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Response of Mountain Yellow-Legged Frogs, *Rana muscosa*, to Short Distance Translocation

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ABSTRACT.—**To determine the response of Mountain Yellow-Legged Frogs to short distance translocations, I placed transmitters on 20 adult frogs and moved them short distances from 144–630 m and monitored their responses for up to 30 days. Of the 20 translocated frogs, seven frogs returned to their original capture site, four frogs moved in the direction of their capture site but had not returned by the end of the study, and nine frogs did not return and were found at the translocation site. Apparently, displacing frogs was stressful, and translocated frogs lost body mass during the study period. Eighteen translocated frogs that were weighed at the beginning and end of the study lost body mass (mean loss was –1.2 g) compared to a group of 18 randomly selected PIT tagged frogs also weighed during the same tracking period (mean gain in body mass = 2.5 g) at our Kings Canyon study site. Translocation of adult *Rana muscosa* as a conservation tool may not be effective because some would simply attempt to return to their original capture site, and their homing may be stressful to an already declining frog population.**

The process of reestablishing threatened and endangered species by relocation, repatriation, and translocation (RRT) has become increasingly used as a wildlife management technique for a variety of animals including birds, mammals (Ralls et al., 1992), and more recently, amphibians, and reptiles (Griffith et al., 1989). Although there is much discussion over the proper definitions, Griffith et al. (1989) define translocation as "the intentional release of animals to the wild in an attempt to establish, reestablish, or augment a population . . ." As species decline, there is considerable interest in moving them from favorable habitats where they may still thrive, to habitats where populations need to be restored. Dodd and Seigel (1991), however, cast doubt on the effectiveness of RRT as conservation strategies for reptiles and amphibians because there are few documented successes (Reinert, 1991). In some studies, there was no way to determine success because no baseline information existed from which researchers could determine whether or not the translocations were successful. Another problem with translocation studies is there is sometimes no post study monitoring. Therefore, Dodd and Seigel (1991) urged caution in the use of RRT and asked that researchers carefully document the studies and monitor the results for several years to determine whether the recovery efforts were successful.

Many examples of potential problems with actual translocations have been discussed (Dodd and Seigel, 1991; Reinert, 1991), including the possibility that animals move once they are translocated or are moved into low quality habitat, or habitat that still harbors problems that contributed to the original decline. If animals home (return to their capture site), then translocation to reestablish a population would be unsuccessful. Another potential problem is that translocations may be stressful and animals may spend valuable foraging or breeding time searching for their home site.

Recent studies have documented that the once-common Mountain Yellow-Legged Frog, *Rana muscosa,* has declined in the Sierra Nevada mountains of western North America in large part because of the introduction of nonnative trout (Bradford, 1989; Bradford et al., 1993; Knapp and Matthews, 2000). Despite the fact that its habitat has been protected in national parks and federal wilderness areas for the past 30–80 yr, *R. muscosa* is now extirpated from at least 50% of historic localities (Bradford et al., 1994; Drost and Fellers, 1996; Jennings, 1996). Because *R. muscosa* is declining and has been petitioned for federal listing, there is interest in trans-

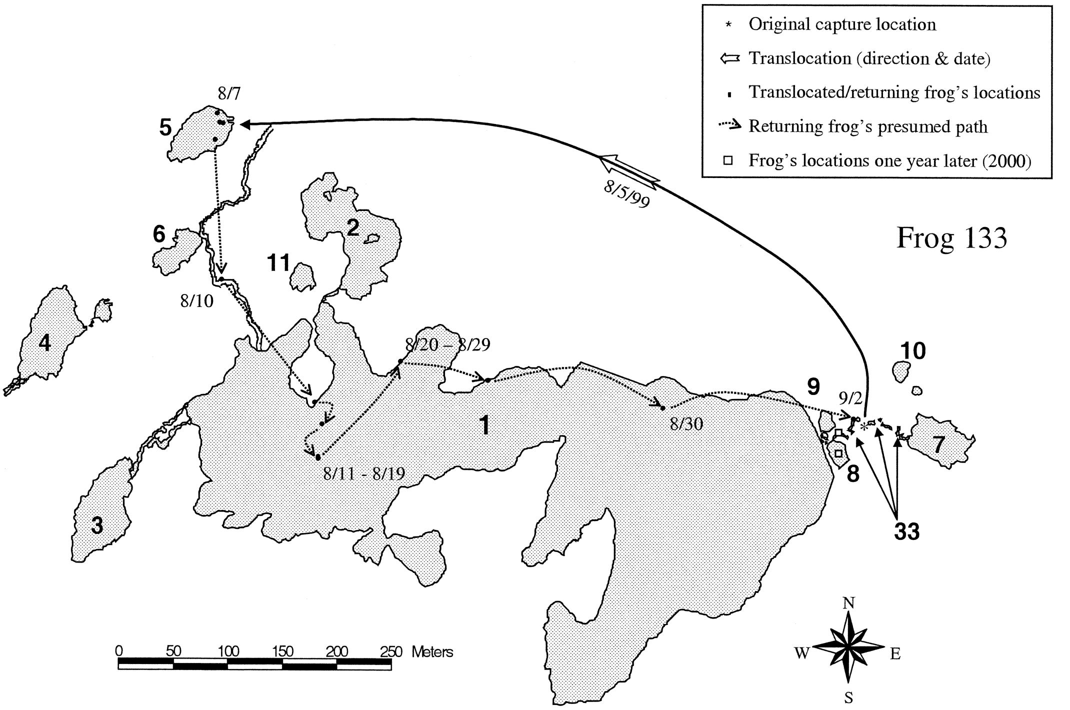

FIG. 1. Map of tagged frog 133 that returned home after relocation during August and September 1999. Asterisks indicate the original capture site and the solid line with arrow indicates the translocation direction and distance. The circles show the locations after relocation, and dotted lines show the assumed return path to the original capture site. The highlighted boxes show frog 133's locations in PIT surveys during 2000. Lake and stream numbers are in bold.

locations. Translocations have been used successfully by European researchers to reestablish populations of the *Rana temporaria* (Cooke and Oldham, 1995), but recent translocations of *R. muscosa* were not successful (G. M. Fellers unpubl. data; R. A. Knapp, unpubl. data). I suspected that adult *R. muscosa* may not be good candidates for translocation because they have high site fidelity and move short distances to relocate previously used breeding and feeding sites (Pope and Matthews, 2001; K. R. Matthews, unpubl. data). This study was conducted to determine the response of *R. muscosa* to short distance (144–630 m) translocations. I used radiotransmitters to monitor the movements of *R. muscosa* after they were translocated to determine whether they returned to their original sites of capture. In addition, I assessed frog stress by comparing their masses at the beginning and end of the tracking period to determine whether loss in mass occurred. Then, I compared these changes in masses to randomly selected frogs in the same study area that had not been translocated.

MATERIALS AND METHODS

Study Area.—My study was conducted in upper Dusy Basin, Kings Canyon National Park, California (37°5′40″N, 118°33′45″W) at an elevation of 3470 m (Fig. 1; additional maps of the study area are found in Matthews and Pope, 1999; Pope and Matthews, 2001). The site supports a large population (several thousand) of *R. muscosa* of varying age classes. This glacially formed, granite basin supports alpine fell field vegetation with low-growing herbaceous plants, dwarf shrubs and few krummholzed white-bark pines (Holland and Keil, 1995). There is a series of streams, lakes, and ponds in the basin that are fed by snowmelt. The study area covers approximately 0.35 km^2. This study focused on 11 lakes and ponds and the adjacent creeks in Dusy Basin (Fig. 1). Only lakes 1 and 3 (all water bodies being considered lakes) support self-sustaining populations of trout. Fish were also found in some creeks that connect between lakes. Lakes ranged in area from 114 m^2 to 5.3 ha and were 0.25–10 m deep. All lakes and streams within the study area have been numbered and mapped using a Trimble Pro XRS (with real-time satellite differential correction) GPS system accurate to < 1 m.

Field Techniques.—On 4 August 1999 I attached radio transmitters (Holohil Systems Ltd.; BD-2 transmitters; $15 \times 7 \times 4$ mm) to 20 *R. muscosa* (snout–vent length, SVL > 55 mm) and allowed at least a 24-h recovery period recovery period after transmitter attachment before frogs were moved (Appendix 1). I chose frogs larger than 55 mm (SVL) to reduce possible adverse effects of transmitter weight on the health of frogs.

To attach radio transmitters, a waist-belt made of aluminum ball or beaded chain was used (Matthews and Pope, 1999). Total weight of transmitter and belt was approximately 1.5 g (ranged from 4–8% of body mass for frogs in this study) with a battery life of one month. Frogs were hand-captured, weighed, measured, tagged with both a radiotransmitter and a Passive Integrated Transponder (PIT) tag, and then released at the capture site. Sex was determined by the enlarged nuptial pad at the base of the inner-most finger found in adult males (Stebbins, 1985).

On 5 August 1999, I moved tagged frogs from their capture site to other lakes and ponds and followed their movements to determine whether they remained stationary or returned to their capture sites. I attempted to remove transmitters and belts just before the battery expired (about one month). After frogs were tagged they were located on an almost daily basis and sometimes twice daily using an Advanced Telemetry Systems (ATS, Islanti, Minnesota) Challenger 4000 receiver and a hand-held three-element Yagi antenna. I monitored transmitters for the predicted life of the battery (up to 30 days). When frogs were located, I recorded their position (using GPS with real-time differential correction) and air temperature. Water temperature data were collected every five minutes for the duration of the study using Onset optic stowaway and tidbit water temperature loggers.

Frogs were moved distances from 144–630 m from one water body (lake or stream) to another water body. To reduce stress on frogs, I attempted to recapture them and return them to their original capture site if they had not returned by the end of the study. Because most translocated frogs (except frog 289) had a PIT tag inserted in 1999, I could search for frogs not recaptured in the summer of 1999 in subsequent PIT surveys (Pope and Matthews, 2001). The study was conducted primarily in August when frogs are generally less mobile and remain within average home ranges of 385 m^2 compared to September when frogs move more and home ranges increase to 5336 m^2 (Matthews and Pope, 1999). Frogs were moved from one water body to another water body that is not typically used, in an attempt to simulate a reintroduction. The longer translocations (> 400 m) would have placed frogs well outside of their maximum home ranges in September (around 5000 m^2; Matthews and Pope, 1999) and possibly into unfamiliar areas.

To determine whether relocating frogs stressed them and resulted in a loss of body mass, I weighed frogs at the beginning and end of the study. I knew from previous work with tagged frogs (Matthews and Pope, 1999) that the effect of the transmitter was minimal and during summer tracking periods frogs with transmitters increased body mass during the study. Eighteen frogs were recaptured at the end of the 1999 tracking period and their transmitter removed; I was unable to relocate two transmittered frogs at the end of 1999. From these 18 frogs I collected body mass data at the beginning of the study and at the end of the tracking (days tracked ranged from 17–30 for these frogs). I determined whether the change in mass over the tracking period differed between the group of translocated frogs and 18 randomly selected PIT tagged frogs from the same study area weighed over the same time period. I also compared the mass changes of the translocated frogs to weight changes of frogs from another study that were transmittered but not translocated (Matthews and Pope, 1999).

Results

Of the 20 translocated frogs, seven returned to their original capture site (within a few meters), four moved in the direction of their capture site but had not returned by the end of the study, and nine did not return and were found at the translocation site (Appendix 1). During the tracking period from 5 August through 4 September 1999, five translocated frogs returned to their original capture site within 11–30 days (Appendix 1). Distance of translocation for these five frogs ranged from 206–485 m. Two additional translocated frogs (115 and 217) were not relocated by the end of 1999 but were found in the summer of 2000 during PIT surveys at their original capture lake (Pope and Matthews, 2001), indicating that they had returned either later in 1999 or in 2000. These two frogs were moved longer distances of 478 and 630 m. One frog (289) was lost during the study period; it was moved from lake 5 to lake 2, followed for 14 days and then its radio signal could not be located.

Frogs that returned within the study period generally stayed at the release site for several days and then took a fairly direct path back to their original capture sites (Fig. 1). For example, frog 133 was moved 485 m from stream 33 (Fig. 1), stayed at the release site for four days and, within 29 days, returned to its original capture site following a fairly direct path using water bodies. Similarly, frog 275 was moved 225 m where it stayed in the same water body for 13 days and was found at its capture site in less than 16 days. All frog relocations were subsequently found closer to the capture site than to the release site, and the frogs were never found moving further away from the release site.

Four frogs did not return to their original capture site by the end of the study period but were found closer to their capture sites (Appendix 1). Frog 350 (Fig. 2) was originally captured in lake 1 and was moved into lake 5 where it stayed for seven days. After seven more days it was found in the stream adjacent to lake 1, and subsequently it moved into the lake 2 where it remained for the study period. Frog 429 exhibited a similar response to translocation as frog 350. After it was moved from lake 1 into lake 7 (430 m), it remained for six days. Subsequently it moved back into lake 1 and more than half way back to its original capture site by the end of the study but was still about 150 m away from its original capture site. Frogs 535 and 615 were moved 595 m and 205 m, respectively, and both were over halfway back to their capture sites by the end of the study.

Frogs that returned during the 30-day tracking period in 1999 were originally translocated a mean distance of 267.6 m (206–485 m). The two transmittered frogs that were moved in 1999 but not found until 2000 were originally moved longer distances of 478 and 630 m.

Nine frogs stayed in the lake where they were translocated (150–615 m) during the study period (Appendix 1). Frog 217 had moved back to stream 33 by 2000 when found in the PIT surveys. Frog 409 was moved from lake 4 to lake 7 and it remained in lake 7 for the entire study. At the end of the study period, I could not find one frog (frog 409, Appendix 1) that had remained at the translocation site; thus, I was not able to return it to its capture site. Frog 409 was still located at the translocation site during the 2000 and 2001 PIT surveys.

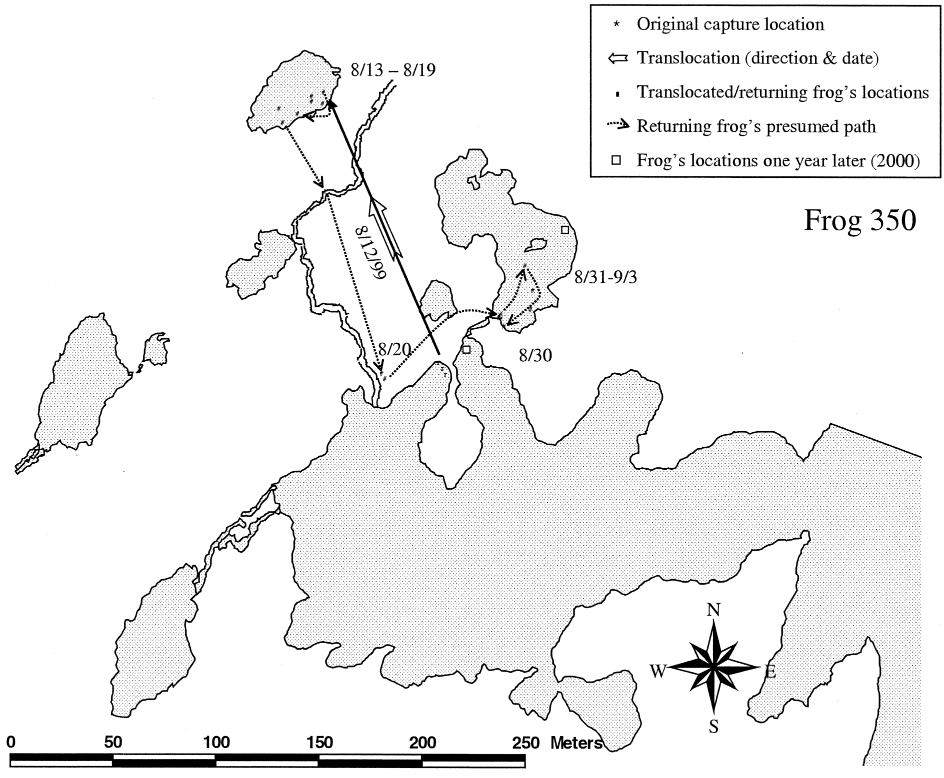

FIG. 2. Map of tagged frog 350 that moved toward its capture site after relocation during August and September 1999. Asterisks indicate the original capture site, and the solid line with arrow indicates the translocation direction and distance. The circles show the locations after relocation, and dotted lines show the assumed return path. Frog 350 was also found in lakes 1 and 2 during PIT surveys in 2000 (highlighted box).

The 18 frogs weighed at the beginning and end of the study lost body mass during the tracking (mean loss of body mass = –1.2 g) compared to a group of 18 randomly selected PIT tagged frogs also weighed during the same tracking period in our Dusy Basin study area (mean gain of body mass = 2.6 g; t-test, $P < 0.001$, normality test passed).

The water temperatures in the lakes ranged from 10–20°C during the study period. These are similar to temperatures encountered during other years in Dusy Basin (Pope, 1999) and suggests that 1999 conditions were similar to previous years.

DISCUSSION

To my knowledge, this is the first published study of *R. muscosa* translocations, and it appears that at least some translocated frogs will return to their initial capture sites. Site fidelity and homing has been demonstrated in several amphibians (Sinsch, 1990, 1992). *Bufo bufo* successfully returned from 3-km displacements (Hueser, 1969), and *Pseudacris regilla* homed from short distance displacements (275 m) but not from longer (914 m) ones (Jameson, 1957). Site fidelity and returning to previously used breeding and feeding areas have been documented in *R. muscosa* (Pope and Matthews, 2001) and is presumably an important factor in their successful relocation of previously used important habitats. Therefore, it is not surprising that some *R. muscosa* returned to their capture sites, especially since they use different water bodies throughout their active season for breeding, feeding, and overwintering (Matthews and Pope, 1999; Pope and Matthews, 2001). Unfortunately, little is known about the extent to which ranids home or what mechanisms (e.g., olfaction, site recognition, etc.) may be involved (Sinsch, 1990). Possibly, Mountain Yellow-Legged Frogs were familiar with the areas into which they were translocated since over the active summer period their home ranges may be up to 5000 m^2, although they did not move much in August in a previous study (Matthews and Pope, 1999).

Apparently, translocations were stressful and translocated frogs lost body mass during the study period compared to other frogs not translocated but in the same Dusy Basin study area. Also, in a study of frogs transmittered but not translocated, Matthews and Pope (1999) found that 10 of 14 transmittered frogs gained weight during the 8–31 days of tracking. Thus, it appears that the relocation and not the transmitters caused the frogs to lose weight. This loss of body mass and possible stress needs to be considered in the risk assessment of doing translocations, especially considering that condition of *R. muscosa* depends on maximizing feeding during the short summer season at high elevations (Pope and Matthews, 2002). Possibly, the additional four frogs that moved toward their capture site but did not return, may have returned if the study had been longer. However, a longer study may have further stressed the frogs.

The results of this study suggest that, given sufficient time, frogs can return to their capture site following short distance translocations and that translocations cause enough stress to result in loss of body mass. Thus, translocations may not be a viable option for adult *R. muscosa*. In addition, there are genetic issues regarding moving frogs from different areas because recent work suggests that the Sierra Nevada may have several different subspecies of *R. muscosa* (Macey et al., 2001). It may be valuable to know whether frogs will also home from longer distance translocations; however, longer movements may cause harm. Translocating egg masses or tadpoles are other possibilities that should be evaluated, as homing would presumably not be a concern.

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APPENDIX 1. A summary of tagged frog information including transmitter number, distance relocated, water body origin, sex, start weight, length, relocation lake number, whether frog returned during study, whether frog was moved back by hand in 1999, PIT location in 2000, end weight, start location tracking, and number of days tracked.

	Trans #	Distance relocated (m)	Water body origin	Sex	Start weight (g)	Length (mm)	Relocation lake	Returned during study	Moved back by hand 99	PIT location 2000	End weight (g)	Start relocation tracking	# days tracked
Returned during study	133	485	33	M	24	60	5	y	n	33	20	8/5/1999	11
	275	225	1	F	31	70	4	y	n	2	28	8/5/1999	17
	477	206	2	F	29	67	4	y	n	1, 2	25	8/5/1999	20
	515	215	2	F	38	73	4	y	n	2	n/a	8/5/1999	30
	556	207	2	F	35	73	4	y	n	2	37	8/5/1999	28
Returned by 2000	115	630	4	F	29	67	7	n	n	4	29	8/5/1999	30
	217	478	33	F	33	63	5	n	n	33	27	8/5/1999	28
Moved toward capture site	350	144	1	M	23	60	5	n	y	2	23	8/11/1999	22
	429	430	1	F	24	63	7	n	y	n/a	22	8/5/1999	28
	535	595	4	F	39	75	7	n	y	4	45	8/5/1999	28
	615	205	2	M	22	61	4	n	y	1	21	8/5/1999	28
Stayed in relocation site	76	600	4	F	34	70	7	n	y	4	35	8/5/1999	28
	95	435	1	M	16	58	7	n	y	n/a	16	8/5/1999	23
	176	485	33	F	23	62	5	n	y	33	19	8/5/1999	30
	250	150	5	F	21	60	2	n	y	n/a	17	8/5/1999	28
	289	160	5	F	25	64	2	n	n	n/a	n/a	8/5/1999	14
	369	615	4	F	22	62	7	n	y	n/a	22	8/5/1999	28
	385	436	1	F	18	56	7	n	y	1	16	8/5/1999	28
	636	165	5	F	22	62	2	n	y	n/a	22	8/5/1999	28
	409	615	4	M	18	56	7	n	n	7	17	8/5/1999	28