.299, P<0.05)，Sheffe 事後檢定結果顯示對照組個體與食用含食物乾物質重 6%白堅木粉末個體之排遺乾重有顯著差異(P<0.05)，對照組個體平均每日排遺乾重爲 9.5±2.4 g (n=4)，食用含食物乾物質重 6%白堅木粉末者爲 12.1±3.3 g (n=5)。食物中聚合性單寧酸濃度對平均每日排遺濕重及排遺坨數，則無顯著影響($F_{(2,41)}$ =0.889, P=0.419；χ^2=0.546, df=2, P=0.761) (表 2)。

二、食物腸道滯留時間

食物中聚合性單寧酸濃度對食物通過腸道時間無顯著影響(χ^2=2.382, df=2, P=0.304)，以攝食含食物乾物質重 6%白堅木粉末之個體的食物通過腸道時間最長，爲 30.8±8.6 hrs (n=5)。攝食含食物乾物質重 6%聚合性單寧酸食物之個體腸道滯留時間亦最長，爲 50.0±4.6 hrs (n=5)，食物中所含聚合性單寧酸濃度對腸道滯留時間無顯著影響(χ^2=4.831, df=2, P=0.089) (表 2)。

三、食物中聚合性單寧酸含量對表面消化率之影響

食物中聚合性單寧酸濃度對台灣獼猴之乾物質消化率有顯著影響(χ^2=6.746, df=2, P<0.05)。對照組之乾物質消化率最高，爲 92.1±2.1% (n=4)，攝食含食物乾物質重 6%白堅木粉末之乾物質消化率最低，爲 89.5±3.0% (n=5)。聚合性單寧酸濃度對台灣獼猴之蛋白質消化率亦有顯著影響(χ^2=9.035, df=2, P<0.05)，對照組個體之蛋白質消化率最高，爲 77.3±8.1% (n=4)，攝食含食物乾物質重 6%白堅木粉末個體之蛋白質消化率最低，爲 68.6±8.8% (n=5) (表 3)。

表 2. 攝入不同濃度聚合性單寧酸之受試台灣獼猴的進食量與排遺量，及食物腸道滯留時間。

Table 2. Food intake, fecal excretion, and gut retention time of captive Taiwanese macaques fed with the diets containing different concentrations of condensed tannin. (quebracho powder)

	Control (n=5)	3% Quebracho (n=5)	6% Quebracho (n=5)
Food intake (g)	939.9±68.2[a,1]	929.4±71.3[a,b]	895.8±65.5[b]
Wet fecal mass (g)	40.3±13.4	42.1±10.6	46.8±16.6
Dry fecal mass (g)	9.4±2.4[a]	11.2±2.6[a,b]	12.1±3.3[b]
Number of feces	4.5±1.7	4.4±1.9	4.0±1.4
Passage time (hr)	25.2±4.1	24.0±3.9	30.8±8.6
Retention time (hr)	45.8±1.0	48.6±3.6	50.0±4.6

[ab] Items with different superscript letters in the same row indicating the significance in the difference at P<0.05 (ANOVA with Tukey's post-hoc analysis).

[1] 平均値±標準差(Mean±SD).

表 3. 攝入不同濃度聚合性單寧酸之受試台灣獼猴的表面營養分消化率。

Table 3. Digestibility of dry matter and crude protein in the diets containing different concentrations of condensed tannin (quebracho powder) for the captive Taiwanese macaques.

Digestibility (%)	Control (n=5)	3% Quebracho (n=5)	6% Quebracho (n=5)	X^2
Dry matter	92.1±2.1[1]	90.8±2.0	89.5±3.0	6.75*
Crude protein	77.3±8.1	73.5±5.8	68.9±8.8	9.04*

* Significant difference at P<0.05 (Kruskal-Wallis test).

[1] 平均值±標準差(Mean±SD)

四、聚合性單寧酸之回收率

受試獼猴個體之排遺分析可獲得聚合性單寧酸回收率，大部分所攝入的聚合性單寧酸由排遺排出，聚合性單寧酸之回收率高於 90%。攝食含食物乾物質重 3%白堅木粉末個體之聚合性單寧酸回收率爲 90.0±1.7% (n=5)，而食入 6%白堅木粉末之回收率爲 92.6±8.0% (n=5)。

討　論

由本試驗獲得資料顯示，台灣獼猴之取食與消化生理受到食物中植物次級化合物單寧之影響，對攝入之聚合性單寧無法進行降解或改變其結構，來排除其對消化之影響。攝入含食物乾物質重 6%白堅木粉末(約 4 g，含 275.4 mg 聚合性單寧酸)個體之進食量顯著下降，攝入聚合性單寧酸亦影響台灣獼猴之乾物質及蛋白質消化率。台灣獼猴近似日本獼猴(*Macaca fuscata*) (Chu *et al*. 2007)，可能與日本獼猴一致爲具盲一結腸發酵消化系統之靈長類(Lambert 1998)，其對所攝入之植物次級化合物之分解有限，故對植物所含營養之消化與吸收會受伴隨攝入之次級化合物的影響，因而植物所含之次級化合物，例如聚合性單寧酸，應是影響台灣獼猴取食模式及覓食策略的重要因素。

一、進食量及腸道滯留時間

Brett *et al*. (1994)將聚合性單寧酸加入草甸田鼠(*Microtus pennsylvanicus*)食糧中，發現聚合性單寧對草甸田鼠食物攝入量是有抑制作用。本研究發現台灣獼猴也有相似情形，食物中聚合性單寧酸濃度對進食量有顯著影響，攝入含食物乾物質重 6%白堅木粉末之受試獼猴，其進食量顯著較對照組的低。然而，食物蛋白質含量不同時，聚合性單寧酸對攝食量影響可能不一致，李等(2003)以根田鼠(*M. oeconomus*)爲對象，分別給予含 10%及 20%蛋白質之食物，發現攝食含乾物質重 10%蛋白質食物之受試個體在實驗進行至第 7 天時，其進食量顯著降低，但聚合性單寧酸對攝食 20%蛋白質食物實驗個體之進食量則無顯著影響，因此，說明了根田鼠進食量是會受到食物中聚合性單寧酸及蛋白質含量交互作用之影響。本研究所給予之食物蛋白質含量約爲 10%，蛋白質含量提高是否改變台灣獼猴對聚合性單寧酸之適應能力仍需進一步探討。可透過操作食物蛋白質含量之實驗設計，檢視當食物蛋白質含量變化時是否也同時影響聚合性單寧酸對取食之影響，探討台灣獼猴在野外環境中是否可利用最大量的蛋白質攝取，來降低聚合性單寧酸對消化生理之負面影響，因而對聚合性單寧酸攝入之容許量有所變化。

根據日本獼猴研究顯示，當食物攝入量降低，其腸道滯留時間較長，排遺的坨數也較少，主要是因爲食糜或殘渣較小，對腸道刺激小而使滯留時間延長(Sawada *et al*. 2011)。本

研究顯示台灣獼猴取食食物乾物質重 6%白堅木粉末時，其腸道通過時間及滯留時間均較對照組有較長的現象，惟可能因爲樣本數較少，個體差異大導致結果差異不顯著。但也有可能反應台灣獼猴對聚合性單寧酸的處理能力較差，影響食物乾物質的消化吸收，導致排遺物質量顯著高於對照組，其對腸道的刺激效應抵消掉聚合性單寧酸的作用。

二、表面消化率

在攝食添加聚合性單寧酸食物的餵食狀況下，台灣獼猴之乾物質及蛋白質消化率顯著降低。聚合性單寧酸可能與蛋白酶作結合，形成不溶性的複合物，從而降低消化道中蛋白酶之活性，進而影響蛋白質之分解，使動物排遺中的含氮量增加，導致動物之蛋白質消化率下降(Freeland and Janzen 1974)。研究結果顯示，台灣獼猴之消化生理無法有效避免聚合性單寧酸降低蛋白質消化效率的作用，但不同聚合性單寧酸濃度對消化率之影響程度是否有差異則尚未釐清，因此，未能由此實驗結果判斷，對台灣獼猴而言，避免累積單一次級化合物濃度是否是一種適應植物化學防禦之策略，有待增加試驗樣本數以作進一步分析。在植物所含次級化合物中，單寧酸並不是影響腸道消化及進食量的唯一次級化合物，已有研究指出酚酸及萜類化合物也會抑制微生物活性而降低消化率(Lowry *et al*. 1993)，這些次級化合物對台灣獼猴消化生理之影響未來值得進一步探討。

三、聚合性單寧酸回收率

由檢測動物排遺聚合性單寧酸之回收率亦可了解該動物是否對攝入之聚合性單寧酸進行分解，而得以降低其對消化之負作用。台灣獼猴對聚合性單寧酸回收率高達 90%以上，顯示沒有辦法對聚合性單寧酸作有效處理。動物不同消化結構與生理與其處理聚合性單寧酸的方式有關，美洲黑熊研究顯示其聚合性單寧酸回收率高達 90%以上，而具前胃發酵消化系統物種綿羊之聚合性單寧酸回收率比台灣獼猴低，攝入含食物乾物質重 3%及 6%白堅木粉末試驗組之聚合性單寧酸回收率分別爲 70±9%及 77±3% (Robbin *et al*. 1991)。前胃發酵動物瘤胃中的微生物可以把單寧酸降解，使成水溶性而易排泄的物質，且適當的聚合性單寧酸可減少瘤胃中微生物對攝入蛋白質之利用；而單胃及盲一結腸發酵動物則是透過小腸酶結合單寧酸以複合物形式並排出體外，因此，前胃發酵動物較不受植物所含單寧酸影響而降低蛋白質利用效率。

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引用文獻

尤仲妮。2000。恆春熱帶植物園台灣獼猴食性及活動模式之研究。國立台灣大學動物學研究所碩士論文。

李俊年、劉季科、陶雙倫。2003。單寧酸對根田鼠食物攝入量和蛋白質消化率的效應。獸類學報 23: 51-57。

吳海音、楊子欣、尤仲妮、范孟雯、陳淑梅、林曜松。2002。由野生台灣獼猴的食性看餵食與危害問題。台灣獼猴保育與經營管理研討會成果報告。行政院農委會。49-55 頁。

吳春利。1997。畜牧學實習—飼料分析。國立編譯館。68 頁。

范孟雯。2004。恆春熱帶植物園區台灣獼猴選果行爲之研究。國立台灣大學生態學與演化生物學研究所碩士論文。

張可揚。1999。福山試驗林台灣獼猴(*Macaca cyclopis*)之覓食策略。國立台灣大學動物學研究所碩士論文。

顏宏達。1985。動物營養學。華香園出版社。477 頁。

Baranga, D. 1983. Changes in chemical composition of food parts in the diet of colobus monkeys. Ecology 64: 668-673.

Brett, A. D., A. E. Hagerman and W. Barrett. 1994. Role of condensed tannin on salivary tannin-binding proteins, bioenergetics and nitrogen digestibility in *Microtus pennsylvanicus*. Journal of Mammalogy 72: 480-486.

Burgess, M. A. and C. A. Chapman. 2005. Tree leaf chemical characters: Selective pressures by folivorous primates and invertebrates. African Journal of Ecology 43: 242-250.

Chu, J. H., H. Y. Wu, Y. J. Yang, O. Takenaka and Y. S. Lin. 1999. Polymorphic microsatellite loci and low-invasive DNA sampling in *Macaca cyclopis*. Primates 40: 573-580.

Chung-MacCoubrey, A. L., A. E. Hagerman and R. L. Kirkpatrick. 1997. Effects of tannins on digestion and detoxification activity in gray squirrels (*Sciurus carolinensis*). Physiological Zoology 70: 270-277.

Coley, P. D., J. P. Bryant and F. S. Chapin. 1985. Resource availability and plant anti-herbivore defense. Science 230: 895-899.

DaSilva, G. L. 1992. The western black-and white colobus as a low energy strategist-activity budgets, energy expenditure and energy intake. Journal of Chemical Ecology 61: 79-91.

Freeland, W. J. and D. H. Janzen. 1974. Strategies in herbivory by mammals: The role of plant secondary compounds. American Naturalist 108: 269-289.

Hagerman, A. E., I. Mueller-Harvey and H. P. Makkar. 2000. Quantification of tannins in tree foliage: A laboratory manual for the FAO/IAEA co-ordinated research project on "Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanninferous tree foliage". Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, from the World Wide Web: http://www-naweb.iaea.org/nafa/aph/public/pubd31022manual-tannin.pdf

Hanya, G., M. Kiyono, H. Takafumi, R. Tsujino and N. Agetsuma. 2007. Mature leaf selection of Japanese macaque: Effects of availability and chemical content. Journal of Zoology 273: 140-147.

Isbell, L. A. and T. P. Young. 1993. Social and ecological influences on activity budgets of vervet monkeys, and their implications for group living. Behavioral Ecology and Sociobiology 32: 377-385.

Lambert, J. E. 1998. Primate digestion: Interactions among anatomy, physiology, and feeding ecology. Evolutionary Anthropology 7: 8-20.

Lowry, J. B., E. A. Sumpter, C. S. McSweeney, A. C. Schlink and B. Bowden. 1993 Phenolic acids in the fibre of some tropical grasses: Effect on feed quality and their metabolism by sheep. Australian Journal of Agriculture Reserch 44: 1123-1133.

McArthur, C. and G. D. Sanson. 1993 Nutritional effects and costs of a tannin in two marsupial arboreal folivores. Functional Ecology 7: 697-703.

McSweeney, C. S., B. Palmer, D. M. McNeill, and D. O. Krause. 2001. Microbial interactions with tannins: Nutritional consequences for ruminants. Animal Feed Science and Technology

91: 83-93.

Moreno-Black, G. S. and E. F. Bent. 1982. Secondary compounds in the diet of *Colobus angolensis*. African Journal of Ecology 20: 29-36.

Norberg, E. A. 1977. An ecological theory on foraging time and energetics and choice of optimal food searching method. Journal of Animal Ecology 46: 511-529.

Robbins, C. T. 1993. Wildlife feeding and nutrition, 2nd ed. New York. Academic Press, p. 251-255.

Robbins, C. T., A. E. Hagerman, P. J. Austin, C. McArthur and T. A. Hanley. 1991. Variation in mammalian physiological responses to a condensed tannin, and its ecological implications. Journal of Mammalogy 72: 480-486.

Roy, J. R. and J. M. Bergeron. 1990. Branch-cutting behavior by the vole. Journal of Chemical Ecology 16: 735-741.

Salminen, J. P., T. Roslin, M. Karonen, J. Sinkkonen, K. Pihlaja and P. Pulkkinen. 2004. Seasonal variation in the content of hydrolyzable tannins, flavonoid glycosids, and proanthocyanidins in oak leaves. Journal of Chemical Ecology 30: 1693-1711.

Sawada, A., E. Sakaguchi and G. Hanya. 2011. Digesta passage time, digestibility, and total gut fill in captive Japanese macaques (*Macaca fuscata*): Effects of food type and food intake level. International Journal of Primatology 32: 390-405.

Schemske, D. W. and C. C. Horvitz. 1988. Plant-animal interactions and fruit production in a neotropical herb: A path analysis. Ecology 69: 1128-1137.

Su, H. H. and L. L. Lee. 2001. Food habits of Formosan Rock Macaques (*Macaca cyclopis*) in Jentse, Northeastern Taiwan, assessed by fecal analysis and behavior observation. International Journal of Primatology 22: 359-377.

Wrangham, R. W. and P. G. Waterman. 1983. Condensed tannins in fruits eaten by chimpanzees. Biotropica 15: 217-222.

溫度與缺水效應對史丹吉氏小雨蛙蝌蚪存活與發育之影響

Effects of Temperature and Water Deprivation on Survival and Development of Microhylid Frog (*Micryletta steinegeri*) Tadpoles

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摘 要

史丹吉氏小雨蛙爲爆發性生殖者，其產卵棲所選擇在暫時性的水域環境，孵化後的蝌蚪則在此靜止水體中活動。本研究選擇了溫度及水分因子，來進行影響該蛙蝌蚪存活與發育的試驗。結果顯示該種蝌蚪在缺少積水的環境下，無法存活超過 1 小時，爲本實驗所檢視的狹口蛙類及其他共同生活在此暫時性水域的無尾目蝌蚪中，最無法忍受無積水環境的物種。在 20℃與 25℃的溫度下，最適合該蛙蝌蚪的成長與發育，其平均變態率可達 38%；在 25℃與 30℃的環境下，最短的蝌蚪發育期僅需 11 天；在 15℃的低溫下，蝌蚪於長出後肢後，成長即趨緩，發育也呈現停滯，因爲無法伸出前肢，因此也無任何個體可達 Gosner 第 42 期之變態高峰。本文也比較不同環境下的蝌蚪發育日數，並探討環境因子對該蛙蝌蚪期長短的影響。

Abstract

The mycrohylid frog *Micryletta steinegeri* is an explosive breeder whose tadpoles live in still waters in the temporal zone. In this study we investigated the effects of temperature and water deprivation on survival and development of the tadpoles. The results showed that the tadpoles could not survive for an hour at 25℃ without water. They had the lowest tolerance to water deprivation among the members of Microhylidae examined and of other anuran tadpoles coexisting in the temporary waters. The optimal temperatures for the growth and development of the mycrohylid tadpoles with a mean metamorphic rate at 38% were at 20℃ and 25℃. The shortest tadpole period was 11 days at 25℃ and 30℃. At 15℃ the growth decelerated and the development ceased at the stage with protruded hind legs; no tadpole stretched out fore legs to reach the metamorphic climax of Gosner's stage 42. Developmental periods of the tadpoles under different environments were compared, and the effects of environmental factors were discussed.

關鍵詞：史丹吉氏小雨蛙、缺水、溫度、蝌蚪

Key words: *Micryletta steinegeri*, water deprivation, temperature, tadpole

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緒　言

野外水體物理性質的表現，常受到天候變化所影響，其中又以暫時性水域(temporary waters)的變化幅度最大。由於暫時性水域中的空間常有重覆出現滿水及乾旱的現象，而其中的生物須經常面臨大量死亡的威脅；因此，許多暫時性水域中的生物，在生理上或生態會發展出適應缺水環境的調整機制(Williams 2005)。

兩棲類蝌蚪的成長與發育除了受到內在遺傳因素所影響外，也受到外在環境因子如溫度、水量、食物或天敵等因素所調控(Duellman and Trueb 1994; Loman 2002; Castaneda *et al*. 2006)。對於生活在暫時性棲所的兩棲類蝌蚪而言，水體的有無直接影響到牠們的生存。至於溫度則直接影響到蝌蚪的生理反應，過高的溫度影響其存活率，過低的溫度會使蝌蚪的成長停滯(Smith-Gill and Berven 1979)，而在此過高與過低的溫度範圍間，蝌蚪則隨著外界環境溫度的上升，加速其成長與發育(Harkey and Semlitch 1988)。由於溫度的高低影響到蝌蚪發育至小蛙的時間，因此也會表現在蝌蚪對於水體的依賴程度上(McDiarmid and Altig 2000)。

史丹吉氏小雨蛙(*Micryletta steinegeri*)分布在台灣中、南部及東部低海拔地區，活動與生殖棲所主要為雨後臨時性的積水環境。每年的 4~9 月間為其繁殖區段，然而在此期間該蛙並不會每天出現或鳴叫，僅在大雨來時，環境瞬間積水，牠們才會大量出現、聚集與鳴叫，產生爆發性的生殖現象。在此暫時性棲所中，雖然下雨時水體的累積很快，但若雨停，積水的消退也會很快，而生活其中的蝌蚪常會面臨水位逐漸降低的困境，以及因缺少水體所引發的水溫升高、食物量不足或易暴露於天敵等威脅。因此本研究選擇該環境中影響蝌蚪最為直接的水分及溫度因子，來進行有無積水對史丹吉氏小雨蛙蝌蚪存活時間的影響，以及不同溫度對史丹吉氏小雨蛙蝌蚪成長、發育與存活之

研究。希望此資料的建立，能提供該蛙類將來保育行動之參考。

材料與方法

研究物種：

史丹吉氏小雨蛙屬於無尾目狹口蛙科(Microhylidae)的兩棲類。剛孵化的蝌蚪身體呈乳黃色，隨著成長體表逐漸變為深褐色。側視蝌蚪尾鰭中段較為寬扁型，而尾部尖則呈現絲狀。蝌蚪會藉此絲狀物在水域中左右的擺動，以維持平衡，屬於典型生活在靜止水域中的蝌蚪。棲所中經常有其他狹口蛙科及部分樹蛙科蝌蚪與之共域。

蝌蚪缺水的耐受試驗

為了解史丹吉氏小雨蛙蝌蚪在微棲所水位降低時，於潮濕土壤間所能存活的時間，於室溫中(25℃)，我們將 12 隻剛長出腳芽之蝌蚪(約在Gosner第26到30期之間，Gosner 1960)，分別置入實驗組中的 12 個底部鋪有潮濕土壤的小塑膠杯中，分別記錄其存活的情形。為了維杯中土壤水分的一致性，我們使用杯口直徑為 8 cm、深 5.5 cm 的小塑膠杯，在底部放置已烘乾且以濾網(2 mm)篩選過之土壤約 0.7 cm 高(所測得的土壤重量為 32 g)，再加入 15 g 逆滲透水，使土壤呈現吸水飽和但無積水的狀態，然後放入蝌蚪，蓋上具透氣孔目的盒蓋，以防止水分過分散失，此時測得每盒總重量為 51 g，實驗過程中則依此重量為依據，每日加入些許水分補充以維持恆定的土壤溼度。而在控制組中，我們也將 12 隻與實驗組體長相當之蝌蚪，分別置入 12 個如同實驗組的小塑膠杯中，所不同的是杯中加入較多的逆滲透水，使水分漫過土壤表面約 2 cm 高。實驗的過程中，兩組別均不予餵食。此外，我們另選擇 7 種共域之兩棲類蝌蚪，種類包含小雨蛙(*Microhyla fissipes*)、黑蒙西氏小雨蛙(*M. heymonsi*)、澤蛙(*Fejervarya limnocharis*)、日本樹蛙(*Buergeria japonica*)、莫氏樹蛙(*Rhacophorus moltrechti*)、面天樹蛙(*Kurixalus idiootocus*)、布氏樹蛙(*Polypedates braueri*)等，進行與上述同樣具有實驗組與控制組的實驗，以便與史丹吉氏小雨蛙蝌蚪的實驗結果進行比較。

溫度實驗

由於史丹吉氏小雨蛙採爆發性的生殖策略，若有生殖時，通常可在同一天晚間採集到大量的卵粒。因此，我們在 2009 年 6~7 月間，於台灣中部南投縣集集鎮低海拔山區採集到史丹吉氏小雨蛙剛產出的卵粒約 10 堆，攜回實驗室等待孵化。史丹吉氏小雨蛙的卵期約 2 天，於第 3 天個體離開卵囊後，才進入蝌蚪期。此時，我們將這些剛孵化的蝌蚪分別置於 15℃、20℃、25℃及 30℃的恆溫培養箱中，以進行不同溫度對史丹吉氏小雨蛙蝌蚪發育與存活率之實驗。實驗方法為每個培養箱中放入 9 盒各 10 隻剛孵化的蝌蚪，以日光燈進行 12L：12D的照明調控，並保持培養箱內 80%的相對溼度。飼養盒長為 14 cm、寬 9.5 cm，水深高度 6 cm，盒內放入 1 cm 高之底泥與落葉，以模擬野外的生存環境。每日以每隻約 0.01 g 之高蛋白質粉狀魚飼料餵食。每 3 天更換約 1/3 體積的水體，以避免因部分蝌蚪死亡而使水質劣化。實驗期間，每日觀察記錄蝌蚪達到Gosner 第 31 期(後肢呈槳狀)、第 37 期(後肢彎曲成 45 度)、第 41 期(後肢彎曲成 90 度)及第 42 期(出現四肢達變態高峰)時所需的發育日數(蝌蚪發育階段參考 Gosner 1960)及當時的存活數目，以比較蝌蚪在不同溫度的連續飼養下，其發育時間與存活率的差異。

分析時，以同一發育階段內之不同溫度處理做為相互比較的對象。蝌蚪達各發育階段所需的時間以其平均數±1 標準誤差(standard error, SE)來表示。不同溫度間之蝌蚪發育日數以巢穴變方分析(Nested ANOVA)進行統計檢定；

若組間有顯著性的差異時，則以杜氏法(Tukey's test)進行平均數之事後多重比較。而不同溫度間之蝌蚪存活率則以卡方檢定(Chi-square test)進行同質性分析；若組間有顯著性的差異時，則以同時信賴區間估計法(simultaneous confidence intervals)進行事後多重比較。以上分析均以PASW 18.0 (SPSS Inc. 2009)進行統計，並以α =0.05 做爲是否達顯著性差異的標準。

戶外飼養與野外觀察

爲了與實驗室的溫度試驗結果進行比較，我們另外增加 2 項蝌蚪於不同成長環境的觀察。第一項爲戶外飼養：我們於 2009 年 6 月間，在南投縣集集鎮野外暫時性積水溝渠內，採集到史丹吉氏小雨蛙剛產出的卵粒 12 堆，待 2 天後，卵全數孵化且開始自由活動時，於第三天我們就地將蝌蚪平均放入 7 個水盆中；每個水盆長爲 60 cm、寬 30 cm，水深高度 20 cm，內部的設置主要模擬採集時的微環境，且在底部舖上 3~5 cm 的泥土與落葉；每日除了補充水分以維持固定之水體外，另投入已磨成粉狀的魚飼料飼養，觀察並紀錄蝌蚪發育至 Gosner 第 42 期所需的日數。第二項爲野外觀察：於 2009 年 6~7 月間，我們於上述同樣的區域，觀察到該蛙產卵後，並不對棲所進行任何的環境或飼養上改變，僅於每日進行觀察；由於野外水域屬開放空間，並不容易追蹤所有蝌蚪的變態情形，因此我們僅能記錄到野外首批蝌蚪變態至 Gosner 第 42 期所需的最短日數。以上兩項蝌蚪成長環境的最大差別在於，戶外飼養的水量固定，且每日供予充足的食物資源；而在全然野外的環境，水體則會因蒸發而逐漸降低，且未再提供額外的食物資源。在全年度的研究期間，我們也收集上述樣區的環境資料，記錄 2009 年的月平均氣溫(將每日最高溫與最低溫平均後，再進行月平均)與月平均積水深度(每日測量固定微棲所的積水深度，再進行月平均)的變化情形，以利進一步分析與比較之用。

結　果

蝌蚪的缺水試驗

在此 8 種蛙類蝌蚪的缺水試驗中，所有實驗組的蝌蚪均隨著時間增加而逐漸死亡，而控制組的蝌蚪於實驗期間均無任何個體死亡。史丹吉氏小雨蛙蝌蚪在飽和水分但無積水的土壤中所能存活的時間最短，在實驗進行後的第一個小時內，實驗組的 12 隻蝌蚪全數死亡，顯示該蛙蝌蚪無法在缺少水體的環境下生存；至於同爲狹口蛙類的黑蒙希氏小雨蛙蝌蚪在 3 小時內陸續死亡；而小雨蛙蝌蚪則在 8 小時內陸續死亡(圖 1)。若將狹口蛙類與其他蛙類蝌蚪的存活情形進行比較，可發現莫氏樹蛙與日本樹蛙蝌蚪的耐旱性最高，在含飽和水分但無積水的土壤環境中可存活 17 天，其次依序爲澤蛙、面天樹蛙與布氏樹蛙的蝌蚪(圖 2)。

溫度實驗

在不同溫度處理下，蝌蚪達各發育階段的日數均有顯著性的差異(見表 1)。整體上，在 30℃的溫度處理下，蝌蚪達各發育階段所需的時間均較短；其次依序爲 25℃、20℃及 15℃的溫度處理。各發育階段內的事後比較也顯示：發育日數在不同溫度間彼此均有統計上的差異，僅於實驗初期在蝌蚪第 31 發育期之 25℃及 30℃的溫度處理間，未達統計上的顯著性差異。在 15℃的溫度處理下，僅有 7 隻蝌蚪能發育至第 41 期，亦即後肢彎曲成 90 度，之後便停滯生長；直至實驗結束，該溫度下的蝌蚪仍無法發育至第 42 期。至於其他溫度處理下，均有個體到達第 42 期，亦即達變態高峰，其蝌蚪期範圍在 11~28 天之間。其中最短的蝌蚪期爲 11 天，分別出現在 25℃及 30℃的溫度處理下(見表 1)。

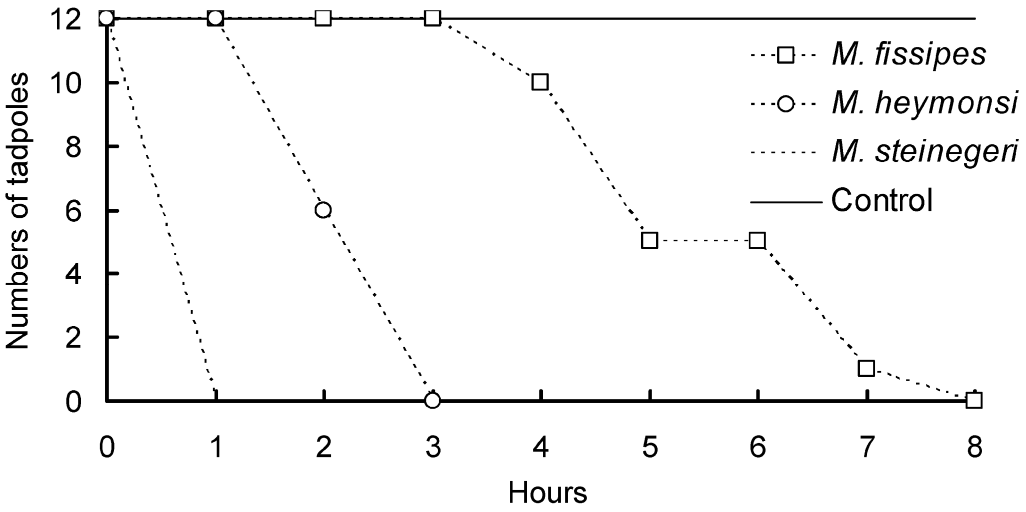

圖 1. 缺水效應對於 3 種狹口蛙類蝌蚪存活時間之影響(每一種物種之實驗組與控置組蝌蚪數均為 12 隻)。

Fig. 1. Surviving periods (hours) of three species of microhylid tadpoles under water deprivation (number of individuals = 12 for the control and each of the test species).

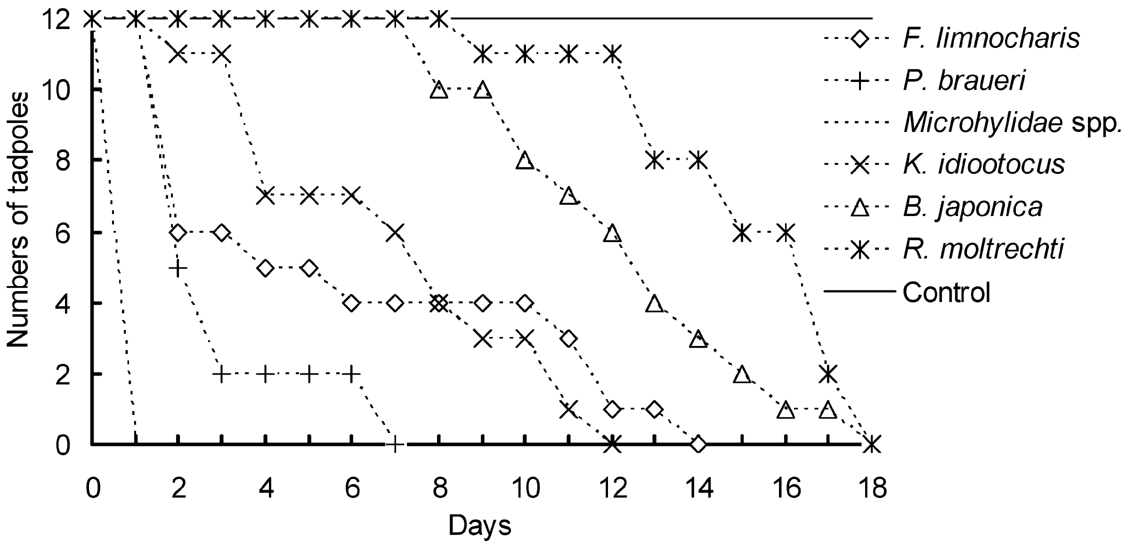

圖 2. 缺水效應對於共同生活在暫時性水域的 8 種無尾目兩棲類蝌蚪存活時間之影響(每一種物種之實驗組與控置組蝌蚪數均為 12 隻)。

Fig. 2. Surviving periods (days) under water deprivation for eight species of anuran tadpoles coexisting in the temporary waters (number of individuals = 12 for the control and each of the test species).

表 1. 四種不同溫度處理，對史丹吉氏小雨蛙蝌蚪達各發育期所須之時間(平均數±標準誤差) (同一發育階段內，以杜氏法進行事後比較，不同字母a, b, c及d代表彼此在發育日數上具有顯著的差異)。

Table 1. Developmental periods (mean ± standard errors) to four Gosner's stages at four temperatures (℃) for *Micryletta steinegeri* tadpoles (different letters a, b, c and d within a stage indicating significant differences among the periods by Tukey's test).

Stages	Temperatures	Days	Ranges	*F*	*Df*	*P*
31	15	21.0a±0.2	17-26	83.1	3,131	< 0.0001
	20	16.7b±0.1	13-18			
	25	9.0c±0.1	7-11			
	30	8.3c±0.2	7-11			
37	15	35.8a±0.2	32-39	385.5	3,106	< 0.0001
	20	20.5b±0.1	18-22			
	25	10.3c±0.1	8-12			
	30	9.2d±0.1	8-11			
41	15	38.1a±0.3	37-39	285.5	3, 69	< 0.0001
	20	21.9b±0.1	20-24			
	25	12.3c±0.1	10-14			
	30	11.4d±0.3	10-13			
42	15	-	-	131.1	2, 59	< 0.0001
	20	25.0a±0.1	21-28			
	25	13.0b±0.1	11-15			
	30	12.2c±0.3	11-15			

在不同溫度處理下，蝌蚪達各發育階段之存活率均有統計上的顯著性差異(見表 2)。各發育階段的事後比較也顯示：整體上，在20℃及 25℃的溫度處理下，蝌蚪達各發育階段的存活率均較 15℃及 30℃的溫度處理來的高；僅於實驗初期在蝌蚪達第 31 發育期時，30℃的溫度處理下蝌蚪的存活率與 20℃及 25℃溫度處理的結果，未達統計上的顯著性差異。於20℃及 25℃的溫度處理下，蝌蚪在達第 42 期的存活率均爲 38%；而 30℃的溫度處理下，蝌蚪在第 42 期的存活率爲 7%；至於在 15℃的溫度處理下，因蝌蚪僅發育至第 41 期，並無達第 42 期的個體，因此無法顯示其存活率。

不同的飼養環境與氣象資料

戶外飼養：史丹吉氏小雨蛙胚胎於野外約 36 小時後可從卵粒中抖動離開卵囊。剛流入水體中的胚胎，常以黏液狀的細絲懸浮於水表下方，約在產出 48 小時後，才可成爲自由活動的蝌蚪。在戶外飼養的 7 個水盆中，共有 540 隻個體完成變態，其蝌蚪期平均爲 11.8 天，時間範圍在 10~18 天之間，蝌蚪詳細的變態日數分布情形請參考圖 3。

野外觀察：2009 年 6 月及 7 月間我們共記錄到 3 次野外史丹吉氏小雨蛙完整的胚胎與蝌蚪的發育過程，在此期間各棲所中的水體均逐日減少，但還不至於乾涸。我們記錄由卵發育到Gosner第 42 期所需的最短日數分別爲 10,11 及 11 日，將以上數值減去 2 日的卵發育期，則得蝌蚪期日數。當時白天的最高氣溫平均爲

表 2. 四種不同溫度處理下，史丹吉氏小雨蛙蝌蚪達各發育期之存活率(同一發育階段內，以同時信賴區間估計法進行事後比較，不同字母 a, b, c 及 d 代表彼此在存活率上具有顯著的差異)。

Table 2. Survival rates of *Micryletta steinegeri* tadpoles at four Gosner's stages under four test temperature (℃) regimes (different letters a, b, c and d within a stage indicating significant differences among the survival rates by simultaneous confidence intervals).

Stages	Temperatures	Survivals	Survival rates	X^2	*Df*	*P*
31	15	27	0.30a	83.1	3	< 0.0001
	20	49	0.54b			
	25	48	0.53b			
	30	35	0.39ab			
37	15	15	0.17a	385.5	3	< 0.0001
	20	45	0.50b			
	25	46	0.51b			
	30	27	0.30a			
41	15	7	0.08a	285.5	3	< 0.0001
	20	39	0.43b			
	25	36	0.40b			
	30	8	0.09a			
42	15	-	-	131.1	2	< 0.0001
	20	34	0.38a			
	25	34	0.38a			
	30	7	0.08b			

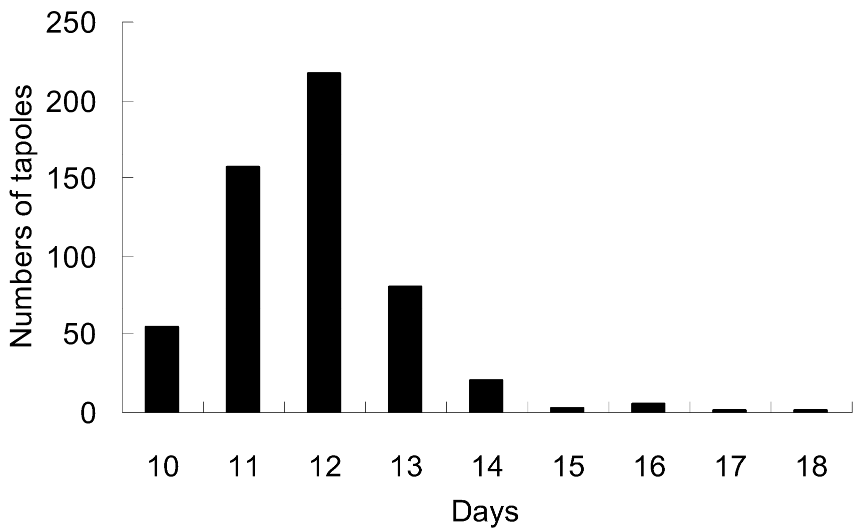

圖 3. 於戶外環境條件下，史丹吉氏小雨蛙蝌蚪達變態高峰(Gosner 第 42 期)所需發育時間的頻度分布。

Fig. 3. A frequency distribution of the developmental periods (days) of *Micryletta steinegeri* tadpoles to reach the metamorphic climax (Gosner's stage 42) under outdoor conditions.

30.7℃，夜間的最低氣溫平均為23.8℃。本實驗中，不同的成長環境對史丹吉氏小雨蛙蝌蚪達第42發育期所需之日數整理如表3。

氣象資料：2009年的4~9月間為該蛙的繁殖時期，該時期的月平均氣溫範圍在21.9~28.0℃間；同一時期，每個樣區的每月平均積水高度範圍則在13.0~30.8 cm間，為一年當中溫度較高且棲所較易積水的時期。研究期間(2009年)，史丹吉氏小雨蛙野外棲地的每月平均氣溫與平均積水高度變化情形，請參考圖4。

表3. 在不同的環境下，史丹吉氏小雨蛙蝌蚪期所需之日數。

Table 3. Tadpole periods of *Micryletta steinegeri* under different environments.

Environments	Temperatures	Water levels	Food	Tadpole period[1/], days
Laboratory	Fixed	Stable	adequate	11-28
Outdoors	Unstable[2/]	Stable	adequate	10-18
The wilds	Unstable[2/]	Decreasing	Unknown	8-

[1/] Number of days to reach the metamorphic climax (Gosner's stage 42)

[2/] Daily air temperature fluctuation of 23.8° to 30.7℃.

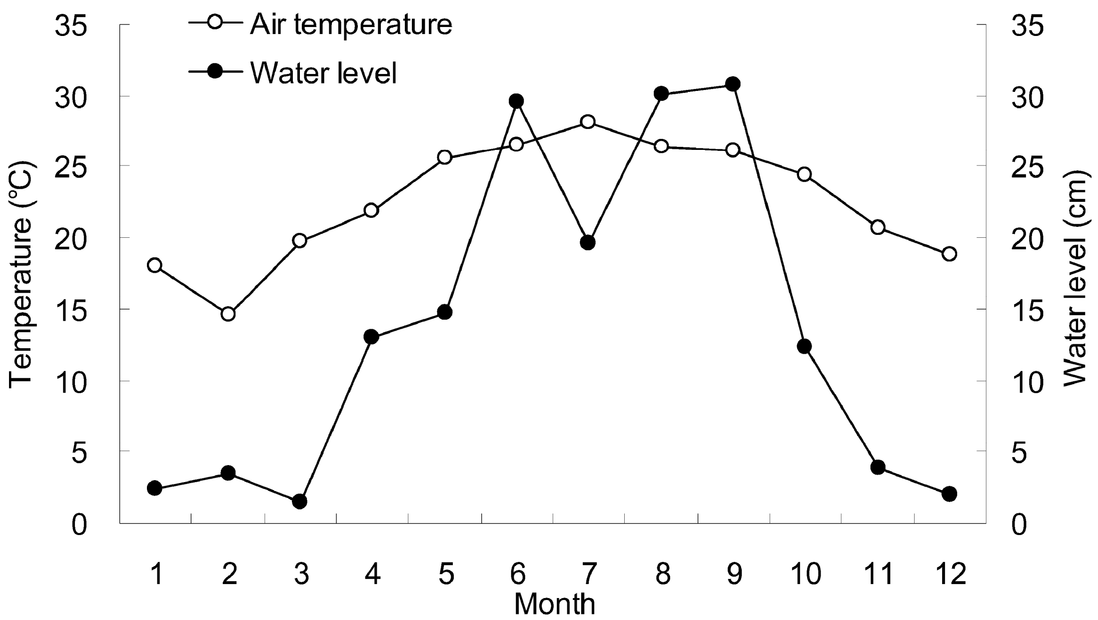

圖4. 臺灣南投縣集集地區史丹吉氏小雨蛙棲地的月平均氣溫與月平均積水高度(2009年)。

Fig. 4. Monthly average temperatures and water levels at the habitat of *Micryletta steinegeri* in Jiji, Nantou, Taiwan, 2009.

討　論

本研究之狹口蛙科相較其他科蛙類蝌蚪，更無法忍受無積水的環境，其中又以史丹吉氏小雨蛙蝌蚪對水體的依賴程度最高。Downie 及 Smith (2003)提出產卵於陸域環境中所孵出的蝌蚪，較產卵於水域環境中所孵出的蝌蚪更具有耐旱的能力。本研究也支持該研究者的觀點，由於狹口蛙科蝌蚪，是由漂浮在水表上方的卵塊所孵化，相較於在陸地上由卵泡方式所孵出的樹蛙科蝌蚪，前者對於無積水環境的忍受程度，則遠低於後者的表現。本研究中也觀察到在暫時性水域中，許多共域的蝌蚪均能在水位降低至無積水狀態的微棲所時，躲藏在落葉層與土壤間的空隙，藉由微環境中飽和溼度的狀態維持數日之久，待雨水再次補充時，才繼續成長與發育。然而對於同樣生活在此棲所的史丹吉氏小雨蛙或其他狹口蛙類蝌蚪而言，並不具備這樣的耐旱的能力，棲所中的水體若未能持續補充，或因大量蒸發而失去積水，整群的蝌蚪在短時間內將因缺水而快速死亡。因此該科別的蝌蚪勢必要演化出其他的應對的方式，才能面對暫時性水域經常出現的缺水危機。

暫時性水域的蝌蚪，其成長與發育常受到溫度、水分與食物所影響(Williams 2005)。在本研究的溫度處理試驗中，我們提供穩定的水體環境與充足的食物，因此影響該蝌蚪成長與發育的主要表現應為不同溫度所致。由於高溫會加速蝌蚪成長與發育的速率(Marian and Pandian 1985; McDiarmid and Altig 2000)，因此在 25 及 30℃的飼養環境下，史丹吉氏小雨蛙蝌蚪可達最短的發育時間。但若考慮此兩溫度處理下，蝌蚪達各發育階段的存活率表現，在 30℃的高溫環境中，蝌蚪的死亡常會導致密閉水域之水質快速劣化，使得該溫度下蝌蚪可達變態高峰的存活率僅有 8%；而在 25℃的飼養環境下，蝌蚪達變態高峰時的存活率則可相對較高。在低溫對蝌蚪的影響方面，許多研究顯示牠會降低蝌蚪神經內分泌(neurorndocrine)及甲狀腺(thyroid)的活動(Voitkevich 1963; Murata and Yamauchi 2005)，進而使蝌蚪的生成長及發育產生抑制，或者使變態過程趨於停滯(Just 1972)。有研究顯示非洲牛蛙(*Lithobates catesbiana*)蝌蚪在 12.8℃以下則停止發育(Viparina and Just 1975)。而本研究在 15℃的環境下，蝌蚪達各發育階段的時間均較其他溫度處理的結果久，且在實驗初期蝌蚪的存活率也顯著地降低，於後期雖有 7 隻蝌蚪長出後肢且明顯可見其突出的前肢手肘，但終究僅達第 41 發育期，無法伸出前肢變態成為小蛙。

兩棲類蝌蚪變態的時間點，會因為應環境的穩定度而有不同的表現時機。一般生活在暫時性積水環境中的兩棲類蝌蚪，為了適應環境的劇變，以及其他不可預測的變化，蝌蚪變態所需的時間，通常會比較短，且在早期快速地分化定型(Travis 1984)。本研究在不同環境下之史丹吉氏小雨蛙蝌蚪發育日數的比較，顯示出在無人為操作的野外環境中，蝌蚪期最短。因為在野外的環境中，蝌蚪每天須經歷高低溫的波動及水分多寡的刺激，若有接連續數日不下雨，牠們也可能會面臨水位降低進而產生水溫升高、食物不足，及蝌蚪更容易暴露於天敵等接連性的威脅。此時若蝌蚪已達變態最小體型，選擇快速變態成小蛙，減緩對水的依賴性，才有機會提高個體的存活數量。

不同無尾目兩棲類的蝌蚪期變化幅度很廣，可從 2 星期至 4 年之久(Brown 1990; Duellman and Trueb 1994)，其中發育較為快速的種類，多屬生活在暫時性水域或乾燥環境中的物種。目前已知蝌蚪期最短的物種為鏟足蟾類(*Scaphiopus*)，該類群分布於北美之草原或沙漠中(King 1960; Voss 1961; Wright and Wright 1949)，常利用雨後之暫時性水域生殖，再加上蝌蚪體型小、發育快速且耐高溫，因此該類群在野外的蝌蚪期僅 8~86 日(Buchholz and Hayes 2002)。其中庫其氏鏟足蟾(*S. couchii*)在

實驗室 32℃的恆溫飼養下，約 10 日即可伸出前肢達到變態高峰(Buchholz and Hayes 2000, 2002)。本研究之史丹吉氏小雨蛙在野外的蝌蚪期亦僅需 8 日，而實驗室 25 或 30℃的恆溫飼養環境下，約 11 日可達變態高峰，與前述鏟足蟾類具有相似的生殖習性與棲所，同為目前已知野外蝌蚪期最短的兩棲類物種。

在暫時性水域中，如何讓水體持續存在一段時間，或加速蝌蚪的成長與發育，是影響蝌蚪存活的重要因素。野外觀察發現在暫時性水域的棲所中，若能有較多的植被或結構物遮蔽，將有利於延長水體存續的時間；此外若能將繁殖季配合多雨的時期，也有助於隨時補充所流失的水分。史丹吉氏小雨蛙配合天候環境，於一年中棲所較易積水且溫度較高的時期生殖，以提高蝌蚪族群的存活率。在台灣每年 4 月份起，因逢梅雨季的來臨，許多暫時性棲所開始有短暫且間歇性的積水，史丹吉氏小雨蛙則開始了當年度的繁殖行為；直到 9 月颱風季過後，環境中的水位陡降，逐漸趨向乾涸，該蛙也停止了該年度的繁殖。在此繁殖時期，野外的氣溫範圍約在 21.9~28.0℃之間(實際的水溫應會降低約 2℃左右)，配合本次溫度試驗的結果，在 20 與 25℃的環境下，蝌蚪變態時的存活率最高，顯示野外該時期的溫度可讓蝌蚪有較高的存活率。但對於偶發的更高溫時，蝌蚪也會藉由縮短蝌蚪期的方式來應對環境的變化。

Wells (2007)指出蝌蚪生活在暫時性水域主要面臨的問題在於水體蒸發時，蝌蚪是否已經有能力完成變態而離開水體。本蝌蚪缺水試驗的研究顯示史丹吉氏小雨蛙蝌蚪即使在飽和潮濕的微棲環境下，也無法存活超過 1 小時，對於環境中的積水有絕對的需求。因此對該物種而言，勢要有其他的應對策略，以減少對水分的依賴。暫時性的棲所在水體蒸發的同時，也常伴隨著水溫的升高，因此藉由高溫加速蝌蚪的發育以縮短對水分的依賴，便成為該蛙蝌蚪生活在暫時性水域中的最重要因應策略。Mayhew (1968)也指出：快速的發育及較高溫的耐受性為兩棲類蝌蚪生存於暫時性水域的特色。而在天擇作用的下，也有利於具有該能力的蝌蚪種類留存下來(Zweifel 1977)。史丹吉氏小雨蛙蝌蚪能忍耐較高溫度，其變態時間上的塑性，使牠們在面臨缺水危機或伴隨著水溫上升時，能在最短時間內變態成為小蛙，可能為該族群避免大量死亡的重要生存策略。

文引用獻

Brown, H. A. 1990. Morphological variation and age-class determination in overwintering tadpoles of the tailed frog, *Ascaphus truei*. Journal of Zoology, London 220: 171-184.

Buchholz, D. R. and T. B. Hayes. 2000. Larval period comparison for the spadefoot toads *Scaphiopus couchii* and *Spea multiplicata* (Pelobatidae: Anura). Herpetologica 56: 455-468.

Buchholz, D. R. and T. B. Hayes. 2002. Evolutionary patterns of diversity in spadefoot toad metamorphosis (Anura: Pelobatidae). Copeia 2002 (1): 180-189.

Castaneda, L. E., P. Sabat, S. P. Gonzalez and R. F. Nespolo. 2006. Digestive plasticity in tadpoles of the Chilean giant frog (*Caudiverbera caudiverbera*): Factorial effects of diet and temperature. Physiological and Biochemical Zoology 79: 919-926.

Downie, J. R. and J. Smith. 2003. Survival of larval *Leptodactylus fuscus* (Anura: Leptodactylidae) out of water: Developmental differences and interspecific comparisons. Journal of Herpetology Vol. 37 (1): 107-115.

Duellman, W. E. and L.Trueb. 1994. Biology of amphibians. The Johns Hopkins University Press. Maryland.

Gosner, K. L.1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 18: 183-190.

Just, J. J. 1972. Protein-bound iodine and protein concentration in plasma and pericardial fluid of metamorphosing anuran tadpoles. Physiological Zoology 45: 143-152.

King, O. M. 1960. Observations on Oklahoma toads. Southwestern Naturalist 5 (2): 102-103.

Loman, J. 2002. Temperature, genetic and hydroperiod effects on metamorphosis of brown frogs *Rana arvalis* and *Rana temporaria* in the field. Journal of Zoology 258: 115-129.

Marian, M. P. and T. J. Pandian. 1985. Effect of temperature on development, growth and bioenergetics of the bullfrog tadpole *Rana tigrina*. Journal of Thermal Biology 10 (3): 157-161.

Mayhew, W. H. 1968. Desert Biology: The biology of desert amphibians and reptiles. Academic Press, New York.

McDiarmid, R. W. and A. Ronald. 2000. Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, Chicago.

Murata, T. and K. Yamauchi. 2005. Low-temperature arrest of the triiodothyronine-dependent transcription in *Rana catesbeiana* red blood cells. Endocrinology 146: 256-264.

Oldham, R. S. 1977. Terrestrial locomotion in two species of amphibian larvae. Journal of Zoology 181: 285-295.

Smith-Gill, S. J. and K. A. Berven. 1979. Predicting amphibian metamorphosis. American Naturalist 113: 563-585.

SPSS Inc. 2009. PASW Modeler, version 18. Chicago, USA.

Travis, J. 1984. Anuran size at metamorphosis experimental test of a model based on intraspecific competition. Ecology 65: 1155-1160.

Viparina, S. and J. J. Just. 1975. The life period, growth and differentiation of *Rana catesbeiana* larvae occurring in nature. Copeia 1975: 103-109.

Voitkevich, A. A. 1963. The effect of temperature on the function of the preoptic nuclei in the amphibian hypophysis. Bulletin of Experimental Biology and Medicine 53 (5): 124-128.

Voss, W. J. 1961. Rate of larval development and metamorphosis of the spadefoot toad, *Scaphiopus bombifrons*. The Southwestern Naturalist 6 (3-4): 168-174.

Wells, K. D. 2007. The ecology and behavior of amphibians. University of Chicago Press, Chicago.

Williams, D. D. 2005. The biology of temporary waters. Oxford University Press. New York.

Wright, A. H. and A. A. Wright. 1949. Handbook of frogs and toads of the United States and Canada. 3rd ed. Cornell University Press, Ithaca, New York.

Zweifel, R. G. 1977. Upper thermal tolerances of anuran embryos in relation to stage of development and breeding habits. American Museum Novitates 2617: 1-21.

無尾目兩棲類在黃緣步行蟲食性與生活史中的重要性

Importance of Anurans in Diet and Life History of the Ground Beetle *Epomis nigricans*

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摘　要

大部分兩棲類的昆蟲天敵多屬水棲性，牠們可捕食水中的蛙卵、蝌蚪或剛變態的小蛙。本研究中發現，陸棲性的黃緣步行蟲成蟲及幼蟲能捕食陸域環境中的小蛙，甚至比自身體型還大之成蛙。2007 年夏季，我們於馬祖地區進行兩棲類相調查時，在黑眶蟾蜍腹部、貢德氏赤蛙後腳掌及地面上共發現 3 隻黃緣步行蟲幼蟲，帶回實驗室圈養及繁殖後，進行其食性、掠食行為與生活史週期之研究。結果顯示：成蟲僅對蛙類活體展現掠食行為。幼蟲的發育共有 3 個齡期，每一齡期的幼蟲須附著於蛙類體表取食，脫皮前才離開蛙體掉落地面。換言之，每 1 隻幼蟲至少須獵食 3 隻蛙類個體才可發育完成。幼蟲以大顎附著於蛙類體表吸食體液。取食之後，常造成蛙類傷口潰爛，有時也會造成組織或肢體的缺損，甚至個體的死亡。於室溫下(26~30℃)，卵發育至成蟲平均為 26.4 ± 1.1 天。雖然黃緣步行蟲在台灣本島也有分布紀錄，但其掠食蛙類的行為則尚未有所報導，需要野外更進一步的研究，以深入了解該物種的掠食行為。

Abstract

Most of the insects preying on amphibians are aquatic forms that feed on eggs, tadpoles, or newly metamorphosed juveniles in water. In this study we found that adults and larvae of the terrestrial beetle *Epomis nigricans* preyed on juvenile and adult frogs on land, whose sizes were usually bigger than those of the beetles themselves. In the summer 2007, we surveyed the amphibian fauna of the Matsu islands off the coast of mainland China, and observed three larvae of *E. nigricans* that preyed on adult frogs; one attached on the abdominal body wall of *Duttaphrynus melanostictus*, one attached on the tarsal skin of *Hylarana guentheri*, and the other one roamed on the ground. They were brought back to the laboratory and bred in captivity, and their diet, predatory behavior, and life cycle were investigated. The results showed that adults of *E. nigricans* preyed only on live frogs. For larvae at the 3 instar stages, each larva attached on a live frog for feeding, detached from the prey in ecdysis, and then preyed on another live frog for the next instar stage. In other words, a larva of *E. nigricans* requires preying at least three frogs during its 3 instar stages for developing to the adult stage. In predation the larva attached on frog's skin with its mandibles and sucked the prey's body fluids. The area attached became a festering lesion, in some cases, resulting in loss of tissues or legs, or even in death of the prey. It took the larvae for 26.4 ± 1.1 days at room temperatures (26-30℃) to develop from eggs to adults. *E. nigricans* has been also recorded from Taiwan but its predation on frogs has never been reported. Further studies are required in the field to better understand the predatory behavior of this species.

關鍵詞：黃緣步行蟲、食性、生活史、掠食

Key words: *Epomis nigricans*, diet, life history, predation

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緒　言

野生蛙類於生活史的不同階段有著不同的天敵種類，對於水生時期的卵及蝌蚪而言，許多的無脊椎動物，如渦蟲(platyhelminthes)、螺類(gastropoda)、水蛭(hirudinea)以及節肢動物(arthropoda)都可能是其潛在的天敵，其中又以水棲昆蟲所占的比例最高(Wells 2007)。隨著蝌蚪的成長與變態，蛙類的活動棲所逐漸由水域過渡到陸域環境，其主要的天敵則轉爲蛇類、鳥類及哺乳動物等大型掠食者(Toledo *et al.* 2007)，以及部分的無脊椎動物。根據Toledo (2005)整理已變態蛙類遭受無脊椎動物捕食的文獻顯示，其天敵主要爲蜘蛛(占 48%)，其次爲水棲性半翅目昆蟲(占 25%)，而陸棲性的昆蟲天敵則較少，僅有步行蟲、螳螂及螞蟻等種類。

步行蟲爲陸棲性的昆蟲，其所屬的步行蟲科(Carabidae)爲鞘翅目(Coleoptera)肉食亞目(Adeohaga)中，種類最多的一科，除了部分沙

漠地區外，廣泛分布於全世界各種棲地(Stehr 1991)。由於成蟲具發達大顎，多數種類屬多食性(polyphagous)掠食者，食性非常廣泛；少部分種類才屬植食性(phytophagous)或雜食性(omnivorous)；而幼蟲則多爲肉食性(sarcophagous)，其食物種類主要爲昆蟲、蚯蚓及各種蠕蟲等(Lövei and Sunderland 1996)。目前以發表的文獻中，具掠食蛙類行爲的步行蟲有 7 種，包括某種Chlaeniini族幼蟲(Moore 1971)、*Catadromus lacordairei* 成蟲(Littlejohn and Wainer 1978)、*Cicindela sedecimpunctata* 成蟲(McCormick and Polis 1982)、*Chlaenius darlingensis* 成蟲(Robertson 1989)、*Epomis dejeani* 成蟲與幼蟲(Elron *et al*. 2007; Wizen and Gasith 2011)、*E. circumscriptus* 成蟲與幼蟲(Brandmayr *et al*. 2010; Wizen and Gasith 2011)，以及黃緣步行蟲 *Epomis nigricans* 成蟲與幼蟲(Toshiaki 2006; cited in Elron *et al*. 2007)等。

本研究之黃緣步行蟲 *E. nigricans* 分布於台灣本島、中國、朝鮮半島、日本、東南亞及印度(林等 2003)，屬於廣域分布的物種。然而，目前台灣本島及相鄰離島的採集紀錄卻相當少，除了本研究所調查的馬祖列島之外，其他地區則僅蘭嶼有觀察紀錄(張 1998)，有關其食性與生活史的描述更是付之闕如。因此本研究藉由提供各類食物資源，以定性的方式來觀察該成蟲及幼蟲的可能食性，並由其完整生活史的建立，進一步探討蛙類在黃緣步行蟲各發育階段中所扮演的角色。

材料與方法

研究物種的取得與飼養

我們於 2007 年 7 月初在馬祖列島進行野外兩棲類資源普查時，於東莒島上的人工水池邊，發現 1 隻昆蟲幼蟲附著於貢德氏赤蛙(*Hylarana guentheri*)的後腳掌上；另於南竿島上的水庫泥灘地所採的黑眶蟾蜍(*Duttaphrynus melanostictus*)腹部及附近地表，亦各採得 1 隻相同的幼蟲。爲瞭解此昆蟲的種類及與蛙類之間的關係，我們將此 3 隻幼蟲帶回台灣本島之特有生物研究保育中心內飼養，待其成蟲羽化後，成功取得 1 對成蟲，經鑑定爲黃緣步行蟲。雌蟲與雄蟲的體長分別爲 21.5 及 20.3 mm，體重約爲 0.2 g。於同年 8~11 月間，我們將此對黃緣步行蟲放回觀察箱中繼續飼養，使其自然交配，且於產卵後，每日收集卵粒，以供後續進行黃緣步行蟲的食性、掠食行爲與生活史之相關研究使用。

成蟲食性試驗

依過去文獻顯示野外的黃緣步行蟲成蟲可能具掠食蛙類的能力(Toshiaki 2006)。因此，我們提供當時野外常見的澤蛙(*Fejervarya limnocharis*)與拉都希氏赤蛙(*H. latouchii*)小蛙給予成蟲，以驗證文獻所記載的結果。此外，爲了進一步了解該成蟲的潛在食物資源，我們亦提供蟲體於野外環境有可能遇到的活體生物類群，以進行成蟲的食性測試，其種類包括：蝎虎(*Hemidactylus frenatus*)、黃斑黑蟋蟀(*Gryllus bimaculatus*)、雙紋姬蠊(*Blattella bisignata*)、狼蛛(*Lycosa* sp.)、扁蝸牛(*Bradybaena similaris*)、雙線蚰蝓(*Meghimatium bilineatum*)、微小雙胸蚓(*Bimastus parvus*)、孔雀魚(*Poecilia reticulata*)及澤蛙蝌蚪等。實驗時將待測物與饑餓 3 天以上之成蟲各 1 隻，同時置於上述的飼養箱中約 1 日，觀察測試動物是否被該成蟲所掠食。

另爲瞭解成蟲對蛙類最大體型個體之掠食能力，我們選擇剛完成變態的澤蛙小蛙與黃緣步行蟲成蟲各 1 隻，同時置於長 40 cm、寬 16 cm 及高 28 cm 且裝有潮濕土壤之大型置物箱內。若成蟲能成功掠食，則使其饑餓 3 天後再投入較大體長之澤蛙個體，依此逐次增加獵物體型，以測定成蟲所能捕食的最大獵物體長。本項實驗共進行了 16 次的測試，實驗時爲降

低對動物的干擾，我們使用 Sony 硬碟式攝影機以紅外線模式進行錄影，隔日再由所錄製的影片中，檢視成蟲掠食澤蛙的過程。

幼蟲食性試驗

在幼蟲的食性方面，我們除了以上述測試成蟲食性之物種測試外，另投以更多不同種類的蛙類活體以進行幼蟲食性試驗，其種類包括：黑眶蟾蜍、日本樹蛙(*Buergeria japonica*)、花狹口蛙(*Kaloula pulchra*)、面天樹蛙(*Kurixalus idiootocus*)、美洲牛蛙(*Lithobates catesbeiana*)、小雨蛙(*Microhyla fissipes*)、梭德氏赤蛙(*R. sauteri*)。試驗方式為將測試物靠近一齡幼蟲的頭端，觀察是否產生取食反應。若幼蟲能以大顎咬合並附著於獵物體表，並順利取食且發育至二齡幼蟲，則定義該獵物為幼蟲可利用的食物資源。順利發育至下一齡期的幼蟲，則持續以相同食物類別餵食。此外，我們也收集因受幼蟲掠食而死亡的蛙類體長數據，以瞭解不同齡期幼蟲對蛙類致死能力之影響。

黃緣步行蟲的生活史

我們將飼養成蟲過程中所得的卵粒取出，置於裝有潮濕土壤的布丁杯中，每日觀察並紀錄卵期、幼蟲各齡期、蛹期至成蟲期間之各階段的發育時間、體長大小及相關行為上的變化，以建立該步行蟲完整的生活史資料。在幼蟲的發育期間，我們以當時容易取得的蛙類供幼蟲取食。雖然我們於馬祖地區所採得之幼蟲附著於蛙類腹部或後腳掌，與文獻中 *E. dejeani* 幼蟲多附著於蛙類腹部及後肢的情況相似(Elron *et al*. 2007)，但為避免幼蟲受獵物四肢撥動或因撞擊而脫落，進而影響該階段發育時間的紀錄。因此，我們將幼蟲置於蛙類背部取食，而不讓幼蟲自行選擇附著部位。由於各齡期幼蟲取食蛙體直至蛻皮前才會脫離獵物，為避免蟲體被體型懸殊的蛙類食入，在蟲體掉落地表等待轉齡時，我們即將蛙體取出，待幼蟲蛻皮完成且開始活動後，才提供新的獵物。過程中我們紀錄各齡期幼蟲於單隻獵物體表的取食天數、掠食獵物前(pre-feeding)與食畢脫離獵物後(post-feeding)的幼蟲體長(大顎末端至尾毛基部的長度)。此外，為更精準記錄各齡期幼蟲在蛙類體表的發育時間，我們會在幼蟲開始活動後，於最短時間內提供蛙體，以縮短蟲體因尋找獵物所導致時間紀錄上的偏差，因此本實驗中所得生活史總天數將會較野外實際的發育天數為短。末齡幼蟲鑽入土後數天，我們即挖掘土壤使蛹體露出，以觀察羽化之確切時間，完成生活史各階段的紀錄。

結　果

成蟲的食性

在所有供試活體動物中，黃緣步行蟲成蟲僅對蛙類成體展現出明確的掠食行為；而對蚯蚓、蝌蚪及魚類雖有趨近試探的行為，但因獵物扭動掙扎而放棄；對於其他動物種類則無展現任何趨近的動作，因此也無掠食行為的發生。由攝影機的錄影結果發現，當成蟲接近澤蛙時，即向前突進並攀附其上，在蛙體掙扎跳躍的過程中，成蟲即以大顎啃食蛙體，而被成蟲捕獲的澤蛙，均於短時間內出現反應遲緩或癱瘓不動的現象。在 16 次成蟲掠食蛙類的紀錄中顯示，測得雄、雌成蟲所能捕食澤蛙的最大吻肛長分別為 23 mm (1.0 g)及 30 mm (2.3 g)。

幼蟲的食性

在幼蟲的食性試驗方面，結果顯示：所有供試的蛙類皆可被 1 齡幼蟲利用，且幼蟲均可成功發育至下一齡期；對於蚯蚓、蝌蚪及魚類的體表幼蟲雖有趨近且嘗試取食，但卻無法成功以大顎附著，因此這些測試物應屬於幼蟲無法利用的食物資源；而對其他供試種類，幼蟲則無任何取食反應。各齡期幼蟲掠食蛙類個體所需的取食天數、取食前後的體長變化，以及

其獵物的最大致死體長請參考表 1。整體上來看，1 齡幼蟲在蛙體的取食天數在 3~4 天間(n = 24)，但到 3 齡幼蟲時，取食天數僅 1~2 天(n = 14)即可完成；1 齡的幼蟲於取食前體長均為 4 mm (n = 10)，而在 3 齡幼蟲的取食後，體長已可達 19~21 mm (n = 6)；各齡期幼蟲在脫落獵物後的轉齡過程中，體長均會略為縮小；1 齡幼蟲到 3 齡幼蟲於掠食蛙類後，蛙體死亡的最大吻肛長分別為 25, 40 及 50 mm (表 1)。觀察中也發現蛙體在被幼蟲取食後，常造成附著處的組織潰爛或缺損；若蛙體被取食部位在四肢，則可能導致肢體殘缺；若被取食範圍過大者，甚至會導致死亡。通常體型大於幼蟲的蛙類，若兩者間的體型差距較大，蛙類較能於掠食後存活；反之，若兩者體型差距太小，常導致蛙體死亡。觀察中也發現，幼蟲不取食已略有腐敗的食物；因此取食的過程中若獵物提早死亡，即使幼蟲未獲取該齡期發育所需的食物量，依然會棄之不食。

表 1. 於室溫 26~33℃下，黃緣步行蟲各齡期幼蟲掠食蛙類個體所需的取食天數、取食前後的體長變化以及其獵物的最大致死體長(括號內數字代表樣本數)。

Table 1. Feeding durations and body lengths of *Epomis nigricans* larvae at the 3 instar stages under laboratory conditions at 26°-33℃, and the maximum sizes of the preys (frogs) killed (sample sizes in parentheses).

Instar stages	Feeding durations, days	Body lengths, mm		Maximum sizes of frog killed, mm
		pre-feeding	post-feeding	
1st	3-4 (24)	4 (10)	12-13 (10)	25
2nd	2-3 (18)	10-11 (9)	17-19 (8)	40
3rd	1-2 (14)	14-15 (8)	19-21 (6)	50

黃緣步行蟲的生活史

室溫(26~30℃)下，黃緣步行蟲由卵連續飼養至成蟲所需時間，平均歷時 26.4 ± 1.1 天 (n = 10)。卵的發育期非常固定，均為 4 天(n = 54)。幼蟲發育的過程中共須經歷 3 個齡期，在各齡期間，幼蟲會脫離蛙體掉落地表等待蛻皮；之後，再重新掠食另一個體。所以在本生活史試驗中，每隻黃緣步行蟲至少須成功利用 3 隻蛙類個體才能完成生活史。各齡期幼蟲附著於一隻蛙類體表的取食天數從 1~4 天不等，其取食時間隨著齡期增加而縮短，其中又以末齡幼蟲的取食時間最短，最快約 1 天即可離開獵物(表 1)。終齡幼蟲在取食蛙體後便掉落地表，鑽入土中開始製造蛹室，蛹期約 10~11 天(n = 10)。羽化後的成蟲 3 天後爬出地面活動(n = 1)。成蟲經長期飼養，壽命可超過 1 年以上(n = 7)。

討　論

多數步行蟲成蟲屬肉食性，可利用發達的大顎捕食獵物，常見的食物包括昆蟲綱(Insecta)、蛛形綱(Arachnida)、腹足綱(Gastropoda)、等足綱(Isopoda)及蚯蚓等無脊椎動物(Lövei and Sunderland 1996)，以及受傷或死亡的脊椎動物(LittleJohn and Wainer 1978)。由本試驗結果可知，黃緣步行蟲成蟲對蛙類具有相當高的掠食專一性，有能力捕食健康且體型大於本身體型之蛙類。另由遭受成蟲咬傷後澤蛙短暫癱瘓的表現，推測掠食過程中成蟲可能有痲痺獵物的能力。步行蟲為了提高掠食成功率，有些種類會先麻痺獵物(Lövei and Sunderland 1996)。

Toshiaki於2006年在日本目擊體長20.4 mm的黃緣步行蟲成蟲正在取食吻肛長為36.0 mm的黑斑赤蛙(*Pelophylax nigromaculatus*)活體，雖然該蛙體型遠大於成蟲，但卻無法移動掙脫。雖然蛙類相對於一般的無脊椎動物，體型不但較大，活動力也較強，屬於較難以制伏的獵物。然而許多無脊椎動物卻能使用毒液、織網或集體掠食等方式，捕食體型相對較大的獵物(Toledo *et al*. 2007)。在過去長期的兩棲類調查中，雖然我們在台灣本島並無發現過黃緣步行蟲，但卻常見大黃紋炮步行蟲(*Pheropsophus javanus*)與小黃紋炮步蟲(*P. occipitalis*)成蟲沿著水際邊快速爬行，是否同樣具掠食蛙類的行為，有待後續的深入觀察與驗證。

黃緣步行蟲原歸屬於 *Chlaenius* 屬，而 *Epomis* 為其下的一個亞屬(subgenus)。然而，Brandmayr *et al*. (2010)藉由外部形態的觀察，認為 *Epomis* 幼蟲具獨特大顎構造，可能與掠食蛙類的行為有關，且其形態異於其他近緣類群，因而將之提升至屬的分類階級。由於形態結構上的專化，黃緣步行蟲幼蟲相較於成蟲，在掠食蛙類的行為上應更具專一性。目前被歸類於 *Epomis* 屬的步行蟲種類約有20餘種，主要分布於地中海地區(Mediterranean region)、古北區(Palearctic area)，以及非洲地區(Brandmayr *et al*. 2010)。目前僅已知3種 *Epomis* 屬幼蟲具有掠食蛙類的紀錄，其發生地點分別為日本及以色列地區(Elron *et al*. 2007; Brandmayr *et al*. 2010)，其中，*E. dejeani* 幼蟲主要掠食吻肛長介於12~33 mm的蛙類個體(Elron *et al*. 2007)。本次野外觀察雖然僅有2筆幼蟲掠食蛙類的紀錄，其獵物分別為20 mm的黑眶蟾蜍及60 mm的貢德氏赤蛙，不過在當時在該樣點附近可見相當多剛變態的小蛙，應可為黃緣步行蟲幼蟲提供非常豐富的食物來源。

黃緣步行蟲幼蟲為食性專一的動物，僅能利用蛙類才能成長與發育，對蛙類族群的依存度遠高於成蟲，這類僅於生活史某一階段對獵物展現專一食性的掠食者，依 Toledo *et al*. (2007)歸類為短暫性專一掠食者(temporary specialized predators)。大部分步行蟲幼蟲多為肉食性且食性較為專一，口器屬食液式(liquid-feeding) (Lövei and Sunderland 1996)。取食時，具中空管道的鐮刀狀大顎，能將消化酵素注入獵物體內，待組織液化後，連同原本的酵素再吸回消化道，如此的取食方式可讓小型掠食者在不需耗費太多時間與能量下，即可利用無法直接食入的大型獵物(Cohen 1995)。Brandmayr *et al*. (2010)對同樣掠食蛙類的 *E. dejrani* 及 *E. circumscriptus* 幼蟲曾有以下掠食行為的描述：當1齡幼蟲附著於蛙體表面吸食體液時，通常固定不動，此時的幼蟲對於獵物稱為外寄生狀態(ectoparasitic habitus)；而幼蟲發育至2齡及3齡時，多數個體開始出現頻繁移動的行為，並開始啃咬並取食蛙體組織，此時稱為掠食(predation)狀態。本研究觀察黃緣步行蟲幼蟲，同樣也有出現取食策略轉變的類似現象。由於幼蟲主要以大顎附著於蛙體，倘若在獵物尚具活力時即鬆開大顎，非常容易自蛙類體表脫落，如此必須再花費額外的能量與時間尋找另一獵物，造成極高的生存風險，因此較小之幼蟲或於取食初期，幼蟲通常於附著後，較不易移動取食位置。此外，由於幼蟲無法利用已腐敗的食物，再加上較大齡期的幼蟲，對獵物所造成的傷害愈大，故當獵物虛弱或死亡之初，幼蟲為了加快取食速度，便開始出現反覆開合大顎以擠壓獵物組織的現象；在此同時，幼蟲也會移動位置以擴大取食範圍。黃緣步行蟲幼蟲依獵物生命狀態而轉變取食模式，以在取食效率與脫落風險間取得最佳的適存度(fitness)。

在生活史的研究中，我們主動提供食物給各齡期幼蟲取食，由卵發育至成蟲約歷時 26天，此結果與 *E. dejeani* 相似(Elron *et al*. 2007)。然而，野外個體的發育歷程中，須額外花費時間尋找或等待獵物，實際發育時間應遠長於

此。若幼蟲於野外長時間無法遇到蛙類，會增加被其他生物捕食或因飢餓而導致死亡的風險。因此，成蟲產卵地的選擇若能與蛙類族群棲所重疊，可能有助於提升幼蟲日後尋找獵物的機會。本研究樣本來自馬祖列島，昔日為軍事重地，地勢陡峭及人口密度低，保有相對完整的生態環境；此外，由於該地區缺乏天然水系，當地居民為保留珍貴的淡水資源，設置許多各式蓄水池，因而提供蛙類良好的繁殖場域，同時也成為黃緣步行蟲理想的覓食與繁殖環境。參考該蟲在日本地區的紀錄報告，牠們可分布於平原或低海拔山區，甚至在人類活動頻繁的農耕地亦可發現，為當地常見的物種(中根等 1963; Toshiaki 2006; Yahiro and Yano 1997)。台灣本島雖然列為黃緣步行蟲的可能分布區域(林等 2003)，但目前並無實際的採集紀錄，因此無法瞭解其詳細的棲息環境。黃緣步行蟲的成蟲或幼蟲皆能以蛙類為食，其中幼蟲必須利用蛙類方能發育與成長，為絕對依賴蛙類族群的陸生昆蟲。本研究藉由對黃緣步行蟲成蟲與幼蟲的食性測試，與其生活史的探討與觀察，希望有助於未來進一步地了解黃緣步行蟲在生態上的角色，以及對共域蛙類族群所造成的可能影響。

引用文獻

林宗岐、林佑安、周文一、蔡明諭、汪良仲、陳建宏。2003。馬祖昆蟲生態導覽。連江縣政府。

張永仁。1998。昆蟲圖鑑。遠流出版事業股份有限公司。

中根猛彥、大林一夫、野村鎮、黑尺良彥。1963。原色昆蟲大圖鑑第 2 卷(甲蟲篇)。北隆館。東京。

Brandmayr, P., T. Bonacci and T. Z. Brandmayr. 2010. Larval morphology of *Epomis circumscriptus* (Duftschmid 1812) and of first instar *E. dejeani*, Dejean, (Coleoptera, Carabidae, Chlaeniini), with morphofunctional remarks. Zootaxa 2388: 49-58.

Cohen, A. C. 1995. Extra-oral digestion in predaceous terrestrial arthropoda. Annual Review of Entomology 40: 85-103.

Elron, E., A. Shlagman and A. Gasith. 2007. First detailed report of predation on anuran metamorphs by terrestrial beetle larvae. Herpetological Review 38: 30-33.

Littlejohn, M. J. and W. Wainer. 1978. Carabid beetle preying on frogs. Victorian Naturalist 95: 251-252.

Lövei, G. L. and K. D. Sunderland 1996. Ecology and behavior of ground beetles (Coleoptera: Carabidae). Annual Review of Entomology 41: 231-256.

McCormick, S. and G. A. Polis. 1982. Arthropods that prey on vertebrates. Biological Review of Cambridge Philosophical Society 57: 29-58.

Moore, B. P. 1971. Notes on an extraordinary blood-feeding carabid larva (Coleoptera) from Port Elizabeth. Annals of the Natal Museum 20: 479-482.

Robertson, J. G. M. 1989. Predation by a carabid beetle on Australian frogs. Herpetological Review 20: 7-9.

Stehr, F. W. 1991. Immature insects. Kendall/Hunt Company, Dubuque, Iowa.

Toledo, L. F. 2005. Predation of juvenile and adult anurans by invertebrates: Current knowledge and perspectives. Herpetological Review 36 (4): 395-400.

Toledo, L. F., R. S. Ribeiro and C. F. B. Haddad. 2007. Anurans as prey: An exploratory analysis and size relationships between predators and their prey. Journal of Zoology 271: 170-177.

Toshiaki, H. 2006. Predation by a carabid beetle

(*Epomis nigricans*) on a juvenile frog (*Rana nigromaculata*). Bulletin of the Herpetological Society of Japan 2006: 99-100.

Wells, K. D. 2007. The ecology and behavior of amphibians. University of Chicago Press, Chicago.

Wizen, G. and A. Gasith. 2011. Predation of amphibians by carabid beetles of the genus *Epomis* found in the central coastal plain of Israel. Zookeys 100: 181-191.

Yahiro, L. and K. Yano. 1997. Ground beetles (Coleoptera, Carabidae) caught by a light trap during ten years. Esakia 37: 57-69.

以救援病例回溯分析台灣穿山甲的傷病原因

Retrospective analysis of the causes of morbidity of wild Formosan pangolins (*Manis pentadactyla pentadactyla*)

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摘　要

本研究回溯分析 1993~2009 年間台灣地區野生穿山甲(*Manis pentadactyla pentadactyla*)送至特有生物研究保育中心野生動物急救站醫療處理之病例，探討造成傷病原因與處理結果。此期間醫療處理的穿山甲病例共有 117 隻，來源地以南投縣最多，占病例總數 42.7%，其中 99 隻有性別和年齡紀錄的病例中，以成年雄性居多，占 55.6%。4~7 月為穿山甲救傷處理的數量高峰期，占病例總數 53.9%。以 2001~2009 年間穿山甲每月累加病例數，分別與平均溫度及雨量做相關分析，發現皆呈顯著正相關。就診原因以創傷最多，占病例總數 51.3%，其次為健康但被民眾誤撿拾占 17.1%、營養不良或消瘦 16.3%、幼獸 6.8%、疾病 3.4%，未知原因占 5.1%。創傷案例中有 70%為陷阱造成，以後肢被獸鋏夾傷比例最高。經醫療處理後野放之個體占 60.7%、醫療期間死亡或安樂死占 35.1%、永久殘廢須長期收容占 3.4%，而尚在療養中為 0.9%。穿山甲遭獸鋏夾傷死亡率高、預後不佳且常須截肢保命，醫療後倖存的個體通常無法野放，僅能長期收容。由本次病例分析得知，創傷是造成台灣穿山甲需要接受醫療處理的主因，而獸鋏是造成創傷的主要獵具。

Abstract

A retrospective study was conducted to determine the causes of morbidity of wild Formosan pangolins (*Manis pentadactyla pentadactyla*) and to evaluate the results of their treatments. During the period from 1993 to 2009, 117 morbid pangolins were admitted for treatments at the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan. Most of them were from Nantou County (42.7%) and in April to July (53%). Their ages and sexes were identified for 99 cases; adult males occupied 55.6%. The numbers of the pangolins admitted were positively correlated with monthly average temperatures and precipitations. Trauma was the major cause accounting for 51.3% of all admitted cases; other causes were healthy animals but incautiously caught by people (17.1%), malnutrition and emaciation (16.3%), juveniles (6.8%), disease (3.4%), and unknown (5.1%). About 70% of the traumas were caused by gin traps. After the treatments 60.7% were released to the wild, 35.0% died or euthanized, and 3.4% crippled and kept in captivity. The trapped pangolins usually had high mortality rate and poor prognoses. In many cases they needed amputation to save their lives and were unable to be released to wild later.

關鍵詞：穿山甲、傷病、創傷、獸鋏

Key words: pangolin, morbidity, trauma, gin trap

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緒　言

穿山甲(*Manis* spp.)屬於鱗甲目(Pholidota)穿山甲科(Manidae)。世界上現有 8 種穿山甲分布於非洲及亞洲的熱帶與亞熱帶地區，分為樹棲型與陸棲型(金 2007b; Gaubert and Antunes 2005; Newton *et al*. 2008)。中國穿山甲(*M. pentadactyla*)有 2 個亞種，分布於台灣的為 *M. p. pentadactyla*，與分布於中國內地與海南島的為 *M. p. aurita* (史和解 2009)。台灣穿山甲屬於珍貴稀有保育類野生動物(野生動物保育工作手冊 2009)，以螞蟻及白蟻為主食，白天穴居、夜間活動，獨居但繁殖季節時雌雄會居於同一穴(吳 2004a)。

中國民間傳統上以穿山甲肉為美食，鱗片具中藥療效(許 1977; 謝 1987)，又皮革可加工製成皮件，因此獵捕壓力極為龐大(趙 1989; Chao *et al*. 2005; Newton *et al*. 2008)。在 1950~1970 年間，台灣的穿山甲皮革加工產業極為興盛，每年因皮革需求的穿山甲竟高達 6 萬隻，長年大量獵捕使得台灣穿山甲數量急遽下降(趙 1989)。如今穿山甲被華盛頓公約列為附錄II的物種，在國際貿易上受到管制，2000 年將中國穿山甲、印度穿山甲(*M.*

crassicaudata)、菲律賓穿山甲(*M. culionensis*)與馬來穿山甲(*M. javanica*)貿易配額定為 0 (CITES 2009; Compton and Shepherd 2009)。然而，在亞洲目前仍有龐大的消費市場，近年來於台灣、中國大陸、越南與印尼查緝了數噸重的穿山甲或鱗片(徐和柯 2007; Chao *et al*. 2005; Compton and Shepherd 2009)。因人工養殖困難，故買賣的穿山甲皆由野外獵捕(Compton and Shepherd 2009)。除獵捕壓力外，因台灣穿山甲偏好棲息海拔 200~500 m的丘陵地與台地(趙 1989; 金 2007b)由於人為開發正逐漸稀少，棲地消失與破碎化亦造成穿山甲生存威脅。台北動物園於 2004 年邀請世界自然保育聯盟(IUCN)物種存續委員會(Species Survival Commission, SSC)的保育繁殖專家群(Conservation Breeding Specialist Group, CBSG)針對穿山甲以電腦軟體進行族群及棲地活存率評估(Population and Habitat Viability Assessment, PHVA)(王 2007; Chao *et al*. 2005)，結果表示若目前保育狀況未改善，穿山甲可能於 20 年後自台灣滅絕(台北動物園 2004; 金 2007a)。

利用回溯性分析探討救援與醫療單位中野生動物傷病或死亡的原因，可提供有用的野生動物族群健康資訊，亦可作為污染與疾病等環境壓力指標(Deem *et al*. 1998; Brown and Sleeman 2002; Kelly and Sleeman 2003; Richards *et al*. 2005; Sleeman 2008)。王(2007)曾對台灣救傷單位進行穿山甲的保育學應用研究。台北動物園曾分析於 1995~2004 年剖檢 68 隻穿山甲屍體，發現肺炎與胃潰瘍為最常見病變(Chin *et al*. 2006)，然對於野外穿山甲為何傷病並無著墨。本研究回溯分析 1993~2009 年間送交特有生物研究保育中心(以下簡稱特生中心)野生動物急救站的穿山甲被傷病原因及處理結果，以提供資訊作為台灣穿山甲族群保育的參考。

材料與方法

一、樣本來源

本研究之樣本蒐集為 1993~2009 年間，來自台灣各地區，因民眾拾獲，或民間保育團體及政府機關送至特生中心野生動物急救站醫療處理的穿山甲醫療紀錄。每隻穿山甲皆記載病例資料，包括病例編號、受理日期、來源地、發育階段、性別、體重、臨床診斷和醫療處理結果等。

二、傷病分類

每隻穿山甲都經過獸醫師臨床檢查，就穿山甲脫水程度、體重與傷病等臨床症狀記錄之。穿山甲被救援的原因分類為創傷、幼獸、營養不良及消瘦、疾病、健康但被民眾誤撿拾，與不明原因。其中創傷細分為撞擊、陷阱、動物攻擊及未知因素。穿山甲傷病原因之歸類，由主治獸醫師依據個別病例的病史資料、臨床檢查、實驗室檢查、病理解剖發現，以及組織病理檢查等結果判斷決定。

三、年齡判定

穿山甲的發育階段根據王(2007)研究將未達 1,500 g 歸類為幼體、1,500~2,350 g 為亞成體、超過 2,350 g 為成體。

四、氣候資料

溫度與雨量資料來自中央氣象局網站所公布之新竹、台中、日月潭、嘉義與高雄 5 處的氣象監測站。

五、統計分析

病例資料經歸納後以電腦軟體(Microsoft Excel)整理成數位資料，並依來源地、發育階段、性別、體重、傷病原因、創傷分類、獸鋏傷害部位、月份、醫療處理結果等進行比較。檢測不同發育階段與性別之比例以卡方分析

(Chi-square test)是否相當。檢測不同發育階段的平均體重以 t 檢定(*t*-test)是否有性別差異。將平均體重與吳等(2004b)發表之中國穿山甲體重(mean = 4088g, n = 43)以*t*-test 檢定有無差異。以上統計分析皆以$\alpha = 0.05$定義爲顯著差異與否的標準。因 2001~2009 年每年就診的穿山甲數量較穩定，故將各月份的穿山甲數量加總，與 9 年間台灣西部地區平地與低海拔的每月平均氣溫及雨量做相關係數分析。

結　果

一、數量與體重

自 1993~2009 年特生中心野生動物急救站醫療處理之穿山甲共 117 隻。有發育階段記錄的穿山甲共 108 隻，成體占 67.6%、亞成體 18.5%與幼體 13.9%。其中 99 隻有性別和發育階段紀錄的個體，雄性占 69.7%、雌性占 30.3%，以成年雄性居多，占 55.6%。幼體與亞成體的雌雄數量無顯著差異，成年雄性則顯著多於雌性(卡方檢定，$p = 0.011$)。將初診體重做分析，穿山甲的平均體重(mean ± SD)爲 3,287.8 ± 1,500g (n = 108)，雄性平均體重爲 3,779.5 ± 1,442.7g (n = 69)、雌性平均體重爲 2,567 ± 1,189.9g (n = 30)，雄性平均體重顯著大於雌性($t = 4.04$, $p < 0.01$) (圖 1)。病例中最輕爲 603 g之幼年雌性、最重爲 6,700 g之成年雄性。台灣穿山甲與吳等(2004b)發表之中國穿山甲的平均體重間有顯著差異($t = -2.54$, $p = 0.014$)。

二、來源地與受理日期

來源地分析發現以台灣西部爲主，前 5 名縣市以南投縣數量最多，其次爲台中縣市、新竹縣市、嘉義縣市與苗栗縣(表 1)。以年度數量來看，以 2007 年最多，其次爲 2009、2001 與 2005 年等(圖 2)。以月份數量來看，將各年度月份病例數量累加後，以 4~7 月爲數量高峰期，每月皆超過 10 隻，且總和隻數占病例總數 53.9%，其中又以 6 月最多；1、2 月數量最少(圖 3)。若以性別區分，雄性以 4~8 月、雌性以 4~7 月數量較多(圖 4)。以年齡區分，成體於 4~7 月數量較多，亞成體 6 月較多，幼體則爲 7 月較多(圖 5)。

三、數量與雨量、數量與溫度關係

將 2001~2009 年 1~12 月份的穿山甲數量累加後，分別和新竹、台中、日月潭、嘉義與高雄 5 處的雨量與溫度之每月平均數做相關係數分析，結果發現穿山甲的就診數量與溫度($R = 0.68$, $p = 0.016$)和雨量($R = 0.71$, $p = 0.009$)皆呈顯著正相關(圖 6)。

四、處理結果與傷病分析

以 117 隻穿山甲經醫療處理後之結果作分析，野放占總病例數 60.7%爲最多，其次爲死亡 35%、收容 3.4%和療養中 0.9%。以傷病原因分析發現創傷占多數，其次爲健康但被民眾誤撿拾、營養不良或消瘦、幼獸等(圖 7)。創傷病例中以獸鋏傷害占最多(圖 7)。獸鋏傷害共 41 隻，又以後肢受傷占 65.9%最多，其次爲前肢 21%、尾部 9.8%與頭頸部 2.4%。獸鋏傷害的病例中處理結果爲死亡與安樂死占 51.2% (圖 8)。

討　論

本研究中指出特生中心野生動物急救站醫療處理穿山甲數量在 1993~2009 年間呈現上升趨勢，於 2005~2009 年間平均病例每年超過 10 隻，此趨勢可能與民眾保育概念的提升有關，拾獲穿山甲的民眾較有意願送到野生動物救援機構醫治。

穿山甲病例來源地以台灣西部地區的中部縣市(南投縣和台中縣)爲主，南部與北部其次，東部地區最少，可能因特生中心野生動物

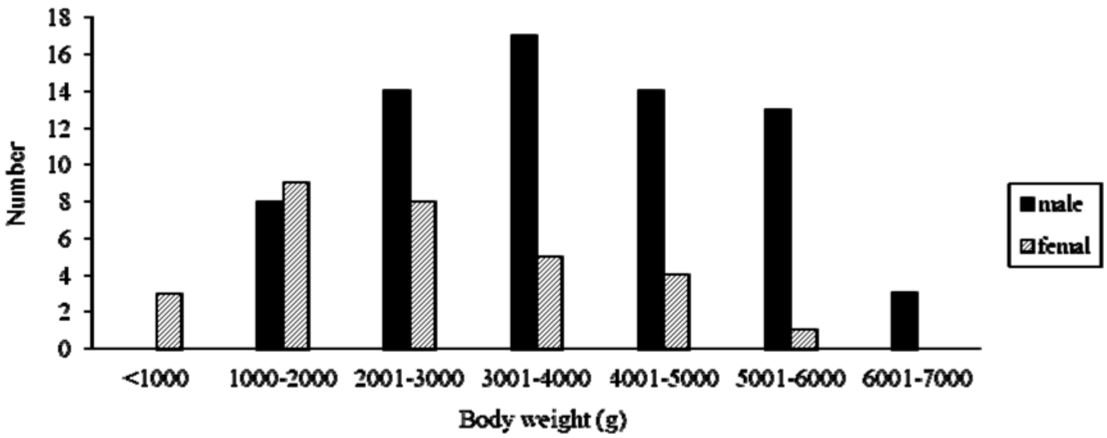

圖 1. 自 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理穿山甲不同性別之重量分布圖。

Fig. 1. Frequency distributions of body weights of male and female morbid pangolins admitted to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

表 1. 自 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理穿山甲之來源縣市與數量。
Table 1. Number by county/city of morbid pangolins admitted to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

	Country/City	Number	%
南 投 縣	Nantou	50	42.74%
台中縣市	Taichung	14	11.97%
新竹縣市	Hsinchu	12	10.26%
嘉義縣市	Chiayi	11	9.40%
苗 栗 縣	Miaoli	6	5.13%
高 雄 縣	Kaohsiung	6	5.13%
雲 林 縣	Yunlin	5	4.27%
台南縣市	Tainan	4	3.42%
花 蓮 縣	Hualien	3	2.56%
台 北 縣	Taipei	2	1.71%
彰 化 縣	Changhua	2	1.71%
台 東 縣	Taitung	1	0.85%
屏 東 縣	Pingtung	1	0.85%
總 計	Total	117	100%

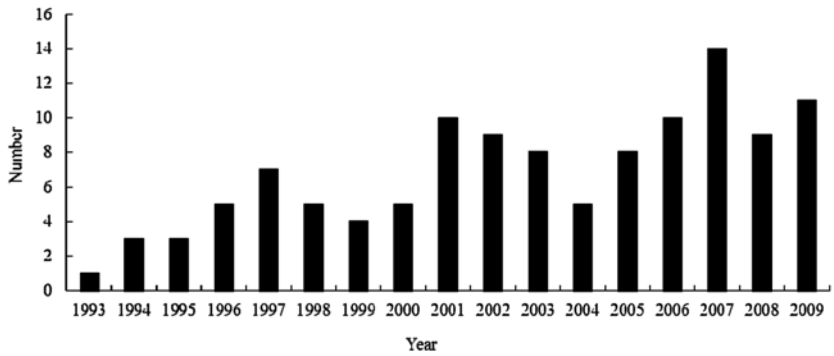

圖 2. 自 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理穿山甲之年度數量分布圖。
Fig. 2. Annual numbers of morbid pangolins admitted to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

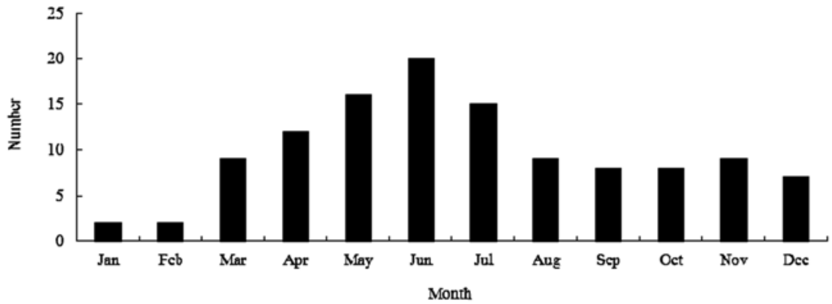

圖 3. 自 1993~2009 年特有生物研究保育中心野生動物急救站每月醫療處理之穿山甲數量分布圖。
Fig. 3. Mumbers of morbid pangolin admitted by months to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

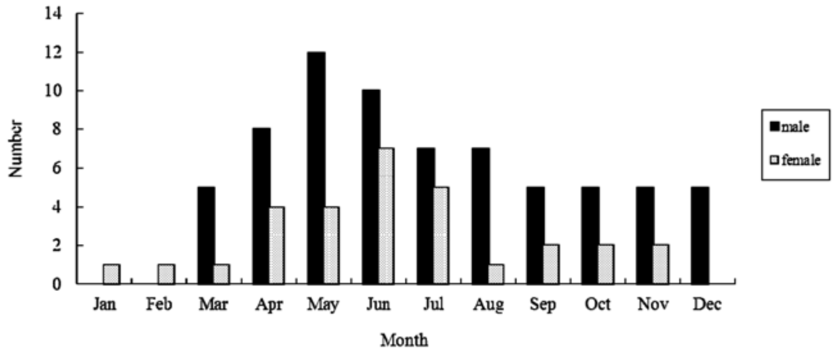

圖 4. 自 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理之不同性別穿山甲之月份數量分布圖。
Fig. 4. Numbers of male and female morbid pangolins admitted by months to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

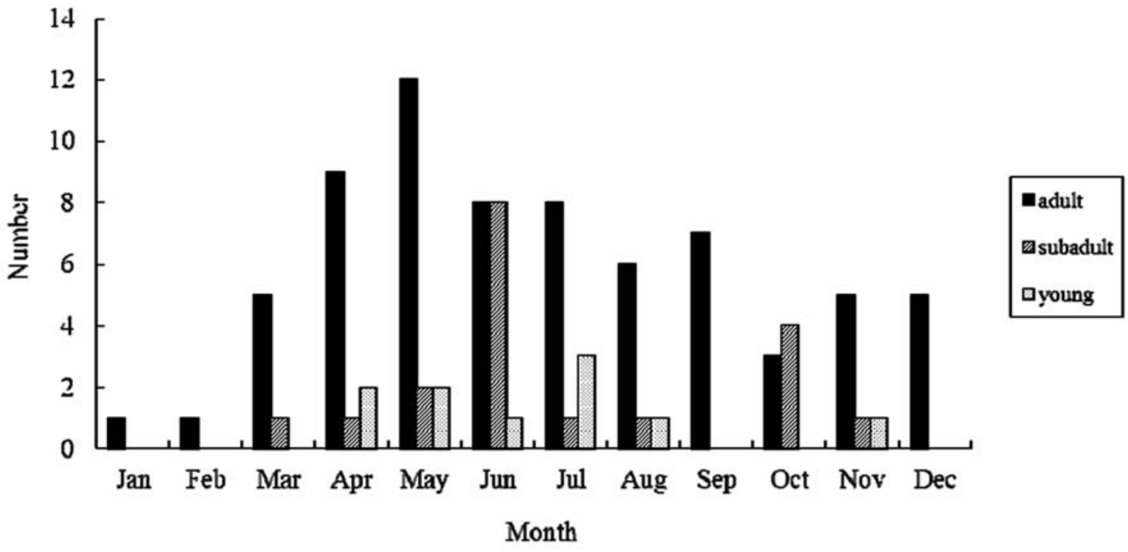

圖 5. 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理不同發育階段穿山甲之月份數量分布圖。

Fig. 5. Numbers of adult, subadult, and young pangolins admitted by months to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

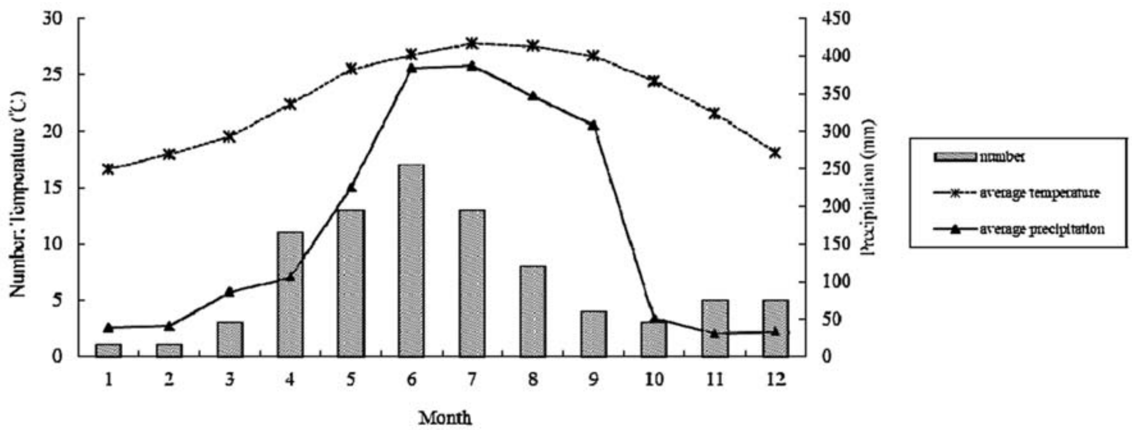

圖 6. 自 2001~2009 年特有生物研究保育中心野生動物急救站每月醫療處理之穿山甲數量分布圖，與每月平均雨量和溫度分布圖。

Fig. 6. Monthly average temperatures and precipitations, and monthly numbers of morbid pangolins admitted to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 2001-2009.

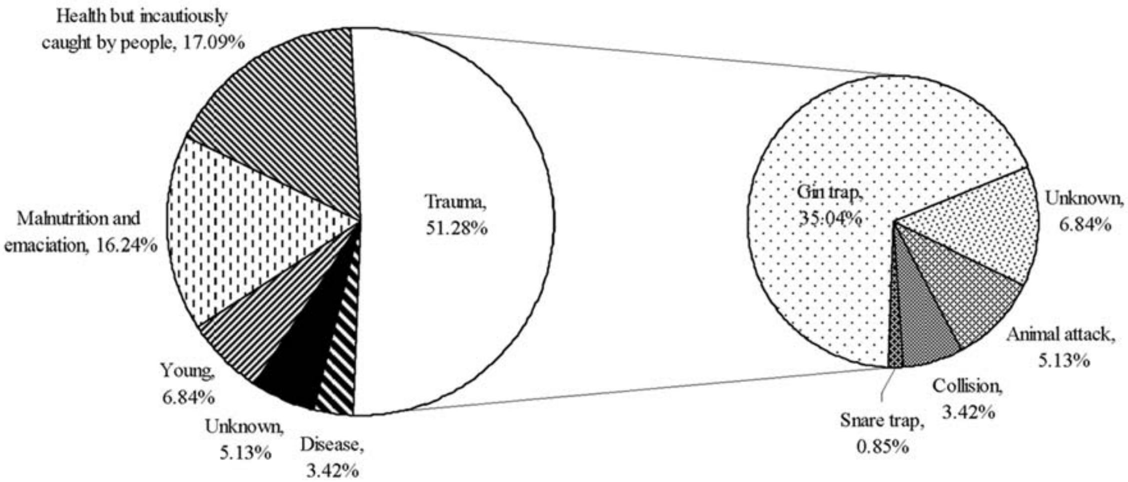

圖 7. 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理 117 隻穿山甲的傷病原因與創傷分類。

Fig. 7. Percentage compositions of the causes of morbidity (left figures) and trauma (right figure) of 117 pangolins admitted to the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

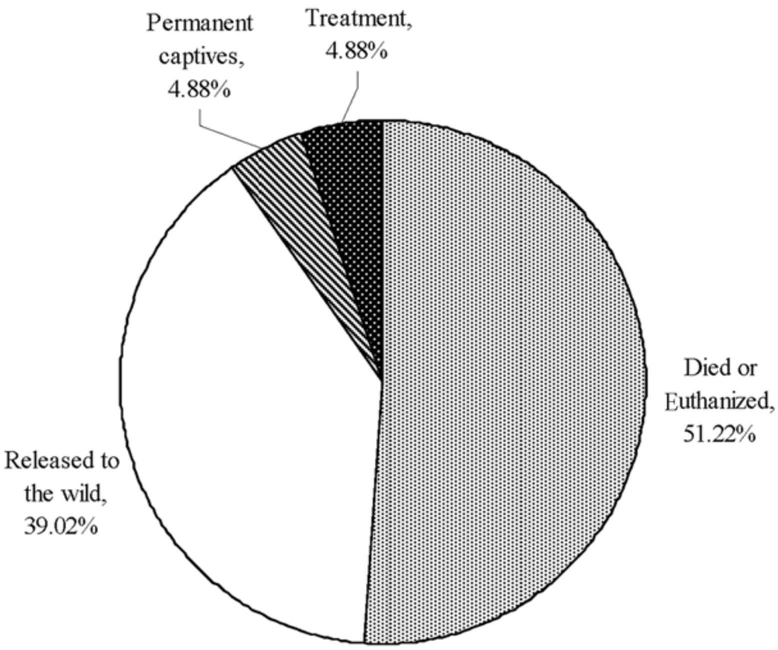

圖 8. 1993~2009 年特有生物研究保育中心野生動物急救站醫療處理之 41 隻被捕獸鋏傷害穿山甲的處理結果。

Fig. 8. Percentage composition of the outcomes of 41 trapped pangolins after treatments at the Wildlife First Aid Station of Endemic Species Research Institute, Taiwan, 1993-2009.

急救站座落於南投縣集集鎮之地緣關係緣故。與美國維尼亞野生動物中心發表之 2 篇有關於爬蟲類與狐狸的回溯性病例分析研究報告有相似結果，動物來源地以救傷中心所在地周圍的城市爲主(Brown and Sleeman 2002; Kelly and Sleeman 2003)。據研究人員在台灣南部與東部訪查報告顯示，發現當地的居民仍會食用與販售穿山甲，且大多不會通報保育單位處理(王 2007)，加上野生動物救援機構大多分布於台灣西部，可能是造成南部與東部穿山甲病例數偏低的原因。

在體重方面，台灣穿山甲體重與吳等(2004b)發表之中國穿山甲體重以 *t*-test 檢定，結果發現有顯著差異，可知台灣穿山甲亞種體重低於中國穿山甲。於本報告中台灣穿山甲雄性體重顯著大於雌性，此結果與吳等(2004b)報告的中國穿山甲及 Heath and Coulson (1997)報告的南非穿山甲(*M. temminckii*)結果相符。

本病例分析中發現於 2001~2009 年間 4~7 月份爲穿山甲送達野生動物急救站的數量高峰期，且 2001~2009 年間的就診數量分別和溫度與雨量皆呈顯著正相關，顯示穿山甲出現頻度可能受到溫度和雨量影響。在越南，穿山甲獵人表示雨季時較容易發現穿山甲(Chao *et al*. 2005; Newton *et al*. 2008)，又依據中央氣象局網路資料指出，台灣地區 5~6 月爲梅雨季、7~9 月爲颱風季，故可能因梅雨與颱風造成豐沛的雨量，增加了穿山甲在洞穴外活動的時間，所以較常被人發現。林和裴(2010)以無線電追蹤研究 6 隻雌性穿山甲，研究穿山甲日棲洞穴利用的情形，發現 5~8 月間洞穴外活動時間較秋冬季爲長，推測因氣溫或食物資源變化，導致 5~8 月洞外活動較頻繁，可能因此被人發現機率較高。在繁殖季節方面，王(2007)推測 5~6 月時亞成獸開始獨立生活，台北動物園(2006)報告則指出 6~8 月可能爲穿山甲的主要發情期，故也可能因發情期活動頻繁及亞成體向外擴散，使穿山甲較容易被發現。雄性數量爲雌性的 2.3 倍、成年數量約爲未成年 2 倍，可能與成年雄性活動範圍較大有關(Heath and Coulson 1997)。上述的推論皆尚待進一步的研究證實。

本次報告中有 17.1% (20/117)初診爲健康的穿山甲，可能與穿山甲遇到危險時會將身體捲縮保護自身安全，在此情況下健康的個體可能被民眾誤撿拾送到野生動物急救站。類似的情形也發生在維吉尼亞野生動物救傷中心(Kelly and Sleeman 2003)，在 694 隻野生爬蟲類病例中，有 21 隻爲健康，但被民眾撿拾送到中心。台北動物園所進行的族群及棲地變因評估之報告中，提到在 15 年間救援的台灣穿山甲，估計約 20~30%的傷害是犬所造成(Chao *et al*. 2005)。但於本次報告中則只有 5.13% (6/117)穿山甲疑似被動物傷害，而以獸鋏傷害占穿山甲被救傷的比例 35.04% (41/117)最高。

台灣民間仍有非法盜獵與食用野外穿山甲的情形，獵捕的方法有使用煙霧將穿山甲自洞中趕出、於夜間在棲地直接捕捉、趁大雨土壤鬆動時挖出洞中的穿山甲，或用陷阱捕捉(Chao *et al*. 2005)。近年來特生中心野生動物急救站，曾接獲民眾發現穿山甲被販售，購買後再送醫治療，診療發現這些穿山甲皆被獸鋏傷害。獸鋏常造成穿山甲骨折、大面積皮膚與肌肉撕裂傷，且傷口多預後不佳，常須截肢以維持生命。然被截肢的穿山甲大多運動能力不佳，在野外難以生存，故無法野放，僅能長期收容。

由特生中心野生動物急救站 2005~2009 年的病例統計，得知哺乳類、鳥類與爬蟲類皆會遭獸鋏害，但仍以哺乳類最多，占所有傷病哺乳類 18.7%，其中又以穿山甲、台灣獼猴和鼬獾的數量較多(未發表資料)。台灣地區的野生動物保育法及動物保護法，雖然規定禁止使用捕獸鋏捕捉動物，但因獸鋏容易自市面五金行與賣場購買，且價格便宜，仍容易遭人濫用。主管機關應研擬對策，有效地禁止獸鋏的使用，以降低穿山甲遭獸鋏傷害的發生機率。

由本次病例分析得知，特生中心野生動物急救站所醫療處理的台灣穿山甲病例，傷病的主因是創傷，而造成創傷的主要獵具是獸鋏。惟台灣各地區野外穿山甲的族群密度與遭受獵捕的頻度仍未知，尚須更多的生態研究、獵人訪查與棲息地的獵具密度調查等，以釐清台灣穿山甲是否遭遇過度獵捕的問題。

引用文獻

王珮蓉。2007。台灣穿山甲救傷通報系統在保育上的應用。台灣大學生命科學院生態學與演化生物學研究所碩士論文。

史密斯、解焱。2009。中國獸類野外手冊。湖南教育出版社。

吳詩寶、劉迺發、馬廣智、唐玫、陳海、徐昭榮。2004a。穿山甲生態學研究概況。動物學誌 39：46-52。

吳詩寶、劉迺發、張迎梅、馬廣智。2004b。兩種穿山甲外形量衡度的測定及比較。獸類學報 24：361-364。

金仕謙。2007a。探索盔甲精靈。動物園雜誌 108：26-31。

金仕謙。2007b。盔甲精靈—台灣穿山甲。清流月刊 59-64。

林敬勛、裴家騏。2010。穿山甲日棲洞穴利用之研究。生物科學 52：12。

徐宏發、柯瑞戈。2007。中國野生動植物貿易狀況—2006 年中國野生動植物資源貿易信息。東亞野生物貿易研究委員會中國項目。

許鴻源。1977。動物性中藥之研究。國立中國醫藥研究所。

許鴻源。1980。中藥之炮炙。新醫藥出版社。

謝明村。1987。中國藥材學。國立編譯館。

趙榮台。1989。台灣穿山甲之繁殖保存研究：一般生物學與現況分析。中華民國 78 年生態研究第 032 號。行政院農業委員會。

野生動物保育工作手冊。2009。行政院農業委員會林務局。

台北動物園。保育聯合國聚首臺北異業聯合發聲全球。2004。台北動物園新聞稿。2010 年 5 月取自：http://www.zoo.gov.tw/news_content.asp? xid=489

台北動物園。2006。台北市立動物園九十四年度穿山甲基礎生物學及行爲學期末報告。台北動物園。

Brown, J. D. and J. M. Sleeman. 2002. Morbidity and mortality of reptiles admitted to the wildlife center of Virginia, 1999 to 2000. Journal of Wildlife Disease 38: 699-705.

Chao, J. T., E. H. Tsao, K. Traylor-Holzer, D. Reed and K. Leus. 2005. Formosan pangolin population and habitat viability assessment: Final report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, USA.

Chin, S. C., C. H. Liu, J. C. Guo, S. Y. Chen and L. S. Yeh. 2006. A 10-year review of autopsy of rescued Formosan pangolin (*Manis pentadactyla pentadactyla*) in Taipei zoo. pp. 43. *In*: Proceedings of AZWMP 2006. Chulalongkorn University Faculty of Veterinary Science, Bangkok, Tailand.

CITES Appendices I, II and III. 2009. CITES (Convention on International Trade in Endangered Species) available at: www.cites.org/eng/app/appendices.shtml

Compton, J. and C. Shepherd. 2009. Scaling-up pangolin trade enforcement efforts-multi-stakeholder workshop points the way. Living Forests 15: 23-24.

Deem, S. L., S. P. Terrell and D. J. Forrester. 1998. A retrospective study of morbidity and mortality of raptors in Florida: 1988-1994. Journal of Zoo and Wildlife medicine 29: 160-164.

Gaubert, P. and A. Antunes. 2005. Assessing the taxonomic status of the Palawan pangolin

Manis culionensis (Pholidota) using discrete morphological characters. Journal of Mammalogy 86: 1068-1074.

Heath, M. and I. Coulson. 1997. Home range size and distribution in a wild population of Cape pangolins, *Manis temminckii*, in north-west Zimbabwe. African Journal of Ecology 35: 94-109.

Kelly, T. R. and J. M. Sleeman. 2003. Morbidity and mortality of red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) admitted to the wildlife center of Virginia, 1993-2001. Journal of Wildlife Disease 39: 467-469.

Newton, P., T. V. Nguyen, S. Roberton and D. Bell. 2008. Pangolins in peril: Using local hunters' knowledge to conserve elusive species in Vietnam. Endangered Species Research 6: 41-53.

Richards, J., A. Lickey and J. M. Sleeman. 2005. Decreasing prevalence and seasonal variation of gunshot trauma in raptors admitted to the wildlife center of Virginia: 1993-2002. Journal of Zoo and Wildlife medicine 36: 485-488.

Sleeman, J. M. 2008. Use of wildlife rehabilitation centers as monitors of ecosystem health. pp. 97-104. *In*: Fowler, M. E. and R. E. Miller (eds.). Zoo and wild animal medicine: Current therapy, 6 th. Saunders Elsevier, Philadelphia, USA.

Effect of Stress from Cage Transfer on Fecal Corticosterone Concentration of Collared-Scope Owls (*Otus bakkamoena*)

移籠緊迫對領角鴞糞便中皮質酮濃度變化之影響

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Abstract

Corticosterone is secreted from adrenal glands in response to environmental stress and/or emotional arousal. It is regulated by hypothalamic-pituitary-adrenal axis (HPA axis). Its measurement with the non-invasive technique has become an important tool for assessing environmental or other stress in wild animals. In this study we used 14 collared-scope owls (*Otus bakkamoena*) as test animlas. They were caged together for more than six months and then transferred into individual cages for 21 days. The fecal samples were collected during the pre-transfer period and post-transfer period. Fecal corticosterone concentration was measured with EIA. The food intake was recorded during the post-transfer period. The results showed that a peak corticosterone concentration was found within first 2 days after transfer. All owls showed poor food intake, indicating that the cage transfer caused stress on the owls from handing, examining, and change in cage environment. The fecal corticosterone concentration decreased gradually on the third to sixth day after transfer in response to diminishing in the stress effect. Food intake gradually recovered. The mean corticosterone concentration decreased to a baseline level on the eighth to the twenty-first day after transfer, that was only a third of that prior to transfer. It is concluded that the collared-scope owls needed 6 to 8 days after cage transfer to adapt to a new cage environment.

摘 要

腎上腺皮質酮(corticosterone)屬於固醇類荷爾蒙，受下視丘、腦下垂體所調控，能反應環境壓力與情緒變化，因此又被稱爲「壓力荷爾蒙」。以糞便檢測動物體內的腎上腺皮質酮濃度變化，爲一種非侵入性檢測技術，在野生動物研究領域能成爲論證工具，用以評估環境對動物的影響。本試驗利用農委會特有生物研究保育中心長期收容暫時無法野放的領角鴞進行研究。試驗動物皆經混籠飼養 6 個月以上，試驗前先隨機收集移籠前之糞便樣本，之後移入隔離籠舍、個別飼養。收集移籠後 21 天內之糞便樣本，以 80%乙醇進行萃取，並以 EIA 檢測分析，比較移籠前、後糞便中的皮質酮濃度變化，並記錄移籠後的個別進食狀況。結果發現，移籠後的 2 天內，動物因受到人爲的抓取、檢查與環境改變的緊迫所刺激，皮質酮濃度上升，且多數試驗動物個體有拒食的狀況。移籠後第 3~6 天皮質酮濃度逐漸下降，個體漸漸適應環境，所有的個體進食狀況漸漸恢復正常。移籠後的第 8~21 天，期間皮質酮濃度穩定無變化且其值低於移籠前 1/3。結果證實，以糞便檢測領角鴞的皮質酮濃度變化，能了解領角鴞對環境改變的生理反應，並發現圈養之領角鴞對新環境之適應期 6~8 天左右，移籠後的進食狀況可反映出動物的適應狀況。

Key words: stress, owl, corticosterone, cage transfer, feces

關鍵詞：緊迫、貓頭鷹、腎上腺皮質酮、移籠、糞便

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Introduction

Environmental stress may cause physiological stress of animal, often resulting in sickness or even death (Wasser *et al*. 1997; Del Hoyo *et al*. 1999). As a body experiences the stress, adrenal gland secretes glucocorticoids. There are two kinds of glucocorticoids: corticosterone for birds and rodents, and cortisol for mammalians such as primates and carnivores (Walsh *et al*. 1985; Touma and Palme 2005).

A non-invasive technique has been developed to assay corticosterone concentration in feces. It has become an important tool for measuring environmental stress of wild birds, particularly for endangered species. The method can get a correct physiological data without puncture to the birds. It has been also used in assaying glucorticoid concentrations in many of other animals (Touma and Palme 2005). It has excellent practicability, high accuracy, and many other advantages. It does not need to use invasive collection of blood that affects animal welfare (Goymann 2005; Touma and Palme 2005).

It has been known that there is a positive relationship in corticosterone level between serum and feces (Dehnhard *et al*. 2003; Ludders *et al*. 2001), Furthermore, glucocorticoid concentration in owl's fecal samples are found to be more stable than that in the urine samples (Wasser and Hunt 2005). Therefore, the measurement of fecal corticosterone concentration has been used in investigation in the fields of ecology, reproductive biology, and conservation (Wasser *et al*. 1997; Dehnhard *et al*. 2003). Up-to-date, effect of stress caused by cage transfer for captive wild-birds has not been well understood. Wasser *et al*. (1997) first used the non-invasive method to measure physiological stress from disturbance on the northern spotted owl.

In this study we used the non-invasive method to investigate the effect of stress caused by cage transfer on fecal corticosterone concentration of captive collared-scope owls. The objectives were to determine whether the fecal corticosterone level of the collared-scope owl is quantifiable, and to understand whether the stress of cage transfer affects the corticosterone level. The results obtained may be useful in wild animal's husbandry and also provide us an observatory period required for the owl in cage transfer to adapt a new cage environment.

Materials and Methods

The collared-scope owl (*Otus bakkamoena*) is a small nocturnal raptor, belonging to the family Strigidae of the order Strigiformes. It is a common resident bird in Taiwan and adapts to live with people. The collared-scope owls are catalogued as a rare and specious species by the Wildlife Conservation Act of Taiwan.

We used 14 captive collared-scope owls which received medical treatment at Wildlife Clinic Center, Taiwan Endemic Species Research Institute, as test animals. They were 8 males, 5 females, and 1 unknown sex with body sizes ranged from 23 to 25 cm and body weights from 164 to 188g.

Prior to the experiment, all of the owls were housed together in four common cages for more than six months. Then, each of the owls was transferred to an individual cage of 70x50x115 cm^3. Its bottom was placed 70 cm above the ground for collecting feces without interference on owls. A horizontal tree branch was placed inside 25cm above the cage bottom to provide the roosting place. Food and water were placed on the bottom of the cage. The experiment was conducted at room temperature of about 25℃ under natural light.

The experimental period was from October to November. At the beginning of the experiment, each owl was given a physical examination, and then, transferred into an individual cage on 17 October. Its feces was collected and fresh diet was given daily. Otherwise, there was no other disturbance on the test animal.

A total of 18 fecal samples were collected randomly from the owls from the common cages in October during the pre-transfer period. After transfer, fecal samples were collected from each of the individual cages at 08: 00 to 10: 00 AM on the 1st, 2nd, 3rd, 4th, 6th, 8th, 10th, 14th, 17th and 21st days. We collected all feces on the cage bottom, excluding white urine. When collection, no matter how many feces on the bottom, we collected all feces and classified to become a sample. The samples only separated into which owl and which day. Then, the fecal samples collected were dried at 55℃ and preserved at-20℃, the weight was varied from 2.275g (maximal) to 0.01g (minimal). When extraction, the samples did ran out on one-time extraction, and corticosterone was extracted with 80% ethanol (Wasser *et al*., 1994; Wasser and Hunt 2005), and the volume of ethanol was 3-fold sample's volume. The corticosterone-ethanol solution was centrifuged, and the supernatant was collected. The above extracted steps were repeated twice. Then, solution dried at 55℃, and recovered with the buffer of the Corticosterone ELIA Kit (Assay designs, Inc., Ann Arbor, MI), the recovered buffer volume was sample's weight and finally preserved at-20℃ to wait assayed. The corticosterone concentration was assayed with the Enzyme-linked immunoassay (ELIA) method with the Corticosterone ELIA Kit (Assay designs, Inc., Ann Arbor, MI).

Data of fecal corticosterone concentrations were expressed as mean ± standard deviation (Table 1, 2). Student t-test was used to compare the corticosterone concentrations between the pre-transfer period and the post-transfer period. Analysis of variance (ANOVA) was used to determine significance ($P< 0.05$) of transfer stress on the eighth, tenth, fourteenth, and twenty-first days.

Results

The corticosterone concentrations of 18 fecal samples collected prior to transfer were 158.9 ± 63.1 ng/g with the range of 69.9 to 239.3 ng/g. After transfer the fecal corticosterone concentrations rapidly increased to a peak on 1st or 2nd days after transfer (Fig. 1). The highest concentration was detected mostly on the 1st day. The concentrations of these two days were 359.4 ± 139.4ng/g with a range of 139.4 to 591.8 ng/g (Table 1). The mean concentration after transfer was 2.3 fold higher than that of prior to transfer. Twelve owls excreted their first feces in the first two days after transfer, and remaining two owls excreted on the 4th day.

Then, the fecal corticosterone concentrations gradually declined and stabilized at a low level on 8th day, indicating the adaptation of the owls to the new cages. There was no significant difference in the mean concentration between pre-transfer and post-transfer periods on the 3rd to 6th days after the transfer (Table 1). The mean concentrations from 8th to 21st day were significantly decreased and lower than one third of that of the pre-transfer period.

Amounts of food consumed by the owls during the post-transfer period are shown in Table 2. They varied from none feeding, common feeding to high feeding. All owls showed poor appetite on the 1st day; 7 owls had none feeding, and 7 had common feeding. There was none of high feeding. The poor appetite continued to 6th day and get better on 7th day. All owls ate well on 10th day and after.

Discussion

When birds are under environmental stress, corticosterone is secreted from adrenal glands. With it also fecal corticosterone concentration increased (Wasser *et al*., 1997; Hischenhauser *et al*. 2005). When northern spotted owls (*Strix ocidentalis caurina*) had the stress induced with

Table 1. Fecal corticosterone concentrations of collared-scope owls during the pre-transfer period and post-transfer period.
表 1. 比較領角鴞個體移籠前後的皮質酮濃度變化。

Corticosterone (ng/g)	Pre-transfer period	Post-transfer period (day)					
		1st-2nd	3rd-4th	6th	8th	10th-14th	17th-21th
mean concentration	158.9	359.4*	222.4	201.5	80.7*	69.1*	55.5*
standard deviation	63.1	139.4	86.4	159.9	51.9	34.0	30.5
number of samples	18	16	10	10	12	23	23

* $P < 0.05$ (paired t-test)

Table 2. Food intake of collared-scope owls after transferring to individual cages. (none, no food intake; high, food intake at 70% by our provision; common, between none and high; number under the feeding condition, number of owls)
表 2. 領角鴞個體於移籠後的每日進食量變化。其中“None”表示拒食，“High”表示對於我們所供給的食物進食量超過 70%，“Common”表示有進食，但進食未到達“high”的程度。再進食量下的數字代表的是個體數。

Days after transfer	Food intake			Days after transfer	Food intake		
	None	Common	High		None	Common	High
1	7	7	0	11	0	5	9
2	1	12	1	12	0	5	9
3	3	7	4	13	0	2	12
4	2	1	11	14	0	8	6
5	2	9	3	15	0	5	9
6	1	1	12	16	0	4	10
7	0	6	8	17	0	2	12
8	0	6	8	18	0	6	8
9	2	6	6	19	0	11	3
10	0	0	14	20	0	5	9

ACTH stimulation, the highest fecal corticosterone concentration was found at 12 h postinfusion. After punctured ACTH, their fecal corticosterone concentrations increased within 2 h postinfusion and an 3 fold increase at 12 h postinfusion (Wasser *et al*. 2000). In our study the corticosterone concentration of collared-scope owls had a peak on the 1st and 2nd day after transfer with a 2.3 fold increase (Table 1), fairly similar to that observed for northern spotted owls by Wasser *et al*. (2000). The result of this study suggested that the collared-scope owls suffered with stress from cage transfer.

Cage transfer stress on captive wild-birds has not been well understood. Wasser *et al*. (1997) collected the blood and fecal samples of northern spotted owls at Woodland Park Zoological Gardens.

The results showed that both blood and fecal corticosterone concentrations had an acute increase after transfer and then returned to baseline level gradually. The similar case was found in our study; the fecal coticosterone concentration increased rapidly on the first two days after cage transfer and then decreased gradually to a stable concentration level on the 8th day (Fig. 1).

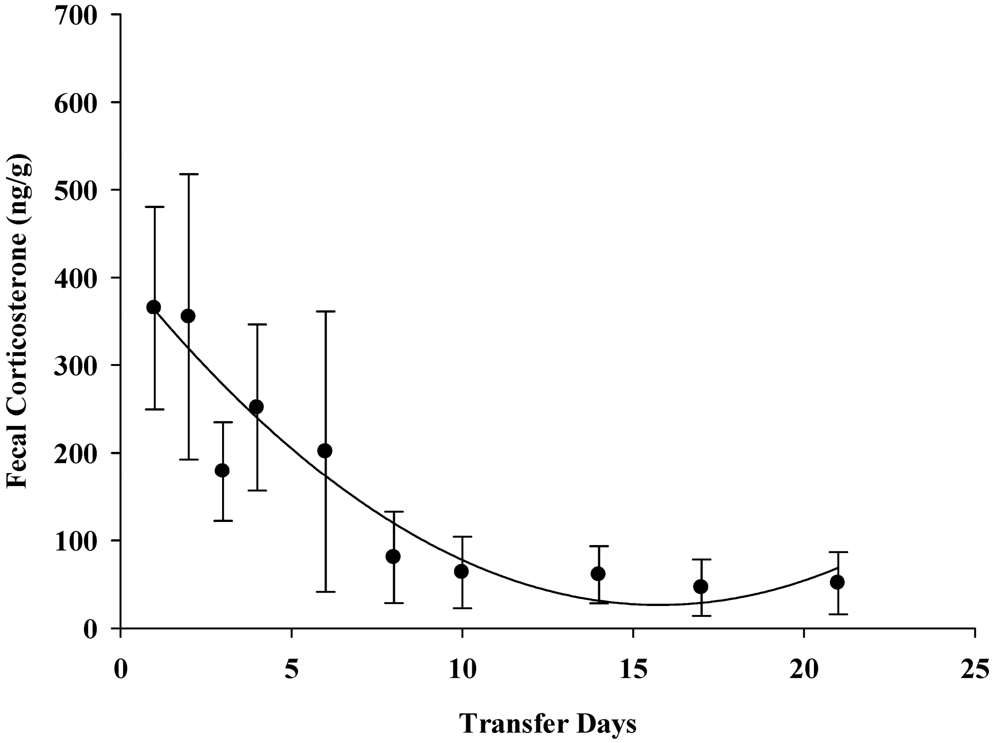

Fig. 1. Fecal corticosterone concentrations (solid circles, means; vertical lines, standard deviations) on 1st day to 22 days after cage transfer. $Y = 445.509 - 67.945X + 3.768X^2 - 0.068X^3$；$r^2 = 0.615$.

圖 1. 移籠後的皮質酮濃度的平均值與標準差，回歸曲線爲 $Y = 445.509 - 67.945X + 3.768X^2 - 0.068X^3$；$r^2 = 0.615$。圖中可明確地發現，在第 8 天之後個體適應新環境，生理上皮質酮濃度分泌穩定，形成基礎值濃度。

The *ad lib* feeding models was used in this study. "High feeding" is defined as a good food intake, "common feeding" as normal food intake, and "none feeding" as anorexia (Table 2). None feeding was observed on the first day when a peak concentration of fecal corticosterone was detected (Fig. 1). Then, the owls were gradually adapted to the new cage environment. With it the corticosterone concentration gradually declined and food intake improved from 3rd to 6th days. The corticosterone concentration decreased to the baseline level on 8the day, while the food intake returned to common or high feeding after 6th days. The results of our study found that the response in cage transfer-induced stress was in correspondent to the change in food intake. After the corticosterone concentration decreased to baseline level, the food intake also returned normal at the same time. It took 6-8 days for the captive wild owls to return normal from the cage transfer-induced stress.

Because of old cages were used to house several owls together prior to transfer, we were unable to collect fecal samples from each of the owls. When the mean fecal corticosterone concentrations of pre-transfer period when the owls were caged together were compared to those after transfer when the owls were caged individually, we found that the concentrations on the 8th to the 21st days after transfer were only a third of those prior to transfer. This may be attributable to two reasons. Firstly, the collared-scope owl is a territorial bird, and competes for foraging and survival (Carere *et al*. 2003). Prior to transfer, several owls were housed together in old cages that they competed for the territories. After transfer, each of the owls was housed in an individual cage that was fairly similar to a natural condition with independent territory. In other words, in the period prior to transfer, the owls already had the stress from competition for the territory, and thus, the corticosterone concentrations were higher than the baseline level on 8th to 21 th days after transfer. Secondly, the lower concentrations on the 8th-21st days might be due to individual difference or the HPA axis negative feedback. Carere *et al*. (2003) showed that there was correlation between territorial behavior and fecal corticosterone level in great tits (*Parus major*); some individuals would restrain the corticosterone secretion through HPA axis negative feedback. It is a body's protective mechanism for regulating the adrenal cortex activity after excitement and for avoiding deleterious effects after high secretion of corticosterone by stress (Kitaysky *et al*. 2001).

Conclusion

The trend of the change in fecal corticosterone concentration during the post-transfer period may be divided into three phases: (1) the acute increase phase on the 1st or 2nd day after transfer; the fecal corticosterone concentration reaches to a peak level, (2) the gradual decline phase on 3rd to 6th day; the corticosterone level gradually decreased from the peak level and the owls started to adapt the new cage environment, and (3) the stabilized phase on 8th-21th day; the corticosterone concentrations decreased to a new baseline level; the owls have adapted to the new cage.

This study first demonstrated that the stress of cage transfer can be shown on the food intakes of the birds. After the corticosterone concentration decreased to baseline level, the food intake also returned to normal at the same time. It took 6-8 days for captive wild owls to adapt new cages after stress induced by the cage transfer. The individual difference in corticosterone concentration may be due to individual difference in adaptivity or in physiology, particularly in HPA axis regulation. A further research is needed in the future.

References

Carere, C., T. G. G. Groothuis, E. Mostl, S. M. Daan and J. M. Koolhaas. 2003. Fecal corticosteroids in a territorial bird selected for different personalities: Daily rhythm and the response to social stress. Hormones and Behavior 43: 540-548.

Dehnhard, M., A. Schreer, O. Krone, K. Jewgenow, M. Krause and R. Grossmann. 2003. Measurement of plasma corticosterone and fecal glucocorticoid metabolites in the chicken, the great cormorant, and the goshawk. General and Comparative Endocrinology 131: 345-352.

Del Hoyo, J. A. Elliott and J. Sargatal. 1999. Handbook of The Birds of The World. Volume 5, Barn-owl to Humming birds. Lynx Edicions, Barcelona, pp. 157-158.

Goymann, W. 2005. Noninvasive monitoring of hormones in bird droppings: Physiological validations, sampling, extraction, sex differences, and the influence of diet on hormone metabolite levels. Annals of the New York Academy of Sciences 1046: 35-53.

Hischenhauser, K., K. Kotrschal and E. Mostl. 2005. Synthesis of measuring steroid metabolites in goose feces. Annals of the New York Academy of Sciences 1046: 138-153.

Kitaysky, A. S., E. V. Kitaiskaia, J. C. Wingfield and J. F. Piatt. 2001. Dietary restriction causes chronic elevation of corticosterone and enhances stress response in red-legged kittiwake chicks. The Journal of Comparative and Physiological Psychology B 171:701-709.

Ludders, J. W., J. A. Langenberg, N. M. Czekala and H. N. Erb. 2001. Fecal Corticosterone on Florida Sandhill Cranes. Journal of Wildlife Diseases 37(3): 646-652.

Touma, C. and R. Palme. 2005. Measuring fecal glucocorticoid metabolites in mammals and birds: The importance of validation. Annals of the New York Academy of Sciences 1046: 54-74.

Walsh, M. T., R. A. Beldegreen, S. L. Clubb and C. L. Chen. 1985. Effect of exogenous ACTH on serum corticosterone and cortisol concentration in the Moluccan cockatoo. American Journal of Veterinary Research 46 (7): 1584-1588.

Wasser, S. K., S. L. Monfort, J. Southers and D. E. Wildt. 1994. Excretion rates and metabolites of oestradiol and progesterone in baboon (*Papio cynocephalus cynocephalus*) faeces. Journal of Reproduction and Fertility 101: 213-220.

Wasser, S. K., K. Bevis, G. King and E. Hanson. 1997. Noninvasive Physiological Measures of Disturbance in the Northern Spotted Owl. Conservation Biology 11(4): 1019-1022.

Wasser, S. K., K. E. Hunt, J. L. Brown, K. Cooper, C. M. Crockett, U. Bechert, J. J. Millspaugh, S. Larson and S. L Monfort. 2000. A generalized fecal glucocorticoid assay for use in a diverse array of nondomestic mammalian and avian species. General and Comparative Endocrinology 120: 260-275.

Wasser, S. K. and K. E. Hunt. 2005. Noninvasive Measures of Reproductive Function and Disturbance in the Barred Owl, Great Horned Owl, and Northern Spotted Owl. Annals of the New York Academy of Sciences 1046: 109-137.

臺灣擔子菌新紀錄種－沙生腹菌

Hymenogaster arenarius (Basidiomycota) Newly Recorded to Taiwan

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摘　要

本文描述一種臺灣擔子菌新紀錄種－沙生腹菌(*Hymenogaster arenarius*)，其屬地下眞菌，採集自南投縣和社的青剛櫟林，爲外生菌根菌。

Abstract

This paper describes and illustrates a new record of hypogeous fungus, *Hymenogaster arenarius* (Basidiomycota), from *Cyclobalanopsis glauca* forest of Taiwan.

關鍵詞：外生菌根菌、地下眞菌、青剛櫟。

Key words: Ectomycorrhizal fungus, Hypogeous fungus, *Cyclobalanopsis glauca*.

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緒　言

地下眞菌中最出名的就是塊菇屬(*Tuber*)，俗名松露，它屬於子囊菌門；而擔子菌門的地下眞菌，大部分屬腹菌綱的腹菌目，特徵爲子實體扁球形，孢體迷路型，肉質至脆骨質，罕粉末狀，無孢絲，多爲外生菌根菌。臺灣已發表之地下生的腹菌目種類僅有 1 種，爲紅鬚腹菌 *Rhizopogon rubescens* (Rhizopogonaceae)，它生長在松林地下(張等 2001)。本研究新發現之沙生腹菌(*Hymenogaster arenarius*)，屬地下眞菌，爲外生菌根菌(Allen 1993; Cannon and Kirk 2007)。

性狀描述

沙生腹菌(圖 1& 2)

Hymenogaster arenarius Tul. & C.Tul., Giorn. Bot. Ital. 1 (7-8): 55. 1845

= *Hymenogaster pusillus* Berk. & Broome, Ann. Mag. Nat. Hist. 18: 75. 1846.

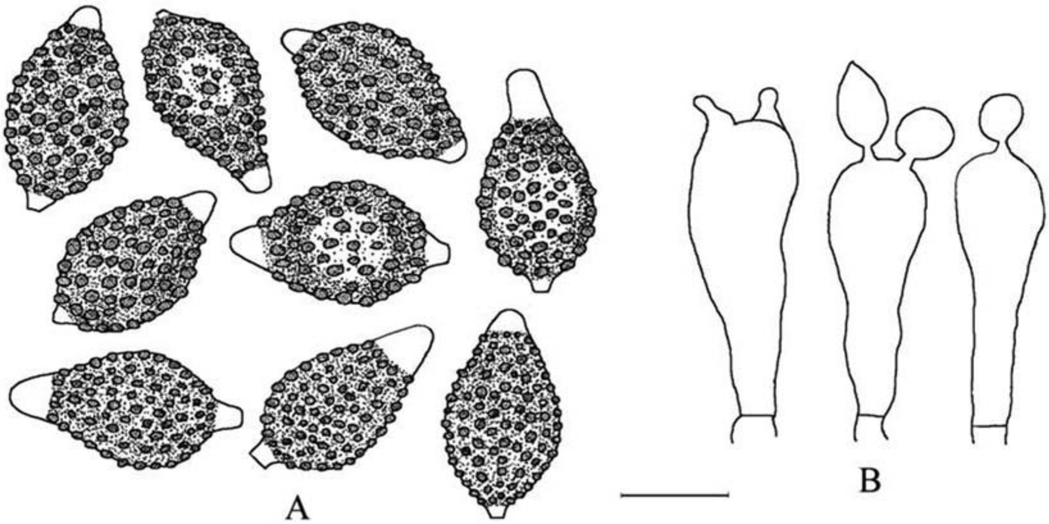

圖 1. 沙生腹菌。A. 擔孢子；B. 擔子。比例尺＝10 µm。

Fig. 1. Baisidiospores (A) and basidia (B) of *Hymenogaster arenarius* (bar length = 10 μm).

子實體圓球狀至塊莖狀，徑 1~2 cm，白色帶白黃色，平滑，軟骨質；外皮薄，內有迷路狀腔室的產孢組織，淡褐色。擔孢子橢圓形至檸檬形，頂端乳頭狀突起，表面有疣狀突起，下端有短柄，亮褐色，非類澱粉質反應，15-24 × 9-12 μm；擔子棒形，單孢型或二孢型，28-35 × 8-10 μm。菌絲無扣子體。

棲息地：低海拔青剛櫟林地下散生。

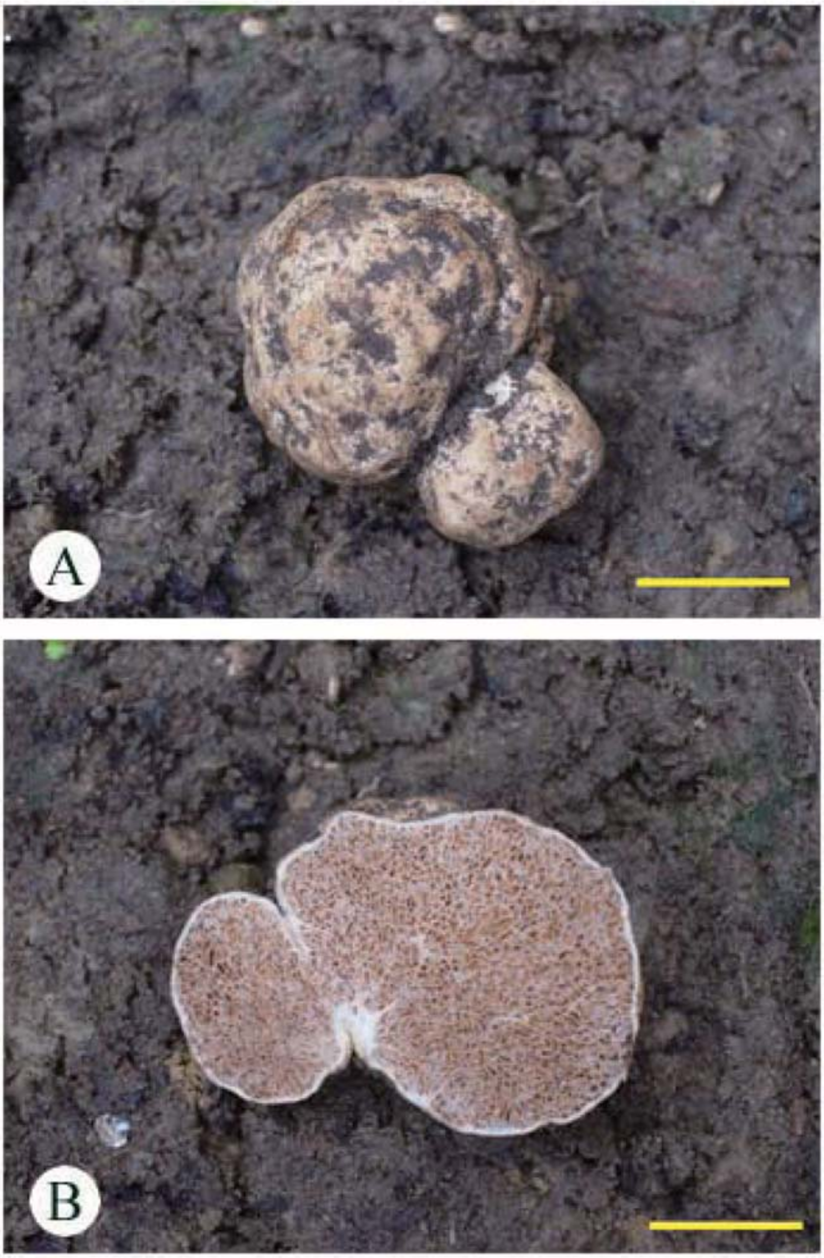

圖 2. 沙生腹菌。A. 子實體；B. 切面。比例尺＝1 cm。
Fig. 8. Fruit body (A) and section (B) of *Hymenogaster arenarius* (bar length = 1 cm).

研究標本：南投縣和社，海拔 300 m，2011 年 2 月 11 日，周文能 CWN 09763 (TNM)。

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附記：沙生腹菌屬腹菌科(Hymenogastraceae)，與鬚腹菌科最大不同是孢子非平滑，有疣狀突起或膜質包被，顏色深色(Coker and

Couch 1974; Liu 1984; Miller and Miller 1988)。本種最大特徵是外皮薄，孢子大型，表面有疣狀突起，下端有短柄(Dodge and Zeller 1934; 今關六也、本鄉次雄 1989)。

引用文獻

今關六也、本鄉次雄。1989。原色日本菌類圖鑑(2)。保育社。

張東柱、周文能、王也珍、朱宇敏。2001。大自然魔法師－臺灣大型眞菌。行政院農業委員會出版。

Allen, M. F. 1993. Mycorrhizal functioning: an integrative plant-fungal process. Springer Publications, 534 pp.

Cannon, P. F. and P. M. Kirk. 2007. Fungal families of the world. CABI Publications, 456 pp.

Coker, W. C. and J. N. Couch. 1974. The gasteromycetes of the eastern United States and Canada. Dover Publications, Inc. 195 pp.

Dodge, C. W. and S. M. Zeller. 1934. Hymenogaster and related genera. Ann. Mo. Bot. Gard. 21: 625-708.

Liu, B. 1984. The gasteromycetes of China. Beihefte Zur Nova Hedwigia Heft 76, 235 pp.

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1. Manuscript should be written in a sequence of 1) Title, 2) Authors' full name, 3) Author(s) affiliations(s) and address(es), 4) Abstract, 5) Key words, 6) Introduction, 7) Materials and methods, 8) Results, 9) Discussion, 10) Conclusions, 11) Acknowledgements, 12) Literature Cited. Of them 1 to 5 should be written in dual languages, Chinese and English.
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6. Abstract must be a single paragraph not exceeding 500 words.
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For journals:

Clough, B. 1998. Mangrove forest productivity and biomass accumulation in Hinchinbrook Channel, Australia. Mangroves and Salt Marshes 2: 191-198.

Pimm, S. L. and J. L. Gittleman. 1992. Biodiversity: Where is it? Science 255: 910-940.

Baker, C. S., F. Cipriano and S. R. Palumbi. 1996. Molecular genetic identification of whale and dolphin products from commercial markets in Korea and Japan. Molecular Ecology 5: 671-685.

For books and symposiums:

Soule, M. E. and B. A. Wilco. 1980. Conservation biology: An evolutionary-ecological approach. Sinauer Associates, Sunderand, Massachusetts.

Jinchu, H. and W. Fuwen. 1990. Development and progress of breeding and rearing giant pandas in captivity within China. pp. 322-325. *In*: H. Jinchu (ed.). Research and progress in biology of the giant panda. Sichuan Publishing House of Science and Technology, Sichuan, China.

8. Table should be typed on a separate sheet and be headed by a title of dual languages (Chinese and English). It consists of only horizontal lines and typed with English terms (if possible) and Arabic numerals. If foot notes are required, mark with superscripts ^{1}, ^{2}, *, $^{\#}$, etc.
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