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OBSERVATIONS OF *JUGA* IN THE DIET OF LARVAL PACIFIC GIANT SALAMANDERS (*DICAMPTODON TENEBROSUS*)

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The Pacific giant salamander, *Dicamptodon tenebrosus*, is often the dominant vertebrate in small, high gradient, head water streams of the Pacific Northwest (Murphy and Hall 1981; Corn and Bury 1989). Murphy and Hall (1981) found larval *D. tenebrosus* to account for as much as 99% of total predator biomass in small streams in western Oregon and northern California. Despite studies of the diet and foraging ecology of *Dicamptodon* (Antonelli and others 1972; Parker 1992, 1993, 1994) the pleurocerid snail *Juga* spp. has rarely been reported as a significant dietary component. *Juga* spp. inhabit many low elevation streams in western Oregon and composes up to 90% of invertebrate standing crop biomass in certain streams (Hawkins and Furnish 1987).

Although *Juga* are presumably easily captured by salamanders, the thick, hard shell is considered to provide protection from vertebrate predators (Hawkins and Furnish 1987). Here, we report predation by larval *D. tenebrosus* on *Juga* and compare salamander diets in stream reaches with and without *Juga*.

The study was conducted on two reaches of Lookout Creek in the H.J. Andrews Experimental Forest, Lane County, Oregon. Lookout Creek is a 4th order stream located on the west slope of the Cascade mountains. Substrate primarily consists of cobble and small boulders. Woody riparian vegetation is dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and willow (*Salix spp.*) For detailed description see Nakamura and Swanson (1994).

We used Smith-Root backpack electrofishers to capture 20 larval *D. tenebrosus* from pool habitats in each reach. We sampled the lower reach (*Juga* present) on 3 August 1995 and the upper reach (*Juga* absent) on 5 September 1995. We attempted to collect individual salamanders of approximately the same size. The lower reach (460 m elevation) on Lookout Creek starts 1 km above the confluence with Blue River reservoir and the upper reach (590 m elevation) starts 7 km above the confluence.

Salamanders were held for 2 to 3 hr before being anesthetized with a dilute solution of MS-222 (tricaine methanesulfonate). We measured total length (TL) and snout-vent length (SVL) of each individual to the nearest mm and mass to the nearest 0.1 g. Stomach contents were flushed (Legler and Sullivan 1979) and preserved in 95% ethanol. Salamanders were released after a 6-hr recovery period. We tested stomach flushing on 6 *D. tenebrosus* from Tidbits Creek (a tributary to Blue River) by first flushing their stomachs and then removing and examining the remaining contents of their digestive tracts. Flushing removed all of the contents of the stomach (including large items) as well as the contents of the 1st quarter of the intestine.

We identified prey items to the most specific taxonomic level possible, usually family or genus. All identifiable prey items and parts were considered in the analysis, unless the possibility of counting individual prey items multiple times existed. In these cases, we recorded the minimum number possible for that particular taxon. Any items that could not be identified to at least the level of order were not considered in the analysis.

Mean SVL of larval *D. tenebrosus* was 113 mm in the upper reach and 121 mm in the lower reach ($t = 1.91$, $p = 0.063$). Mean TL was 191 mm in the upper reach and 206 mm in the lower reach ($t = 1.91$, $p = 0.063$). Mean mass was 49.5 g in the upper reach and 57.5 g in the lower reach ($t = 1.68$, $p = 0.10$).

We identified 327 prey items from 20 stomachs in the upper reach and 99 prey items from 19 stomachs (1 was empty) in the lower reach (Table 1). The mayfly *Baetis* was the most numerous item in stomachs in the upper reach; one stomach contained 110 subimagoes. *Juga* was the most frequent prey item in the lower reach, occurring in 12 of 20 (60%) stomachs. One individual had 11 *Juga* flushed from its digestive tract. Crayfish (Astacidae: *Pacifasticus*) were common prey items for *D. tenebrosus* in both reaches. In the upper reach the remains of 9 crayfish were identified in 8 individuals. In the lower reach 9 crayfish were identified in 9 individuals. *D. tenebrosus* were found with both crayfish parts (usually the chelae) and whole crayfish in their stomachs.

Number of prey per stomach was greater in the upper reach than in the lower reach (Mann-Whitney *U*-test, $z = 2.498$, $p = 0.012$). Eight stomachs from the upper reach contained > 10 prey items and 14 stomachs from the lower reach contained 0 to 5 prey items (Fig. 1). A greater diversity of prey were taken in the upper reach where 9 stomachs contained ≥ 6 different taxa, compared to the lower reach, where the greatest number of taxa recorded from a single stomach was 5, and 12 stomachs contained ≤ 3 taxa.

Several hypotheses may explain the observed differences in diet. First, the prey base composition may differ between the reaches. Hawkins and Furnish

TABLE 1. List of all prey items with occurrence frequency (% of stomachs in which each taxon occurs), total number of each taxon in the group (N), mean ($N/20$), and standard deviation (SD) of the mean.

Prey item	Occurrence (%)	N	Mean	SD
Upper reach				
Ephemeroptera				
Baetidae	45	150	7.5	24.40
Baetis	40	148[a]	7.4	24.43
Siphlonuridae				
Ameletus	60	23	1.15	1.46
Leptophlebiidae				
Paraleptophlebia	25	11	0.55	1.15
Heptageniidae	50	14	0.70	0.86
Ephemerellidae	35	9	0.45	0.69
Timpanoga	25	5	0.25	0.44
Other Ephemeroptera	70	39	1.95	2.39
Trichoptera				
Glossosomatidae	45	28	1.4	2.37
Lepidostomatidae				
Lepidostoma	20	5	0.25	0.55
Hydropsychidae	5	2	0.10	0.45
Philopotamidae				
Wormaldia	5	1	0.05	0.22
Polycentropodidae				
Polycentropus	5	1	0.05	0.22
Limnephilidae	10	3	0.15	0.49
Other Trichoptera	40	10	0.50	0.69
Plecoptera				
Leuctridae	5	1	0.05	0.22
Perlidae	25	5	0.25	0.44
Coleoptera				
Elmidae	10	2	0.10	0.31
Diptera				
Tipulidae	10	2	0.10	0.31
Hydracarina	20	6	0.30	0.73
Terrestrial insects	15	5	0.25	0.64
Decapoda				
Astacidae				
Pacifasticus	40	9	0.45	0.60
Cottidae	5	1	0.05	0.22
Total		327		
Lower reach				
Pleuroceridae				
Juga	60	53	2.65	3.34
Ephemeroptera				
Baetidae	15	3	0.15	0.37
Baetis	5	1	0.05	0.22
Siphlonuridae				
Ameletus	20	4	0.20	0.41
Leptophlebiidae				
Paraleptophlebia	15	3	0.15	0.37
Heptageniidae	20	4	0.20	0.41
Other Ephemeroptera	40	9	0.45	0.60
Trichoptera				
Lepidostomatidae				
Lepidostoma	10	2	0.10	0.31
Other Trichoptera	15	4	0.20	0.52
Plecoptera				
Leuctridae	5	1	0.05	0.22
Other Plecoptera	5	1	0.05	0.22
Coleoptera				
Elmidae	5	1	0.05	0.22
Orthoptera				
Tridactylidae	5	1	0.05	0.22

TABLE 1. Continued.

Prey item	Occurrence (%)	N	Mean	SD
Diptera				
Chironomidae	10	2	0.10	0.31
Hydracarina	5	1	0.05	0.22
Decapoda				
Astacidae				
Pacifasticus	45	9	0.45	0.51
Cottidae	5	1	0.05	0.22
Total		99		

[a] One stomach contained 110 *Baetis* subimagoes.

(1987) suggested that *Juga* is a competitive dominant in some streams and may profoundly influence abundances of other invertebrates, specifically less mobile scrapers and collector-gatherers. Quantitative analysis of invertebrate populations is needed to assess prey availability and whether or not *Juga* may be competing with other invertebrates in the lower reach. Second, *D. tenebrosus* may select *Juga* (optimal foraging behavior). For example, low search and handling time may result in a preference for *Juga*. Lastly, *Juga* shells may remain in the digestive tract of *D. tenebrosus* for extended periods, thus resulting in an overestimate of their dietary importance and possibly preventing ingestion of other prey. Dietary analyses require the assumption that all food items are digested at equal rates. Larger items should take longer to digest due to their low surface-to-volume ratios. Prey items housed inside protective shells or exoskeletons may also take longer to digest. *Juga* shells were observed in the intestines of dissected salamanders, leading us to believe that the shells are passed completely through the digestive tract. Further study with replicated sites and measures of prey base composition and dietary electivity will be required to determine specific causal mechanisms responsible for the observed difference in diets.

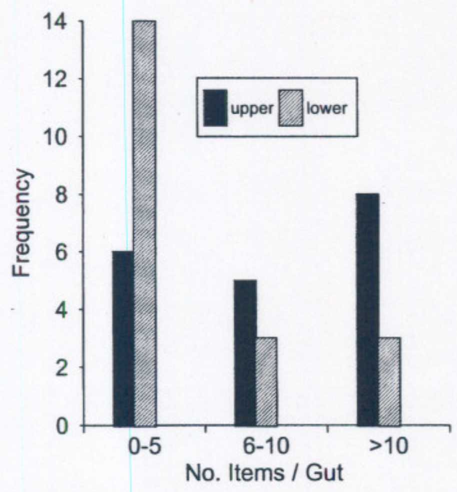

FIGURE 1. Frequencies for number of prey items per gut with one outlier removed from the upper population (outlier value = 124).

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