

## Morphology and Distribution of the Chiang Mai Crocodile Newt *Tylototriton uyenoi* (Urodela: Salamandridae) in Chiang Mai Province, Northern Thailand

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### ABSTRACT

The morphology and distribution of the Chiang Mai Crocodile Newt *Tylototriton uyenoi* (Urodela: Salamandridae) in Chiang Mai Province, Northern Thailand were studied. The morphological characters were compared and revealed that the male body size did not differ from the female body size. In the group from Doi Chiang Dao Wildlife Sanctuary and the group from Doi Suthep-Pui National Park showed that the female body size that is no different than the female type specimens; however, in the group from Doi Inthanon, the male was smaller than the female type specimens. In this report, a new *Tylototriton uyenoi* locality was reported at Doi Lang, Mae Ai District, Chiang Mai Province, Northern Thailand. This study provides information on morphology and distribution which can be used to aid conservation, protection, and taxonomy.

**Keywords:** Morphological, *Tylototriton uyenoi*, Doi Lang.

### INTRODUCTION

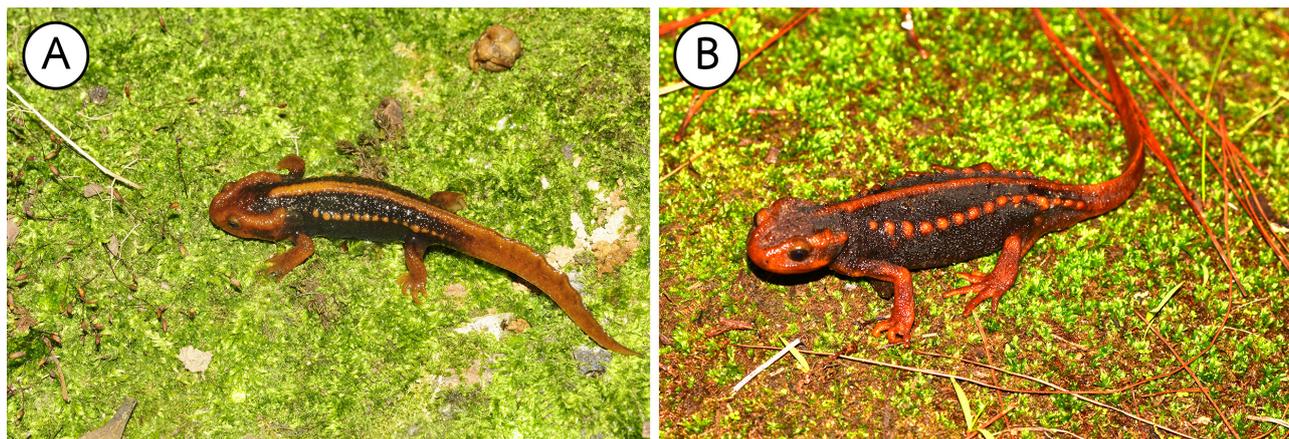
The newt genus *Tylototriton* has been reported from eastern Himalayas, Indochina, central China, and southern China (Hou *et al.*, 2012; Zhao *et al.*, 2012; Nishikawa *et al.*, 2013; and Bernardes *et al.*, 2020). *Tylototriton uyenoi* (Nishikawa *et al.*, 2013) (Figure 1) was described from nine specimens from Doi Suthep, Chiang Mai Province, northern Thailand and two specimens from Doi Inthanon, Chiang Mai Province, Northern Thailand. This species was separated using molecular and morphological evidence (Nishikawa *et al.*, 2013). The distribution of *Tylototriton uyenoi* was reported at Doi Ang Khang, Doi Chang Kien, Doi Suthep and Doi Inthanon Chiang Mai Province, Northern Thailand (Gerlach, 2012, 2020; Nishikawa *et al.*, 2013; and Michaels, 2015), the Maesa-Kogma Biosphere Reserve, Chiang Mai Province, Northern Thailand (Dowwiangkan *et al.*, 2018), Doi Mon Jong, Tak Province, northwestern Thailand and Doi Mak Lang, Mae Ai District, Chiang Mai Province, Northern Thailand (Hernandez *et al.*, 2019) and Khao Laem National Park, Kanchanaburi Province, Western Thailand (Hernandez and Pomchote, 2020). This report examined the samples kept in the collection of the Natural History Museum, National Science Museum, Thailand (THNHM).

### MATERIAL AND METHODS

We examined 21 specimens by using morphological characters and compared them to the type specimens. The specimens were kept in the collection of the Natural History Museum, National Science Museum, Thailand (THNHM), Pathum Thani, Thailand. The specimens studied consisted of: 2 adult females (THNHM 25210 and 06525) and 3 adult males (THNHM 20983, 20527, and 20528) from Ban San Pa Kia, Chiang Dao, Chiang Mai; 3 adult females (THNHM 19601, 19602, and 19605) from Doi Chiang Dao Wildlife Sanctuary, Chiang Dao, Chiang Mai; 6 adult females (THNHM 13866, 13868 - 13870, 13873, and 14062) and 2 adult males (THNHM 13871-13872) from Doi Inthanon, Chom Thong, Chiang Mai; 1 adult male (THNHM 13031) from Doi Lang, Mae Ai, Chiang Mai; 3 adult females (THNHM 10318, 10319 and 10321) and 1 adult male (THNHM 20170) from Doi Suthep-Pui National Park, Mueang, Chiang Mai.

### Morphological comparisons

The morphological characteristics were compared between the type specimens and specimens in Natural History Museum, National Science Museum, Thailand



**Figure 1.** Photographs of *Tylototriton uyanoi* in life: (A) Juvenile from Doi Lang, Mae Ai District, Chiang Mai Province. THNHM 21000; and (B) Adult from Chiang Dao District, Chiang Mai. THNHM 25210. Photographs by S. Makchai.

(THNHM). The study of the specimens morphological characters were based on Nishikawa *et al.* (2011) using the following 29 measurements: **SVL** (snout-vent length) from tip of snout to anterior tip of vent; **HL** (head length); **HW** (head width); **MXHW** (maximum head width); **SL** (snout length); **LJL** (lower jaw length); **ENL** (eyelid-nostril length); **IND** (internarial distance); **IOD** (interorbital distance); **UEW** (upper eyelid width); **UEL** (upper eyelid length); **OL** (orbit length); **AGD** (axilla-groin distance); **TRL** (trunk length); **TAL** (tail length); **VL** (vent length); **BTAW** (basal tail width); **MTAW** (medial tail width); **BTAH** (basal tail height); **MXTAH** (maximum tail height); **MTAH** (medial tail height); **FLL** (forelimb length); **HLL** (hindlimb length); **2FL** (second finger length); **3FL** (third finger length); **3TL** (third toe length); and **5TL** (fifth toe length); **VTW** (vomerine teeth series width); **VTL** (vomerine teeth series length). All measurements were made with digital calipers and recorded to the nearest 0.1 mm. Sex was determined by noting the presence cloacal opening. A comparison of measurements was made among the type specimens and the populations of *Tylototriton uyanoi* in Chiang Mai Province, Northern Thailand.

### Statistical analysis

We performed multivariate analyses to examine the overall morphological differences between the sexes and examined the morphological differences between locations by compared SVL ratios between groups (1) Ban San Pa Kia, group (2) Doi Chiang Dao Wildlife Sanctuary, group (3) Doi Inthanon, group (4) Doi Lang, group (5) Doi Suthep-Pui National Park and type specimens using females in comparison of *Tylototriton uyanoi*. The difference in the SVL and the ratio between the two samples was tested by testing the student's t-test and Mann-Whitney's U test, respectively significant at the 95% in all statistical tests.

## RESULTS

Here we present records of *Tylototriton uyanoi* from Chiang Mai Province, Northern Thailand based on the examination of 21 specimens. We provide novel data on external morphology and distribution.

### Morphology

In general, specimens were morphologically similar. The results of morphological measurements are presented in Table 1. In the sexual dimorphism difference test, it was shown that the female SVL did not have a statistically significant difference with that of the male SVL at a 95% confidence level ( $t=0.642$ ,  $p>0.050$ ). In the locality difference test, Group (1) Ban San Pa Kia and (4) Doi Lang were unable to be compared due to insufficient data. Group (2) Doi Chiang Dao Wildlife Sanctuary female body size was statistically not different compared to the female size of type specimens at 95% confidence level ( $t=1.388$ ,  $p>0.050$ ). Group (5) Doi Suthep-Pui National Park female body size was statistically not different compared to the female size of type specimens at 95% confidence level ( $t=2.140$ ,  $p>0.050$ ). However, Group (3) Doi Inthanon male body size was significantly smaller compared to the female of type specimens at 95% confidence level. ( $t=3.229$ ,  $p<0.050$ )

### Recent Distribution

**THAILAND: CHIANG MAI PROVINCE**, Chom Thong District; Doi Inthanon (Gerlach, 2012, 2020, Nishikawa *et al.*, 2013; Michaels, 2015; and this study), Fang District; Doi Ang Khang (Nishikawa *et al.*, 2013 and Dowwiangkan *et al.*, 2016), Muang District; Doi Chang Kien, Doi Suthep (Nishikawa *et al.*, 2013 and this study), Maesa-Kogma Biosphere Reserve (Dowwiangkan *et al.*, 2018, 2020), Mae Ai District; Doi Mak Lang (Hernandez *et al.*, 2019) and Doi Lang (this study),

**Table 1.** Measurements (in mm) of *Tylototriton uyanoi* examined (Means  $\pm$  SD of SVL and medians of characters)

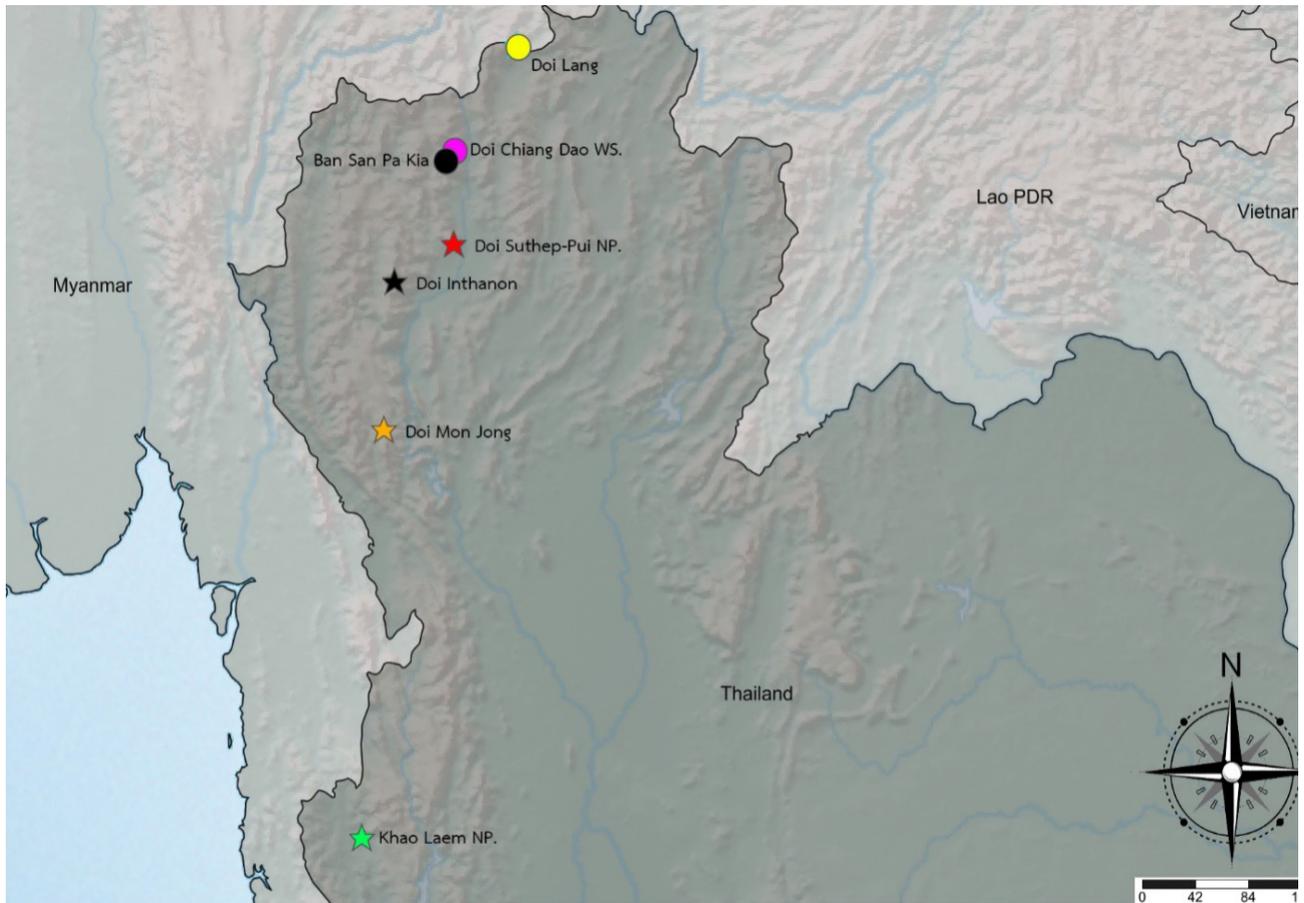
Location	Type specimens		Ban San Pa Kia		Doi Chiang Dao NP.		Doi Inthanon		Doi Lang		Doi Suthep-Doi Pui NP	
	9 M	2 F	3 M	2 F	3 F	2 M	6 F	1 M	1 M	1 M	3 F	
SVL	68.1 $\pm$ 3.8 (63.9-74.9)	69.3, 78.3	67.8 $\pm$ 4.0 (64.9-72.4)	72.7, 73.9	67.1 (62.4-71.8)	57.8, 59.1	63.7 (60.3-69.0)	68.4	69.4	65.7 (63.4-68.1)		
RHL	24.7 (23.0-28.0)	25.8, 26.9	19.2 (16.8-22.4)	17.7, 17.7	16.0 (15.6-16.5)	14.7, 16.4	16.0 (15.6-17.8)	17.3	19.8	15.8 (15.5-16.1)		
RHW	25 (22.2-26.5)	23.1, 24.0	15.3 (14.4-16.5)	14.8, 15.4	14.0 (13.3-14.6)	14.3, 14.3	14.5 (13.6-15.9)	15.4	15.7	14.8 (14.5-15.0)		
RMXHM	25.9 (23.6-26.8)	23.6, 25.0	17.2 (16.3-17.7)	17.2, 18.1	16.3 (15.3-17.2)	15.6, 15.8	16.2 (15.5-17.1)	17.3	17.2	16.9 (16.7-17.1)		
RSL	9.7 (8.5-10.6)	10.0, 10.5	6.5 (6.2-6.7)	7.4, 7.5	6.5 (5.7-7.1)	6.3, 6.5	6.6 (6.1-7.1)	6.7	7.0	6.4 (5.7-6.9)		
RLJL	19.8 (17.5-20.5)	19.2, 19.3	11.8 (11.0-12.0)	11.9, 12.6	12.5 (11.5-13.0)	9.6, 10.6	10.7 (9.3-12.1)	12.2	11.1	11.5 (11.2-12.0)		
RENL	6.7 (5.7-7.2)	6.5, 6.8	4.7 (4.0-5.3)	5.0, 5.6	5.4 (5.1-5.7)	5.1, 5.2	4.9 (4.3-5.4)	5.0	4.8	5.5 (5.3-5.8)		
RIND	7.0 (6.2-7.6)	7.0, 7.1	5.2 (5.1-5.3)	4.8, 5.9	4.9 (4.8-5.1)	3.8, 5.4	4.5 (3.9-5.2)	5.4	5.6	5.2 (5.1-5.4)		
RIOD	11.0 (9.5-12.2)	8.9, 9.1	8.2 (8.1-8.5)	8.6, 9.6	8.6 (7.5-9.9)	6.7, 7.1	8.5 (7.7-9.2)	8.9	9.4	8.5 (7.9-9.3)		
RUEW	3.8 (3.3-4.3)	3.3, 4.2	5.1 (4.4-5.7)	5.4, 5.7	5.4 (5.0-6.0)	3.9, 4.6	4.8 (3.4-5.5)	5.4	5.7	5.1 (4.5-5.5)		
RUEL	7.6 (6.7-8.4)	6.9, 6.9	4.0 (3.6-4.5)	3.5, 4.5	2.9 (2.7-3.2)	3.2, 3.3	3.7 (3.2-4.4)	4.0	4.1	3.6 (3.2-4.1)		
ROL	5.0 (4.5-5.9)	5.1, 5.2	3.6 (3.3-3.9)	3.7, 3.9	3.9 (3.7-4.2)	3.5, 4.0	3.5 (2.9-3.9)	3.7	3.3	3.6 (3.2-4.1)		
RAGD	48.8 (46.7-51.5)	47.9, 50.7	32.3 (31.2-33.2)	32.1, 35.1	34.3 (29.2-39.8)	23.9, 28.5	30.5 (27.8-32.8)	32.6	34.5	32.7 (30.6-35.6)		
RTRL	75.3 (72.0-77.0)	73.1, 74.2	47.2 (43.9-50.3)	53.6, 56.3	53.7 (49.3-56.7)	41.0, 41.7	46.9 (44.2-50.0)	49.9	47.8	49.1 (47.2-50.8)		

Table 1. Measurements (in mm) of *Tylosotriton uyenoii* examined (Means ± SD of SVL and medians of characters) (continued)

Location	Type specimens	Ban San Pa Kia	Chiang Dao NP.	Doi Inthanon	Doi Lang	Doi Suthep-Pui NP	Location	Type specimens	Ban San Pa Kia	Chiang Dao NP.
RTAL	115.0 [n=8] (101.4-127.7)	88.0, 97.0	75.8 (69.6-82.6)	69.0, 73.4	70.0 (58.1-77.3)	66.3, 66.4	66.3 (52.9-72.9)	67.0	85.0	77.8 (71.3-84.2)
RVL	7.4 (6.0-9.0)	1.7, 1.9	7.1 (6.1-8.4)	3.3, 4.2	7.2 (5.8-8.1)	4.6, 6.5	5.6 (3.3-10.0)	7.6	5.4	6.9 (6.7-7.1)
RBTAW	8.5 (8.0-9.9)	7.3, 7.6	5.0 (4.4-5.3)	5.2, 5.4	4.7 (3.9-6.3)	3.8, 4.1	4.9 (3.8-5.8)	5.2	5.2	4.6 (4.4-4.9)
RMTAW	4.9 (4.5-5.2)	4.0, 4.8	2.6 (2.1-3.2)	2.4, 3.6	2.0 (1.5-2.6)	1.9, 2.0	2.8 (2.1-3.8)	7.3	2.2	2.0 (1.9-2.1)
RBTAH	12.4 (10.0-14.5)	12.0, 13.9	7.4 (7.0-8.4)	6.9, 8.0	4.9 (4.0-5.4)	6.5, 6.6	7.6 (5.4-9.4)	6.1	6.6	6.9 (6.7-7.0)
RMXTAH	13.1 (10.9-15.0)	12.0, 13.9	7.7 (7.2-8.2)	7.4, 9.3	6.0 (5.6-6.5)	6.5, 6.6	8.1 (6.2-10.1)	9.3	7.1	6.2 (4.3-7.4)
RMTAH	10.9 (9.2-13.3)	8.7, 11.3	6.6 (5.9-7.6)	5.8, 8.6	3.8 (3.3-4.7)	3.6, 4.4	6.8 (4.1-10.0)	3.1	4.6	5.9 (5.1-7.4)
RFL	34.3 (29.3-36.3)	30.6, 32.7	22.7 (20.7-25.0)	21.9, 25.0	23.0 (20.4-27.0)	21.5, 22.1	21.3 (14.4-25.9)	25.2	24.9	22.8 (21.2-24.3)
RHLL	37.5 (35.9-42.1)	37.4, 37.4	23.1 (21.6-25.1)	20.4, 21.8	22.7 (19.7-24.6)	21.5, 22.3	21.5 (19.1-22.6)	25.0	18.0	22.6 (22.0-23.1)
R3FL	6.3 (1.8-6.9)	5.3, 6.4	4.7 (3.8-5.5)	4.5, 5.0	4.8 (3.7-5.5)	4.6, 4.8	4.4 (3.9-4.8)	5.2	4.2	4.9 (4.7-5.3)
R3FL	6.9 (2.5-11.9)	6.5, 7.4	5.8 (5.6-6.1)	5.1, 5.9	4.8 (4.4-5.5)	4.1, 5.0	4.7 (4.1-5.6)	6.1	4.5	5.4 (5.3-5.5)
R3TL	9.4 (7.1-11.3)	9.5, 9.7	6.9 (6.7-7.1)	7.0, 7.2	7.5 (6.9-8.5)	6.6, 7.8	6.4 (4.9-7.5)	7.5	7.3	7.0 (6.5-7.4)
R5TL	2.9 (2.0-5.0)	4.0, 4.1	2.8 (1.9-3.5)	2.9, 3.7	3.0 (2.4-3.6)	1.8, 2.7	3.3 (2.6-4.7)	3.0	3.4	3.6 (3.2-4.1)
RVTW	7.6 (6.5-9.1)	6.6, 7.0	5.6 (4.3-7.0)	4.7, 5.2	5.1 (4.9-5.4)	3.9, 4.0	5.0 (4.3-5.3)	6.2	6.0	5.6 (5.4-5.8)
RVTL	10.3 (9.1-11.9)	8.8, 10.2	7.5 (6.5-8.)	8.6, 8.9	7.2 (6.7-7.7)	7.4, 7.4	7.2 (6.6-7.6)	8.1	8.8	8.4 (8.1-8.7)

Chiang Dao District; Doi Chiang Dao Wildlife Sanctuary and Ban San Pa Kia (this study). **TAK PROVINCE**, Sam Ngao District; Doi Mon Jong (Hernandez *et al.*,

2019), **KANCHANABURI PROVINCE**, Sangkhla Buri District; Khao Laem National Park (Hernandez and Pomchote, 2020) (Figure 2).



**Figure 2.** Distribution of *Tylototriton uyenoii* in Thailand. Star symbols (red star: type locality) correspond to localities reported by Nishikawa *et al.* (2013) and Gerlach (2012, 2021) and (black star) correspond to localities reported by Nishikawa *et al.* (2013) and Michaels (2015); (yellow star) correspond to localities reported by Hernandez *et al.* (2019); (green star) correspond to localities reported by Hernandez and Pomchote (2020); and circle symbols are localities reported in this paper (NP. = National Park and WS. = Wildlife Sanctuary).

## CONCLUSION

In this study, we found that the specimens male and female specimens of *Tylototriton uyenoii* which were preserved in the Natural History Museum, National Science Museum, Thailand (THNHM) were not significantly different in body size. When comparing the size of the type specimens and the specimens in the THNHM collection, statistical analysis showed that that the female sizes of Group (2) Doi Chiang Dao Wildlife Sanctuary and Group (4) Doi Suthep-Pui National Park were not statistically significant, but in group (3) Doi Inthanon, male body size was significantly smaller than the female size of type specimens. The distribution of *Tylototriton uyenoii* was not previously reported to have been found in Doi Lang, Mae Ai District, Chiang Mai Province, Northern Thailand, making this a new distribution locality of this species herein recorded.

In this study, there may be insufficient data to study *Tylototriton* with more accuracy, possibly because the number of specimens used and available is still too small for some localities. We hope that the information from this study will contribute in aiding the conservation of this species, increase the focus on conservation areas that need protection, and be useful to taxonomists.

## ACKNOWLEDGEMENTS

The authors would like to thank Department of Biology, Faculty of Science, Khon Kaen University and Natural History Museum, National Science Museum, Thailand, we are grateful to Yodchaiy Chuaynkern for reviewing an earlier manuscript and our special thanks go to Chatchaiy Chueachat, Prapaiporn Thongproh and Chadakorn Pholdongnok.

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Received: 16 March 2021

Accepted: 16 May 2021

Published: xx xxx 2021

Published in Print: 30 June 2021