GENERAL NOTES

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PREDATION BY PACIFIC GIANT SALAMANDER LARVAE ON JUVENILE STEELHEAD TROUT

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Larvae of the Pacific giant salamander (*Dicamptodon tenebrosus* [formerly *D. ensatus;* see Good 1989]) are prominent members of stream communities throughout their range, which extends from southwestern British Columbia to northwestern California (Stebbins 1985). They are often the dominant vertebrate in small, high gradient streams (Hawkins et al. 1983; Corn and Bury 1989; Parker 1992) and have been reported to comprise greater than 90% of total predator biomass in some of these systems (Murphy and Hall 1981). Larval *Dicamptodon* commonly co-occur with early life stages of anadromous salmonids, and, in some streams, with all life stages of resident salmonids. With the exception of Antonelli et al. (1972), who compared diets of larval *Dicamptodon* (both *D. tenebrosus* and *D. copei*), rainbow trout (*Oncorhychus mykiss*) and sculpin (*Cottus tenuis*), interactions between *Dicamptodon* larvae and fish have been unexplored.

A key factor influencing interactions between larval salamanders and fish is their relative body sizes. Larval salamanders, in general, are gape-limited predators (Zaret 1980) that include larger prey items in their diet as they grow (*e.g.*, Petranka 1984; Leff and Bachmann 1986). Thus, while young-of-the-year (YOY) *Dicamptodon* are susceptible to predation by large salmonids (personal observation), by the end of their first year they likely attain a size refuge and in turn grow large enough to prey on YOY salmonids. Antonelli et al. (1972) reported that on 5 of 7 dates between April and October salmonids comprised a small proportion of the diet of larval *Dicamptodon* in a mid-size Washington stream. Parker (1992, in press) found that YOY steelhead trout (*Oncorhychus mykiss*) were consumed by larval *Dicamptodon* on 3 of 11 dates over a one year period. In this note I present a brief description of larval salamander predation on juvenile steelhead in two northwestern California streams. Specifically, I present records of juvenile steelhead taken from the stomach contents of larval salamanders, comparing their respective sizes, and describe direct observations of larval salamanders preying on fish.

STUDY AREA AND METHODS

The observations presented here were made in two streams in northern Mendocino County, California. North Fork Caspar Creek is a small, first-order stream located within the Jackson State Demonstration Forest (California Department of Forestry and Fire Protection) and Fox Creek is a second-order tributary of the South Fork Eel River located within the boundaries of the Northern California Coast Range Preserve (The Nature Conservancy and University of California Natural Reserve System). Channels of both streams consist of relatively long pools connected by short riffles or steep plunges, with heterogenous substrata of cobbles (64–254 mm diameter) and small boulders (254–500 mm) overlying finer sandy sediments. Larval salamander densities and size distributions differed considerably between the two streams. During spring and summer the salamander population in North Fork Caspar Creek consisted of larvae in their first year of development and a smaller number of second-year, premetamorphic individuals (Parker 1991; Fig. 1). Average salamander densities ranged from 1.21–2.45/m^2 between April 1987 and September 1989 (M. S. Parker, unpubl. data). The salamander population in Fox Creek consisted of a number of overlapping size classes with large, second- and third-year individuals and paedomorphs being fairly common (Fig. 1). Between 1987 and 1990, larval salamander densities in Fox Creek ranged from 0.9–1.24/m^2 (Parker 1992).

Over a 30 month period (April 1987–October 1989), in conjunction with a number of other studies (Parker 1991, 1992; Messer et al., in press), I examined the stomach contents of 186 *D. tenebrosus* larvae from North Fork Caspar Creek and 601 from Fox Creek. Of the North Fork Caspar Creek samples, 41 were obtained by dissecting preserved salamanders and 145 were collected by stomach flushing in the field. All of the Fox Creek samples were collected by stomach flushing. Larval salamanders were sampled by thoroughly searching short stream segments (10–25 m long), overturning all potential cover objects and probing deeper crevices and under-cut banks with a blunt stick, and collecting exposed salamanders with a dip net.

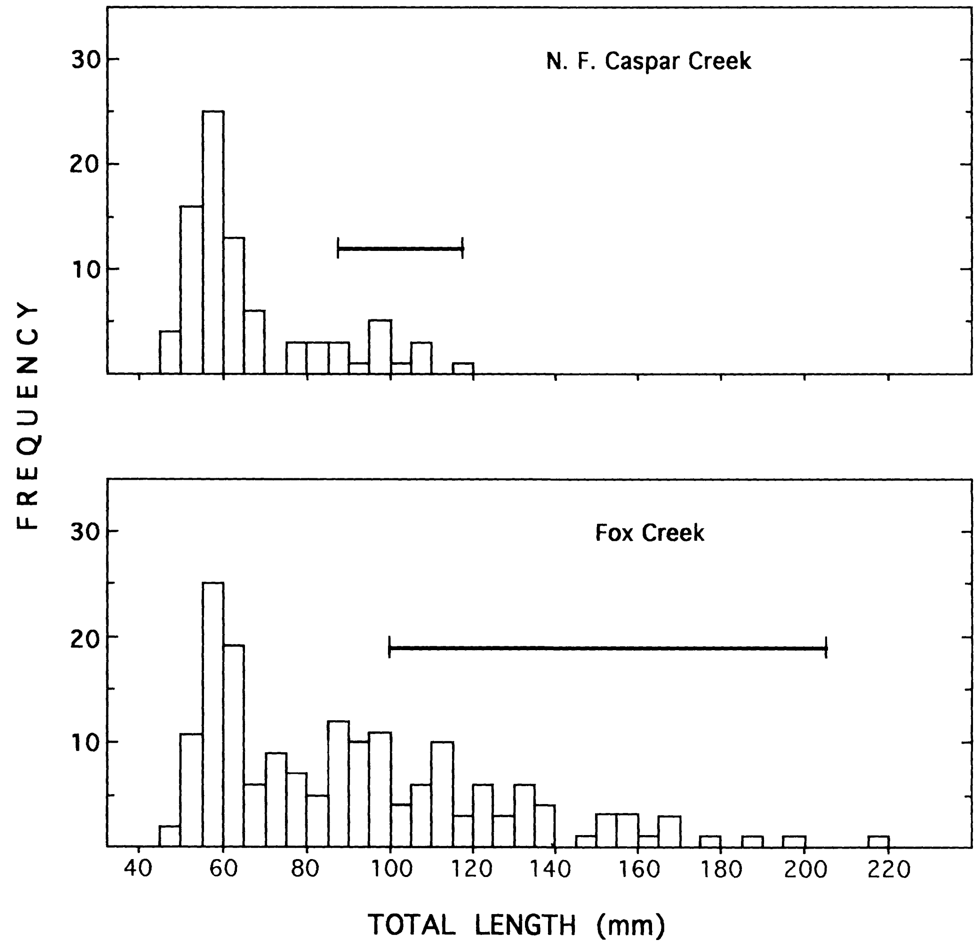

FIGURE 1. Length-frequency distributions of larval *Dicamptodon tenebrosus* collected in May and June 1988–1989 from two streams in northwestern California. Mean salamander lengths (±1 SD) were 66.4 mm ± 16.8 ($N = 84$) and 86.7 mm ± 33.4 ($N = 174$) for North Fork Caspar and Fox creeks respectively (median lengths = 56 mm and 88 mm respectively). Horizontal bars indicate the size range of salamanders whose stomach contents contained juvenile steelhead.

Observations

Contents of 16 stomachs contained juvenile steelhead. In each case a single YOY steelhead had been consumed by a large, second-year or older salamander larva (Table 1, Fig. 1). On three occasions I directly observed interactions in which a larval salamander attacked, captured, and consumed an individual fish. All three were fortuitous observations made from shore, 2–4 m from the site of the interaction. Following each observation I captured the salamander, removed its stomach contents by flushing, and weighed and measured both salamander and fish.

The first observation occurred at night (2320–2400 hr PDT) on 15 June 1987 in a shallow pool (0.15 m mean depth) in North Fork Caspar Creek. I observed two small juvenile steelhead (25–35 mm standard length) maintaining a position near the stream bottom within 5–7 cm of a large, flat stone under which a large salamander larva was partially concealed. The salamander slowly approached the fish until its head and forelimbs were protruding from under the stone and the tip of its nose was 1–2 cm from the nearest fish. It remained in this position for approximately 5 sec before lunging and capturing the nearest fish, grasping its body between the caudal and dorsal fins. This resulted in the salamander moving a distance of 8–10 cm, becoming entirely exposed on

TABLE 1. Records of juvenile *Oncorhynchus mykiss* taken from stomach contents of larval *Dicamptodon tenebrosus* from two streams in northern California.

		Salamander		Steelhead	
Date	Stream	Total length (mm)	Mass (g)	Standard length (mm)	Mass[a] (g)
24 May 1987	NF Caspar	88	6.3	24	0.37
24 May 1987	NF Caspar	101	6.9	25	0.41
15 June 1987[b]	NF Caspar	96	6.6	33	0.77
01 April 1988	NF Caspar	111	8.2	27	0.49
10 May 1988	NF Caspar	106	7.4	31	0.67
10 May 1988	NF Caspar	100	7.0	29	0.57
04 June 1988	NF Caspar	106	7.8	36	0.94
30 August 1988	NF Caspar	98	6.4	39	1.13
06 April 1989	NF Caspar	118	11.6	24	0.37
18 May 1988	Fox	156	20.9	33	0.77
18 May 1988	Fox	198	31.5	41	1.27
29 June 1988[b]	Fox	124	10.9	46	1.65
03 May 1989[b]	Fox	140	21.8	39	1.13
02 June 1989[c]	Fox	200	36.8	26	0.44
28 June 1989[c]	Fox	140	23.5	21	0.27
20 September 1989[c]	Fox	99	6.0	45	1.57

[a] Mass estimated using regression equation based on fish collected from N. F. Caspar Creek: Mass = $0.00025SL^{2.297}$ ($N = 16$, $r^2 = 0.91$).
[b] Indicates direct observations described in text.
[c] From Parker 1992.

the streambed. While subduing the fish the salamander shook its head vigorously from side to side, alternately crawling and swimming over a distance of 1.3 m, finally entering a crevice between two large stones. Although I initially discovered the salamander while passing the beam of a headlamp over the streambed, I held the light pointing away from the stream while making the above observation to minimize the potential influence of increased light intensity.

The second observation occurred on the morning (0600–0630 hr PDT) of 29 June 1988 near the tail of a relatively deep pool (0.35 m mean depth) in Fox Creek. In this case a large salamander lunged from under a partially submerged log to capture one of a group of 6–8 juvenile steelhead actively swimming 3–15 cm upstream of the log. This fish was grasped between the head and dorsal fin. While subduing the fish the salamander was entirely exposed for a period of approximately 3 min, crawling and swimming erratically over a 1 m^2 area, before returning to cover under the submerged log.

The third observation occurred on the morning (0700–1030 hr PDT) of 3 May 1989 in a shallow (0.15 m mean depth), slow-flowing (5–10 cm/sec) section of Fox Creek. I initially observed five juvenile steelhead maintaining their position at the end of a narrow chute between two small boulders. One of the fish swam rapidly towards the streambed in apparent pursuit of a prey item. When it was approximately 2–3 cm from a crevice formed by one of the boulders and the streambed a large salamander lunged from the crevice, attempting, but failing to capture the fish. All five fish rapidly dispersed. I returned to this site 30 min later and observed three fish in the same position, but could not see the salamander. Several minutes later, a small branch fell from an overhanging tree into the stream inducing the fish to seek cover. One of the fish swam into the crevice between the two boulders and was attacked and captured by the salamander I had observed earlier. The fish was nearly 50% ingested immediately after being grasped. As in the previous observations the salamander vigorously shook its head from side to side while subduing the fish. During this time it swam into a shallow area near the stream margin (a distance of approximately 2 m) where it remained entirely exposed until the fish was completely ingested (a process that took 3–4 min), after which it crawled beneath a large stone less than 1 m away.

DISCUSSION

Acts of predation by cryptic predators, such as larval salamanders that are typically under cover much of the day, are rarely observed in nature. The observations and records of stomach contents presented here provide interesting insights into the natural history of two of the most common vertebrates inhabiting Pacific Northwest streams. That only small YOY salmonids were consumed by larval salamanders, and the majority were found in samples collected in spring and early summer, suggests the importance of this interaction may be restricted seasonally. In addition, juvenile salmonids are among the largest prey consumed by larval *Dicamptodon* (Parker, in press) and, as shown here, only larger salamander size classes are capable of capturing and ingesting them (Fig. 1). Larval *Dicamptodon* size distributions vary considerably among streams of different sizes and with different flow regimes (Nussbaum and Clothier 1973). Thus, among streams, the frequency of predation on juvenile salmonids by larval *Dicamptodon* will depend in large part on salamander population structure and the density of larger size classes. For example, Fig. 1 illustrates differences in salamander size distributions between North Fork Caspar and Fox creeks, and shows that a larger proportion of the population in Fox Creek is capable of consuming juvenile fish. Assuming a threshold size of 88 mm TL (Table 1), the proportions of the two populations capable of consuming fish would be 14.3% and 50.0% for North Fork Caspar and Fox creeks, respectively.

A common feature of the three direct observations was that fish were "ambushed" by salamanders that were initially under cover. Thus, a key factor likely to influence the interaction between larval salamanders and juvenile salmonids is overlap in their use of microhabitats, particularly their use of similar cover objects. Crevices among large stones and under large organic debris are used as cover by both. An interesting question that arises from this observation is whether or not juvenile fish can detect the presence of large salamanders under specific cover objects and avoid these objects as a means of reducing predation risk.

Larval *Dicamptodon* feed predominantly on benthic macroinvertebrates and terrestrial invertebrates that fall into the stream (Metter 1963; Antonelli et al. 1972; Parker, in press). Although individual large prey, such as juvenile salmonids, are uncommon in the diet they may be energetically important to individual salamanders. Larval *Dicamptodon* in Fox Creek were shown to have daily consumption rates that were approximately 2% of their body mass (Parker 1992). Based on records presented here, a single juvenile salmonid can represent between 3.2 and 26.2% of a salamander's body mass. Although such large individual meals may provide substantial energetic benefits, they may also have associated costs. For example, increased activity while capturing and subduing a large prey item, and reduced mobility after ingesting it, may increase the susceptibility of larval salamanders to their own predators.

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RANGE EXTENSION AND HABITAT OF *PEROMYSCUS TRUEI* IN EASTERN OREGON

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Hall (1981:704), based on Hoffmeister's (1951) monograph, listed marginal records of the piñon mouse, *Peromyscus truei*, east of the Cascade Range in Oregon as: "Warmsprings," [Jefferson Co.]; "Crooked River, 20 mi. [12.4 km] SE Prineville," [Crook Co.]; and "Crooked River, 4 mi. [2.5 km] W Bear Creek," [Crook Co.]. Since 1972, we (LNC, BJV, and students in our classes) collected 57 specimens at 18 localities in the vicinity of these records (Fig. 1).

In April 1981, a student from Boise State University on a field trip conducted by EY collected a specimen on the east face of Steen's Mountain, Harney Co. However, the locality was not recorded in the literature because the specimen and field notes, to our knowledge, were not deposited in any mammal collection.

On 19 June 1992, based on EY's recollection and verbal description of the locality at which the specimen was collected in 1981, we (LNC, BJV, and LFA) set 19 Sherman live traps on a series of four rimrocks, each 1–2 m high, on a south-facing slope low on the east face of Steen's Mountain 28.0 km N, 10.6 km E Fields (T30S, R35E, Sec. 35 and T31S, R35E, Sec. 2), Harney Co., Oregon. Western juniper (*Juniperus occidentalis*) trees 0.6–0.8 m in diameter at breast height grew from crevices in the rimrocks; big sagebrush (*Artemisia tridentata*), cheat grass (*Bromus tectorum*), and smaller junipers dominated between the rimrocks. Four *P. truei* were captured at the site on 20 June 1992; prepared specimens were deposited at the University of Kansas Museum of Natural History (KU 145215–145218). We also sampled sites similar in physiognomy and vegetation on the northwest slope of Steen's Mountain 2.3 km N, 1.9 km E Diamond (T29S, R33E, E½ Sec. 11) and 0.2 km S, 0.2 km W Ant Hill (T29S, R33E, SW¼NE¼ Sec. 36), Harney Co., Oregon. We captured two juvenile *P. truei* at the first of these sites on 22 June 1992 (KU 145219–145220). These localities extend the range of *P. truei* in Oregon approximately 225 km southeast of previously published records (Fig. 1).