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Comparative Morphology of Pre-extrusion Larvae of the Sharp-beaked Redfishes, *Sebastes mentella* and *S. fasciatus*

by

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ABSTRACT

Morphometrics, meristics and pigmentation characteristics were recorded for late-stage, pre-extrusion larvae taken from adult females of the sharp-beaked redfishes, Sebastes mentel and Sebastes fasciatus, from NAFO Div. 3Ps. The adults were identified to species by gas bladder musculature criteria. Univariate statistics were calculated and the utility of eact variable as a potential species identification criterion was evaluated. Discriminant analys correctly classified up to 95% of larvae examined. The potential of the discriminant functi in species identification for planktonic larvae is discussed.

INTRODUCTION

Attempts to identify planktonic larvae of Sebastes sp. in North Atlantic waters are nearly as old as the controversy surrounding the taxonomic status of the adults. Templeman and Sandeman (1959) reported that, in S. mentella, pre-extrusion larvae were much more likel to have one or more sub-caudal melanophores than larvae of S. marinus. The status of this proposed identification character fell into doubt when studies in the Irminger Sea and Icelandic areas reported planktonic larvae of S. mentella did not possess these melanophores (Henderson 1964, 1965; Raitt 1964; Bainbridge and Cooper 1971). More recently, Barsukov (1972), Barsukov and Zakharov (1972), and Templeman (1980) concluded that a third species, S. fasciatus, should be recognized in western North Atlantic waters and Templeman (1980) propos that the specimens reported to be S. mentella by Templeman and Sandeman (1959) were probably mixture of both S. mentella and S. fasciatus and hence the confusion over whether S. mentell possessed sub-caudal melanophores. Templeman (1980) and Moser et al. (1977) determined tha S. fasciatus pre-extrusion larvae usually had two or more sub-caudal melanophores while S. mentella pre-extrusion larvae usually had none or one.

The usefulness of sub-caudal melanophores and other characters (Moser et al. 1977; Serebryakov MS 1982) continued to be plagued by uncertainty concerning the identification of the parents and also the fact that none of the proposed characters gave a clear separation c species. In this study, gas bladder musculature criteria (Ni 1981a; Litvinenko 1980; Powe and Ni 1982) were used to identify adults of S. mentella and S. fasciatus containing late-stage, pre-extrusion larvae. A detailed examination of larval morphology was carried and characters examined as potential species identification criteria. Discriminant analysis was used to identify characters with the best potential for future classification of planktonic larvae.

METHODS

During a cruise to NAFO Div. 3Ps in early June, 1982, adult female S. mentella and S. fasciatus containing larvae were collected by stratified random bottom trawling. Late-stage, pre-extrusion larvae of both species, with yolk sacs fully resorbed or nearly s were used in a comparative morphological analysis. Only fully developed larvae were used t ensure that any interspecific differences observed were not affected by variations in developmental stage. Due to this requirement, only two adult specimens of S. mentella and four of S. fasciatus could be used. All other captured female redfish either contained unhatched eggs or hatched larvae in early developmental stages.

The specimens used in the analysis were caught at two locations: 46°44'N 57°45'W at 316 m and 46°41'N 58°33'W at 428 m on 4-5 June, 1982. The adults were identified according gas bladder musculature criteria (Litvinenko 1980; Ni 1981a; Power and Ni 1982). Randomly selected sub-samples of 25 larvae were measured from each adult redfish. A total of 11 morphometric measurements, 3 meristic measurements and 12 pigmentation characteristics were recorded. Details of these measurements and abbreviations used throughout the text are contained in the Appendix.

Larvae collected from S. mentella adults were larger than those from S. fasciatus. Th mean total length for S. mentella was 7.89 mm (s^2 = 0.036) while that of S. fasciatus was 7.34 mm (s^2 = 0.207). Both the mean and variance were significantly different (t = 10.49, Prob > t = 0.0001; Folded F' = 5.77, Prob > F' = 0.0001). Linear regressions of each of t morphometric variables indicated all were signicantly correlated with total length. Becaus of this, interspecific differences in the means and variances of the morphometric variables could not be directly compared. To eliminate interspecific differences, due to the unequal mean length of the two species samples, the residuals from each linear regression of variabl versus total length, instead of the raw data, were compared. The mean residuals for each species were compared by t-tests and residual variances by the Folded F' statistic (SAS, STATISTICAL ANALYSIS INSTITUTE, 1982). Because the t-test is influenced by unequal variance whenever the variances were significantly unequal (Prob F' < .05) the t value was calculated using the individual variances rather than the pooled variance (SAS, STATISTICAL ANALYSIS INSTITUTE, 1982) and Satterthwaite's (1946) approximation for df (Steel and Torrie, 1980).

RESULTS

The results of the univariate analyses on the 11 morphometric variables are presented i Table 1. These results show that, of 11 morphometric variables measured, the mean residuals of 7 differed significantly but only 3 residual variances were significantly different. Onl pectoral fin base depth and eye diameter residuals differed in both mean and variance with head length residual variances significantly different between species but not the residual means. The significantly different residual means were snout to anus length, body depth at both the pectoral and anus and head depth. For S. fasciatus, the variables with larger mean residuals were pectoral fin base depth and snout length. For S. mentella, the variables with larger mean residuals were body depth at both pectoral and anus, snout to anus length, eye diameter and head depth. The mean residuals for pectoral fin length, caudal peduncle depth, head length and interorbital width were not significantly different between species.

The χ^2 statistics comparing frequency distributions of the meristic and pigmentation variables are summarized in Table 2. Of the 15 meristic and pigmentation variables measurec 10 were found to have significantly different (Prob < .05) frequency distributions between species. The five not significantly different were number of pre-anal myomeres, and the ty of the melanophores on the dorsum, ventrum, nape and interorbital space.

S. mentella larvae have 30-32 body myomeres with a mode at 31 (Fig. 1a). In contrast, fasciatus had relatively fewer body myomeres (29-32) with a mode at 30. A similar situatio existed with respect to number of post-anal body myomeres (Fig. 1b). In S. mentella larvae, the number of post-anal body myomeres was modal at 23 and ranged from 22 to 24. In S. fasciatus the frequency distribution of post-anal body myomeres was still modal at 23 but th frequency of larvae with 22 post-anal body myomeres was next highest while, in S. mentella, relatively more larvae had 24 post-anal myomeres. In S. mentella and S. fasciatus (Fig. 1c), most larvae had 7 pre-anal body myomeres, some had 8, and a few had 9. The interspecific frequency differences for number of pre-anal myomeres are not significant.

Several pigmentation patterns, the visually most noticeable of which is the line of melanophores on the dorsum, showed several important differences between species. Firstly, DOR-BEGIN, the anterior start of the melanophore line on the dorsum (Fig. 2a), tended to be more anteriorly in S. fasciatus than in S. mentella. In S. mentella, no individuals had t dorsal melanophore line starting before post-anal myomere 10. The frequency distribution w modal at post-anal myomere 13 and ranged from 10 to 15. In contrast, S. fasciatus dorsal melanophore patterns ranged from post-anal body myomere 9 to 15 with all but 2% ranging fro to 13. The DOR-BEGIN frequency distribution for S. fasciatus was modal at post-anal myome 11. The posterior end of the dorsal body melanophore pattern (DOR-END) similarly tended to end more anteriorly in S. fasciatus than in S. mentella (Fig. 2b). In S. mentella, the DOR-END frequency distribution was modal at post-anal myomere 22 and ranged from 19 to 23.

S. fasciatus, the frequency distribution was modal at 21 and ranged from 19 to 23. Because these interspecific differences in starting and ending post-anal myomere, the length of the dorsal melanophore pattern (DOR-LEN) for S. mentella is shorter, when measured in myomere units, than the corresponding pattern in S. fasciatus (Fig. 2c). In S. mentella, the modal frequency is 9 (range 8 to 13) while, in S. fasciatus, the modal frequency is 11 (range 8 to 14). Although there were differences in type of dorsal melanophores (DOR-TYPE), these were not statistically significant. Most larvae of both S. mentella and S. fasciatus, 64% and 74 respectively, exhibited a pattern of melanophores grown together into a tangled mass for mor than half of the total extent of the melanophore pattern. A further 22% and 20% of S. mentella and S. fasciatus, respectively, had completely separate, distinct melanophores only with the remainder being in the intermediate condition of melanophores grown together for le than half of their total extent.

Interspecific differences in pigmentation on the ventrum were also apparent. In S. mentella, the start of the pigment pattern on the ventrum (VEN-BEGIN) was more anterior than in S. fasciatus (Fig. 3a). In both S. mentella and S. fasciatus, the VEN-BEGIN frequen distribution was modal at post-anal myomere 5 but, in S. mentella, the range was 4 to 6 whil in S. fasciatus, the range was from 3 to 6. In S. mentella, the end of the pigment pattern the ventrum (VEN-END) was further anterior than in S. fasciatus for most individuals (Fig. 3b). In S. mentella and S. fasciatus, the VEN-END frequency distribution is modal at post-anal myomere 22 but the range for S. mentella is 21 to 24 while, in S. fasciatus, the range is 21 to 23. These interspecific differences in VEN-BEGIN and VEN-END are also reflected in the total length, measured in myomere units, of the ventral pigment pattern (VEN-LEN). In S. mentella, the VEN-LEN frequency distribution is modal at 17 myomeres rangi from 17 to 20 (Fig. 3c). In contrast, the VEN-LEN frequency distribution for S. fasciatus i modal at 18 but still ranges from 17 to 20. The interspecific differences in type of melanophores on the ventrum (VEN-TYPE) were not significant. Most larvae of both species ha all or nearly all of the melanophores joined into a single line of pigment (Fig. 4a) and a f had all or nearly all melanophores separated into distinct, contracted spots.

The frequency distributions for type of pigment patterns on the dorsal surface of the head (HEAD-TYPE) were significantly different (Fig. 4b). In S. mentella, most larvae (88%) had a solid mass of many expanded melanophores covering the top of the head like a cap. The remaining 12% had diffuse, amorphous pigment of no detectable pattern. In S. fasciatus, onl 45% had the solid cap of expanded melanophores. The modal frequency of 49% had a mixture of some distinct, expanded melanophores interspersed with diffuse pigment. The remaining 6% ha all diffuse pigment.

All larvae of both S. mentella and S. fasciatus had no pigment in the interorbital spac Most larvae of both species, 94% and 89% respectively, also had no pigment at the nape. In those which did have some pigment, this usually consisted of one or two contracted, small spots. The number of sub-caudal melanophores (CAUMEL) differed significantly between specie (Fig. 4c). In S. mentella, 42% had no sub-caudal melanophores while only 18% of S. fasciatu completely lack sub-caudal melanophores. The CAUMEL frequency distribution for S. mentella was modal at 1 while only 4% had 2 sub-caudal melanophores. In S. fasciatus, the CAUMEL frequency distribution is also modal at 1, but 38% had 2 sub-caudal melanophores and the remaining 2% had 3.

Three different discriminant functions were determined and the variables with most classification power identified (Table 3). In the first discriminant function, only morphometric residuals were used. In the second, only meristic and pigmentation variables were used and, in the third, all variables were combined. When only morphometric residuals are used, the resultant discrimant function includes 5 residuals; BODPEC, SNANLEN, EYED, SNTLEN, and PECTLEN. All other morphometric residuals did not increase the number of cases correctly classified. When only meristic and pigmentation variables are used, the resultant discriminant function includes 6 variables; DOR-BEGIN, HEAD-TYPE, VEN-BEGIN, MYOM, VEN-TYPE, and POST-MYOM. The variables include characteristics of pigmentation on the dorsum, ventrum head and numbers of body myomeres. Inclusion of any other meristic or pigmentation variable did not increase the number of cases correctly classified. The third discrimant function, based on all variables combined, identified nine useful variables: DOR-BEGIN, HEAD-TYPE, VEN-BEGIN, BODPEC, PECTLEN, SNANLEN, POST-MYOM, VEN-TYPE, and CAUMEL. Inclusion of any othe variables did not increase the number of cases correctly classified.

The relative classification power of each discrimant function is shown in Table 4. Function 1, based on morphometric residuals only, correctly classified 79% of both species. Function 2, based on meristic and pigmentation variables only, correctly classified 90% of S mentella and 83% of S. fasciatus. Function 3, with all variables combined, correctly classified 94% of S. mentella and 95% of S. fasciatus.

DISCUSSION

Univariate statistical tests have revealed significant morphometric, meristic and pigmentation differences between late-stage, pre-extrusion larvae of S. mentella and S. fasciatus. Morphometrically, pre-extrusion larvae of S. mentella may be characterized as deeper-bodied than S. fasciatus larvae as evidenced by their relatively greater body depth at the anus and pectoral fin and greater head depth. S. mentella larvae had larger eye diameter and greater snout to anus lengths than larvae of S. fasciatus. S. fasciatus larvae had larger snouts and greater pectoral fin base depth. The pre-extrusion larvae of S. mentella were larger than those of S. fasciatus, even though the two samples were estimated to be at approximately the same developmental stages. This observation, considered with findings of Magnusson and Magnusson (MS1977) suggest that larvae of S. mentella are larger at extrusion than larvae of either S. fasciatus or S. marinus. These observations constitute the first morphometric descriptions of pre-extrusion larvae of S. mentella.

In terms of meristics, only body myomeres may be counted in pre-extrusion redfish larvae. S. mentella larvae may be characterized as having 30-32 body myomeres while S. fasciatus has 29-32. Given a 1:1 ratio of eventual number of vertebrae (including the urostyle) to number of body myomeres (Dunn 1983), this frequency for body myomeres agrees well with past determinations of numbers of vertebrae in adults of these species (Ni 1981b; Barsukov and Zakharov 1972). The range of body myomeres found in S. mentella is the same as that reported by Fahay (1983) but is substantially different from the range (28-31) reported by Serebryakov (MS1982). The range reported here for S. fasciatus is greater than the range (29-30) reported by Fahay (1983). No previous reports of number of post-anal myomeres exist for either of these species. S. mentella may be characterized as tending to have 23-24 post-anal myomeres while S. fasciatus usually has 22-23. Both species usually have either 7 or 8 pre-anal myomeres.

In terms of pigmentation, S. mentella differed from S. fasciatus in several aspects. dorsal and ventral body pigmentation tended to begin and end more posteriorly in S. mentella than in S. fasciatus. The overall length of these pigmentation patterns tended to be longer in S. fasciatus than in S. mentella. No detailed description of these pigmentation patterns exist for S. mentella but the results reported here seem to be in general agreement with Serebryakov (MS 1982). Moser et al. (1977), from Gulf of Maine specimens, reported the ventral body pigment began on post-anal myomeres 1-4 (mean = 2.9) and ended on post-anal myomeres 19-22 (mean = 21.3) in S. fasciatus. In this study, the ventral body pigment began on post-anal myomere 3-6 (mode = 5) and ended on post-anal myomeres 21-23 (mode = 22) for S. fasciatus. Moser et al. (1977) also reported the dorsal body pigment began on post-anal myomeres 7-14 (mean = 10.9) and ended on post-anal myomeres 14-22 (mean = 19.1) for the same larvae from Gulf of Maine. In this study, the dorsal body pigment began on post-anal myomeres 9-13 (mode = 11) and ended on post-anal myomeres 19-23 (mode = 21).

Moser et al. (1977) reported pre-extrusion larvae of S. fasciatus in the Gulf of Maine also had a pigment spot at the nape. In this study, larvae of both S. fasciatus and S. mentella usually had no nape pigment. Only 6% and 11% of S. mentella and S. fasciatus respectively had nape pigment and this sometimes consisted of several spots instead of one as reported by Moser et al. (1977).

Moser et al. (1977) found S. fasciatus pre-extrusion larvae always had one or more sub-caudal melanophores. In their study of larvae in the Gulf of Maine, 33% had one sub-caudal melanophore, 53% had 2, 12% had 3, and 2% had 4. Templeman (1980) reported larvae from NAFO Div. 2H to 3P usually had three sub-caudal melanophores, but often two or four and occasionally five while S. mentella usually had one or none and only occasionally two sub-caudal melanophores. Serebryakov (MS1982), in a sample of unknown origin, reported S. mentella larvae to have no sub-caudal melanophores, a finding similar to that of Henderson (1965) and Bainbridge and Cooper (1971) for S. mentella in the Icelandic and Irminger Sea areas. In this study, S. mentella usually had one or none and occasionally two while S. fasciatus usually had one or two, sometimes none and occasionally three sub-caudal melanophores.

No differences in pigmentation type on the head have been reported previously for either species. In this study, S. mentella larvae usually had a pattern of distinct, but expanded, melanophores on the head while S. fasciatus tended to have a greater amount of diffuse, amorphous pigment.

It is not clear whether the differences in pigmentation reported in this paper compared to other published accounts are due to geographic variation or whether they are due to the different methods of classification. Fahay (1983) and Moser et al. (1977) apparently assume their specimens to be S. fasciatus based on their origin from the Gulf of Maine, Scotian She

area. Templeman (1980) used morphological characters to classify adult redfish and the meth used by Serebryakov (MS1982) is unknown. This study represents the first time pre-extrusion larvae of S. mentella and S. fasciatus were identified by the gas bladder musculature characteristics of the parents.

The use of discriminant analysis successfully identified variables with the best possib potential for classification of planktonic sharp-beaked redfish larvae. Although the characteristics of S. marinus, the third species of Sebastes in western North Atlantic water (Power and Ni 1982) have not been reported here, they are presumed to be very similar to tho of S. mentella and S. fasciatus (see Moser et al. 1977; Fahay 1983). However, in most areas this may not present a problem in classification of planktonic larvae because S. marinus occurs only in small numbers west of Flemish Cap (Barsukov and Zakharov 1972; Templeman 198(Ni 1981a and b). Therefore, the discriminant analysis functions proposed here may prove valuable in classification of redfish larvae in all areas except Flemish Cap. These characters may prove problematic in other ways when extended to planktonic larvae. The body proportions and pigmentation patterns of fish larvae may change dramatically during ontogeny and redfish are no exception (Moser et al. 1977; Fahay 1983; Serebryakov MS 1982). Usage of discriminant function based on pigmentation characters, although giving the best classification of pre-extrusion larvae, will have to address these ontogenetic changes. The resultant 95% correct classification reported here is encouraging, particularly in its potential applicability to the younger, newly-extruded redfish larvae. Finally, it is interesting to note that, in this analysis, the number of sub-caudal melanophores had very little classification power compared to characteristics of the pigmentation on the dorsum and ventrum. This indicates that the emphasis on studies of sub-caudal melanophore patterns may have been mis-guided.

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Table 1. Summary of univariate statistics, including comparison of means and variances, for all morphometric residuals of S. mentella and S. fasciatus.

	Residuals							
	S. fasciatus		S. mentella				Folded	
Variable	$\bar{X}$	Std. err.	$\bar{X}$	Std. err.	T	Prob > T	F'	Prob > F'
SNANLEN	-0.014	0.0047	0.028	0.0077	4.79	0.0001	1.31	N.S.
SNTLEN	0.007	0.0039	-0.014	0.0060	3.02	0.0030	1.16	N.S.
EYED	-0.005	0.0033	0.010	0.0071	1.99	0.0500	2.20	0.0009
HDLEN	0.006	0.0051	-0.013	0.0114	1.58	N.S.	2.41	0.0001
HDDEP	-0.015	0.0060	0.030	0.0094	4.14	0.0001	1.20	N.S.
INTORB	-0.004	0.0038	0.008	0.0060	1.82	N.S.	1.18	N.S.
BODPEC	-0.019	0.0059	0.039	0.0092	5.47	0.0001	1.19	N.S.
BODAN	-0.011	0.0041	0.023	0.0066	4.68	0.0001	1.31	N.S.
CAUPED	-0.001	0.0019	0.001	0.0031	0.58	N.S.	1.36	N.S.
PECTLEN	0.004	0.0071	-0.008	0.0092	0.94	N.S.	1.22	N.S.
PECTDEP	0.005	0.0036	-0.010	0.0038	2.88	0.0047	1.94	0.0126

Table 2. Summary of χ^2 statistics comparing the frequency distributions of 15 meristic and pigmentation variables for S. mentella and S. fasciatus.

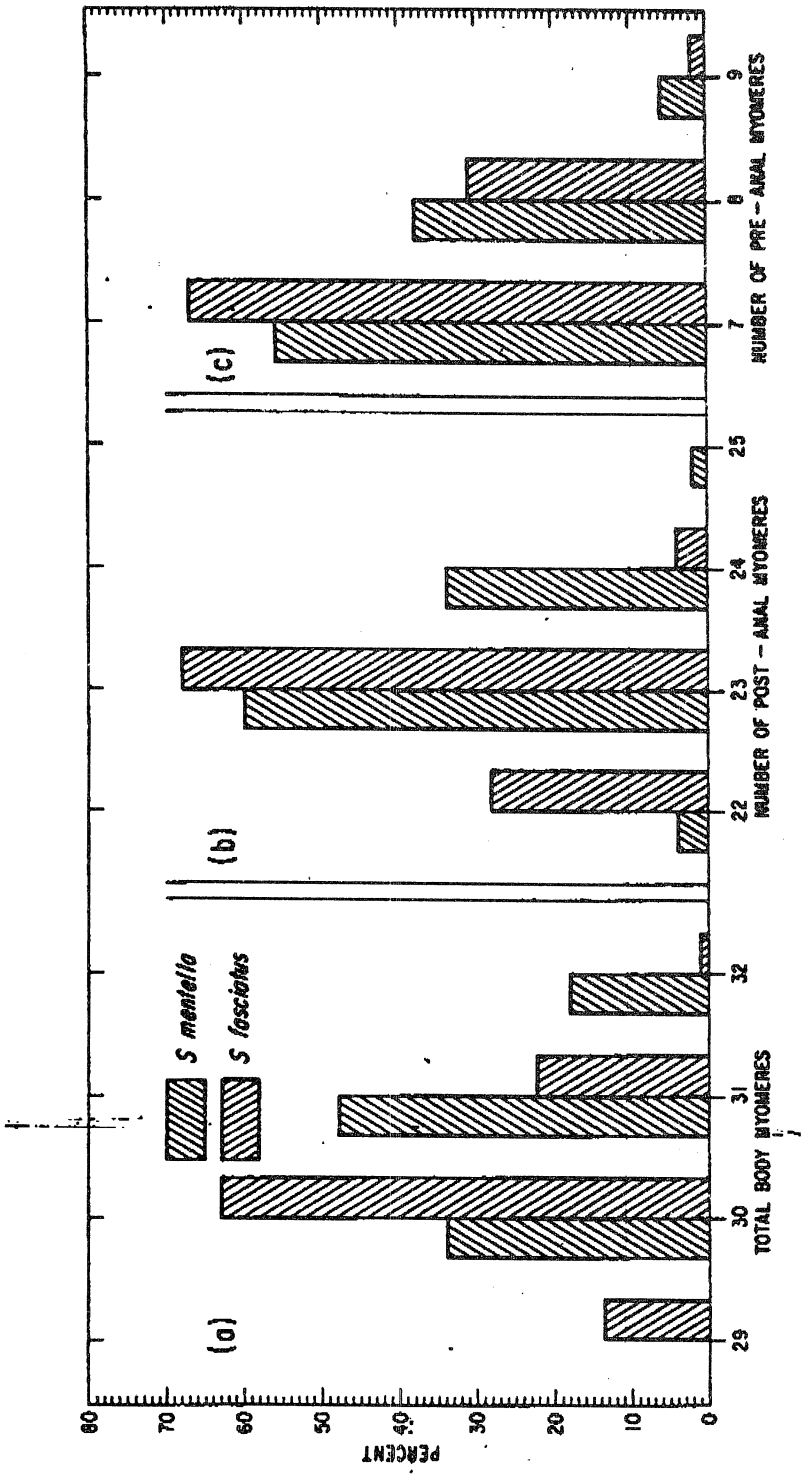
Variable	χ^2	Prob > χ^2
PRE-MYOM	2.82	N.S.
POST-MYOM	34.17	0.0001
MYOM	34.3	0.0001
DOR-BEGIN	60.78	0.0001
DOR-END	13.65	0.0085
DOR-LEN	32.07	0.0001
DOR-TYPE	4.57	N.S.
VEN-BEGIN	23.01	0.0001
VEN-END	18.83	0.0003
VEN-LEN	8.19	0.0422
VEN-TYPE	0.66	N.S.
INTORB-TYPE	0.49	N.S.
NAPE-TYPE	4.16	N.S.
HEAD-TYPE	36.53	0.0001
CAUMEL	23.62	0.0001

Table 3. In descending order of classification power, variables useful in posterior classification of cases with their accompanying F statistics for three discriminant functions: (1) morphometric residuals only (2) meristic and pigmentation variables only (3) all variables combined.

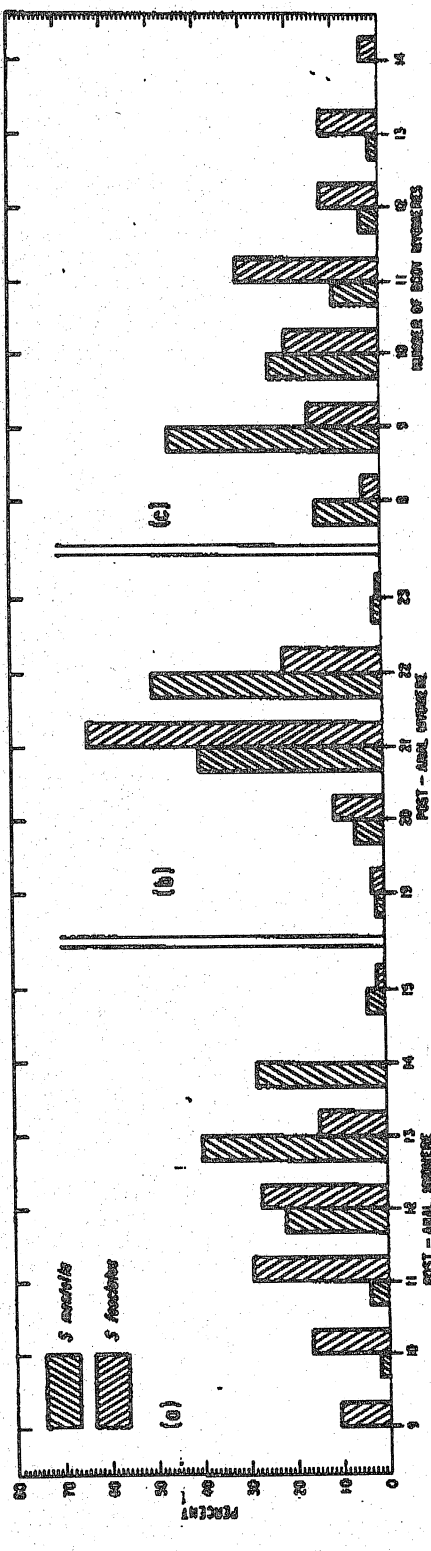
Variables								
(1)			(2)			(3)		
Morphometric residuals only			Meristic and pigmentation only			All variables combined		
Variable entered	F	Prob > F	Variable entered	F	Prob > F	Variable entered	F	Prob > F
BODPEC	27.9	0.0001	DOR-BEGIN	68.6	0.0001	DOR-BEGIN	68.6	0.0001
SNANLEN	15.1	0.0002	HEAD-TYPE	27.7	0.0001	HEAD-TYPE	27.7	0.0001
EYED	6.6	0.0114	VEN-BEGIN	26.8	0.0001	VEN-BEGIN	26.8	0.0001
SNTLEN	5.2	0.0240	MYOM	10.4	0.0015	BODPEC	17.3	0.0001
PECTLEN	3.4	0.0682	VEN-TYPE	5.7	0.0186	PECTLEN	13.8	0.0003
			POST-MYOM	2.6	0.1081	SNANLEN	15.1	0.0002
						POST-MYOM	7.3	0.0078
						VEN-TYPE	7.9	0.0056
						CAUMEL	4.6	0.0339

Table 4. Percent correct posterior classification for three discriminant functions: (1) morphometric residuals only (2) meristic and pigmentation variables only (3) all variables combined. Species 1 is S. mentella, Species 2 is S. fasciatus.

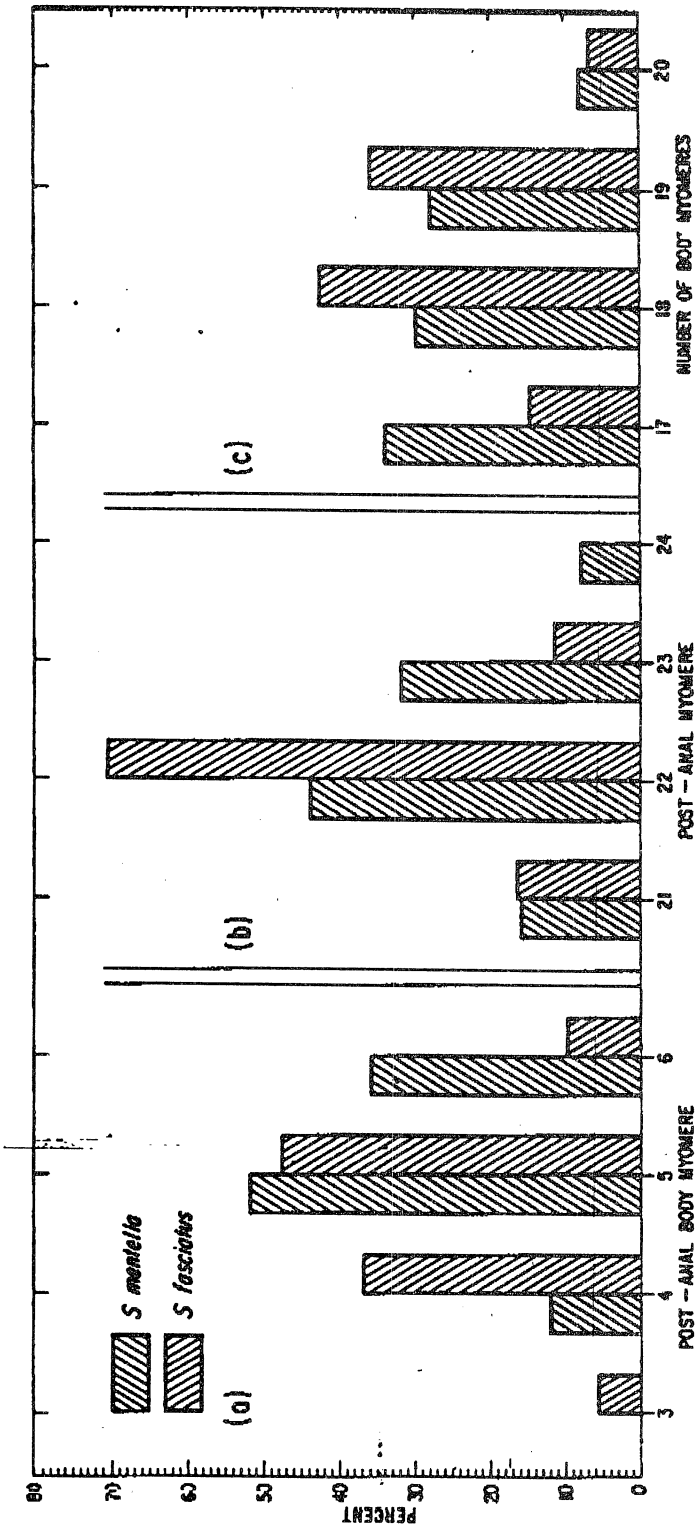
Discriminant function								
(1)			(2)			(3)		
Morphometric residuals only			Meristic and pigmentation only			All variables combined		
From species	To species		From species	To species		From species	To species	
	1	2		1	2		1	2
1	79	21	1	90	10	1	94	6
2	21	79	2	17	83	2	5	95



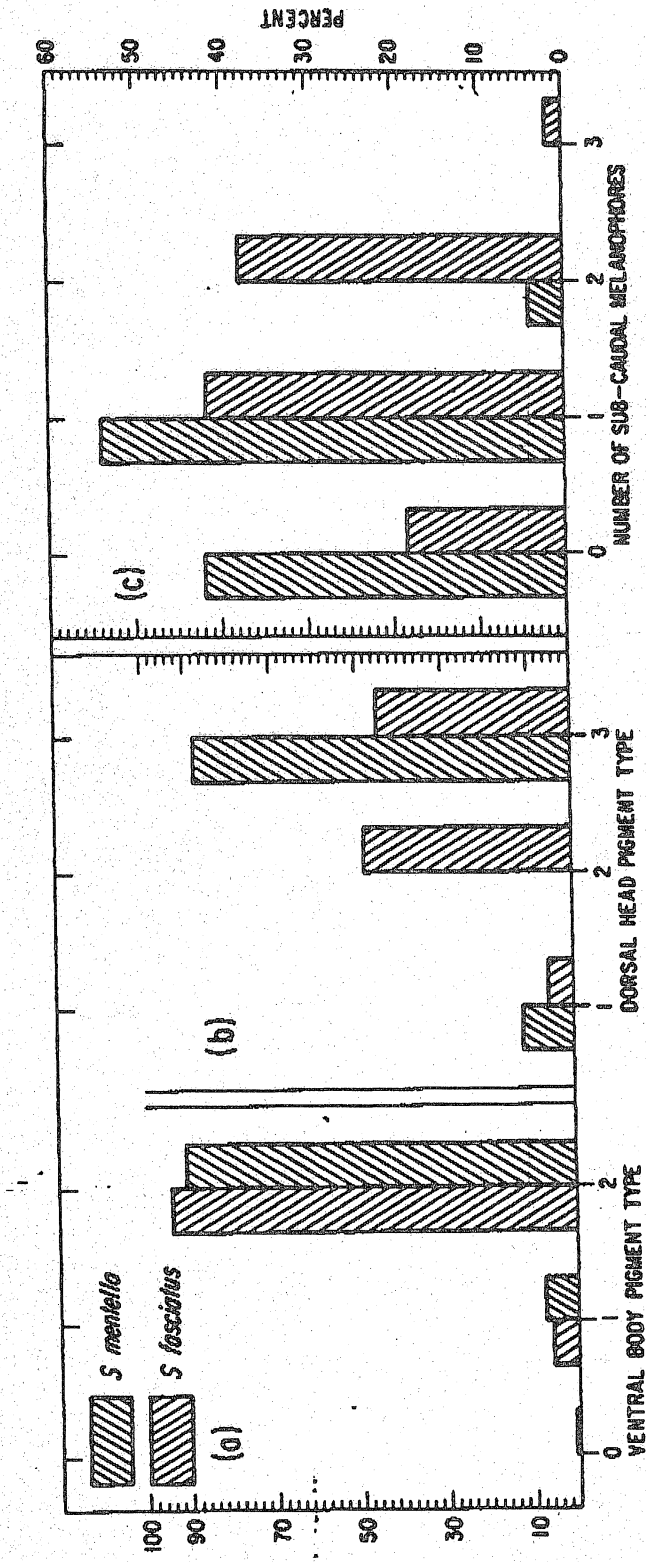
1. Frequency distributions (%) of body myomeres in pre-extrusion larvae of S. mentella and S. fasciatus. (a) total body myomeres, (b) number of post-anal myomeres, (c) number of pre-anal myomeres.



2. Frequency distributions (%) of melanophore patterns on the dorsum of pre-extrusion larvae of S. mentella and S. fasciatus. (a) DOR-BEGIN, the anterio start of the melanophore line, (b) DOR-END, the posterior end of the melanophore line, (c) DOR-LEN, the length of the melanophore line.



3. Frequency distributions (%) of melanophore patterns on the ventrum in pre-extrusion larvae of S. mentella and S. fasciatus. (a) VEN-BEGIN, the anterior start of the melanophore line, (b) VEN-END, the posterior end of the melanophore line, (c) VEN-LEN, the length of the melanophore line.



4. Frequency distributions (%) of melanophore patterns in pre-extrusion larvae of S. mentella and S. fasciatus. (a) VEN-TYPE, the type of melanophores on the ventrum, (b) HEAD-TYPE, the type of melanophores on the dorsal surface of the head, (c) CAUMEL, the number of sub-caudal melanophores.

APPENDIX

Description of morphological variables with their abbreviations as used in the text.

A. Morphometrics

1. BODPEC — Vertical body depth measured at the insertion of the pectoral fin.
2. SNANLEN — Length from tip of snout to the anus.
3. PECTLEN — Length of the longest ray of the pectoral fin measured from its poir of insertion.
4. PECTDEP — Width of the pectoral fin base.
5. CAUPED — Width of the caudal peduncle at its narrowest point.
6. HDLEN — Horizontal distance from the tip of snout to the posterior edge of t opercle.
7. SNTLEN — Tip of snout posteriad to the intersection of a vertical line from t anteriormost edge of the orbit.
8. BODAN — Vertical body depth measured at the anus.
9. EYED — Maximum horizontal width of the eye.
10. INTORB — Horizontal distance through the interorbital space.
11. HDDEP — Head depth along a vertical line through the centre of the eye.

B. Meristic and pigmentation variables

1. PRE-MYOM — Number of pre-anal myomeres.
2. POST-MYOM — Number of post-anal myomeres.
3. MYOM — Total body myomeres.
4. CAUMEL — Number of sub-caudal melanophores.
5. VEN-TYPE — Melanophores on the ventrum
   0. No melanophores present
   1. contracted, separate melanophores not forming a line
   2. expanded but separate melanophores not forming a line
   3. melanophores merged into a distinct line
6. INTORB-TYPE — Melanophores in the interorbital space
   1. all separate, distinct melanophores
   2. melanophores arranged into a ring
   3. pigment diffuse, no distinct melanophores
   4. no pigment

7. NAPE-TYPE — Melanophores at the nape

1. single melanophore, expanded in appearance
2. one or more contracted melanophores
3. diffuse pigment
4. no pigment

8. DOR-TYPE — Melanophores on the dorsum

1. distinct melanophores forming a complete line or nearly so
2. distinct melanophores forming a line for more than half the tota extent of the melanophore pattern
3. distinct melanophores forming a line less than half of the total extent of the melanophore pattern
4. all distinct, separate melanophores

9. HEAD-TYPE — Melanophores on top of the brain

1. pigment diffuse, no distinct melanophores
2. partly diffuse and partly forming a solid cap of pigment
3. distinct melanophores merging into a solid cap
4. some distinct, some merged into a cap
5. some distinct and separate, and partly diffuse pigment
6. all separate, distinct melanophores

10. DOR-BEGIN — Post-anal myomere on which the anteriormost melanophore on the dors begins.

11. DOR-END — Post-anal myomere on which the posteriormost melanophore on the dors ends.

12. VEN-BEGIN — Post-anal myomere on which the anteriormost melanophore on the ventr begins.

13. VEN-END — Post-anal myomere on which the posteriormost melanophore on the ventrum ends.

14. DORLEN — Total length, in myomeres, of the dorsal body melanophore line.

15. VENLEN — Total length, in myomeres, of the ventral body melanophore line.