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Studies of the Habitat and Food of Sympatric Populations of *Plethodon cinereus* (Green) and *Plethodon dorsalis* Cope in South Central Parke County, Indiana

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Introduction

The purpose of this study was to examine the ecological relationships between sympatric populations of the closely related red-backed salamander, *Plethodon cinereus* (Green), and the zigzag salamander, *Plethodon dorsalis* Cope. At one time regarded as conspecific, these salamanders are now established as separate species (Thurow, 1955, 1956; Highton, 1962).

Highton (1962) stated that sympatric populations of the two species occur in Georgia, Tennessee, Oklahoma, and Indiana, and that hybridization had not been reported. Highton (1962) also said that the two species appear ecologically separated even when occurring sympatrically, with *P. cinereus* being associated with the forest floor and *P. dorsalis* being associated with ravines and exposed rock. Rubin (1967) found no gross differences in the habitats of the species but noted that they were rarely found under the same object.

The objectives of this study were to compare the habitats (soil moisture and cover) and food of these two species in a Parke County, Indiana area where both occur.

Description of the Study Area

The study area was located in south central Parke County, Indiana, one and a half miles north of Rosedale and one mile east of Coxville, on a west-facing slope above the Raccoon creek flood plain. In many places the slope is cut by ravines, often the result of coal mining which took place around 1920. Outcroppings of limestone overlying sandstone are frequent along the slope. The soil ranges from forest humus in depressions and gently sloping areas to sandy gravel in steeper areas. A major portion of the study area was below a large limestone cliff.

The forest is beech-maple along the slopes and ravines, grading to oak-hickory in drier situations. Much of the forest is old growth, and in places there is undergrowth of sassafras (*Sassafras albidum*), pawpaw (*Asimina triloba*), redbud (*Cercis canadensis*) and other shrubs. Herbaceous plants, particularly touch-me-not (*Impatiens* sp.), are often dense in less shaded areas. Ferns are common in the ravines.

Methods and Materials

Salamander studies are often based on specimens collected by sampling methods that could introduce bias, such as by collecting only under stones and logs and by disregarding leaf litter. In order to eliminate this bias, all cover was examined in randomly selected plots.

This study was based on 71 individuals of *P. dorsalis* and 72 of *P. cinereus* taken between September 24 and November 22, 1967, from random plots within the study area. The salamanders were preserved in alcohol.

Salamanders were later examined with a dissecting microscope and measured with calipers and a millimeter ruler. Species, pattern, secondary sex characteristics, and snout-vent length were noted. The stomach was removed and its contents identified. The intestine was examined for parasites. The gonads were measured, and color and degree of development were noted. In each mature female, the number of developing eggs was counted, and the largest and smallest eggs were measured.

The study area was a 1000 by 2000 foot wide area along an east-west slope parallel to the ridge. This area was mapped, divided into wet (stratum I) and dry (stratum II) portions, and divided into 8000 five by five foot plots, which were numbered consecutively. Random plots for study were selected via a random numbers table. Plots were located in the field by pacing appropriate distances from the nearest permanent marker to the northwest corner of the plot.

The moist stratum consisted of 1194 plots lying below a limestone cliff and along ravines. Stratum II consisted of the remainder of the area. A total of 266 plots was examined from August 27 to November 22, 1967. A total of 221 plots was examined in the moist area, with 77 yielding 143 salamanders, whereas the 45 plots in stratum II yielded three salamanders. A border of leaf litter six inches wide surrounding each plot was removed so that any organisms moving to or from the plot could be seen. A sketch was made showing rocks, woody material and leaf litter. Percentage estimates were made of the amount of canopy cover, understory cover and herbaceous cover as each of these appeared looking down upon the plot. The per cent of the individual species forming each cover layer was noted. An estimate of per cent leaf litter, woody material and stone covering the surface of each plot was made. Leaf litter depth was estimated. Soil texture (humus, sand, gravel or clay) and per cent slope were recorded. A soil sample was placed in a plastic bag for later moisture estimates. Soil samples were weighed, then dried in a drying room at approximately 40°C and reweighed until no further weight loss occurred for two consecutive weighings. Soil moisture was recorded as per cent wet weight.

Each plot was examined for salamanders and invertebrates by removing all movable rocks and wood material and sorting through all leaf litter and debris. At the time of capture, general characteristics of each salamander (species, size, color phase, and pattern irregularities) were recorded. One square foot of leaf litter around each salamander was collected and placed in a plastic bag for examination for invertebrates. The cover the salamander was under was noted.

Leaf litter samples were placed in Berlese funnels until dry to extract invertebrates. Invertebrates were preserved in 70% alcohol and identified and counted with the aid of a dissecting microscope.

Results

Size Distribution

Snout-vent lengths of the salamanders were graphed (Figure 1). They fell into three groups. These groups probably reflect the ages of the salamanders, the first group representing hatchlings of the year (13-22 mm.), the second representing salamanders one year old (23-32 mm.), and the third representing salamanders two or more years old (33-47 mm.). This assumption is supported by the fact that the salamanders in the third group were mature individuals and Thurow (1955) indicated that both species mature in two years. These groups form the three size classes referred to throughout this paper.

The snout-vent length distributions of the two species indicate that their maturation rates are similar. Both species mature in two years, and growth is slower after maturation.

P. dorsalis	Length in Millimeters	P. cinereus	
	13	H	
HH	14	HH	
HHHH	15	HHHHH	
HHHHHHHHHH	16	HHHH	
HHHHHH	17	HHH	Hatchlings
HHHHHH	18	HH	
HHH	19	H	
H	20		
	21	H	
	22		
	23	H	
	24	HH	
HH	25	H	
HHHHH	26	H	
H	27	HHH	
H	28	HHHH	
HH	29	HHHHHH	One Year Old
HH	30	HH	
HHH	31	H	
	32	H	
N	33	EE	
	34	EN	
E	35	E	
N	36		
NNN	37	E	Two Years and Older
NEE	38	NNNN	
NEE	39	EEEN	
NN	40	EEENNNNN	
N	41	EEE	
E	42	N	
NNN	43		H = immature salamander
N	44	N	
N	45		E = mature male
E	46		
N	47		N = mature female

FIGURE 1. Snout-vent lengths of 71 *P. dorsalis* and 70 *P. cinereus* taken in south central Parke County, Indiana, during the fall of 1967.

Sex Ratios

During the study 28 mature individuals of *P. cinereus* were taken, 14 males and 14 females, twenty-three of *P. dorsalis*, seven males and 16 females. Although this difference contrasted markedly with *P. cinereus* and its 50:50 ratio, it was not significant (Chi-Square = 1.76, 1 df), and may have been due to chance. However, such sex ratios have been reported for other Plethodons (Dumas, 1956).

Eggs

The mean number of developing eggs in 15 mature individuals of *P. dorsalis* was 6.33 and in 14 of *P. cinereus* it was 8.29. This difference was not significant (T = 1.703, 27 df). These means were slightly higher than means reported by Thurow (1955) (*P. dorsalis*, 4; *P. cinereus*, 7).

Cover

Highton (1962) reported that the two species appeared ecologically separated in sympatric populations with *P. cinereus* being associated with the forest floor and *P. dorsalis* with exposed rock and ravines. Comparison of the average cover percentages per plot of the three major types of cover (leaf litter, rock and wood) revealed no significant differences between the cover types utilized by these species (Table 1).

TABLE 1. Occurrence of salamanders by size class and per cent per plot of different cover types for 68 *P. dorsalis* and 71 *P. cinereus* from Parke County, Indiana, during the fall of 1967

		P. dorsalis			*P. cinereus*	
Size Class	Wood	Rock	Leaf Litter	Wood	Rock	Leaf Litter
10-24 mm.	8	10	12	2	4	11
25-34 mm.	5	7	5	3	13	13
35+ mm.	4	16	11	6	8	11
Total	17	23	28	11	25	35
Avg. % cover per plot	5.0	23.5	64.5	5.5	23.9	66.5
No. salamanders expected from avg. % cover	3.7	17.2	47.2	3.9	17.6	49.2
% salamanders occurring in cover types	24.3	32.9	40.0	15.5	35.2	49.3

Both were in significantly greater numbers under wood and rocks and fewer under leaf litter (*P. cinereus*, Chi-Square = 19.91, 2 df; *P. dorsalis*, Chi-Square = 54.2, 2 df). There was no significant difference in cover between *P. dorsalis* and *P. cinereus* (rock, Chi-Square = 0.002, 1 df; leaf litter, Chi-Square = 2.61, 1 df; wood, Chi-Square = 0.79, 1 df) but the figures suggest that *P. cinereus* may have a slight preference for leaf litter and *P. dorsalis* for wood cover, while both have nearly equal affinity for rock (Table 1).

There was no apparent correlation between size class and cover either within or between species (Table 1).

The two species were found occurring together in 16 of the 221 plots examined in the favorable strata. This is significantly greater than would be expected by chance (Chi-Square = 108.1, 1 df).

Rubin (1967) reported that the two were seldom found under the same object. This was true in the present study, except for two instances. Two immature individuals were found under a rock and two mature females were found in a depression under leaf litter.

Moisture

Comparison of the per cent moisture at the site of collection showed a significant difference between the two species (Table 2). *P. dorsalis* was found in the moister habitat ($F = 5.53$, $df = 1,137$). Comparison of the moisture of plots containing *P. dorsalis, P. cinereus*, and those without salamanders showed a significant difference ($F = 6.00$, $df = 2,220$). Plots with salamanders had a higher per cent moisture than those without salamanders. Often *P. dorsalis* was found in an area of seepage below a limestone bluff where the soil was nearly saturated. *Plethodon cinereus* was seldom found in this type of situation, but inhabited drier environments.

TABLE 2. Average per cent moisture of plots.

Type of Plot	Number of plots examined	Number of salamanders captured	Average % moisture
Stratum I (less favorable)	45	3	23.2
Stratum II (favorable)	221	140	31.6
P. dorsalis found	41	71	35.5
P. cinereus found	45	72	31.1
No salamanders found	189	—	28.9

Food

The food of *P. cinereus* has been described by several writers (Smallwood, 1928; Hamilton, 1932; Jameson, 1944; and others). Little food study work has been published on *P. dorsalis*. Holman (1955) lists *P. dorsalis* foods as insects, spiders, mites, snails and slugs, concluding as did previous workers on *P. cinereus*, that it is an indiscriminate feeder with availability determining food items. Thurow (1955) concluded that any difference between food items of *P. cinereus* and *P. dorsalis* probably reflects habitat differences rather than food preference or feeding behavior, moisture being perhaps the most critical factor differentiating them.

The stomachs of 72 individuals of *P. cinereus* and 71 of *P. dorsalis* were examined. Five of the *P. cinereus* and 11 of the *P. dorsalis* stomachs were empty. Smallwood (1928) said that *P. cinereus* males taken during breeding season had very little food in their stomachs, but this was not the case in this study; 12 of 14 mature *P. cinereus* males taken had filled stomachs. Ten of the 11 *P. dorsalis* without food were small and immature ($N = 10$, Range $= 14.7$-25.6 mm., $\bar{x} = 18.45$ mm.) while two of the five *P. cinereus* (19.5 mm. and 18.6 mm.) were small and immature. The reason for the number of small *P. dorsalis* in this category may be that hatchlings of these species, but particularly *P. dorsalis*, apparently feed little if at all before hibernation (Thurow, 1955).

A summary of the stomach contents for the 67 *P. cinereus* and 60 *P. dorsalis* with filled stomachs is presented (Table 3). *Plethodon cinereus* consumed a greater variety of food items than did *P. dorsalis.* Insect material comprised approximately half of the food items in each species, although *P. cinereus* ate a significantly greater number of insects than *P. dorsalis*, 576 items to 308 items respectively (Table 1, Chi-Square = 25.90, 1 df).

Plethodon cinereus consumed more small items than did *P. dorsalis* (mites, 194 to 166 respectively; and Collembola, 324 to 162 respectively). *Plethodon cinereus* also ate a greater quantity (125 items) and variety (10 families) of Coleoptera than did *P. dorsalis* (54 items, 6 families).

Both species ate many larvae with *P. cinereus* eating more Coleoptera and Diptera larvae and *P. dorsalis* more Lepidoptera larvae.

P. cinereus ate a greater variety (13 groups to 10 groups) of non-insect materials but *P. dorsalis* ate a greater quantity (57.9% as compared to 46.3% volume), due mainly to the greater number of earthworms.

The stomachs of *P. cinereus* showed a high occurrence of seeds, but it is likely that these were accidentally taken with other food items. Although *P. dorsalis* contained fewer seeds than *P. cinereus*, it had a greater amount of vegetable material (1.97% to 0.36%) volume.

The most important food items by per cent volume (Table 4) show some differences between the species. *Plethodon dorsalis* ate significantly more earthworms (Table 4, Chi-Square = 10.02, 1 df), its major food item, than did *P. cinereus.* Coleoptera, the major food item of *P. cinereus*, was eaten in significantly greater numbers by *P. cinereus* than by *P. dorsalis* (Table 4, Chi-Square = 6.63, 1 df). This difference of beetles vs earthworms was the most striking of the food differences between the two species. Among beetles, the family Anthicidae was most important with a significant difference (Table 3, Chi-Square = 11.16, 1 df). *Plethodon cinereus* ate significantly more Collembola (Table 4, Chi-Square = 18.80, 1 df). Araneids, sixth in importance by volume to *P. cinereus*, were seldom eaten by *P. dorsalis.*

Size is surely an important factor when considering the food habits of salamanders, since as the salamander grows older it can ingest larger pray. Smaller *P. dorsalis* and *P. cinereus* ate more small food items such as mites and Collembola than the larger *P. dorsalis* and *P. cinereus* (Table 5). Chi-Square test on the size classes of both species indicate a significant difference in the consumption of mites (*P. dorsalis*, Chi-Square = 53.06, 2 df; *P. cinereus*, Chi-Square = 6.02, 2 df) and Collembola (*P. dorsalis*, Chi-Square = 40.53, 2 df; *P. cinereus*, Chi-Square = 27.30, 2 df).

Larger *P. dorsalis* and *P. cinereus* ate greater numbers of larger food items such as earthworms and Coleoptera, though Coleoptera formed a larger per cent volume in the smaller size class of *P. dorsalis* than the larger size class (Table 5). Chi-Square tests on the size classes in both species indicate a significant difference in the consumption of earthworms (*P. dorsalis*, Chi-Square = 49.97, 2 df; *P. cinereus*, Chi-Square – 23.32, 2 df) and Coleoptera (*P. dorsalis*, Chi-Square = 11.31, 2 df; *P. cinereus*, Chi-Square = 43.81, 2 df).

The small *P. dorsalis* ate more mites and Collembola than the small *P. cinereus* and, although these food items became less important in the larger size classes, the large *P. cinereus* ate more mites and Collembola than the large *P. dorsalis* (Table 5). Chi-Square tests on the smallest size class indicate no significant difference between species (mites, Chi-Square = 2.56, 1 df; Collembola, Chi-Square = 0.35, 1 df). In the largest size class *P. dorsalis* ate significantly more mites than *P. dorsalis* (Chi-Square = 4.97, 1 df), but there was no significant difference in the consumption of Collembola (Chi-Square = 0.35, 1 df).

TABLE 3. A stomach analysis of 67 *Plethodon cinereus* and 60 *P. dorsalis* from south central Parke County, Indiana, taken during the fall of 1967

	P. dorsalis			*P. cinereus*		
	Total Items	% Freq.	% Vol.	Total Items	% Freq.	% Vol.
Total insects	(308)*	(42.1)	(576)		(53.7)	
COLEOPTERA	(54)		(8.1)	(125)		(20.7)
Anthicidae	16	15.0	1.8	63	41.8	9.3
Cucujidae	1	1.7	.1	11	14.9	2.0
Histeridae	11	11.7	1.5	9	10.5	1.3
Curculionidae	1	1.7	.2	1	1.5	.2
Staphylinidae	1	1.7	.2	1	1.5	.2
Phalacridae	—	—	—	3	4.5	1.0
Chrysomelidae	—	—	—	1	1.5	.1
Elateridae	—	—	—	2	3.0	.4
Pselaphidae	—	—	—	2	1.5	.3
Dascillidae	2	1.7	.1	—	—	—
Unid. Coleoptera	16	23.3	4.3	10	11.9	1.5
Coleoptera Larvae	6	8.3	.3	22	28.4	4.5
HOMOPTERA	(7)		(1.0)	(9)		(3.2)
Cercopidae	2	3.3	.5	3	4.5	1.9
Cicadellidae	1	1.7	.3	3	4.5	.6
Aphididae	2	3.3	.1	1	1.5	.1
LEPIDOPTERA Larvae	9	13.3	4.2	10	9.0	2.8
NEUROPTERA Larvae	3	5.0	.6	1	1.5	.2
MECOPTERA	—	—	—	1	1.5	.1
Unid. Misc. Larvae	6	10.0	1.1	.11	9.0	.6
TOTAL NON-INSECTS	(293)		(57.9)	(311)		(46.3)
Earthworms	105	60.0	36.7	57	35.9	19.9
Araneida	5	5.0	.6	18	23.9	3.7
Gastropoda	4	6.7	.6	18	14.9	1.5
Isopoda	—	—	—	4	4.5	1.0
Chilopoda	1	1.7	.2	1	1.5	.1
Diplopoda	—	—	—	2	3.0	.3
Pseudoscorpionida	1	1.7	.2	4	5.9	.4
Nematoda	—	—	—	4	3.0	.1
Shed Skin	2	3.3	.4	2	3.0	.9
Misc. Animal Material	—	38.3	12.8	—	49.21	14.0
Mites	166	58.3	4.6	194	64.2	3.1
Seeds	11	10.0	.4	9	9.0	1.1
Misc. Plant Material	—	11.7	2.0	—	4.5	.4
TOTAL	(601)			(887)		
Unid. Homoptera	2	3.3	.1	2	3.0	.6
DIPTERA	(37)		(12.98)	(59)		14.1
Misc. Diptera	9	11.7	3.8	12	10.5	.5
Bibionidae Larvae	4	7.7	2.3	19	17.9	5.9
Misc. Diptera Larvae	24	40.0	6.9	28	41.8	7.7
HEMIPTERA	(10)		(2.9)	(8)		(1.8)
Tingidae	7	10.0	1.6	5	7.5	.5
Pentatomidae	2	1.7	1.0	—	—	—
Cydnidae	1	1.7	.3	—	—	—
Hydrometridae	—	—	—	1	1.5	.5
Anthocoridae	—	—	—	1	1.5	.6
Misc. Hemiptera	—	—	—	1	1.5	1.2
HYMENOPTERA	(20)		(2.4)	(28)		(2.4)
Formicidae	15	20.9	2.0	19	18.3	1.2
Misc. Hymenoptera	5	6.7	.3	9	9.0	.5
COLLEMBOLA	(162)		(8.4)	(324)		(6.2)
Smynthuridae	43	36.7	3.0	93	44.8	1.8
Entomobyridae	67	53.3	4.0	100	47.8	3.4
Poduridae	52	25.0	1.5	131	19.4	1.6

*Numbers in parentheses indicate totals for that category

Table 4. Major food items by per cent volume from a stomach analysis of 60 *P. dorsalis* and 67 *P. cinereus*

P. dorsalis				*P. cinereus*			
FOOD ITEM	% VOL.	% FREQ.	NO. of ITEMS	FOOD ITEM	% VOL.	% FREQ.	NO. of ITEMS
Earthworms	36.7	60.0	105	Coleoptera	20.7	66.3	125
Diptera	13.0	40.0	37	Earthworms	19.9	35.8	57
Misc. animal Material	12.8	38.3	—	Diptera	14.1	46.5	59
Collembola	8.4	58.7	162	Misc. Animal Material	14.0	49.2	—
Coleoptera	8.1	31.3	54	Collembola	6.8	72.3	324
Mites	4.6	58.3	166	Araneida	3.7	23.9	18
Lepidoptera	4.2	13.3	9	Homoptera	3.2	12.0	9
Hemiptera	2.9	11.7	10	Mites	3.1	64.2	194
Hymenoptera	2.4	27.6	20	Lepidoptera	2.8	9.0	10
Misc. Veg. Material	2.0	11.7	—	Hymenoptera	2.4	24.3	28
Unid. Larvae	1.1	10.0	6	Hemiptera	1.8	12.0	8
Homoptera	1.0	10.0	7	Gastropoda	1.5	14.9	18
Araneida	0.6	5.0	5	Seeds	1.1	9.0	9
Gastropoda	0.6	6.7	4	Isopoda	1.0	4.5	4
Shed Skin	0.4	3.3	2	Shed Skin	0.9	3.0	2
Seeds	0.4	10.0	11	Chaetopoda	0.4	5.9	4

Between the smallest size classes of the species there was no difference in the number of Coleoptera eaten. Comparing the middle and large size classes, *P. cinereus* ate significantly more Coleoptera than *P. dorsalis* (Chi-Square = 5.27, 1 df) and *P. dorsalis* ate significantly more earthworms (Chi-Square = 15.54, 1 df).

Table 5. A comparison of food items eaten in different size classes of *P. dorsalis* and *P. cinereus*

	P. dorsalis			*P. cinereus*		
	10-24 mm. (24)*	25-34 mm. (14)	35+ mm. (22)	10-24 mm. (21)	25-34 mm. (24)	35+ mm. (22)
SMALL ITEMS						
Collembola						
% Vol.	18.4	3.1	.9	11.5	7.3	3.9
% Freq.	75.0	57.1	27.3	57.1	54.2	42.7
No. Items	89	82	32	103	32	27
Mites						
% Vol.	9.6	2.6	.4	6.0	2.4	1.1
% Freq.	75.0	71.4	31.2	76.2	66.7	50.0
No. Items	108	37	21	68	79	47
LARGE ITEMS						
Coleoptera						
% Vol.	9.2	6.9	6.5	9.0	23.3	21.6
% Freq.	7.9	18.2	14.1	19.6	64.2	50.8
No. Items	8	13	37	7	35	63
Earthworms						
% Vol.	17.2	35.7	58.7	14.3	18.3	27.0
% Freq.	37.5	64.3	81.2	28.6	29.2	50.0
No. Items	9	28	68	8	13	36

*Figures in parentheses represent number of individuals in each size class

A comparison between per cent items in stomachs and per cent items in Berlese samples was used to determine relative predilection, but it has shortcomings since many factors important to salamanders, such as size of an organism, its ability to escape, or its occurrence in a humus layer different from the one that the salamander feeds in, are not reflected in funnel extractions. For example, the habitat samples contained large percentages of Chilopoda and Araneida while only small percentages were found in the stomach samples because the large size of many of them may have discouraged predation. Further, the efficiency of the sample method is undetermined (Murphy, 1962). Accuracy may be lessened because it fails to extract inert stages, predation may occur during the drying period, and unknown factors may reduce the extraction of other organisms. The discrepancy between the small percentage of earthworms and the large percentage found in stomachs indicate an inefficient extraction technique for them.

To determine selectivity, a comparison index was calculated using per cent of stomach items and per cent of Berlese sample items. The larger value was divided by the smaller for each item. An index value of one indicates that items in the stomachs and in the habitats were the same. Positive values indicate that items occurred more often in stomachs and negative values that items occurred more often in Berlese samples (habitats).

Because of the inefficiencies of the Berlese method in reflecting the items available to the salamander, the comparison index does not accurately reflect the sensitivity of a species and must be weighed lightly. It can be used to show differences in selection between species since Berlese samples for both species are comparable, by examining the comparison index for both species. A higher value indicates that the species takes a larger per cent of the items available, thus showing a stronger selection for the item than the other species (Table 6).

TABLE 6. A comparison in per cent of items in stomachs to items in the habitat (Berlese funnel samples) for *P. dorsalis* and *P. cinereus* Comparison index = higher per cent items divided by lower per cent item. Positive values indicate higher per cent items in the stomach, negative values indicate higher per cent items in the Berlese sample.

	P. dorsalis			*P. cinereus*		
Food Item	% of Stomach Items	% of Berlese Items	Comparison Index	% of Stomach Items	% of Berlese Items	Comparison Index
Mites	26.56	51.77	−1.94	21.17	58.13	−2.
Collembola	25.92	3.70	7.00	35.36	4.05	8.
Earthworms	16.80	——	——	6.22	0.27	23.
Diptera	12.16	3.36	3.62	10.69	6.90	1.
Coleoptera	8.16	−2.49	13.68	13.68	11.83	1.
Hymenoptera	3.20	3.03	1.06	3.05	1.62	1.
Hemiptera	1.60	1.50	1.07	.84	2.30	−2.
Lepidoptera	1.44	0.32	4.50	1.09	——	——
Homoptera	1.28	0.84	1.52	0.95	0.67	1.
Unid. larvae	0.96	——	——	1.20	——	——
Spiders	0.80	13.15	−16.44	1.96	9.62	−4.9
Gastropoda	0.64	0.32	2.00	1.96	——	——
Centipede	0.16	1.85	−11.56	.10	3.11	−31.10
Pseudoscorpion	0.16	——	——	0.43	0.40	1.08
Neuroptera larvae	0.16	——	——	0.32	——	——
Isopoda	——	——	——	0.42	——	——
Diplopoda	——	——	——	0.21	——	——
Mecoptera	——	——	——	0.10	——	——

Mites are more numerous in *P. cinereus* habitats than *P. dorsalis* habitats (58.13% and 51.77% respectively) although eaten more often by *P. dorsalis* (26.56%) than *P. cinereus* (21.17%). Thus *P. dorsalis* shows a greater selectivity for mites than does *P. cinereus*.

Coleoptera, although found more frequently in *P. dorsalis* habitat that in *P. cinereus* habitat (20.30% and 11.83% respectively), were more often eaten by *P. cinereus* than *P. dorsalis* (13.68% and 8.16% respectively), therefore indicating that *P. cinereus* selected for Coleoptera more than *P. dorsalis* did. Further *P. dorsalis* selects more Diptera, Hemiptera, and mites than does *P. cinereus, but P. cinereus* selects more Coleoptera, Araneida, Hymenoptera and Collembola. Items eaten only by one species or not appearing in Berlese samples were not comparable in this manner.

Further indications of differences in selection of items by the two species could be found by comparing the stomach contents of salamanders that occurred together, since both would be selecting from the same organisms. Examination of Berlese data from those plots in which both species occurred showed significant differences in the occurrence of Coleoptera (Chi-Square = 5.12, 1 df) and mites (Chi-Square = 6.36, 1 df).

Differences in the fauna surrounding the top species may indicate habitat differences better than measurement of physical characteristics since the combination of factors present affects each salamander and its surrounding fauna similarly. Comparison of Berlese funnel collections from capture sites of the two species suggests through the different fauna associated with each species that habitat differences do exist (Table 6). Diptera and Hemiptera were about twice as numerous in the habitat of *P. cinereus*, while Coleoptera and Hymenoptera were over twice as numerous in the *P. dorsalis* habitat.

TABLE 7. A comparison of per cent food items and per cent Berlese sample items for *P. dorsalis* and *P. cinereus* found in the same plots and in separate plots

Species	Coleoptera		Mites		Collembola	
	% Items	No. Items	% Items	No. Items	% Items	No. Items
P. cinereus w/*P. dorsalis* (26)*						
Stomach items	17.0	64	23.9	90	32.2	121
Berlese items	12.9	69	59.9	561	3.8	21
P. dorsalis w/*P cinereus* (28)						
Stomach items	8.8	18	25.6	70	22.3	69
Berlese items	23.9	120	52.7	349	3.6	19
P. cinereus (41)						
Stomach items	12.2	69	22.0	125	35.7	203
Berlese items	10.3	97	57.2	308	4.3	40
P. dorsalis (34)						
Stomach items	7.6	24	25.2	80	24.9	79
Berlese items	17.5	116	47.2	247	3.8	25

*Numbers in parentheses indicate the number of specimens in each group.

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