SALAMANDRA **50**(4) | 245–248 | 30 December 2014 | ISSN 0036–3375

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Observations on overwintering larvae of *Tylototriton verrucosus* (Caudata: Salamandridae) in Darjeeling, Himalaya, India

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Manuscript received: 16 October 2013
Accepted: 13 March 2014 by Dennis Rödder

Amphibians restrict their reproduction to short periods that present the most favourable conditions. Usually, this event coincides with the rainy season (Deuti & Hegde 2007) as water availability is crucial for the larval development of these species. The only caudate amphibian of India, the Himalayan crocodile salamander, *Tylototriton verrucosus*, is also found in southern China, northern Myanmar, eastern Nepal, Bhutan, and Thailand (Kuzmin et al. 1994), and is possibly now extinct in Vietnam (IUCN 2013). In the Darjeeling Hills of India, this species is known to reproduce between March and May (up to September) (Kuzmin et al. 1994). Generally, metamorphosis takes place between August and October (Kuzmin et al. 1994). If larvae have not metamorphosed into adults by the end of the breeding season, it is said that they overwinter (Dasgupta 1988, Anders 2002).

We conducted a survey in the Darjeeling Hills for breeding habitats of the salamander between June and August of 2012, during which eggs, larvae, and adults of this species were found in marshlands, temporary or permanent, artificial or natural pools and puddles in Darjeeling and Kurseong subdivisions located in the northern part of West Bengal State in eastern India (Fig. 1). Breeding habitats of the salamander were recorded from these subdivisions in the distant past (Annandale 1907, 1908). We identified 49 high-altitude wetlands as breeding habitats of the salamander and investigated 35 of these from 3–12 February 2013, searching for the presence of overwintering larvae. We also surveyed two new localities (Location IDs 36 and 37; Tab. 1) in 2013, bringing the total to 37 breeding sites distributed between 1,404 and 2,317 m above sea level. Locations of habitats were recorded with a < 10 m error margin using a global positioning system (Garmin etrex™). Active searches in the water bodies were carried out between 10:00 and 2:00 h on for total of 60 man-hours. Amongst the surveyed habitats, only 25 (68%, N = 37) were permanent water bodies, and overwintering larvae were found in only seven (28%, N = 25) of them: 9th Mile, Middle Chhabbishey, and Mechikhola in the Mirik region, Pokhriabong Basty 2, Sumria Paani Topline 1, and Sumria Paani Topline 2 in the Pokhriabong region, and Chimney school grounds in Kurseong (Tab. 1).

Overall, 30 overwintering larvae of *T. verrucosus* were observed in seven ponds. We grouped 25 permanent ponds on the basis of the presence or absence of larvae. In these ponds, we measured water temperatures with a mercury thermometer, water pH with universal pH-paper strips (Indicators™, product #74886A), and water depth by immersing a graduated pole at the centre of the pond. There were no significant differences in these variables between ponds in which larvae were found overwintering and those containing none (one way-ANOVA; pH: $F = 0.16$, $df = 1$; water depth: $F = 0.8$, $df = 1$; water temperature: $F = 4.27$, $df = 1$; $p > 0.05$). The mean values of the variables in the seven overwintering habitats were the following: water temperature: 10.8°C (SD = 1.4), water depth: 174 mm (SD = 84.8), and pH: 7.64 (SD = 0.48). All ponds were surrounded with woody vegetation at varying distances from the edge of the water, and there was no overhanging vegetation. They were fully exposed to solar radiation except at Sumria Paani Topline 2, where a dense canopy provides shade to the man-made reservoir. The breeding sites with overwintering larvae had stagnant water bodies, with the exception of Chimney School Grounds, where the site serves as a pasture that is devoid of woody vegetation and the larvae were found in a small rivulet flowing through this habitat. The woody vegetation surrounding the ponds was dominated by plantation crops such as *Alnus nepalensis, Camellia*

Table 1. Names, locations, and altitudes of the sites in West Bengal State, India, surveyed from 3–12 February 2013; 2, 3, 10, 24, 25, 32, 37 are location IDs of permanent ponds with larvae and correspond to the numbers in Figure 1.

Location ID	Name of the location	Latitude	Longitude	Altitude in m a.s.l.
1	Margaret's Hope tea Estate, Sonada, Darjeeling	26°56'37.8"	88°16'42.2"	1,577
2	9th mile, Simdhap, Mirik, Darjeeling	26°54'36.1"	88.9'19.1"	1,708
3	Middle Chhabishey, Mirik, Darjeeling	26°55'35.5"	88°8'28.6"	1,961
4	Nakapani, Mirik, Darjeeling	26°54'55.7"	88°9'0.4"	1,775
5	Okaity, Mirik, Darjeeling	26°54'24.9"	88°9'23.3"	1,692
6	Pokhritar, Kurseong	26°55'34.2"	88°19'43.1"	1,974
7	Kaylagudam, Kurseong	26°55'53"	88°19'26.2"	1,816
8	Namthing Pokhri, Kurseong	26°55'40.2"	88°23'52.5"	1,404
9	Chimney, 6th Mile, Kurseong	26°55'14.5"	88°18'36.2"	2,100
10	Chimney, School Ground, Kurseong	26°54'56.8"	88°18'30.5"	2,043
11	Chimney, Kurseong	26°55'17.6"	88°18'38.8"	2,105
12	Okaity TE, Mirik, Darjeeling	26°54'3"	88°9'2.5"	1,586
13	Fuldhan Golai, Mirik, Darjeeling	26°54'20.3"	88°9'32.2"	1,658
14	Mirik Municipality ward no. 8, Darjeeling	26°53'25.4"	88°10'43.2"	1,589
15	Mahindragaon, Mirik, Darjeeling	26°53'28.7"	88°10'42.5"	1,598
16	Raidhap, Mirik, Darjeeling	26°52'54.7"	88°11'2.6"	1,630
17	Aquarium, Mirik, Darjeeling	26°53'23.6"	88°11'8.1"	1,600
18	Beruidhara, Mirik, Darjeeling	26°53'27.3"	88°11'8"	1,588
19	Naribhawan, Darjeeling	26°52'52.5"	88°11'22"	1,584
20	Ninglay, Beech gaon, Darjeeling	26°54'3.2"	88°9'47.7"	1,591
21	Ningalay Fatak, Mirik, Darjeeling	26°54'5.9"	88°9'54.7"	1,567
22	Tiffin Dara, Pokhriabong, Darjeeling	26°57'39.1"	88°9'59.6"	1,867
23	Panihas, Pokhriabong, Darjeeling	26°57'32.8"	88°10'13.7"	1,856
24	Pokhriabong Basty, No. 2, Darjeeling	26°57'56.1"	88°10'26.2"	1,624
25	Sumria Paani Topline1, Pokhriabong, Darjeeling	26°56'54.7"	88°11'16.4"	1,710
26	Sangma TE, Pokhriabong, Darjeeling	26°56'37.4"	88°11'6"	1,725
27	Majhidhura Forest Village, Darjeeling	27°0'16.2"	88°10'23.6"	2,075
28	Shanu Pokhri, Dundungay Dara, Darjeeling	27°0'42.3"	88°10'46.2"	2,251
29	Thulo Pokhri 1, Dundungay Dara, Darjeeling	27°0'49"	88°11'10.2"	2,297
30	Thulo Pokhri Main, Dundugay Dara, Darjeeling	27°0'48.2"	88°11'8"	2,317
31	Torzan, Gairi Gaon, Pokhriabong, Darjeeling	26°57'2.9"	88°10'33.7"	2,311
32	Sumria Paani Topline2, Pokhriabong, Darjeeling	26°56'48.3"	88°11'17.7"	1,693
33	Chhattakpur, Johnsonnata, Darjeeling	26°57'56.4"	88°16'45.6"	2,166
34	Chhattakpur Lake, Darjeeling	26°57'59.9"	88°18'51.8"	2,265
35	Panchpokhri, Kurseong	26°54'57.5"	88°22'52.1"	1,479
36	Chhabbishey, Mirik, Darjeeling	26°55'25.5"	88°8'41.7"	1,926
37	Mechhikhola, Mirik, Darjeeling	26°55'18.2"	88°8'42.1"	1,863

sinensis and *Cryptomeria japonica*. All habitats surveyed had human habitation associated with them at distances ranging from 2 to 200 m to the edge of the water. The larvae encountered were motionless on rocks, sand or on the bottom of the pools. Upon disturbing the water, the larvae escaped under rocks or in the loose soil of the bottom of their ponds. They were collected by hand, photographed, and then released back into the water.

The larvae of *T. verrucosus* are characterized by plumose gills, paired balancers, and an absence of limbs at Stage 1, the presence of forelimbs at Stage 2, the presence of hind limbs at Stage 3, by opercular folds and a yellowish orange hue on the tip of the toes at Stage 4, and by dorsolateral skin folds and a brownish black body colour at Stage 5 (Dasgupta 1988, Smith 1924, Deuti & Hegde 2007). All larvae observed during the present survey were devoid of balancers, had pilose gills and well-developed hind and forelimbs. Furthermore, the larvae observed at breeding sites 2, 3, 10, and 37 were at Stage 4 with an average body length of 39 mm (SD = 4.1) and a mottled olive brown to light brown colouration (Fig. 2). Larvae at breeding sites 24, 25 and 32 were at Stage 5 and had an average body size

of 52 mm (SD = 5.2). The Stage 5-larvae had a dark brownish black dorsum, smaller gills, broader than longer heads, dorsolateral skin folds on the body, and a yellow orange colour on the venter and the tips of their digits.

Advantages of overwintering are: (i) reduced intraspecific competition; (ii) prolonged larval period that might produce a larger juvenile at metamorphosis, probably with a more successful breeding period than adults with short larval periods, as most of the stored body fat of female salamanders is utilized for the formation of egg (Pinder et al. 1995); and (iii) reduced risk of predation, as larvae are less exposed to terrestrial predators (Pinder et al. 1995). At the

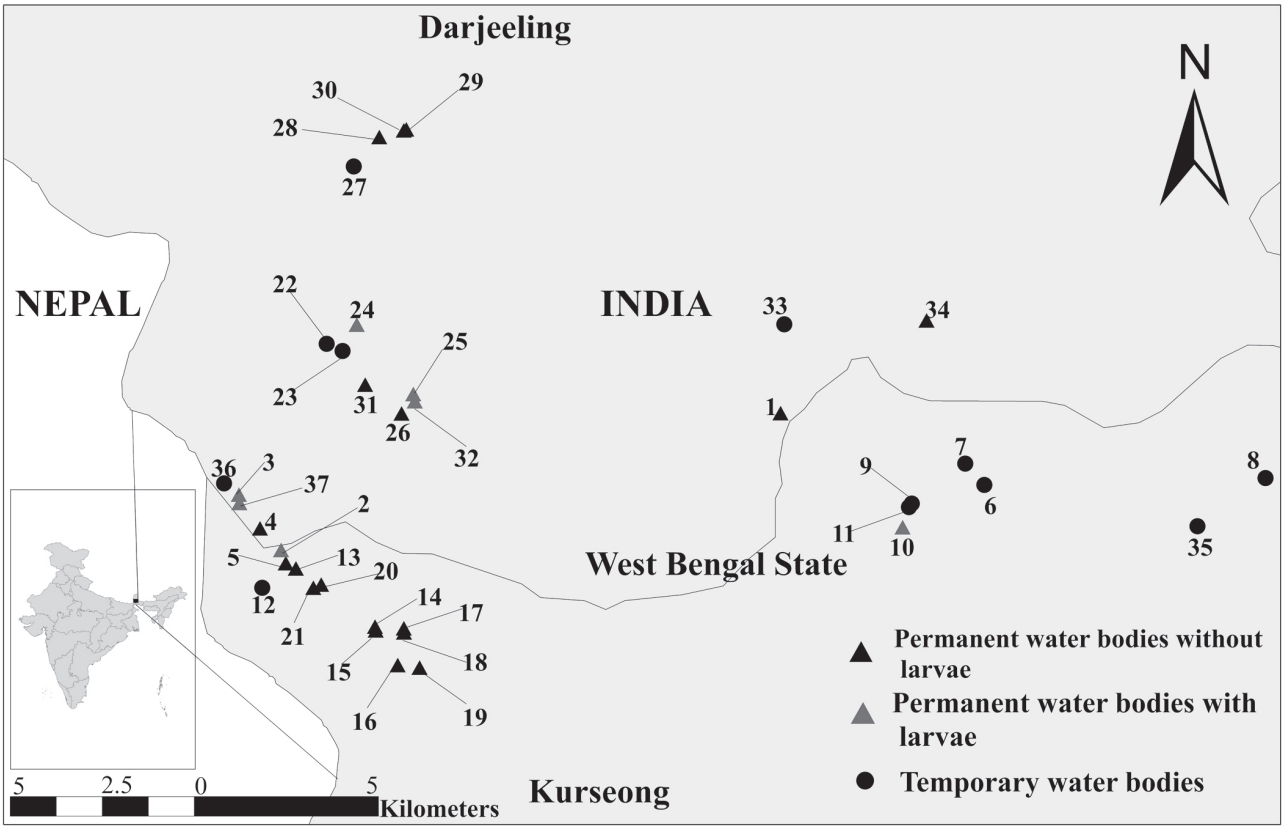

Figure 1. Geographic locations of water bodies surveyed for overwintering larvae of *T. verrucosus* in West Bengal State, India, distinguished as permanent and temporary ponds, respectively.

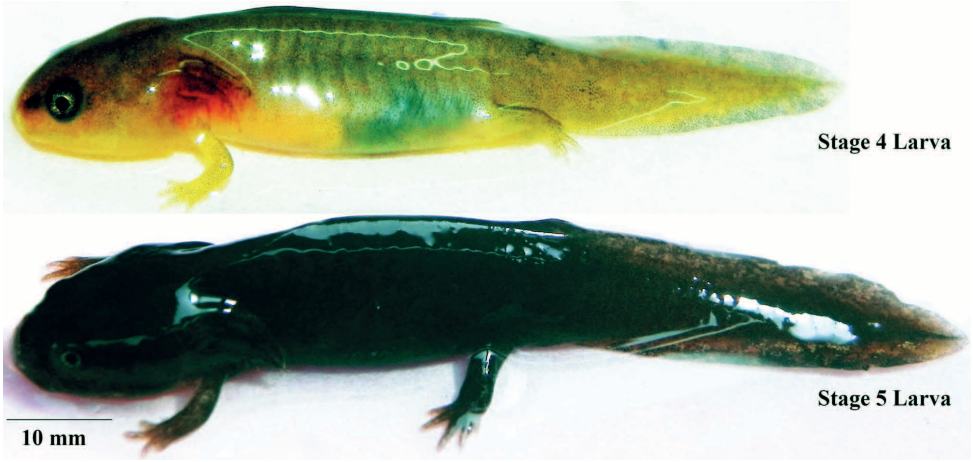

Figure 2. Overwintering larval stages of *T. verrucosus* in the Darjeeling Hills, West Bengal State, India.

same time, during the prolonged larval period, the larvae might accumulate to a greater extent pollutants from the sediments, which might affect their growth and chances of survival (Snodgrass et al. 1994).

Overwintering *T. verrucosus* larvae from Darjeeling Himalayas, India, were already reported on by Kuzmin et al. (1994). Salamandridae larvae are also known to overwinter in Europe (Smith 1951, Steward 1969). Whether overwintering is specific to certain populations of a species at northern latitudes only is not known.

The present survey revealed seven breeding sites of *T. verrucosus* with overwintering larvae in Darjeeling and Kurseong subdivisions, India. Ecological factors influencing the occurrence of overwintering larvae of terrestrial salamanders are poorly known. Hence, repeat surveys for overwintering larvae in the region are required.

Acknowledgements

This work was carried out with the support by Grants-in-aid for research from the Wildlife Institute of India. We thank the West Bengal Forest Department for their permission to carry out this research. We thank Samuel Thomas for facilitating contacts to local people in the Darjeeling District. We also thank Shruti Sengupta, Suresh Kumar, Kaushik Deuti, Abesh Kumar Sanyal, S. S. Rasailly, U. S. Tamang, Uttam Pradhan, Deepak Rasaily, Ramesh Gazmere, Nima Bhutia, Dawa Tamang, Lawang, and Sanjeev Pradhan for their support and assistance during our survey.

References

Anders, C. (2002): Class Amphibia (Amphibians). – pp. 133–140 in: Schleich, H. H. & W. Kästle (eds): Amphibians and Reptiles of Nepal. – Königstein.

Annandale, N. (1907): Eggs of *Tylototriton verrucosus*. – Records of the Indian Museum, **1**: 273–279.

Annandale, N. (1908): Breeding habits of *Tylototriton verrucosus*. – Records of the Indian Museum, **2**: 305–306.

Dasgupta, R. (1988): The young of the Himalayan newt. – Journal of the Bombay Natural History Society, **7**: 3–10.

Deuti, K. & V. D. Hegde (2007): Handbook on Himalayan Salamander. – Nature Books India: New Delhi, India.

IUCN (2013): IUCN Red List of Threatened Species. Version 2013.1. – www.iucnredlist.org, last accessed on 23 October 2013.

Kuzmin, S. L., R. Dasgupta & E. M. Smirina (1994): Ecology of the Himalayan Newt (*Tylototriton verrucosus*) in Darjeeling Himalayas, India. – Russian Journal of Herpetology, **1**: 69–76.

Pinder, A. W., K. B. Storey & G. R. Ultsch (1995): Estivation and hibernation. – pp. 250–276 in: Feder, M. E. & W. W. Burggren (eds): Environmental Physiology of the Amphibians. – University of Chicago Press, Chicago, London.

Smith, M. A. (1924): The tadpole of *Tylototriton verrucosus*. – Records of the Indian Museum, **26**: 309–310.

Smith, M. (1951): The British Amphibians and Reptiles. – London, Collins.

Snodgrass, W. J., W. A. Hopkins, B. P. Jackson, J. A. Baionno & J. Broughton (2005): Influence of larval period on responses of overwintering green frog (*Rana clamitans*) larvae exposed to contaminated sediments. – Environmental Toxicology and Chemistry, **24**: 1508–1514.

Steward, J. W. (1969): The tailed amphibians of Europe. – New York, Taplinger Publishing Company.