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AMPLEXUS-LIKE BEHAVIOUR OF HIBERNATING *RANA CHENSINENSIS* IN NORTHERN CHINA

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Rana chensinensis David, 1875, was once regarded as a subspecies of *R. temporaria*, and more recently proposed as an independent species endemic to China (for taxonomic reviews see Pope & Boring, 1940; Liu & Hu, 1961; Xie *et al*., 2000). Adapted to a cold climate and less-polluted water, the frog occurs widely in mountain rivers over northern China. So far, little has been published on the behavioural ecology of the species. During the winter period of 1992, I observed hibernation behaviour of *R. chensinensis* at two localities, Jie-xiu (37°04'N, 112°03'E; annual mean temperature 9.5°C, January mean -5.8°C) and Yu-she (37°32'N, 115°58'E; annual mean temperature 8.1°C, January mean -7.4°C), in Shanxi province, northern China. In Jie-xiu the frogs inhabited a small stream less than 2 m wide, surrounded by loess ravine with shrubs and farmland, while in Yu-she the frogs used a relatively complex river system encircled by woodland. I searched hibernation sites in each of the two study areas during the daytime. Once located, all individuals at a site were caught by hand as rapidly as possible. I determined the sex and age of the frogs by checking secondary sexual characters and measuring body length (SVL): sexually mature males had nuptial pads on the forefeet, while sexually mature females had a SVL > 35 mm in Jie-xiu and > 30 mm in Yu-she (Lu 1991, 1994). Then the frogs were released. In Jie-xiu, water temperatures at the bottom of the hibernating sites were measured on days when frogs were captured.

Like its close relatives, *R. temporaria* in Europe (Koskela & Pasanen, 1974) and *R. dybowski* in northeastern China (Huang, 1959; Ma, 1982; Li & Gao, 1984), *R. chensinensis* in the two study areas overwintered in groups in aquatic habitats. While hibernating, the frogs in Jie-xiu exhibited clear aggregation, with group size ranging from seven to 250 frogs (Table 1) in hollows under the stream bank and in warm springs. In contrast, in Yu-she the animals were relatively well-separated, under stones or other objects in the river, and the number of frogs found at any of the hibernation sites was less than seven individuals.

The most remarkable finding of the survey was that some individuals in hibernating groups showed amplexus-like behaviour. In this behaviour, a sexually mature male clasped the chest of a sexually mature female with his forelimbs – just as in the breeding season, except that the male's hind legs were relaxed and the female was in a state of torpor with legs relaxed. No male-male, female-female or female-male clasping bonds were detected, except for two cases in which 4-5 individuals in a stream were found clasping each other in mid-November. I examined over 200 individuals along the stream in Jie-xiu during the pre-hibernation period (late-October) when they moved towards hibernation habitats, and I found no individuals clasped together. This indicates strongly that the amplexus-like behaviour was initiated early in the hibernation period (mid-November). The clasping was very tight and persistent. Several clasping frogs brought to the laboratory remained together for at least 48 hours. In Jie-xiu, I regularly visited two springs where the hibernating frogs could be seen in the clear water. Clasping frogs were observed there from early until late in the hibernation period (i.e. early November until mid-January). I am not certain whether clasping bonds changed during the hibernation period, owing to the lack of marked individuals, but in both the cold stream covered with ice (near 1°C) and the warm springs (about 10°C), the frogs remained inactive and in a state of torpor throughout the wintering period. Therefore, although a few frogs were occasionally found swimming in spring habitats, it seems likely that those clasping-bonds formed early in the hibernation period could be relatively stable.

Over a four-year period the earliest egg-laying took place in mid-February for the frog population in Jie-xiu, and in mid-March in Yu-she (X. Lu personal observation). During the hibernating period, despite the relatively high spring water temperature that allows spawning, the frogs exhibited no other behaviour associated with reproduction. Perhaps the low air temperature is ultimately a limiting factor. Thus, the amplexus-like behaviour was not directly associated with reproduction. One possible explanation under consideration is avoidance of male-male competition for mating in the subsequent spawning period. It has been shown that for explosive breeders, with a short breeding season, the male-male competition for mates is remarkable (Wells, 1977). In *R. temporaria*, male-male competition is not intense enough to lead to non-random mating in natural populations with operational sex ratio (OSR) more than 0.5, but it may be so in experimental populations with a heavily male-biased OSR and high male density (Elmberg, 1991). In my data (Table 1), no significant correlation was found either between occurrence of hibernation clasping and hibernating group size (r_s=0.502, df=11, P=0.115) or between occurrence and OSR (r_s=-0.191, df=11, P=0.573). Furthermore, the higher OSRs of the breeding population in the study areas, where spawning lasts for about six weeks (Jie-xiu: 77/87=0.89; Yu-she: 79/43=1.84, X. Lu personal data) seemed not to suggest the occurrence of intense male-male competition. Comparing the body lengths of eight males (37.7±1.6 mm) and eight females (39.0±1.7 mm) in-

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TABLE 1. Group size, sex ratio and occurrence of amplexus-like behaviour in different hibernating refuges of *Rana chensinensis* in northern China. [1]The number of sexually-immature frogs is given in parentheses. [2]Value of sexually-mature specimens. [3]Number of clasping-bonds/number of females x 100. *Pooled data comprising specimens caught at different hibernating refuges, with 1-7 sexually mature frogs at any one.

Date	Winter refuge	Water temperature (°C)	Group size[1]	Female	Male	Sex ratio[2] (female/male)	Clasping-bond	
							no.	%females[3]
(1) *Jie-xiu*								
19 Nov	Stream	1.5	20 (0)	5	15	0.33	2	40.3
20 Nov	Stream	1.0	25 (0)	8	17	0.50	0	0.0
20 Nov	Stream	1.0	50 (0)	18	32	0.57	2	11.0
20 Nov	Stream	1.2	140 (8)	59	81	0.73	8	13.5
21 Nov	Stream	1.7	11 (0)	3	8	0.38	0	0.0
21 Nov	Stream	1.5	14 (0)	4	10	0.40	1	25.0
25 Nov	Spring	11.2	249 (6)	71	178	0.40	25	35.1
15 Dec	Spring	10.5	43 (1)	25	18	1.33	1	4.1
16 Dec	Spring	10.5	131 (3)	60	71	0.85	45	74.8
17 Jan	Stream	1.2	21 (0)	8	13	0.62	0	0.0
17 Jan	Stream	1.0	13 (2)	7	6	1.20	0	0.0
19-25 Nov	Stream	—	22 (4)*	6	16	0.38	0	0.0
15-16 Dec	Stream	—	31 (4)*	10	21	0.48	0	0.0
(2) *Yu-she*								
9-12 Dec	Stream	—	67 (19)*	37	30	1.23	8	21.6

volved in clasping in Yu-she with those of 29 sexually-mature males (36.5±0.8 mm) and 22 females (38.2±1.1 mm) hibernating singly, I found no significant difference either between males (t=0.70, df=35, P=0.49) or between females (t=0.40, df=28, P=0.69). This suggests that the amplexus-like behaviour occurred at random with regard to body size. Therefore, to explain the adaptive significance of the amplexus-like behaviour during hibernation, further study should estimate the reproductive success of the individuals involved in the clasping-bonds.

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