STUDIES ON THE BIOLOGY OF TWO AMBYSTOMID AND FIVE PLETHODONTID SALAMANDERS OF WESTERN OREGON

by

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STUDIES ON THE BIOLOGY OF TWO AMBYSTOMID AND FIVE PLETHODONTID SALAMANDERS OF WESTERN OREGON

Introduction

Studies of salamanders often omit certain phases of ecology which are necessary for tracing the complete cycle of a species' life history. The purpose of this study is to discover some of these omissions, and to add data to aspects of the life histories that seem, at present, inadequate.

Seven species of salamanders were collected and examined in order to compile data on (1) the behavior and habitat of individuals of each species in the field, (2) total-length frequency within the species, (3) differences in secondary sex characters exhibited by each species, (4) variations in the reproductive system at different stages of maturity, and (5) food items consumed by the individuals of each species.

The species studied in the investigation were Dicamptodon ensatus (adults and larvae), Rhyacotriton olympicus, Plethodon dunni, Plethodon vehiculum, Batrachoseps wrighti, Ensatina eschscholtzii oregonensis and Aneides ferreus.

Materials and Methods

A total of 464 specimens of salamanders was collected in the field. Specimens were collected in every month during 1953, except in August and September. All specimens were collected in Benton County, Oregon, except the 11 specimens of Batrachoseps

which were collected in Marion County, Oregon. Immediately after being collected, each specimen was placed in 70 per cent alcohol which acted as a killing and preserving agent, keeping the salamander and the contents of the digestive tract in excellent condition. For each salamander captured, the data recorded included information on slope, cover, vegetation, moisture, temperature, animal associates, occasional behavior notes, and the date.

In addition to the collected specimens, 30 salamanders (Dicamptodon larvae) now in the collection of the Museum of Natural History, Oregon State College, were studied.

Laboratory observations included the following information: species, sex, body measurements, condition of the gonads, condition of the reproductive ducts, size and position of the fat bodies, contents of the stomach, and anomalies.

Dicamptodon ensatus

Field Observations

During this investigation, three adults and 30 larval *Dicamptodon* were examined. One adult was collected on each of the following dates: June 28, July 5, and November 28, 1953. The larvae were collected during the months of May, July, August and September in the years 1949, 1950 and 1952.

The three adult *Dicamptodon* were collected in or immediately adjacent to small permanent streams. Two of the individuals were taken from beneath rocks on the stream bank. The third individual was collected in the water beneath the protection of an overhanging rock. All three specimens were extremely slippery and active when captured.

On one occasion, an adult *Plethodon vehiculum* and a *Dicamptodon* were found sharing the same protective rock.

Larval *Dicamptodon* were collected from larger streams by using hooks baited with meat.

Total-length Frequency

Table 1 shows the frequency of total-length differences in larval *Dicamptodon ensatus*. Note that the female larvae show wide variation in total length, from 234 millimeters to 302 millimeters.

Table 1. Frequency of total-length differences in *Dicamptodon ensatus* (larval female)

Length in mm.	Frequency of Females	Frequency of Immature
68		1
174		1
176		1
182		1
234	1	
236		
238		
240		
242	1	
244	1	
246		
248	2	
250		
252		
254	1	
256	1	
258	1	
260		
262	2	
264		
266		1
268	1	
270	1	
272	1	
274	2	
276		
278		
280	1	
282	1	1
284	1	
286		
288	1	
290		
292		
294	3	
296	1	
298		
300		
302	1	

Sexual Dimorphism

In the specimens examined, no external sex differences could be noted in either the adults or larvae because of the following:

(1) The three Dicamptodon that had metamorphosed could not be accurately sexed because of the immature condition of the gonads.

(2) Twenty-four of the thirty neotenic larvae examined were females; six appeared to be immature females. An explanation for this strange sex ratio is difficult. The time of the year that collections were made, more aggressive behavior of females in rising to bait or an actual inequality of sex ratio are possible explanations.

Reproductive System

Adult--The gonads of each of the three metamorphosed Dicamptodon were too immature to accurately determine the sex Gonads average approximately 25 millimeters in length, five millimeters in width and are granular in appearance. No pigmentation is present in either the gonads or the supporting membranes.

The fat bodies, which occur lateral to the gonads, are yellow fatty structures, exceeding the gonads in length by several millimeters.

Larvae--The immature ovary is a granular structure which averages approximately 35 millimeters in length and not more than 10 millimeters in width. It is cream-colored in appearance,

becoming slightly more yellowish with maturity. Eggs are extremely numerous but too small and fragile to accurately count. There are an estimated 300-500 immature eggs per ovary. As the eggs mature the ovary enlarges, attaining in the mature condition a length of 80 millimeters and a width of 50 millimeters. An average of 101 (68-175) "mature" eggs (more than two millimeters in diameter) per ovary were counted.

Table 2. The number of female Dicamptodon with enlarged ovarian eggs

	May	July	August	September
Number of females collected	3	14	5	1
Eggs less than 1 mm. in dia.	2	9	1	1
Eggs 1-2 mm. in dia.	1	2	3	
Eggs 2-4 mm. in dia.		3	1	

The oviducts in the immature female are thin (two millimeters or less in diameter) and slightly coiled. As the female matures the ducts lengthen. They course in lateral-medial waves which seldom cross one another.

Food Habits

Both larval and adult Dicamptodon often have extraneous material in their digestive tracts, such as leaves, fir needles, mud and small stones. These items constitute approximately 50 per cent by volume of the stomach contents of the larvae.

An examination of the contents of digestive tracts of Dicamptodon ensatus indicates that the larvae feed upon gastropods

and crustacea (Astacidae) almost exclusively. The adults exhibit a more diverse diet, with gastropods present in the largest numbers. The data obtained from these examinations are shown in Table 3.

Table 3. Food items from the stomach contents of *Dicamptodon ensatus* (adult)

Food item		Number of times food item occurred
Mollusca		
Gastropoda		
Helicidae		7
Limacidae		1
Arthropoda		
Crustacea		
Isopoda	*Ligidium gracile*	1
Decapoda		
Astacidae	*Astacus* sp.	1
Diplopoda		1
Insecta		
Plecoptera		
Peltoberlidae		1
Chloroperlidae		1
Coleoptera		
unidentified adult		1
Diptera		
Empididae		1
Chordata		
Plethodontidae	*Plethodon vehiculum*	1

Food items from the stomach contents of *Dicamptodon ensatus* (larvae)

Mollusca		
Gastropoda	*Goniobasis* sp.	52
Arthropoda		
Astacidae	*Astacus* sp.	22
Chordata		
Teleostei	*Cottus gulosus*	3

Rhyacotriton olympicus

Field Observations

Rhyacotriton usually frequents moist seepage areas near cold permanent streams. However, during periods of high rainfall and low temperatures, some individuals migrate away from the stream sites into the adjacent areas. Here they are found in dense tangles of moist, dead vegetation usually protected from above by a board or flat rook. The nine specimens collected for this investigation were taken from beneath boards that were located more than 100 yards from a stream.

Ensatina eschscholtzii and *Plethodon vehiculum* were taken from beneath the same cover as *Rhyacotriton*.

Rhyacotriton when uncovered made no attempt to escape, remaining in a semi-torpid condition.

Total-length Frequency

Table 4. Frequency of total-length differences in *Rhyacotriton olympicus*

Length in mm.	Frequency of Males	Frequency of Females
60		1
61		
62		
63		
64		1
65		
66		
67	1	
68		1
69		1
70		

Table 4. Frequency of total-length differences in Rhyacotriton olympicus (cont.)

Length in mm.	Frequency of Males	Frequency of Females
71		
72		1
73		
74	1	1
75		
76		
77		
78	1	

Sexual Dimorphism

The average total length for the three males was 73.3 millimeters (67.5-78 millimeters), and for the nine females 68 millimeters (60.5-74 millimeters). The population means for the two sexes are not significantly different when tested with a t-test using a one per cent significance level.

Little difference is noted between the snouts of male and female Rhyacotriton (Plate I A).

Male Rhyacotriton have rectilinear lobes present on either side of the vent (Plate I B) which readily distinguish them from the females.

Reproductive System

Male--The testis of immature Rhyacotriton is a white structure which becomes mottled black upon maturity. In the adult it averages approximately seven millimeters in length and

three millimeters in width and assumes a globular appearance.

The sperm ducts are white in the immature condition and become black as the testes mature. They are not coiled.

The mesorchia are non-pigmented.

Female--The immature ovaries of Rhyacotriton are approximately five millimeters in length and are slightly grayish in color. As they mature they lengthen and become colorless. The mature ovaries average approximately 10 millimeters in length and four millimeters in width.

Five of the six females collected had ovarian eggs. These five were collected on January 4 and 18, February 3, March 23 and July 2. There was an average of 10+ eggs per individual, and the eggs ranged in size from 1-3 millimeters in diameter.

The oviducts have a diameter of approximately one millimeter in the immature condition and enlarge to a diameter of approximately four millimeters in more mature individuals. Coiling increases with maturity, until obscured by the increasing size of the ducts.

The fat bodies adhere to the lateral margins of the gonads. They may attain a length as great as that of the gonads and become expanded laterally. However, they are usually smaller and the size seems to have little or no correlation with the condition of the gonads. Occasionally they show black pigmentation.

Food Habits

Several of the stomachs examined contained extraneous materials, such as mud, fir needles and small stones. These items constitute an estimated five per cent by volume of the total stomach contents. The study indicated that insects (especially sminthurids) and isopods compose the main items of food for Rhyacotriton olympicus.

Table 5 lists the food items identified from the stomach contents of nine specimens of Rhyacotriton olympicus.

Table 5. Food items from the stomach contents of Rhyacotriton olympicus

Food item	Number of times food item occurred
Mollusca	
Gastropoda	1
Arthropoda	
Isopoda Ligidium gracile	7
Araneida	
unidentified adults	2
Insecta	
Collembola	
Poduridae	2
Entomobryidae	1
Sminthuridae	19
Plecoptera	
Perlidae	1
Coleoptera	
unidentified larva	1
Staphylinidae	1
Curculionidae	1
Lepidoptera	
unidentified larva	1
Diptera	
unidentified adult	1
unidentified larvae	2

Plethodon dunni

Field Observations

Forty-one specimens of Plethodon dunni were collected in 1953. The specimens were collected in each of the first five months and in October and November.

Plethodon dunni frequents areas of outcropping rock, talus slides and abundant cover. Crevices in the outcrops and slides apparently provide protection during periods of adverse temperatures and low moisture. During favorable periods of moderate temperatures and heavy rainfall, Plethodon dunni individuals radiate away from the outcrops and utilize other available cover.

Plethodon vehiculum frequents the same areas as Plethodon dunni and often individuals of the two species are found beneath the same protective cover. Field observations, however, indicate that Plethodon vehiculum prefers higher temperatures and lower humidity than Plethodon dunni. These observations are similar to those made in the field and substantiated in the laboratory by Dumas (6, pp.44-46).

Dumas felt that there was "slight" competition between the two species. However, on April 24, a Plethodon dunni was collected with a partly digested Plethodon vehiculum in the stomach contents, indicating occasional active competition between the two species in the field.

Total-length Frequency

Table 6. Frequency of total-length differences in Plethodon dunni

Length in mm.	Frequency Males	Frequency Females	Length in mm.	Frequency Males	Frequency Females
70	1		103		1
71	1		104		
72			105		
73			106		1
74			107		
75			108		
76			109	1	
77			110		
78			111	1	
79			112	1	
80			113		
81	1		114	1	
82			115	1	2
83	1		116	1	
84	1		117		
85			118		2
86			119	1	
87		1	120	1	1
88			121		1
89			122		1
90			123	1	
91			124	1	
92			125	1	1
93			126	1	1
94			127	1	
95			128		1
96			129		
97			130		
98			131		1
99			132		
100		1	133		1
101			134		1
102			135		

Sexual Dimorphism

The average length of the males collected in 1953 was 107.2 millimeters (70-127 millimeters). The average length of the females

was 117.7 millimeters (87-134 millimeters). A t-test with a one per cent significance level was used on the data compiled from all sexable, uninjured individuals. The results were not significant, indicating that the means for the male and female populations are equal.

All individuals over 90 millimeters in total length were arbitrarily considered as adults. Tail measurements were taken on 30 salamanders over 90 millimeters in length and with no evidence of previous tail injury. The tails of the 17 females average 57.1 millimeters in length while those of the 13 males averaged 57.0 millimeters. Stebbins (12, p.69) states that male specimens have longer tails than the females. This does not seem to be the case for the individuals collected for this study.

The males may be distinguished from the females by a more truncate snout, swellings in the regions of the nasio-labial grooves (Plate II A) and by a narrow depressed area bordering the vent (Plate II B).

Reproductive System

Male--The immature testis averages approximately six millimeters in length and two millimeters in width. Starting at the posterior tip and moving forward, the testis becomes progressively darker as it matures. The mature testis is entirely black and has attained a length of approximately 11 millimeters and a width of three millimeters.

The sperm ducts are small (less than 1.5 millimeters in diameter) and also become black as the testes mature. Some coiling occurs and is usually more pronounced in mature individuals.

The mesorchia may be pigmented slightly or not at all.

Female--In immature females the ovary is approximately eight millimeters in length and two millimeters in width. Small eggs are usually observable and average approximately 15 per ovary. As the eggs mature the ovary increases in size and becomes irregular in shape. Mature ovaries average approximately 16 millimeters in length, seven millimeters in width and contain an average of 10.25 (7-13) eggs per individual.

The oviducts are straight in immature females and have a diameter of not more than 1.5 millimeters. As the ovary matures the duct lengthens and becomes highly coiled. However, this coiling is obscured in mature individuals because of the increase in diameter of the ducts (up to five millimeters in diameter).

Table 7. The number of female Plethodon dunni with enlarged ovarian eggs (by months)

	Jan.	Feb.	Mar.	Apr.	May	Oct.	Nov.
Number of females collected	4	2	4	3	1	6	1
Females with ovarian eggs less than 2 mm. in diameter	3	1	4	2	1	5	
Females with ovarian eggs more than 2 mm. in diameter	1	1		1		1	

The ovary, mesovaria and ducts are non-pigmented.

The fat bodies of Plethodon dunni, which have black pigmentation, usually exceed the gonads in total length by several millimeters.

Sex Ratio

The sex ratio for each month in which Plethodon dunni specimens were collected is shown in Table 8. A total of 40 specimens was collected. (One individual collected in October was too immature to sex and is not included in the table.) The ratio varies slightly from month to month, but the ratio for the total number approximates 1:1.

Table 8. Ratio of adult females to males according to months

Month	Number in sample	Female to male ratio
January	8	1:1
February	3	2:1
March	6	2:1
April	8	3:5
May	3	1:2
October	10	3:2
November	2	1:1

Food Habits

Table 9 lists the food items identified from the stomach contents of 41 specimens of Plethodon dunni. An examination of the stomach contents indicates that Plethodon dunni feeds upon insects almost exclusively.

Table 9. Food items identified from the stomach contents of *Plethodon dunni*

Food item		Number of times food item occurred
Annelida		12
Arthropoda		
Isopoda	*Ligidium gracile*	18
Chilopoda		
Unidentified		9
Geophilidae		1
Scolopendridae		1
Lithobiidae		4
Diplopoda		
Unidentified		2
Pseudoscorpionida		
Unidentified		3
Phalangiida		
Unidentified		2
Nemastomatidae	*Nemastoma modestum*	2
Araneida		
Unidentified		13
Mimetidae		1
Epeiridae	*Metellina* sp.	1
Agelenidae	*Cicurina* sp.	1
Linyphidae		1
Acarina		47
Insecta		
Collombola		
Poduridae		37
Entomobryidae		38
Sminthuridae		333
Orthoptera		
Locustidae		1
Coleoptera		
Unidentified adults		1
Unidentified larvae		1
Carabidae		3
Carabidae larvae		5
Staphylinidae		5
Staphylinidae larvae		3
Pselaphidae		3
Elateridae		1
Elateridae larvae		4
Hemiptera		
Tingididae		1
Neididae		1
Homoptera		
Aphididae		5
Lepidoptera		
Unidentified larvae		5

Table 9. Food items identified from the stomach contents of Plethodon dunni (Cont.)

Food item	Number of times food item occurred
Arthropoda (Cont.)	
Insecta	
Diptera	
Unidentified adult	1
Unidentified larvae	22
Mycetophilidae	2
Hymenoptera	
Scelionidae *Baeus* sp.	1
Formicidae	10
Mollusca	
Gastropoda	4
Chordata	
Amphibia *Plethodon vehiculum*	1

Table 10 shows an analysis of the stomach contents of *Plethodon dunni* for each month in which specimens were collected. Note that the various food items are apparently taken at random, with no apparent change in diet during different seasons of the year.

Table 10. Stomach contents of *Plethodon dunni* (by months)

	Jan.	Feb.	Mar.	Apr.	May	Oct.	Nov.
Number of stomachs examined	8	3	6	8	3	11	2
Annelid	1			7	2	2	
Isopoda	6	1	6	4		1	
Chilopoda	1	1	1	6		6	
Diplopoda			1				1
Pseudoscorpionida	1				1	1	
Phalangiida			1	1		1	1

Table 10. Stomach contents of Plethodon dunni (Cont.)

	Jan.	Feb.	Mar.	Apr.	May	Oct.	Nov.
Araneida	2	1	1	7		6	
Acarina	1	8	1	4	27	6	
Collembola	178	82	67	40	9	29	3
Orthoptera				1			
Coleoptera	4	7	1	8	2	2	2
Hemiptera	1				1		
Homoptera	1		1			2	1
Lepidoptera			4				1
Diptera	8	4	5	4	2	2	
Hymenoptera	1	1		8		1	
Gastropoda	1					2	1

Table 11, which follows, shows the relative abundance of various items of food in the stomachs of Plethodon dunni. The second column indicates the number of stomachs while the third column indicates the percentage of stomachs containing the food item designated. The chief food of Plethodon dunni was Collembola, which was found in 76 per cent of the stomachs examined.

Table 11. Abundance of food items in stomachs of *Plethodon dunni*

Food item	Number of stomachs containing food item	Percentage of *P. dunni* stomachs containing indicated food item
Gastropoda	4	9.7
Isopoda	9	21.9
Chilopoda	9	21.9
Diplopoda	2	4.8
Pseudoscorpionida	3	7.3
Phalangiida	4	9.7
Araneida	13	31.7
Acarina	13	31.7
Collembola	32	78.0
Orthoptera	1	2.4
Coleoptera	19	46.3
Hemiptera	2	4.8
Homoptera	5	12.2
Lepidoptera	3	7.3
Diptera	10	24.3
Hymenoptera	5	12.2
Annelida	6	14.6

Plethodon vehiculum

Field Observations

One hundred and twenty-eight specimens of *Plethodon vehiculum* were collected during 1953. Collections were made in every month except in August and September.

Plethodon vehiculum inhabits the same type of outcrop habitat as is frequented by *Plethodon dunni*. During most of the year individuals of either species may be collected together. However, since *Plethodon vehiculum* apparently favors higher temperatures and is more tolerant of dry conditions, one or the other species may be present in the habitat alone, depending upon recent weather conditions.

Plethodon dunni, *Ensatina*, *Dicamptodon*, *Taricha* and *Aneides* were all found on occasions sharing cover with *Plethodon vehiculum*.

Total-length Frequency

Note in Table 12 that specimens that were immature and could not be accurately sexed were 63 millimeters or less in total length. All individuals mature enough to be sexed were 63 millimeters or more in total length.

Table 12. Frequency of total-length differences in Plethodon vehiculum (male and female)

Length in mm.	Freq. males	Freq. females	Freq. immature	Length in mm.	Freq. males	Freq. females
38			2	67	1	
39			1	68	1	1
40			1	69	1	
41				70	1	1
42				71		1
43				72	2	
44				73	1	
45			1	74		
46				75	3	3
47				76	2	4
48			1	77	4	2
49				78	2	2
50				79	3	2
51				80	2	2
52				81	2	4
53				82	3	6
54			1	83	3	5
55			2	84	2	8
56				85	2	5
57				86	2	1
58				87	2	5
59				88		2
60				89		1
61				90		5
62				91		2
63	2	1	1	92		
64				93		1
65	1	1		94		1
66				95		

Sexual Dimorphism

The average length of the males collected in 1953 was 77.64 millimeters (63-87 millimeters). The average length of the females was 82.22 millimeters (63-94 millimeters). A t-test with a one per cent significance level was used on the data compiled from all sexable and uninjured individuals. The results

were not significant, indicating that the means for the male and female populations are equal.

The males may be distinguished from the females by a more truncate snout and larger swellings in the regions of the nasio-labial grooves (Plate III A). The males also have a depressed area bordering the vent and an indication of two small flaps just posterior to the vent (Plate III B).

Reproductive System

Male--The testis of immature Plethodon vehiculum is a gray structure averaging approximately four millimeters in length and 1.5 millimeters in width. As the testis matures it becomes progressively darker starting with the posterior margin and proceeding forward. The adult testis averages approximately 10 millimeters in length and three millimeters in width. Occasionally the anterior two-thirds of the testis is expanded while the posterior one-third is constricted and tapers almost to a point. Normally the testis is expanded throughout its entire length.

The sperm ducts are grayish and straight in immature males. As the testes enlarge and darken, the ducts lengthen and become black. In the adult salamander the ducts are entirely black and are greatly coiled. The diameter of the ducts is approximately .5 millimeters in immature individuals and may attain a diameter of 1.5 millimeters in the adult condition.

The mesorchia may show slight or no pigmentation.

Female--The immature ovaries of Plethodon vehiculum average approximately four millimeters in length and one millimeter in width and are white in color. Extremely small eggs are apparent in the maturing ovary. These "immature" eggs (less than .5 millimeters in diameter) average 22 per ovary. More eggs are apparently produced by the ovaries than actually reach maturity, for "mature" eggs average only 3.6 per ovary.

The following table shows the number of Plethodon vehiculum females with ovarian eggs. Note than 84.7 per cent of the total females collected exhibited ovarian eggs.

Table 13. Females of Plethodon vehiculum with ovarian eggs

	Jan.	Feb.	Mar.	Apr.	May	June	Oct.	Nov.	Dec.	Tot.
No. of females collected	17	5	29	3	6	3	4	4	1	72
Females with eggs less than .5 mm. in dia.	6	2	11	3	6	2	1			31
Females with eggs more than .5 mm. in dia.	10	2	12				2	3	1	30
% of females with ovarian eggs	94	80	79	100	100	67	75	75	100	84.7%

The ovaries, mesovaria and the oviducts lack the black pigmentation found in the males.

Sex Ratio

Table 14 shows the sex ratio of the collected Plethodon vehiculum. The ratio varies considerably from month to month.

However, the ratio for the total number of 128 specimens approximates three females to two males, with 10 individuals too immature to accurately sex.

Table 14. Ratio of females to males according to months

Month	Number in sample	Female to male ratio
January	29	17:11
February	11	1:1
March	43	29:13
April	7	3:4
May	17	3:4
June	6	6:0
July	1	0:1
October	8	4:3
November	5	4:1
December	1	1:0

Food Habits

The following table lists the food items identified from the stomach contents of 128 specimens of Plethodon vehiculum. Acarina and insects (Entomobryidae and Sminthuridae) were the most frequent food items consumed by the Plethodon vehiculum collected.

Table 15. Food items of *Plethodon vehiculum*

Food item		Number of times food item occurred
Annelida		28
Arthropoda		
Isopoda	*Ligidium gracile*	14
Chilopoda		
unidentified		4
Geophilidae		7
Scolopendridae		1
Lithobiidae		7
Diplopoda		
unidentified		29
Pseudoscorpionida		
unidentified		97
Phalangiida		
unidentified		9
Phalangiidae	*Leuronychus pacificus*	1
Ischyropsalidae	*Sabacon crassipalpe*	1
Araneida		
unidentified		35
Ctenizidae	*Antrodiaetus* sp.	2
Amaurobiidae	*Callioplus* sp.	1
Dictynidae		1
Theridiidae	*Euryopis* sp.	1
Leptonetidae	*Usofila* sp.	2
Linyphidae		2
Agelenidae	*Calymmaria* sp.	2
	Cybaeus sp.	1
Thomisidae		1
Acarina		481
Insecta		
Collembola		
Poduridae		302
Entomobryidae		387
Sminthuridae		823
Coleoptera		
unidentified larvae		15
unidentified adults		4
Cicindelidae larvae		3
Carabidae larvae		17
Carabidae		2
Silphidae		4
Scydmaenidae		3
Staphylinidae		25
Pselaphidae		15
Cantheridae		1
Elateridae larvae		6
Byrrhidae		1
Cucujidae		2

Table 15. Food items of Plethodon vehiculum (Cont.)

Arthropoda		
Insecta		
Coleoptera (Cont.)		
Colydiidae		2
Chrysomelidae		1
Curculionidae		12
Curculionidae-Scolytidae larvae		4
Scolytidae		2
Hemiptera		
unidentified		6
Lygaeidae		1
Tingididae		13
Miridae		2
Homoptera		
unidentified		1
Cicadellidae		2
Fulgoridae		1
Aphididae		29
Lepidoptera		
unidentified larvae		2
Pyralididae larva		1
Gelechiidae larva		1
Diptera		
unidentified larvae		100
unidentified adults		10
Tipulidae		3
Chironomidae		6
Dolichopidae		3
Phoridae		1
Hymenoptera		
unidentified		3
Braconidae		1
Serphidae		1
Scelionidae	Baeus sp.	4
Formicidae		143
Mollusca		
Gastropoda		19

The following table shows an analysis of the stomach contents of Plethodon vehiculum for each month in which specimens were collected. The food items are apparently taken at random. The Arachnids form a more important part of the diet early in the year,

but are replaced by insects as they become more abundant.

Table 16. Analysis of the stomach contents of Plethodon vehiculum

	Jan.	Feb.	Mar.	Apr.	May	June	July	Oct.	Nov.	Dec.
No. of stomachs examined	29	11	43	7	17	6	1	8	5	1
Annelida	5	2	10	1	1			2	2	
Gastropoda	4		3	1	4	1	1	2	3	
Isopoda	5	1	6					2		
Chilopoda	4	1	9		1		1	2		1
Diplopoda	3	1	9	1	15					
Pseudo-scorpionida	37	21	17	4	10		1	3	3	1
Phalangiida				2	3		2	3	1	
Araneida	19	3	9	3	4	2		8		
Acarina	97	43	215	34	43	10	1	25	10	3
Collembola	709	82	197	71	151	118	4	132	39	9
Coleoptera	23	15	33	16	17	2		5	6	2
Hemiptera	12	2	2		4	1		1		
Homoptera	3	2	5	1	3	7		9	2	1
Lepidoptera	2			1	1					
Diptera	32	19	33	3	14	6		3	9	4
Hymenoptera	30	2	55	26	29	3		5	2	

Table 17 shows the relative abundance of various items of food in the stomachs of Plethodon vehiculum. The first column lists the food items, the second the number of stomachs, while

the third indicates the percentage of stomachs containing the food item. The chief food of Plethodon vehiculum was Collembola, which was found in 87.5 per cent of the stomachs examined.

Table 17. Abundance of food items in the stomachs of Plethodon vehiculum

Food item	Number of stomachs containing food item	Percentage of stomachs containing indicated food item
Annelida	10	7.8
Gastropoda	13	10.1
Isopoda	8	6.2
Chilopoda	18	14.0
Diplopoda	16	12.5
Pseudo-scorpionida	51	39.8
Phalangiida	7	5.4
Araneida	28	21.8
Acarina	96	75.5
Collembola	112	87.5
Coleoptera	66	51.5
Hemiptera	17	13.2
Homoptera	18	14.0
Lepidoptera	4	3.1
Diptera	59	46.1
Hymenoptera	56	43.7

Batrachoseps wrighti

Field Observations

Eleven specimens of Batrachoseps wrighti were collected on May 27, 1953, one mile west of Detroit, Marion County, Oregon. These individuals were collected on a south-facing slope which was burned over in 1941. The slope averages approximately 20 degrees on its lower aspect which is adjacent to Oregon highway 22. At higher elevations the average slope increases to approximately 40 degrees. Burned and decaying logs are numerous, with new-growth Douglas fir, shrubby vegetation and deciduous trees encroaching on the denuded areas.

Specimens of Batrachoseps were taken from under decaying logs. The smallest log was approximately two inches in diameter and the largest exceeded three feet in diameter. All individuals were taken from moist situations, which in this case were the well-shaded, depressed areas and stream-side locations.

Ensatina eschscholtzii oregonensis and Aneides ferreus were also collected on the same hillside. The habitat requirements of Ensatina apparently most nearly approach those of Batrachoseps, for these two species were taken from similar situations. Aneides were taken from drier areas.

Batrachoseps, upon being disturbed, usually assume a tightly coiled position with the head toward the center of the coil. Upon being uncovered, several individuals assumed this

position with their ventral surfaces up. Only one of the 11 captured on May 27, 1953, tried to escape. This individual attempted to proceed into a subterranean tunnel system which appeared to have been constructed by a mole (Scapanus sp.).

On May 23, 1953, Dr. Robert M. Storm collected 36 specimens of Batrachoseps from this same area. On May 30, 1953, a search of more than three hours failed to uncover a single individual. On all three of these collection dates (May 23, 27, 30) rain fell and the temperatures were moderate. Two subsequent attempts to collect Batrachoseps from this area have met with failure.

Total-length Frequency

Table 18. Frequency of total-length differences in Batrachoseps wrighti

Length in mm.	Frequency of males	Frequency of females
54	1	
56		
58		
60	1	
62		1
64		
66		1
68		1
70		
72		
74		
76	1	
78	1	1
80	1	1
82		1

Sexual Dimorphism

The male and female population means for Batrachoseps wrighti are not significantly different when using the Student's t-test with a one per cent significance level. The five males collected averaged 70.3 millimeters in length (55-77.5) and the six females averaged 73.4 millimeters (63-83).

The snout of the male is more truncate (Plate IV A) than that of the female, and in the male the regions of the nasio-labial grooves are swollen.

The vent of the male is bordered by a narrow depressed area with the lips elevated, particularly on the anterior (Plate IV B). The vent of the female is a simple slit.

Reproductive System

Male--The testis of adult Batrachoseps is non-pigmented and multiple, usually consisting of two distinct enlargements connected by a short (four millimeters or less) filamentous isthmus. The anterior enlargements are the largest, averaging approximately five millimeters in length and two millimeters in diameter. The posterior enlargements average approximately three millimeters in length and 1.5 millimeters in diameter. Immature males have single-lobed testes.

The mesorchia of Batrachoseps have a black pigmentation.

The sperm ducts in Batrachoseps are non-pigmented and

although becoming slightly more contorted in adults, they continue to maintain a small diameter (less than one millimeter).

Female--The mature ovaries of Batrachoseps measured from five to ten millimeters in length and from three to five millimeters in width. Five of the six females collected on May 27, 1953, contained ovarian eggs. These eggs varied in diameter from one to three millimeters and in number from one to six, with an average of four per adult female.

The ovaries and oviducts of Batrachoseps lack the black pigmentation found in the mesovaria.

The oviducts of Batrachoseps become greatly expanded, attaining a diameter of four millimeters in mature females; the ducts also exhibit a high degree of contortion.

The fat bodies in Batrachoseps are most apparent in sexually immature individuals. Here they are found anterior and lateral to the gonads and consist of narrow ribbon-like structures which occasionally exceed the gonads in length by several millimeters. Often the fat bodies exhibit black pigmentation similar to that found in their supporting membranes. In sexually mature individuals the fat bodies become smaller and are less apparent because of the enlarged condition of the gonads.

Food Habits

The following table lists the items of food identified from the stomach contents of 11 specimens of Batrachoseps wrighti.

Sminthurids were the most frequent food item in the Batrachoseps collected.

Table 19. Food items of Batrachoseps wrighti

Food item		Number of times food item occurred
Mollusca		
Gastropoda	Polygyra sp.	1
Arthropoda		
Chilopoda		
Lithobiidae		1
Pseudoscorpionida		3
Araneida		
unidentified		2
Acanthymidae	Antrodiaetus pacificus	2
Acarina		2
Insecta		
Collembola		
Poduridae		6
Entomobryidae		1
Sminthuridae		8
Coleoptera		
unidentified larvae		2
Pselaphidae		1
Elateridae larva		1
Hemiptera		
Tingididae	Acalypta mera	1
Lepidoptera		
unidentified larva		1
Diptera		
unidentified larva		1
Phoridae		2
Hymenoptera		
Formicidae		5

Ensatina eschscholtzii oregonensis

Field Observations

One hundred and sixty-three specimens of *Ensatina eschscholtzii oregonensis* were collected in the field during two periods; these periods were from January to June, 1953, and from October, 1953, to January, 1954. Only during the dry period of the year--June through September--were the salamanders absent from their usual habitat.

Ensatina frequents areas where there is abundant cover, such as boards, logs, rocks, leaf litter and bark. Most individuals are found where slopes do not exceed 15 degrees, although several were taken where slopes were as great as 50 degrees. An adequate slope and porous soil provide the necessary drainage.

During adverse conditions of low temperatures and little moisture, *Ensatina* concentrates in areas where there is considerable leaf litter. They become torpid and are covered by a viscous protective secretion which aids in body moisture retention. *Ensatina* are apparently capable of withstanding lower temperature and moisture conditions than *Plethodon dunni* or *Plethodon vehiculum* for both of the latter species disappear from the habitat at these times. Higher temperatures favorable to the two species of *Plethodon* cause *Ensatina* to disappear from the habitat--presumably into underground crevices.

Ensatina are often taken in pairs or small groups from beneath the same cover, especially during February and March. Plethodon vehiculum and Plethodon dunni frequently share cover with Ensatina.

Invertebrate associates found under the same cover with Ensatina are not ennumerated, but all forms observed in the field occur in the itemized list of foods consumed.

Total-length Frequency

Table 20. Frequency of total-length differences in Ensatina eschscholtzii oregonensis

Length in mm.	Male	Female	Imm.	Length in mm.	Male	Female
50		2		78		2
51		1		79		2
52			1	80	2	1
53	1	1		81		4
54		2	1	82	1	5
55	1			83		2
56		1		84	1	2
57		1		85	1	2
58		1		86	2	2
59		1		87	1	2
60				88	2	3
61				89	1	
62		2		90	3	3
63		2		91	1	2
64		1		92		4
65		1		93	2	
66	1	1		94		3
67		4		95	3	1
68	1	4		96	1	
69			1	97	4	
70		5		98		2
71	1	1		99	2	1
72		5		100	1	1
73				101	1	3
74	2	3		102	3	
75		2		103	3	
76		3		104	1	1
77	2	1		105		

Twenty-two specimens of the 163 Ensatina collected in 1953 had lost portions of their tails, the break usually occurring at the constriction just posterior to the vent. The measurements for these individuals were not included in the preceeding table. Note the wide range in size of the various specimens.

Sexual Dimorphism

Adult male Ensatina have long slender tails which are usually as long or longer than the body; the tail of the female is shorter and broader. Males also may be distinguished from females by their more truncate snout (Plate V A), swollen vent region (Plate V B) and the presence of cloacal gland villi in the vent.

The average length of the males collected in 1953 was 91.52 millimeters (53-104 millimeters). The average length of the females was 74.37 millimeters (50.5-104 millimeters). The t-test was used to determine if the male population actually does exceed the female population in total length. Only individuals which showed no evidence of tail injury were used for both the averages and the t-test. The results were significant with both a one per cent and a five per cent significance level, indicating that the male population actually does exceed the female population in total length.

Sex Ratio

In every month that collections of Ensatina were made, the

number of females exceed the number of males, except in October when a single male individual was taken.

The following table shows the sex ratio for Ensatina eschscholtzii oregonensis for each month in which they were collected.

Table 21. Ratio of females to males according to months

Month	Number in sample	Female to male ratio
January	52	39:9
February	43	27:16
March	31	18:13
April	22	8:3
May	6	2:1
October	1	0:1
November	7	4:3
December	1	1:0

The sex ratio varies from month to month, but the ratio for the total number approximates 2:1, females to males.

Reproductive System

Male--The testis of the adult male Ensatina is a white or yellow spindle-shaped organ. In the non-breeding condition it averages approximately four millimeters in length and 1.5 millimeters in width. During the breeding season it increases in length to an average of approximately nine millimeters and a width of 2.5 millimeters.

The sperm ducts remain small at all times, never exceeding 1.5 millimeters in diameter even during the peak of the breeding season. They are slightly coiled.

The mesorchia are non-pigmented.

Female--The ovary, without eggs, is a white structure that is difficult to discern from its supporting membrane. It averages approximately four millimeters in length and not more than 1.5 millimeters in width. When eggs are present the ovary expands with the maturing eggs. Fifty of the 109 females collected had ovarian eggs at some stage of maturity. More eggs are apparently produced by the ovary than actually reach maturity, for there is an average of 17+ "immature" eggs (less than .5 millimeters in diameter) per individual and an average of 10.25 "mature" eggs (more than .5 millimeters in diameter) per individual. The anterior eggs seem to enlarge first while some of the posterior eggs are probably resorbed.

The following table shows the per cent (by months) of the females collected in 1953 with enlarged ovarian eggs.

Table 22. Female Ensatina with enlarged ovarian eggs

	Jan.	Feb.	Mar.	Apr.	May	Nov.	Dec.
Number of females collected	39	27	18	16	9	4	1
Females with ovarian eggs .5-2 mm. in dia.	4	6	9	4	2	3	
Females with ovarian eggs 2 mm. or larger in dia.	5	9	5	3			
% of females with enlarged ovarian eggs	23	56	78	44	22	75	0

The oviducts in the immature females are thin (one millimeter or less in diameter) and slightly coiled. As the female matures the ducts lengthen and become highly coiled with the

diameter remaining small. Females with "mature" eggs present in the ovaries have ducts which are greatly expanded; these may have a diameter of four millimeters or more. This enlargement obliterates most of the coils so that the mature duct is relatively straight. In their expanded condition the walls become almost transparent; spiral striations are found around the ducts.

The fat bodies are golden yellow structures suspended by membranes from the lateral margins of the gonads. The size of the fat bodies apparently is not correlated with the condition or size of the gonads.

Food Habits

The following table lists the food items identified from the stomach contents of Ensatina eschscholtzii oregonensis. An examination of the stomach contents indicates that the main food item of Ensatina consists of Collembola (springtails).

Table 23. Food items from the stomach contents of Ensatina

Food item		Number of times food item occurred
Arthropoda		
Isopoda	Ligidium gracile	50
Chilopoda		
unidentified		3
Geophilidae		8
Scolopendridae	Scolopocryptops sp.	3
Lithobiidae		16
Diplopoda		
unidentified		11
Polydesmidae		2
Pseudoscorpionida		51
Phalangiida		
unidentified		5
Nemastomatidae	Nemastoma modestum	5
Triaenonychidae	Sclerobunus brunneus	6
Cyphophthalmi	Siro acaroides	1
Ischyropsalidae	Sabacon crassipalpe	2
Araneida		
unidentified		24
Acathymidae	Antrodiaetus pacificus	1
Agelenidae	Cryphoeca peckhami	6
	Cybaeus morosus	2
	Cybaeus reticulatus	3
	Cicurina Jonesi	3
	Cicurina pusilla	4
	Calymmaria Emertoni	2
Dipluridae	Hexura sp.	2
Theridiidae	Crustulina sp.	3
	Theridion sp.	2
Linyphidae		3
Leptonectidae	Usofila sp.	3
Gnaphosidae		1
Acarina		55
Insecta		
Collembola		
Poduridae		68
Entomobryidae		309
Sminthuridae		3278
Orthoptera		
Locustidae		2
Coleoptera		
unidentified adults		11
unidentified larvae		17
Cicindelidae larvae	Cicindela sp.	2
Carabidae		5
Carabidae larvae		2
Hydrophilidae larva		1

Table 23. Food items from the stomach contents of Ensatina (Cont.)

Arthropoda		
Insecta		
Coleoptera (Cont.)		
Scydmaenidae		2
Staphylinidae larvae		4
Staphylinidae adults		7
Staphylinidae	Stenus sp.	2
Pselaphidae		14
Meloidae larvae		2
Elateridae larvae		2
Dascillidae		1
Cucujidae larva		1
Erotylidae		1
Mycetophagidae		1
Lathridiidae	Coninomus nodifer	1
Endomychidae		2
Scarabaeidae larvae		5
Curculionidae		
Otiorhynchinae		4
Curculionidae	Brachyrhinus rugosostriatus	5
Scolytidae		1
Hemiptera		
Aradidae		1
Aradidae	Mezira sp.	1
Tingitidae	Acalypta mera	6
Phymatidae		1
Homoptera		
Fulgoridae		2
Phylloxeridae		2
Lepidoptera		
Noctuidae larvae		2
Geometridae		1
Pyralidae larvae		5
Gelechiidae larva		1
Gracilariidae larva		1
Diptera		
unidentified larvae		44
Chironomidae		1
Ceratopogonidae		1
Mycetophilidae		7
Phoridae		1
Chloropidae		1
Hymenoptera		
Chalcididae		1
Perilampinae	Perilampus ?	1
Formicidae		49

The following table shows an analysis of the stomach contents of Ensatina in smaller identified groups for each month in which specimens were collected.

Table 24. Analysis of the stomach contents of Ensatina eschscholtzii (by months)

	Jan.	Feb.	Mar.	Apr.	May	Oct.	Nov.	Dec.
Number of stomachs examined	52	43	31	22	6	1	7	1
Gastropoda	1		1		1		1	
Isopoda	1	8	18	22	1			
Chilopoda	7	6	12	3	1		1	
Diplopoda	2	1	1	5			4	
Pseudoscorpionida	24	10	7	4	1		5	
Phalangiida	12	5		2				
Araneida	16	15	11	10		1	6	
Acarina	20	12	13	5		1	4	
Collembola	1772	788	635	192	33	3	192	40
Orthoptera		1	1					
Coleoptera	30	23	16	14	7	1	2	
Hemiptera	2	1	1	3	1		1	
Homoptera	4							
Lepidoptera	10	3	1				1	
Diptera	23	4	4	3	6		14	1
Hymenoptera	10	15	6	11	6		3	

Table 25 shows the relative abundance of various items of food in the stomachs of Ensatina. The second column indicates the number of stomachs while the third column indicates the percentage of stomachs containing the food item designated.

Table 25. Abundance of food items in Ensatina eschscholtzii

Food item	Number of stomachs containing food item	Percentage of stomachs containing food item
Isopoda	22	13.5
Chilopoda	25	15.3
Diplopoda	12	7.3
Pseudoscorpionida	36	22.0
Phalangiida	11	6.7
Araneida	45	27.6
Acarina	35	21.4
Collembola	154	94.1
Orthoptera	2	1.2
Coleoptera	70	42.9
Hemiptera	9	5.5
Homoptera	4	2.4
Lepidoptera	13	7.9
Diptera	31	19.0
Hymenoptera	30	18.4

The preceeding percentages differ somewhat from those compiled by Zweifel (15, pp.285-287) for Ensatina eschscholtzii

eschscholtzii in Los Angeles County, California. He found sow bugs, centipedes and spiders in more than 40 per cent of the stomachs examined. Each of these groups forms a minor portion of the diet of the individuals examined in this investigation. Springtails were, however, found in large numbers in the stomachs of individuals in both investigations.

Many of the stomachs examined contained extraneous materials, possibly taken accidentally while feeding. These materials included small stems and leaves, fir needles, small stones, sporangia of ferns and fragments of snail shells. The snail shell fragments occurred in four stomachs, and snails might actually form a very minor portion of the diet of Ensatina.

Aneides ferreus

Field Observations

One hundred and nine specimens of *Aneides ferreus* were collected in the field in 1953. One hundred and seven were collected in the period from January to July; the other two specimens were collected in November.

Aneides is usually found in open clearings beneath the loose bark or in the decaying heartwood of felled Douglas fir trees. However, during the wet season many individuals radiate from this type of habitat, and they may be found beneath objects on the ground. Boards or sheets of Douglas fir bark usually provide the salamanders with suitable cover. Heavy muddy soils lacking vegetation of any kind provide the preferred habitat substrate. At least 95 per cent of the specimens collected for this investigation were taken from this type of situation.

During adverse conditions of higher temperatures and less moisture, *Aneides* retreats to its usual habitat in downed trees.

Total-length Frequency

Table 26 shows the frequency of total-length differences in *Aneides ferreus*. Five of the specimens had lost portions of their tails, and these individuals are not included in the table. Note the wide range in size of both the males and the females.

Table 26. Frequency of total-length differences in Aneides ferreus

Length in mm.	Males	Females	Imm.	Length in mm.	Males	Females
37			1	85		2
••				86	1	3
41			1	87		
••				88	1	
50			2	89	2	1
51			4	90	3	1
••				91	2	4
55			1	92	1	2
56			1	93	1	1
57		1	1	94	1	2
58				95	1	
59				96	1	2
60			2	97		
61				98	1	1
62		1		99	1	1
63		1		100	4	4
64				101	1	1
65				102	1	
66				103	3	2
67				104	3	
68		1		105		1
69	1	1		106		1
70		2		107		1
71		1		108		1
72		1		109		
73				110		
74	2			111		
75				112	1	
76	2			113		1
77	1	1		114		
78	2			115		1
79		1		116		
80	1			117	1	
81	3	1		118		
82				119	1	
83		1		120		
84	1	1		121		

Sexual Dimorphism

The adult male Aneides have a more truncate snout and a broader head in the region of the jaw angle (Plate VI A). In preserved specimens the vent has a tendency to gape, revealing

the villi of the cloacal glands. The vent region in males is usually more swollen (Plate VI B).

Immature specimens cannot be sexed by external observation. Of the specimens of Aneides collected in 1953, the males averaged 91.7 millimeters in total length (69-119.5 millimeters) and the females averaged 89.27 millimeters (57-115 millimeters). A t-test with a one per cent significance level was used on the data compiled from all sexable, uninjured individuals. The results were not significant, indicating that the means for the male and female populations are equal.

Reproductive System

Male--The testis of immature Aneides is a white structure averaging approximately three millimeters in length and 1.5 millimeters in width. As the testis matures it lengthens and becomes black. There is a gradual spreading of the pigmentation posteriorly until in mature testes, the entire structure is a mottled black. The adult testis averages approximately seven millimeters in length, three millimeters in width, and has assumed a bean-shaped appearance.

The sperm ducts are white and straight in the immature condition. As the testes enlarge and blacken, the ducts also become black. The pigmentation starts at the anterior end of the ducts and progresses posteriorly. Coiling of the ducts also takes place at this time until a high degree of convolution is

attained in the adult breeding condition. The sperm ducts never exceed 1.5 millimeters in diameter, even in large mature males.

The mesorchia are non-pigmented.

Female--The ovaries of immature Aneides average approximately eight millimeters in length, two millimeters in width, and are granular white in appearance. As the ovary matures small eggs begin to appear in a linear series. At first the eggs are white and extremely soft, and later become cream-colored, clustered and friable.

The oviducts of Aneides are straight and thin (one millimeter or less in diameter) in immature individuals. As the ovaries begin to mature the ducts lengthen and become highly contorted. However, in mature individuals the diameter of the ducts has increased to four millimeters or more, which obliterates most of the coiling.

The ovaries, mesovaria and oviducts lack the black pigmentation found in the males.

More eggs are apparently produced by the ovaries than actually reach maturity. An average of 22 "immature" eggs (.5 millimeters in diameter) per individual was counted as compared to an average of 11.8 (8-17) "mature" eggs per sexually mature female.

The following table shows the per cent (by months) of the females collected in 1953 having ovarian eggs.

Table 27. Female *Aneides* with ovarian eggs

	Jan.	Feb.	Mar.	Apr.	May	June	Total
Total no. of females collected	28	3	5	5	8	1	50
Females with eggs less than .5 mm. in dia.	8	2	3		4	1	18
Females with eggs .5-2 mm. in diameter	2						2
Females with eggs 2+ mm. in diameter	14		2	3	3		22
% of females with ovarian eggs	86	67	100	60	87	100	84

Sex Ratio

One hundred and nine *Aneides ferreus* were collected in 1953. The following table shows the sex ratio in *Aneides* for each month in which they were collected. The sex ratio for the total number of 109 specimens approximates 1:1.

Table 28. Ratio of females to males for *Aneides*, according to months

Month	Number in sample	Female to male ratio
January	63	1:1
February	7	1:1
March	7	5:2
April	10	5:3
May	19	8:7
June	1	1:0
November	2	0:2

Food Habits

The following table lists the food items identified from the stomach contents of 109 specimens of *Aneides ferreus*. The examination indicates that the main food item of *Aneides ferreus* consists of Collembola (springtails).

Table 29. Food items from the stomach contents of Aneides ferreus

Food item		Number of times food item occurred
Mollusca		
Gastropoda		13
Arthropoda		
Isopoda	Ligidium gracile	4
Chilopoda		
unidentified		2
Geophilidae		1
Scolopendridae		1
Lithobiidae		10
Diplopoda		
unidentified		10
Scorpionida		
unidentified		1
Pseudoscorpionida		
unidentified		12
Phalangiida		15
Araneida		
unidentified		17
Micryphantidae		5
	Ergone sp.	1
	Cornicularia sp.	1
	Spirembolus sp.	9
Agelenidae	Cicurina sp.	2
Lycosidae		2
Theridiidae		1
Dipluridae	Hexura picea	1
Linyphidae		3
Thomisidae		1
Clubionidae	Clubiona sp.	2
Acarina		150
Insects		
Collembola		
Poduridae		97
Entomobryidae		588
Sminthuridae		1514
Orthoptera		
Locustidae		2
Isoptera	Termopsis angusticollis	1
Coleoptera		
unidentified adults		8
unidentified larvae		8
Cicindelidae larva		1
Cicindelidae adult		1
Carabidae		21
Silphidae		1
Scydmaenidae		1
Pselaphidae		6
Staphylinidae larvae		3

Table 29. Food items from the stomach contents of Aneides (Cont.)

Food item		Number of times food item occurred
Arthropoda		
Insecta		
Coleoptera (Cont.)		
Staphylinidae adults		15
Elateridae larvae		4
Elateridae adults		3
Byrrhidae		1
Cryptophagidae		1
Colydiidae		1
Tenebrionidae		1
Anobiidae		1
Bostrichidae		1
Scarabaeidae larva		1
Hemiptera		
Aradidae		1
Tingitidae		10
Miridae		1
Homoptera		
Cicadellidae		2
Lepidoptera		
unidentified larvae		6
Pyralidae larvae		3
Diptera		
unidentified larvae		40
unidentified adults		4
Mycetophilidae		2
Dolichopidae		1
Phoridae		1
Hymenoptera		
unidentified adults		5
Chironomidae		1
Ichneumonidae		2
Scelionidae		2
Chalcididae		1
Formicidae		185
Formicinae	Camponotus sp.	13
Myrmicinae		6

The following table shows an analysis of the stomach contents of Aneides ferreus into smaller identified groups for each month in which specimens were collected.

Table 30. An analysis of the stomach contents of Aneides ferreus (by months)

	Jan.	Feb.	Mar.	Apr.	May	June	Nov.
Number of stomachs examined	63	7	7	10	19	1	2
Gastropoda	7				4	2	
Isopoda	3					1	
Chilopoda	9		1	1		2	1
Diplopoda	4		1	4	1		
Scorpionida					1		
Pseudoscorpionida	10				2		
Phalangiida	14						1
Araneida	36	1	2	1	3	1	1
Acarina	100	9	2	2	35		2
Collembola	2130	16	41	11	1		
Orthoptera					2		
Isoptera					1		
Coleoptera	46	6	10	9	5	3	
Hemiptera	10				2		
Homoptera	2						
Lepidoptera	9						
Diptera	38	5	2	1	1	1	
Hymenoptera	86	5	3	25	93		3

Table 31, which follows, shows the relative abundance of various items of food in the stomachs of Aneides ferreus. The second column indicates the number of stomachs, while the third

column indicates the percentage of stomachs containing the food item designated.

Table 31. Abundance of food items in Aneides ferreus

Food item	Number of stomachs containing food item	Percentage of Aneides stomachs containing indicated food item
Gastropoda	4	3.6
Isopoda	4	3.6
Chilopoda	13	11.9
Diplopoda	7	6.4
Scorpionida	1	.9
Pseudoscorpionida	11	10.1
Phalangiida	9	8.2
Araneida	29	26.6
Acarina	47	43.1
Collembola	74	67.8
Orthoptera	1	.9
Isoptera	1	.9
Coleoptera	50	45.8
Hemiptera	11	10.1
Homoptera	1	.9
Lepidoptera	8	7.3
Diptera	24	22.0
Hymenoptera	43	39.4

Storm and Aller (14, pp.59-60) examined the stomach contents of 63 specimens of Aneides ferreus collected in 1946-1947. Comparisons of their percentages with the percentages obtained in this investigation (inclosed in parenthesis) are as follows: Isopoda 14 per cent (3.6 per cent); Chilopoda 3.2 (11.9); Diplopoda 1.6 (6.4); Collembola 3.2 (67.8); Orthoptera 3.2 (.9); Isoptera 11 (.9); Hemiptera 12.8 (10.1); Homoptera 1.6 (.9); Dermaptera 6.4 (0); Coleoptera 34.4 (45.8); Diptera 9.6 (22.0); Hymenoptera 57 (39.4); Araneida 19 (26.6); Pseudoscorpionida 3.2 (10.1); Acarina 19 (43.1).

The dissimilarity noted between the percentages obtained from the two studies may be explained by the variation in the type of habitat from which the salamanders were collected. Most of Storm and Aller's specimens were taken from rotting logs in which ants, termites and isopoda are common. Collembolas, centipedes, pseudoscorpions and mites are not common in this type of habitat. Abundance figures for these groups are just reversed in the type of habitat from which salamanders were taken for this study.

Many of the stomachs of Aneides ferreus contained extraneous materials, which are possibly taken accidentally while feeding. Mud and small stones constitute over 90 per cent of these materials.

Summary

During 1953, 494 salamanders of seven species were collected and examined in order to compile data on (1) the habitat of each species, (2) total-length frequency within the species, (3) differences in secondary sex characters exhibited by each species, (4) variations in the reproductive system at different stages of maturity, and (5) food items consumed by the individuals of each species.

The species studied in this investigation were Dicamptodon ensatus, Rhyacotriton olympicus, Plethodon dunni, Plethodon vehiculum, Batrachoseps wrighti, Ensatina eschscholtzii oregonensis and Aneides ferreus.

Habitat notes were made on each species collected and the following conclusions were made. (1) Plethodon vehiculum, although often found with Plethodon dunni, is more tolerant of higher temperatures and lower moisture conditions. (2) Ensatina is tolerant of low temperatures and a wide range of moisture conditions, with specimens being collected when all other salamanders had disappeared from the habitat, presumably because of low temperatures. (3) Rhyacotriton occasionally is found at low elevations, but only during periods of high rainfall and low temperatures are individuals of the genus found away from the immediate vicinity of streams. The usual habitat for the genus is in wet areas of high elevation. (4) Aneides ferreus normally frequents cleared

areas with numerous downed trees. During cold moist periods, however, individuals radiate away from the logs and are found beneath objects on the ground. As warmer drier periods ensue, Aneides retreat to the protection of loose bark on rotting logs.

Measurements were taken on all of the salamanders. A Student's t-test with a one per cent significance level was used on the total lengths compiled for each species. Only Ensatina showed a significant difference between the male and female populations.

A sex ratio was compiled for each species. The number of females exceeded the males in all species except Batrachoseps where six males were collected to only five females. The other ratios (female to male) were: Ensatina 2.18-1, Aneides 1.04-1, Rhyacotriton 2-1, Plethodon dunni 1.1-1, and Plethodon vehiculum 1.56-1.

Secondary sex characters differ in the shape of the head and snout, the length and form of the tail, and in the structure of the cloacal region.

The male reproductive systems are quite similar; all species have simple testes except Batrachoseps which has the multiple type. Black pigmentation is found in the testes of Rhyacotriton, Plethodon dunni and Plethodon vehiculum; the other species have little or no pigmentation. The sperm ducts remain small in diameter in all species, but lengthen and tend to coil as the salamander matures sexually.

The females of the species studied often possess numerous ovarian eggs even though the ovaries are quite immature. As sexual maturity takes place a few of the immature eggs enlarge causing the ovaries to expand. The average number of mature eggs in the ovaries is as follows: Batrachoseps 4, Ensatina 10.25, Aneides 11.8, Rhyacotriton 104, Dicamptodon (larvae) 202, Plethodon dunni 10.25, and Plethodon vehiculum 7.2.

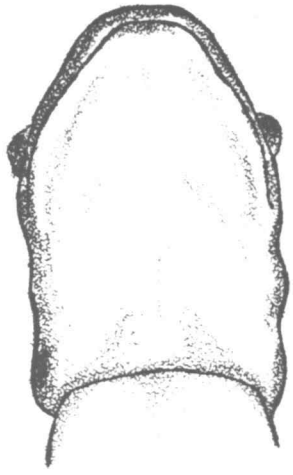
The oviducts are thin and straight in the immature females. As sexual maturity progresses the ducts lengthen, coil and increase several times in diameter.

The fat bodies, which are immediately adjacent to the gonads in all species, vary greatly in size and in color. The size variation seems to have no correlation with the condition of the gonads. Pigmentation is usually noted in the fat bodies for those species having pigmented testes.

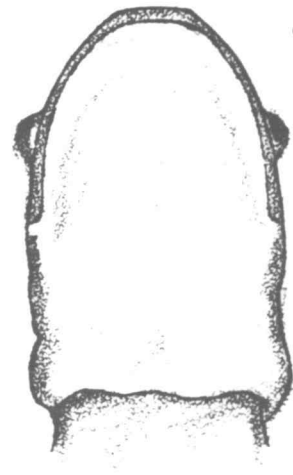
The food items listed for each species may vary somewhat from the items actually consumed by the salamanders. The reason for these irregularities is apparent because of the different rates at which certain forms may be digested. Consequently, such soft bodied forms as annelid worms may be much more important in the diet than their numerical listing would indicate.

Any invertebrate in the proper size range apparently may be eaten by the terrestrial salamanders, and on rare occasions other salamanders may be eaten. The stomach contents of one Plethodon dunni and one Dicamptodon adult each revealed the remains of a

Plethodon vehiculum. Larval *Dicamptodon* were found to feed mainly on bottom-dwelling snails and crayfish. Excluding *Dicamptodon*, the main item of food for all of the species examined was Collembola (springtails). The bulk of the secondary food items consisted of Coleoptera, Acarina and Araneida.



Female

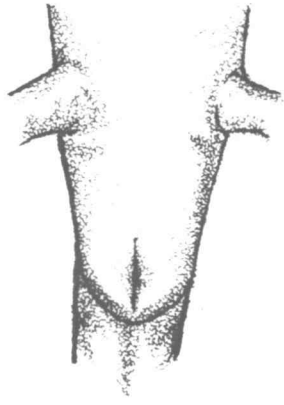


Male

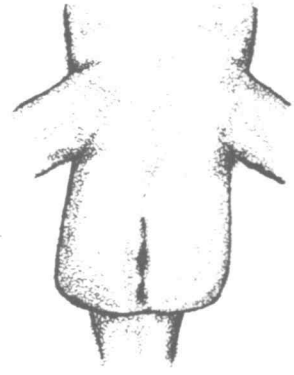
Plate I A. Rhyacotriton olympicus Ventral view of snout. Note similarity of male and female snouts.

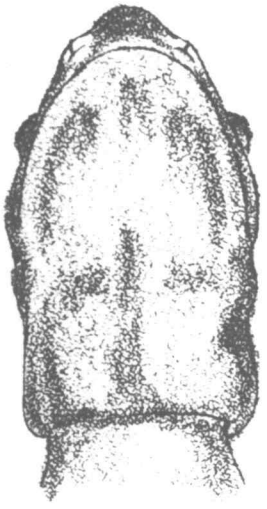
Plate I B. Rhyacotriton olympicus Ventral view of vent region. Note rectilinear lobes present on either side of vent in male.

Female

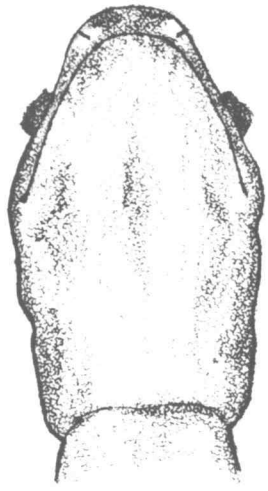


Male





Female

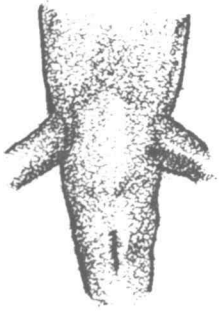


Male

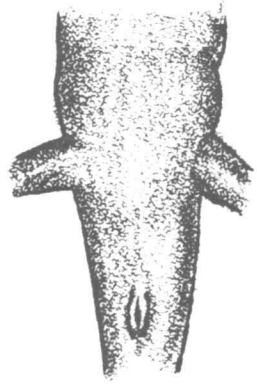
Plate II A. Plethodon dunni Ventral view of snout. Note the slightly more truncate snout in the male.

Plate II B. Plethodon dunni Ventral view of vent region. Note the narrow depressed area bordering the vent of the male.

Female



Male



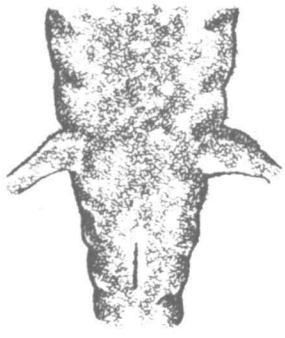
Female

Male

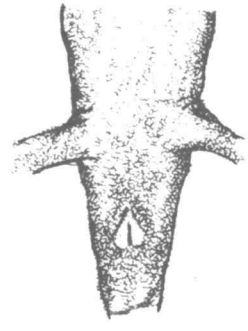
Plate III A. Plethodon vehiculum Ventral view of snout. Note the more truncate snout and the swellings in the region of the nasio-labial groove in the male.

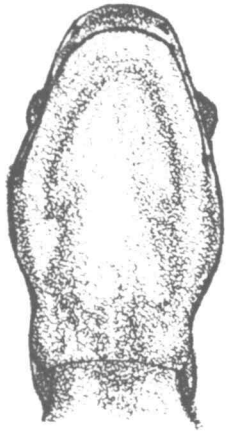
Plate III B. Plethodon vehiculum Ventral view of vent region. Note depressed area bordering the vent of the male.

Female

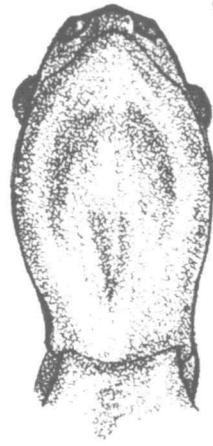


Male





Female

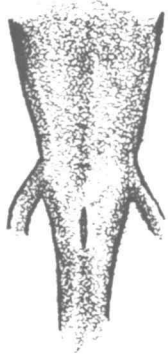


Male

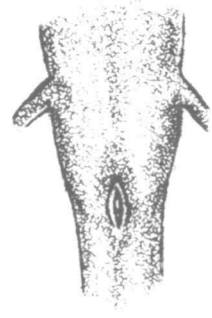
Plate IV A. Batrachoseps wrighti Ventral view of snout. Note the more truncate snout and the swellings in the region of the nasio-labial groove in the male.

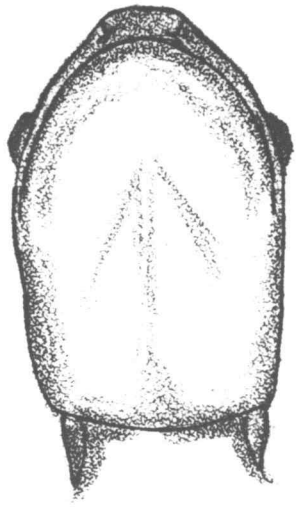
Plate IV B. Batrachoseps wrighti Ventral view of vent region. Note depressed area bordering the vent in the male.

Female

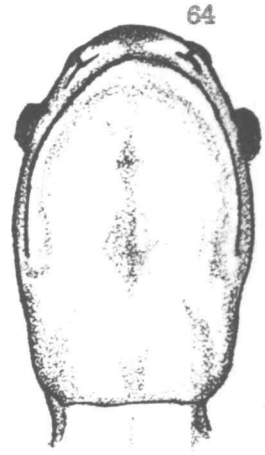


Male





Female

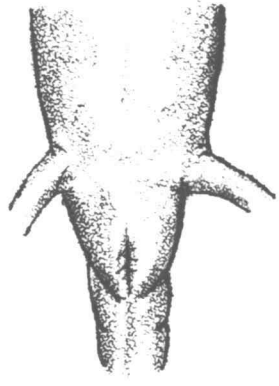


Male

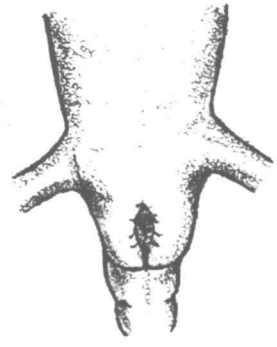
Plate V A. Ensatina eschscholtzii oregonensis Ventral view of snouts. Note the more truncate snout in the male.

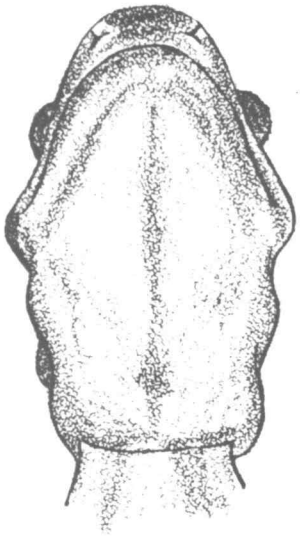
Plate V B. Ensatina eschscholtzii oregonensis Ventral view of vent region. Note swollen vent in male.

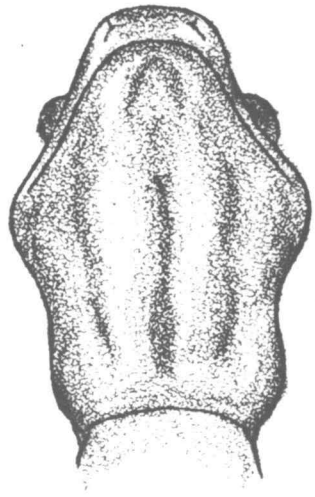
Female



Male





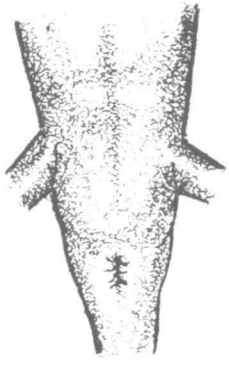


Female Male

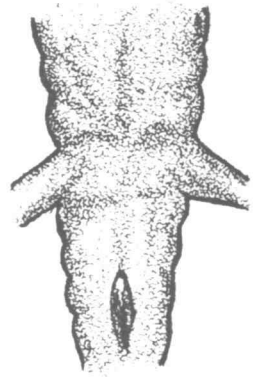
Plate VI A. Aneides ferreus Ventral view of snouts. Note the broader head of the male.

Plate VI B. Aneides ferreus Ventral view of vent region. Note the swollen vent of the male.

Female



Male



BIBLIOGRAPHY

1. Bishop, S.C. A remarkable new salamander from Oregon. Herpetologica 1 (3):93-95. 1937.

2. _____. Handbook of salamanders. Ithaca, N.Y., Comstock, 1943. 555p.

3. Chu, H.F. How to know the immature insects. Dubuque, Iowa, Brown, 1949. 234p.

4. Comstock, John Henry. An introduction to entomology. 9th ed. Ithaca, N.Y., Comstock, 1947. 1064p.

5. _____. The spider book. Rev. ed. Ithaca, N.Y., Comstock, 1948. 727p.

6. Dumas, Philip Conrad. The ecological sympatric relations of Plethodon dunni and Plethodon vehiculum. Ph.D. thesis. Corvallis, Oregon state college, 1953. 48 numb. leaves.

7. Francis, Eric T.B. The anatomy of the salamander. Oxford, Clarendon, 1934. 381p.

8. Jaques, H.E. How to know the insects. Dubuque, Iowa, Brown, 1947. 205p.

9. Noble, G. Kingsley. The biology of the amphibia. New York, McGraw-Hill, 1931. 577p.

10. Pennak, Robert William. Fresh-water invertebrates of the United States. New York, Ronald Press, 1953. 769p.

11. Pratt, Henry Sherring. A manual of the common invertebrate animals. Philadelphia, Blakiston, 1948. 854p.

12. Stebbins, Robert C. Amphibians of western North America. Berkley, Univ. of Calif. Press, 1951. 539p.

13. Stebbins, Robert C. and C.H. Lowe, Jr. The systematic status of Plethopsis with a discussion of speciation in the genus Batrachoseps. Copeia 2:116-129. 1949.

14. Storm, Robert M. and Alvin R. Aller. Food habits of Aneides ferreus. Herpetologica 4:59-60. 1947.

15. Zweifel, Richard G. Comparison of food of Ensatina and Aneides. Copeia 4:285-287. 1949.