A Comparative Study of *Plethodon glutinosus* and *Plethodon jordani (melaventris)* with Respect to External Form

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The slimy salamander, *Plethodon glutinosus*, occurs not only in Indiana, but also throughout most of the eastern portion of the United States. Similar but different salamanders, characteristically from higher altitudes and of much more restricted ranges in the Southeast, first became known in 1901 when Blatchley (4) described a black-bodied and red-cheeked form from the Great Smoky Mountains and named it *Plethodon jordani* in honor of David Starr Jordan. Over the succeeding quarter century other populations which became known included: *P. shermani* in 1906, black with red legs, from the Nanthala Mountains of North Carolina; *P. metcalfi* in 1912, black and unspotted, occupying a large part of the Southern Blue Ridge Province; *P. clemsonae* in 1927, and known only from the type locality, Jocassee Valley in Northwestern Oconee County, South Carolina (5, 7, 13). Regarding *P. metcalfi*, Bailey (1) noted differences in size and color which he suggested might be correlated with altitude. However, in a more extensive distributional study, Grobman (8) found these differences to be of a geographical character; he retained the term *metcalfi* for the northern smaller-bodied and lighter-colored segment of the originally described *metcalfi*, and separated the southern segment of larger and darker forms, lumping them with *P. clemsonae* to the south. Shortly thereafter Pope and Hairston (14) re-separated this southern segment of forms as *P. shermani melaventris* and identified a new population as *P. shermani rabunensis*. Practically simultaneously, Harriston and Pope (12) reviewed the entire complex, reporting evidences of intergradation justifying the recognition of *metcalfi, melaventris, clemsonae, rabunensis*, and *shermani* as all being subspecies of *P. shermani*. Two years later Hairston (10) reported evidences of intergradation between *jordani* and *metcalfi* and also described a new population; as a result of these findings the whole complex of salamanders became the "*jordani* complex" consisting of *Plethodon jordani* exhibiting seven subspecies: *jordani, metcalfi, melaventris, rabunensis, clemsonae, shermani*, and *teyahalee* (6). The most recent event in the taxonomic vicissitudes of these salamander populations occurred a dozen years later; in a review of the Genus *Plethodon*, Highton (13) declined to recognize any of the subspecies, and treated the complex as one single but highly variable species, *Plethodon jordani*.

That a close relationship must exist between the members of the *jordani complex* and the much more widely-ranging *Pletthodon glutinosus* has been recognized by all workers cited above, beginning with Blatchley. In the southern Appalachians *P. glutinosus* overlapped the *jordani* salamanders geographically but generally not altitudinally (9, 11). One member of the complex, *shermani*, was originally described as black-bodied with red spots of pigment on the legs and with no mention of spots elsewhere. Bailey (1) reported on some specimens which also exhibited lateral spotting of the body with white. Bishop found and

described ten such *shermani* with lateral body white, and on this basis made *shermani* a subspecies of *P. glutinosus* (2, 3). This view of the relationship was rejected by Grobman (8), Hairston and Pope (12) and Hairston (10). All, however, indicated a need for more information, a view shared by Highton (13).

Although it has not been by any means the sole criterion used, skin pigment has figured very prominently in all of the studies cited above. It would be no exaggeration to suggest that kind, distribution, and intensity of skin pigment has had more influence in determining taxonomic status of the populations concerned than any other single externally-visible aspect of body organization. The studies reported herein were undertaken for the purpose of investigating certain non-pigmentational characteristics and any implications such may have for the still-undecided degree to which *P. glutinosus* and *P. jordani* may be interrelated.

Procedures

The information on which this paper is based has been accumulated during the period 1956-1966 inclusive, mostly during the summers, but with considerable variation as to length of time spent and intensity of effort expended in different years. During this period some time has been spent in the Southern Appalachians in each of nine summers, and on each such occasion the Highlands Biological Station at Highlands, North Carolina, was the base of operations. During the summers of 1956, 1957, and 1963 the work was aided by National Science Foundation grants administered by the Highlands Biological Station.

Procedurally, collecting activity was interspersed with the taking of observations in order that records be on animals that were fresh, vigorous, and not too long away from the field. In a few exceptional cases some observational delay did occur, and Indiana specimens were observed in North Carolina or North Carolina specimens were observed in Indiana, the transport being accomplished with the live animals on ice in a car refrigerator. When observed, each animal was assigned its individual number, and considerable observational attention was devoted to it. Observations were recorded on Data Sheets which provided for approximately 24 measurements and numerous other descriptive entries, including pigmentation, in detail. All data were obtained from animals in the living state, the observations being made on specimens under chloretone (chlorobutanol) anesthesia as light as was compatible with immobilization. Care was exercised to keep the animal in the unstretched, undistorted, natural position. Examinations were made with the unaided eye and also under binocular stereoscopic magnification. Measurements were made with a micrometer caliper, aided in certain instances by draftsmens' dividers. Weights were taken on balances sensitive to at least 0.01 gm.

For the *jordani* complex, the population chosen for study was *Plethodon jordani melaventris*, a term retained here for specificity of designation, while duly recognizing Highton's (13) recent revision. The range of this population was originally given as "From Swannanoa, Buncombe County, North Carolina, southward to Greenville County, South Carolina, and westward to Highlands, Macon County, North Carolina"; the type

locality was Highlands, North Carolina (Pope and Hairston, 14). Of the specimens collected for this study, 94 came from various locations in the type locality, Highlands, North Carolina; other specimens from Macon County, N. C., included: Ammons Camp—5, Blue Valley—4, Brier Patch —6, Cullowhee Gap—10, Bull Pen Road—7, Whiteside Cove—4, Horse Cove—3, Walkingstick Road—5, Cliffside Recreation Area—22, Browns at Scaly—1, Singletons—1, Skittles Creek Trail—1, Ellicott Rock Trail— 1, a total of 70. Salamanders collected from other locations included: (1) from Jackson County, N. C.: Granite City—17, Route 107 and Whitewater River—1, Upper Whitewater Falls—1, for a total of 19; (2) from Transylvania County, N.C.: Frying Pan Gap—3, Bearwallow Creek—4, Thompson River—1, Upper Whitewater Falls—1, for a total of 9; (3) from Oconee County, South Carolina: Wallhala Fish Hatchery —12, Stumphouse Tunnel Road—1, for a total of 13. The entire sample of the *P. j. melaventris* population encompassed 205 animals.

The *Plethodon glutinosus* sample included 26 specimens from central Indiana, 23 from the Greencastle Area in Putnam County, 1 from the Shades State Park Area of Parke County, and 2 from the Morgan-Monroe State Forest in Morgan County. Southeastern specimens included 21 animals from Macon County, N. C., as follows: Brier Patch —2, Horse Cove—1, Coweeta Hydrologic Laboratory—2, Cliffside Recreation Area—4, Highlands—3, Mulberry Road—7, Cullowhee Gap—2. Georgia specimens included 1 animal from Brasstown Bald in Towns County, plus 67 from Rabun County as follows: Black Rock—1, Satolah —1, Patterson Gap Road—7, Warwoman Dell—58. From South Carolina, 3 specimens from Jocassee Valley in Oconee County were included. The total sample of *P. glutinosus* embraced 117 specimens.

The head length of the specimens was measured from the tip of the snout to the gular fold, and trunk length was measured from the gular fold to the anterior angle of the vent. Tail length was from the latter landmark to the tip of the tail. Head width was measured at two levels: (1) at a lateral bulge right behind the eyes, where the head was usually widest, and (2) at a less pronounced bulge just anterior to the gular fold level. Neck width was measured immediately posterior to the gular fold. Maximal trunk width was measured at the widest part of the body as determined by inspection. The axilla to groin distance was measured from the posterior edge of the front leg to the anterior edge of the hind leg, in each case at the junction of the limb with the trunk.

Since tails are apparently quite expendable aspects of salamander anatomy, the snout-vent (S-V) length was taken as a standard basis of comparison. In both samples, all specimens were arranged in sequence and ascending order by S-V length and then divided into step-interval classes for statistical consideration; for the most part, a frequency distribution by 3 mm step-intervals in S-V length was used.

Results

For detailed consideration, results presented here will for the most part relate to the four step-interval classes which include the largest members, except two specimens, of the *P. j. melaventris* sample. It

would be expected that whatever pecularities characterize *melaventris* would find fullest expression in the most mature, and presumably best-developed, specimens. Since the comparisons are made by groups or step-interval classes, the values included in the accompanying tables are mean values. For reference purposes, for each statistic, an item number is placed above each column in the tables; the mean values in the tables, except indices, are in millimeter units.

1. Body Length Relationships in Absolute Values.

Table 1 is concerned with absolute values of body length relationships. Since the specimens were deliberately classified in 3 mm step-interval classes by S-V length in each of the four classes, Item 1 merely reflects the average S-V length in each. Comparatively, it is of interest to note that 22 *melaventris* and only 7 *glutinosus* fell into the class of shorter S-V length, while only 5 *melaventris* to 11 *glutinosus* occurred in the larger of the four classes, a relationship that could imply that *glutinosus* tends to be a larger animal than *melaventris*. Furthermore, in Item 5, within each class, *glutinosus* exhibited consistently a slightly

TABLE 1

Comparison of *P. j. melaventris* and *P. glutinosus* in four step-interval classes with respect to certain length relationships. All values are means; the number of cases used in calculating each mean value is entered under the entry in the N line.

Class by S-V Length	Spec.	1 S-V Length	2 Head Length	3 Trunk Length	4 Tail Length	5 Total Length
60-62.9 mm	P.j.m.	61.47	14.84	46.63	71.86	133.1
	N	22	22	22	13	13
	P.gl.	61.39	14.46	46.84	72.62	134.3
	N	7	7	7	5	5
63-65.9 mm	P.j.m.	64.31	15.34	48.96	74.79	139.3
	N	16	16	16	12	12
	P.gl.	64.25	15.14	49.11	75.29	139.82
	N	13	13	13	7	7
66-68.9 mm	P.j.m.	67.53	15.98	51.54	77.93	145.5
	N	16	16	16	9	9
	P.gl.	67.98	15.85	52.12	75.48	148.37
	N	13	13	13	9	9
69-71.9 mm	P.j.m.	70.44	16.82	53.62	76.67	144.7
	N	5	5	5	3	3
	P.gl.	70.10	16.45	53.65	76.11	146.13
	N	11	11	11	8	8

Abbreviations:
S-V—length, snout to vent
Spec.—species
P.j.m.—*P. j. melaventris*
P.gl.—*P. glutinosus*

greater total length. In Item 2, *melaventris* exhibited a mean head length slightly greater than *glutinosus*, and did so consistently although the magnitude of the difference is very small. Consistency was also exhibited in Item 3 where mean trunk length of *glutinosus* was greater in all four classes, although again the differences are small. In respect to Item 4, mean tail length in the two smaller classes (by S-V length) is greater in *glutinosus*, in the two larger classes, greater in *melaventris*.

A similar lack of consistency is evident in Table 3, Item 14, where the axilla-groin measurement of *glutinosus* is greater in the two middle-sized classes, greater in *melaventris* in the smallest and largest class. Again, in Item 16, the snout-to-axilla distance of *melaventris* is greater in the two shorter and the longest classes but greater in *glutinosus* in the 66-68.9 mm class.

2. Longitudinal Body Proportions.

To indicate proportions, or part-to-part body relationships irrespective of size in absolute units, individual indices were calculated for

TABLE 2

Mean values of certain indices involving body proportion in *P. j. melaventris* and *P. glutinosus*.

Class by S-V Length	Spec.	6 Index: HdLgth S-V	7 Index: TrLgth S-V	8 Index: TaLgth ToLgth	9 Index: S-V ToLgth	10 Index: HdLgth MxHdWd
60-62.9 mm	P.j.m.	0.2413	0.7590	0.5379	0.4619	1.5175
	N	22	22	13	13	21
	P.gl.	0.2368	0.7648	0.5399	0.4597	1.504
	N	7	7	5	5	7
63-65.9 mm	P.j.m.	0.2385	0.7613	0.5355	0.4643	1.4951
	N	16	16	12	12	16
	P.gl.	0.2355	0.7643	0.5376	0.4622	1.481
	N	13	13	7	7	13
66-68.9 mm	P.j.m.	0.2366	0.7632	0.5344	0.4654	1.4940
	N	16	16	9	9	16
	P.gl.	0.2330	0.7668	0.5260	0.4738	1.469
	N	13	13	9	9	13
69-71.9 mm	P.j.m.	0.2387	0.7611	0.5149	0.4849	1.5010
	N	5	5	3	3	5
	P.gl.	0.2346	0.7652	0.5190	0.4808	1.484
	N	11	11	8	8	11

Abbreviations not previously identified:
HdLgth—head length
TrLgth—trunk length
TaLgth—tail length
ToLgth—total length
MxHdWd—maximal head width

each animal, and the values entered in the tables are means of these individual index values. In the case of Item 6, Table 2, the greater the relative head length, the higher is the value of the index; in all four classes *melaventris* exhibits consistently a very slightly higher proportion of head than does *glutinosus*. In Item 7, the reciprocal is true, the trunk occupying more of the S-V length in *glutinosus* than in *melaventris*.

Items 8 and 9, Table 2, show that in both salamanders the tail is typically longer than the "body" (S-V length). Comparatively, the four classes do not, in Item 8, evince a consistent pattern, three showing greater relative tail length in *glutinosus*, one class a greater relative tail length in *melaventris*, although the differences are small. The comparative relationships in relative S-V length in Item 9 show the exact converse.

The part of the body measured as "trunk" includes a region between the gular fold and the front legs which could be termed a "neck." In order to take this into account and to investigate longitudinal proportions further the snout-to-axilla (S-A) measurements are given in Table 3. Reference to Item 16 shows an inconsistent picture, *melaventris* having the slightly longer absolute snout-to-axilla measurement in

TABLE 3

Mean values of certain measurements and body proportion indices in *P. j. melaventris* and *P. glutinosus*.

Class by S-V Length	Spec.	11 Index: A-G MxTrWd	12 Index: S-V MxTrWd	13 MxTrWd	14 A-G	15 Index: A-G S-V	16 S-A
60-62.9 mm	P.j.m.	3.77	6.71	9.25	34.46	0.5598	20.9
	N	21	21	21	21	21	22
	P.gl.	4.15	7.40	8.45	34.36	0.5596	20.8
	N	6	6	6	7	7	7
63-65.9 mm	P.j.m.	3.67	6.52	9.93	36.37	0.5651	21.98
	N	15	16	16	15	15	15
	P.gl.	3.89	6.83	9.52	36.60	0.5696	21.8
	N	13	13	13	13	13	13
66-68.9 mm	P.j.m.	3.89	6.88	9.91	38.03	0.5635	22.7
	N	16	16	16	16	16	16
	P.gl.	3.87	6.81	10.02	38.75	0.5699	23.2
	N	13	13	13	13	13	13
69-71.9 mm	P.j.m.	3.33	6.04	11.72	38.92	0.5525	23.76
	N	5	5	5	5	5	5
	P.gl.	3.65	6.55	10.79	38.86	0.5542	23.4
	N	11	11	11	11	11	11

Abbreviations not previously identified:
A-G—length, axilla to groin
MxTrWd—maximal trunk width
S-A—length, snout to axilla

three classes, *glutinosus* having it in one class. An identical comparative relationship in terms of proportions is exhibited by the mean index values in Item 17, Table 4.

Farther back along the body axis, the absolute extent of the axilla-to-groin distance (A-G) is given in Table 3, along with an index of this same measurement is a proportion of the S-V length. In Item 14 the mean absolute A-G measure is greater for *melaventris* in the shortest and longest classes, greater for *glutinosus* in the two middle-sized classes. As a proportion of the S-V length, however, Item 15 reveals *glutinosus* to have the greater relative A-G length in all but the class of shortest salamanders.

3. Shape Relations: Slenderness vs. Stockiness.

In Table 3, Item 13 records the mean trunk widths as measured at the widest part of the trunk between axilla and groin. In three classes, *melaventris* exceeds *glutinosus* in mean greatest trunk width, in one class (66-68.9 mm S-V) the opposite relation holds.

Two indices were calculated concerning the relative slenderness or stockiness of the salamander trunk. In Items 11 and 12 of Table 3, the

TABLE 4

Additional measurements and indices in *P. j. melaventris* and *P. glutinosus* in four step-interval classes.

Class by S-V Length	Spec.	17 Index: S-A S-V	18 gm/mm	19 MxHdWd	20 Index: PoHdWd NeckWd	21 PoHdWd	22 NeckWd	23 Diff
60-62.9 mm	P.j.m.	0.3402	0.0322	9.84	1.2572	9.31	7.41	1.90
	N	22	9	21	22	22	22	22
	P.gl.	0.3390	0.0342	9.70	1.2277	8.8	7.17	1.64
	N	7	5	7	7	7	7	7
63-65.9 mm	P.j.m.	0.3416	0.0387	10.25	1.2719	9.77	7.75	2.00
	N	15	10	16	15	16	15	15
	P.gl.	0.3394	0.0354	10.23	1.2328	9.52	7.73	1.79
	N	13	6	13	13	13	13	13
66-68.9 mm	P.j.m.	0.3371	0.0415	10.16	1.2219	10.06	8.24	1.83
	N	16	6	16	16	16	16	16
	P.gl.	0.3410	0.0441	10.79	1.2269	10.32	8.46	1.85
	N	13	8	13	13	13	13	13
69-71.9 mm	P.j.m.	0.3373	0.0482	11.2	1.2114	10.60	8.76	1.84
	N	5	2	5	5	5	5	5
	P.gl.	0.3342	0.0457	11.10	1.2253	10.45	8.55	1.91
	N	11	4	11	11	11	11	11

Abbreviations not previously identified:
PoHdWd—posterior head width
NeckWd—neck width
Diff—difference between posterior head width and neck width

numerical magnitude of the index is directly proportional to the degree of body slenderness, a low value being indicative of stockiness. In Item 11, axilla-groin distance divided by maximal trunk width yielded mean index values indicating *glutinosus* to be slightly more slender in the two shorter and the longest classes, with *melaventris* very slightly the more slender in the 66-68.9 mm class. In Item 12, a longer portion of the body was used by including the neck, and the index was calculated by dividing the snout-vent length by maximal trunk width, but the comparative results remain unaltered and essentially as in Item 11.

4. Head Shape and Proportions.

In Table 4, Items 19 and 21 show that in both *glutinosus* and *melaventris* the maximal head width (just behind the eyes) is consistently greater than head width more posteriorly, just in front of the gular fold level. At both locations, *glutinosus* shows the greater mean absolute value in the 66-68.9 mm class, while *melaventris* has the larger value in the other three classes. The index in Table 2, Item 10, is so calculated that relatives head slenderness is directly proportional to increasing numerical index value. Comparison of the Item 10 mean values in the four classes show that the *melaventris* head is consistently the more slender, a relationship consonant with the slightly greater absolute head length mentioned above in connection with Item 2 of Table 1. Reference to Item 22 of Table 4 will show *glutinosus* to have the wider neck in mean absolute value in the 66-68.9 mm class, *melaventris* to have the wider neck in the other three classes. Item 23 gives the mean absolute difference between posterior head width and neck width; *melaventris* exhibits a greater difference in the two smaller classes, *glutinosus* a greater difference in the two classes containing the larger salamanders. To investigate further distinctness of head in relation to the neck, an index was calculated wherein index value was directly proportional to the head-neck difference in width; the mean values recorded in Item 20, Table 4, shows the *melaventris* head to be the more distinct from the neck in all except the class of largest salamanders.

5. General Body Size and Weight Relations.

The occasional failure to take and record an animal weight, and the prevalence of incomplete tails militated to constrict the weight data available. However, the index in Item 18, Table 4 was calculated by dividing weight in grams by total length in millimeters to yield an index of grams of weight per millimeter of total body length. No consistent pattern emerged; in two of the classes *glutinosus* exhibited the greater mean value, in two *melaventris* did.

In considering the organism as a whole in terms of size relationships, the entire series of 205 specimens of *P. j. melaventris*, when arranged into 3 mm step-interval classes by S-V length, fell into 19 such classes. The larger specimens were classified in the four classes presented in Tables 1-4 plus one additional class, the limits of which were 72-74.9 mm, and which accommodated only two specimens. The smallest *melaventris* had an S-V length of 19.0 mm, the largest, 73.6 mm. The *glutinosus* series, when similarly classified, occupied a span of 20 similar step-intervals. The shortest *glutinosus* had an S-V length of 26.9 mm,

and one class, 39-41.9 mm, contained only one specimen, while another class, 42-44.9 mm, was devoid of representation in the series. Toward the larger end of the scale, however, the *glutinosus* series required no less than three additional step-interval classes to accommodate a total of 15 specimens which had no counterparts at all in the *melaventris* series; the largest *glutinosus* was 83.9 mm in S-V length, over 10 mm longer than the largest *melaventris*.

Because it revealed the characteristics of the population samples to better advantage, both series were re-classified on the basis of a 2 mm step-interval by S-V length, and the results are graphically presented in Figures 1 and 2. Thus classified the *melaventris* sample occupied a

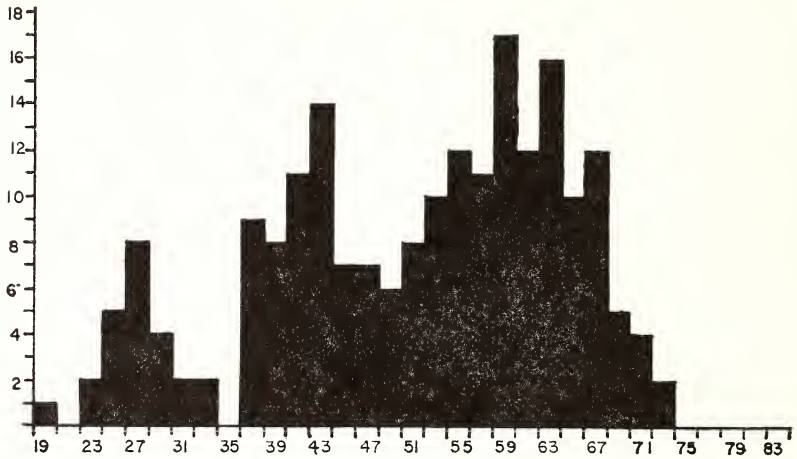

Figure 1. Distribution of 205 specimens of *P. j. melaventris* classified by snout-vent length measured in millimeters. Frequency of cases plotted on vertical axis, class centers for S-V length plotted by 2 mm step-intervals on horizontal axis; limits of smallest class are 18-19.9 mm, of the largest class, 72-73.9 mm, other classes in accordance therewith.

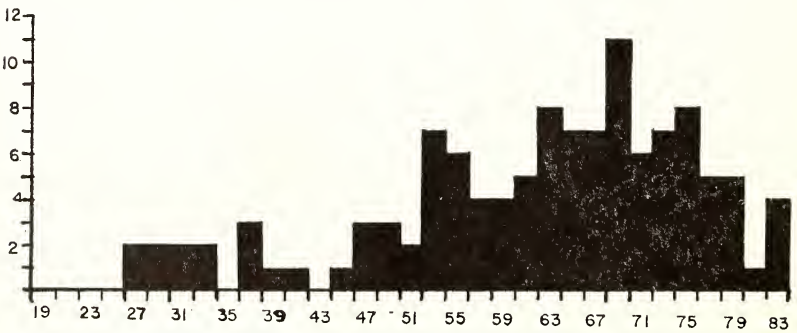

Figure 2. Distribution of 117 specimens of *P. glutinosus* classified by snout-vent length measured in millimeters. Frequency of cases plotted on vertical axis, class centers for S-V length plotted by 2 mm step-intervals on horizontal axis; limits of smallest class are 26-27.9 mm, of the largest class, 82-83.9 mm, other classes in accordance therewith.

span of 28, *glutinosus* a span of 33, step-interval classes. Comparison of these two figures will accentuate the above-mentioned relationships: the *glutinosus* sample exhibited fewer of the animals in the shorter categories, significantly more cases in the longer ones; the *glutinosus* sample required five step-intervals into which fell 23 specimens for which the *melaventris* sample afforded no equivalents in S-V length.

Discussion

In the results just presented, part-by-part comparisons were made between 59 mature specimens of *P. j. melaventris* and 44 mature specimens of *P. glutinosus*, with both population samples arranged into step-interval classes such that the direct comparisons were of animals that could differ in size no more than 3.0 mm in snout-vent length. There were eight anatomical relationships of quantity in which no consistent difference, no tendency to a distinctive and uniform pattern for each sample, could be discerned: tail length (Item 4), axilla-to-groin length (Item 14), snout-to-axilla length (Item 16), trunk width (Item 13), maximal head width (Item 19), posterior head width (Item 21), neck width (Item 22), and width difference between head and neck (Item 23). With respect to these aspects of external organismic form, it could be otherwise stated that the two samples exhibited variation of such magnitude that there was considerable overlapping in the numerical values of these eight measurements. In addition, there occurred eight proportionate relationships which evinced a similar lack of species patternization: relative tail length (Item 8), relative S-V length (Item 9), S-A length as a proportion of S-V length (Item 17), A-G length as a proportion of S-V length (Item 15), maximal trunk width as a proportion of A-G length (Item 11), maximal trunk width as a proportion of S-V length (Item 12), relative distinctness of head from neck (Item 20), and weight per millimeter of body total length (Item 18). Exploration of body proportions by the use of these indices afforded an opportunity for there to be reflected, if such existed, differences in organization such as: relative trunk slenderness or stockiness, relative amount of the body axis occupied by the neck, relative position of limbs along the body axis, and mass-length relationships. The actual results, however, build up to sixteen the quantitative external anatomical relationships in which the samples of *glutinosus* and *melaventris* show overlapping variation. Alternatively expressed, these sixteen aspects of structure would tend to indicate close similarity and a very close biological relationship between the two forms.

A close relationship between *glutinosus* and *melaventris* could also be an interpretation given to two aspects in which the two samples were consistently alike. Both were characterized by a wedge-shaped head when viewed dorsally; a widening occurred just anterior to the head-neck junction at the gular fold level, with the widest part of the head occurring anteriorly at a level just behind the eyes (Items 19, 21). For the record, however, it should be stated that in both population samples an occasional animal had a head deviating from this pattern and exhibiting a head with almost parallel sides; such cases were so frequent that central tendency in head shape is clearly expressed in Items 19 and 21, Table 4. That both *P. glutinosus* and a representative of *P. jordani*

have such a head shape is not in accord with a statement of Bishop (2) which characterized *P. glutinosus* (from the Nantahala mountains) as having a more parallel-sided head as distinct from the then recognized *P. shermani* which had a head shape which he described as oval in outline. A second trait shared by *P. glutinosus* and *P. j. melaventris* was in the fact that tails made up more of the body total length than did the S-V length (Items 8, 9). Finally, an inspection of all the mean values in Tables 1-4 shows that differences between *glutinosus* and *melaventris* are quite small in magnitude, which may be interpreted as evidence for closeness of relationship. For such a relationship, this discussion has thus far mentioned nineteen indications deduced from the results of this study, and they reinforce Highton's (13) statement that "no known character will separate all *glutinosus* and *jordani* consistently."

The part-by-part comparisons did, however, present a few relationships in which the two forms exhibited distinctive patterns, though by differences, as mentioned above, of small magnitude. Concisely characterized, *melaventris* exhibited consistently greater head length (Item 2) and more head as a proportion of S-V length (Item 6) while *glutinosus* exhibited a longer trunk (Item 3) and more trunk as a proportion of S-V length (Item 7). The most definite and outstanding data with respect to *glutinosus-melaventris* differences, however, are those data relating to the property of general organismic size. In the close comparisons wherein no specimen can differ from others by more than 3 mm in S-V length, *glutinosus* consistently exhibited a greater total length (Item 5); in Item 1, the shortest S-V length class contained 22 *melaventris* to seven *glutinosus*, while the longest S-V class contained five *melaventris* to 11 *glutinosus*. Both of these relationships would tend to indicate that *glutinosus* is basically a larger animal than melaventris. This is further highlighted by the fact that 24 specimens or approximately 12% of a *glutinosus* sample of 117 specimens were larger in S-V length than the largest specimen in the *melaventris* sample of 205 animals (Figures 1 and 2).

Occasion may be taken here to comment on some comparative statements concerning *P. glutinosus* and the nominate form of *P. jordani* made by Blatchley (2) in his original description of the latter. One statement was that the *jordani* head was shorter and broader than the *glutinosus* head. As repreesnted in the present report by the form *melaventris*, *P. jordani* has a longer head both actually and relative to S-V length than does *glutinosus*. As to head width or breadth, this has been discussed above as exhibiting overlapping variation. Also, Blatchley described the *jordani* head as more distinct than that of *glutinosus*; this, too, has failed of confirmation in this study since overlapping variation also characterized this relationship of the two forms.

In the introductory part of his classical work on the family *Plethodontidae*, Dunn (7) made mention of what might be termed "impressionistic evaluation" in the observing and classifying of salamanders. He pointed out that the experienced observer forms, somewhat subconsciously, a basis of judgment and evaluation that enables the identification of a specimen almost at a glance, yet if the same observer were asked to verbalize in specifics the several minutiae and subtle nuances

of form manifested by the specimen which were the basis of judgment, the observer would find it very difficult to do. In the course of collecting and observing the animals upon which this paper is based, such an impression was developed, an impression which would have characterized *P. glutinosus* as a stockier, bulky, heavy-bodied animal, and *melaventris* as a more slender and graceful animal. When specimens of approximately the same size were compared directly in a quantified manner, the only basis for such an impression occurred with reference to the head, where the *melaventris* head was both actually longer and relatively more slender (Items 2, 6). At the trunk level there was overlapping variation as revealed by a "slenderness index" that was calculated on two bases (Items 11, 12) but there were numerically more really slender specimens of *glutinosus* than of *melaventris*. To elaborate additionally on impressionistic characterization, a theoretical situation may be entertained. Suppose that, after preservation, the 50 largest *glutinosus* had been selected and arranged in a tray serially and in sequence by ascending S-V length, and alongside these, the 50 largest *melaventris* had been arranged, similarly classified. It is quite likely that observation-by-series would have sustained the general impression of *melanventris* as the more slender and graceful, *glutinosus* as the bulkier and larger, animal. There would have been no assurance at all that such an examination would have made it apparent that virtually 50% of the *glutinosus* sample were so large as to lack completely any counterparts in the *melaventris* series.

This report has refrained from any treatment of pigmentation, although it was freely used as an identification criterion when each individual specimen was studied. Furthermore, consideration of such traits as costal grooves and vomerine teeth has been omitted in favor of emphasis on aspects of external morphology not too commonly or routinely utilized in prior studies of the forms in question. The quantified approach used herein did, as a matter of fact, confirm the impression that *P. glutinosus* is indeed basically a larger animal than *P. j. melanventris*, but it also went beyond mere confirmation by making possible a statement of this and other external differences in fairly precise terms. Also it made possible the setting forth in reasonable detail of the extent and nature of variation of both forms in respect to certain facets of external organismic form, and emphasized the marked similarity of the two forms when comparable-sized specimens were considered. So far as *melaventris* is representative of its species, *Plethodon jordani*, this investigation has reaffirmed that it is distinguishably different from *Plethodon glutinosus*, yet very closely related, and has done so by adding a new and somewhat different dimension to existing knowledge of the populations concerned.

Summary

Direct comparisons were made between 59 specimens of *Plethodon jordani melaventris* and 44 specimens of *Plethoden glutinosus* arranged in four 3.0 mm step-interval classes by snout-vent length. In some 19 quantitative aspects of body form the two forms were either in agreement or exhibited overlapping variation, testifying to a close biological relationship between the two forms. Consistent differences of small

magnitude were revealed which indicated that *melaventris* had a larger head and one that occupied a greater proportion of the snout-vent length that *glutinosus*, while *glutinosus* had a longer trunk and one that occupied a greater proportion of the snout-vent length than *melaventris*. Furthermore, within each of the four step-interval classes compared, *glutinosus* had a slightly greater mean total length. That *glutinosus* is basically a larger animal than *melaventris* was indicated by the frequency distributions of the two samples, and was highlighted by the fact that same 12% of the *glutinosus* sample of 117 specimens were greater in snout-vent length than the longest *melaventris* in a total sample of 205 animals.

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