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Variation of body proportions during
the period of growth of *Trematomus*
(Pisces; *Nototheniidae**)
bernacchii Boul.

ABSTRACT: It was demonstrated that in the fishes of the species *Trematomus bernacchi*, predominant in the regions of the USSR Antarctic Station Mirny (Davis Sea), body proportions changes along with the growth of these specimens. Measurements include 20 plastic features in 171 fishess (total length 110.2—265.0 mm). Statistically significant variations of eleven proportions of the body were stated during the growth of the fishes. Five other proportions changed in a degree of little statistical significance, whereas the last three of the body proportions did not change at all.

KEY WORDS: Antarctic ichthyology, taxonomic measurements

1. Introduction

Taxonomy of a number of the Antarctic species of fishes, also of the genus *Trematomus*, is based on the proportions of various parts of the body (De Witt and Tyler 1960). A wide range of the values of these proportions — probably different in specimens of different size (different age) — may arouse some reservations. This is quite justifiable particularly in the case of none too well known species of the Antarctic ichthyofauna, since on the basis of different values of body proportions in young and adult specimens they could be mistakenly classified into separate systematic groups.

The aim of these studies was to demonstrate whether and if so then to what degree the most frequently mesured taxonomic plastic features are changing along with the growth of *Trematomus bernacchii* Boul. An attempt was made to define a group of features, which on account of great variation should have a limited significance in taxonomy.

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Genus *Trematomus bernacchi* has been known and described for a long time (Norman 1940). The present studies, however, are the first observations of this type made on Antarctic fishes.

2. Material and methods

Material was collected during the 1979 wintering at the USSR Geophysical Observatory Mirny (66°33' S; 93°01' E). From May until November 1979 *Trematomus bernacchi* fishes were caught with hooks and traps in the littoral zone of the Davis Sea. The weight of the fishes ranged from 16.5 to 411.0 g wet weight and their total length ranged from 110.1 mm to 265.0 mm. Dependence of the wet weight (*W*) on the total length (*TL*) is described by the equation of regression in logarithmic form:

$$\log W = a + b \log TL$$

where: *a* and *b* are coefficients of regression. In females, making up about 70% of the collection, barely early developmental stages of oocytes were found. Therefore, in the elaboration of the results specimens were not segregated according to their sex.

Measurements were made on dead, unfixed material directly after catch. In 171 specimens 20 plastic features of the head and the body were measured with a micrometer (± 0.1 mm). The measurements of various parts of the head are presented in relation to the head length (*Lc 1*); other measurements — in relation to the standard length (*SL*). Letter symbols of the selected taxonomic features and used after Baluškin (1976): *TL* — total length, *SL* — standard length, *Lc1* — head length, *O* — orbital diameter, *iO* — interorbital space, *aO* — snout length, *Hc* — head depth, *Lmx* — lower jaw length, *Lmd* — upper jaw length, *aA* — anteanal distance, *H* — body depth, *h₁₀₋₁₁* — body depth at 10—11 dorsal fin rays, *h₂₀₋₂₁* — body depth at 20—21 dorsal fin rays, *LV* — pelvic fin length, *LP* — pectoral fin length, *LVA* — anteventral distance, *aD1* — 1st antedorsal distance, *aD2* — 2nd antedorsal distance, *Lcp* — caudal peduncle length, *Hcp* — caudal peduncle depth.

Five groups of body length (*TL* group) were formed within the range of the total length of caught fishes: I — 110.1—140.0 mm; II — 140.1—170.0 mm; III — 170.1—200.0 mm; IV — 200.1—230.0 mm; V — 230.1—265.0 mm (extended for methodological reasons).

Results from the measurements (proportions) within the range of each *TL* group were worked out statistically, giving means values (\bar{x}), their coefficients of variation (*CV*) and confidence intervals (*CI*). The degree and direction of the changes in body proportions with the growth of fishes were determined by comparison of the mean proportions from each *TL* group ($\bar{x} \pm CI$). Moreover, for the whole groups of 171 specimens "interproportional" correlations were determined, i.e. between the measured features and the length — respectively — of the head (*Lc1*) or the body (*SL*). These relations are described by the coefficient of correlation — "r" (Martin 1967, Iwaniszewska 1976).

3. Results and discussion

Correlation between the total length of the body (*TL* in millimeters) and the wet weight of fishes (*W* in grams) was determined (Fig. 1).

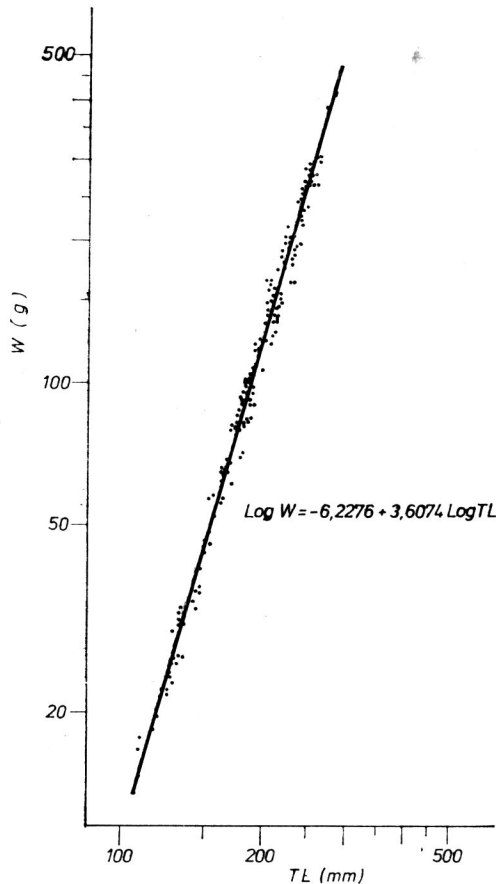


Fig. 1. Correlation between wet weight and total length according to the equation of regression

The value of the coefficient of regression "b" is 3.6074 and indicates a distinctly allometric character of the growth of fishes of the species *Trematomus bernacchii*. Similar interdependence was observed earlier in various species of the genus *Trematomus*, among others also in *Trematomus bernacchii*, and it was suggested that this correlation should be included into the group of taxonomic features (Rakusa-Suszczewski 1972). For instance: *Trematomus borchgrevinki* differing slightly from other species of the genus *Trematomus* (Andrjashov 1966) characterizes a different more isometric character of the growth of the body.

The values of 19 proportions of the body were calculated — mean values for each of the five *TL* groups (Table I—III). Confidence inter-

Table I

Mean body proportions for each TL group of *N* fishes (differences statistically significant) with relevant 0.1% confidence intervals and coefficients of variation
r—coefficients of correlation, ± confidence intervals at *P* (%) for "interproportion,, correlations

TL group	$\bar{x} \pm CI$ (0.1%); CV (%)											
	$\frac{H}{SL}$	$\frac{h_{10-11}}{SL}$	$\frac{h_{20-21}}{SL}$	$\frac{aA}{SL}$	$\frac{LV}{SL}$	$\frac{O}{Lc^1}$	$\frac{Lmd}{Lc^1}$	$\frac{Hc}{Lc^1}$	$\frac{aO}{Lc^1}$	$\frac{Lmx}{Lc^1}$	$\frac{iO}{Lc^1}$	
N=20 II	0.1925 0.0069 4.2597	0.1781 0.0050 3.2430	0.1371 0.0049 4.1697	0.5160 0.0176 3.9727	0.2336 0.0088 4.3456	0.3267 0.0119 4.2174	0.4933 0.0150 3.5351	0.7714 0.0189 2.8501	0.2782 0.0114 4.7464	0.4155 0.0152 3.5351	0.1217 0.0101 9.5917	
N=26 II	0.2019 0.0074 5.0569	0.1895 0.0058 4.1779	0.1458 0.0039 3.6111	0.5306 0.0113 2.9173	0.2260 0.0082 4.9550	0.3089 0.0099 4.4165	0.4875 0.0110 3.0985	0.8027 0.0239 4.0788	0.2882 0.0114 5.4102	0.4140 0.0152 5.0399	0.1300 0.0071 7.5117	
N=48 III	0.2129 0.0063 5.8642	0.2006 0.0061 6.0088	0.1487 0.0037 4.8968	0.5367 0.0086 3.1710	0.2162 0.0057 5.1818	0.3010 0.0055 3.5974	0.5041 0.0110 4.3082	0.8492 0.0232 5.4107	0.3059 0.0104 6.7210	0.4376 0.0081 3.6569	0.1479 0.0045 5.9940	
N=40 IV	0.2116 0.0074 6.2149	0.2060 0.0094 8.0960	0.1451 0.0045 5.5964	0.5633 0.0120 3.7391	0.2068 0.0052 4.4922	0.2957 0.0074 4.4658	0.5136 0.0129 4.4823	0.8862 0.0247 4.9629	0.3092 0.0096 5.5296	0.4465 0.0130 5.1717	0.1518 0.0074 8.6207	
N=37 V	0.2082 0.0079 6.4361	0.2027 0.0095 7.9233	0.1437 0.0042 4.9330	0.5587 0.0144 4.3668	0.1987 0.0059 5.0158	0.2924 0.0075 4.2984	0.5262 0.0130 4.1567	0.8886 0.0172 3.2612	0.3175 0.0079 4.1853	0.4616 0.0116 4.2455	0.1531 0.0080 6.5967	
N=171 <i>r</i> ± CI <i>P</i> (%)	0.3285 0.1760 99	0.5008 0.1885 99.9	-0.0992 0.0482 50	0.6210 0.1550 99.9	-0.7791 0.0989 99.9	-0.6260 0.1530 99.9	0.4773 0.1524 99	0.6754 0.1073 99	0.5964 0.1621 99.9	0.6283 0.1523 99.9	0.6705 0.1385 99.9	

Table II

Differences of little significance statistically

TL group	$\bar{x} \pm CI$ (0.1%); CV (%)				
	$\frac{SL}{TP}$	$\frac{LP}{SL}$	$\frac{LVA}{SL}$	$\frac{Lcp}{SL}$	$\frac{Hcp}{SP}$
	$N=20$ I	0.8882 0.0108 1.3848	0.1862 0.0115 7.1737	0.2533 0.0153 7.0464	0.0910 0.0065 8.3762
$N=26$ II	0.8858 0.0055 0.8490	0.1986 0.0094 6.4937	0.2602 0.0127 6.6920	0.0854 0.0050 7.9763	0.0794 0.0021 3.8971
$N=48$ III	0.8896 0.0032 0.7198	0.1978 0.0090 8.9957	0.2585 0.0121 9.2781	0.0842 0.0040 9.3749	0.0748 0.0019 5.1030
$N=40$ IV	0.8941 0.0038 0.7524	0.1962 0.0071 6.4127	0.2792 0.0122 7.7608	0.0831 0.0041 8.7846	0.0720 0.0018 4.4466
$N=37$ V	0.8958 0.0052 0.9843	0.2017 0.0067 5.6225	0.2789 0.0127 7.6775	0.0820 0.0043 8.9216	0.0714 0.0020 4.7825
$N=171$ r	0.3935	0.2172	0.4912	-0.3215	-0.4353
$\pm CI$	0.1668	0.1880	0.1909	0.2256	0.1599
P (%)	99	99	99.9	99.9	99

vals (CI), coefficients of variation (CV) and the number (N) of the examined specimens in each TL group are given in the Tables. For a better explanation of the variation of body proportions the tabulated values are presented graphically (Figs. 2—4). Numerical denotations are not given in the Figures but the same scale of variations $\bar{x} \pm CI$ is always maintained.

On the basis of the analysis of the values of the confidence limits ($CL = \bar{x} \pm CI$) three groups of the body proportions of the fishes were differentiated:

1. Body proportions undergo variations statistically significant (Table I, Fig. 2);
2. Variations of proportions are little significant statistically (Table II, Fig. 3);
3. Variations are not statistically significant (Table III, Fig. 4).

Variation of proportions in the first group (Table I, Fig. 2) indicates, most of all, a disproportionately quick development of the parts of the head — mainly in the direction of massiveness. This is evident from the increase of head depth/head length ration, interorbital space/head length ration and the rate of the accretion of the snout length and both jaws. The confirmation of these observations may be found in variations of the proportions associated with body depth and variations of the

Table III

Differences statistically insignificant

TL group	$\bar{x} \pm CI (0.1\%): CV(\%)$		
	$\frac{aD_1}{SL}$	$\frac{aD_2}{SL}$	$\frac{Lc1}{SL}$
	<i>N</i> =20 I	0.3304 0.0121 4.1697	0.4019 0.0102 2.9655
<i>N</i> =26 II	0.3346 0.0080 3.2777	0.4078 0.0060 2.0126	0.2977 0.0057 2.6278
<i>N</i> =48 III	0.3288 0.0056 3.3466	0.4037 0.0063 3.0776	0.2961 0.0050 3.3265
<i>N</i> =40 IV	0.3291 0.0067 3.6557	0.4065 0.0098 4.3146	0.2957 0.0047 2.8075
<i>N</i> =37	0.3315 0.0070 3.5451	0.4084 0.0076 3.1293	0.2944 0.0040 2.2905
<i>N</i> =171 <i>r</i>	-0.0141	0.1405	-0.0369
$\pm CL$	0.0099	0.1230	0.0290
<i>P</i> (%)	10	90	30

remaining proportions in this group. With the growth of the fish body the values of pelvic fin length/standard length ratio and orbital diameter/head length ratio decrease. In this way a well-known morphologic feature is revealed in younger fishes, which are characterized by long pelvic fins and relatively long orbital diameters.

Less explicit conclusions may be drawn on the basis of the analysis of the second group of body proportions varying in a degree of little significance statistically (Table II, Fig. 3). A general increase of standard length), total length ration with simultaneous decrease of caudal peduncle length/standard length ration might indicate indirectly that already in the fishes from the TL Group I. there is a tendency toward a setback in the relative development of caudal fin. On the other hand, pectoral fins continue to develop to a slight degree, which is subsequent to the variations of pectoral fin length/standard length ratio.

During the growth of the body of the fishes *Trematomus benacchii* only the following three proportions did not undergo any variations: 1st antedorsal distance/standard length ration, 2nd antedorsal distance/standard length ratio and head length/standard length ratio (Table III, Fig. 4). The last proportion is mentioned in the Keys for denotation of the genus and in the descriptions of the species *Trematomus bernacchii* from various collections (De Witt and Tyler 1960, and other authors). On the basis of the studies it seems that $\frac{aD1}{SL}$ and $\frac{aD2}{SL}$ likewise are good

taxonomic features of this species.

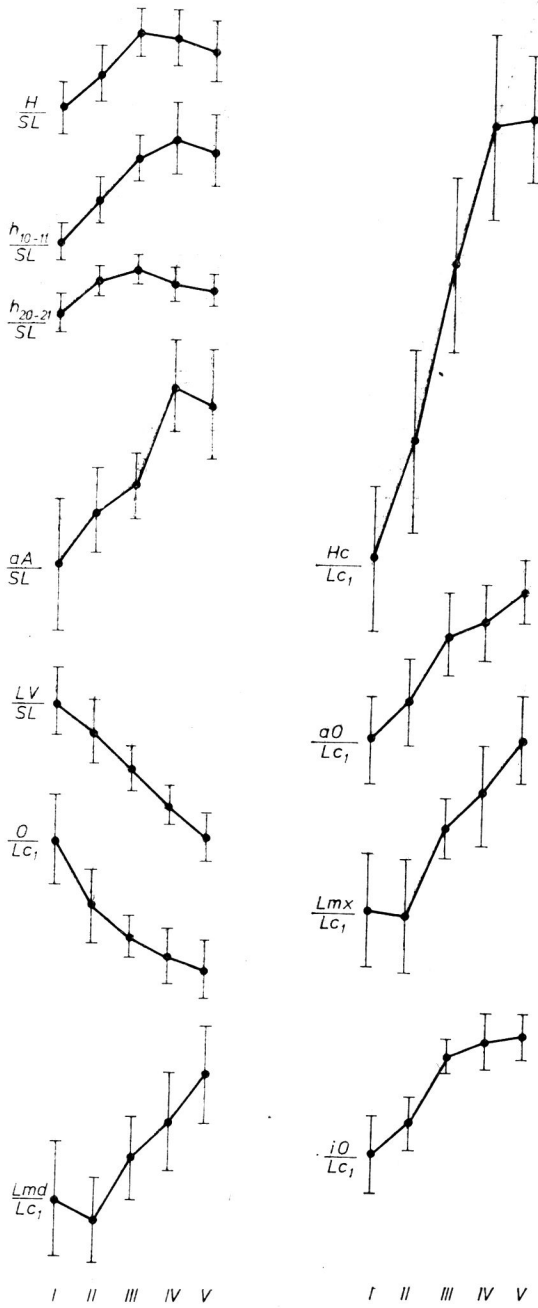


Fig. 2. Statistically significant variations of body proportions in I—V TL groups of fishes

Perpendicular lines marks out the range of the confidence limits at the same scale of values for all the proportions

It was stated that in most cases there is a lack or very weak linear correlations of "inter-proportions" i.e. between the plastic features forming proportions of the fish body (Tables I—III). Coefficients of correlation "r" are lower in the groups of proportions varying in a degree statistically little significant or insignificant. Strong correlations were noted merely in the case of the proportions: $\frac{LV}{SL}$ (negative), $\frac{Hc}{Lc1}$ and $\frac{iO}{Lc1}$ (Table I). On this account, these three proportions, varying under a regular dependence upon the size of the fishes, could be also used for description of the genus *Trematomus*. It should be emphasized that in general low values of the coefficient of correlation "r" do not indicate a complete lack of the dependence of the variations of plastic features upon the head length or standard length. These indicate merely the lack of linear correlation, which makes impossible the extrapolation of the results beyond the range of the TL groups of the examined fishes.

Hitherto, the studies on variations of the proportions of the body were not conducted in Antarctic fishes. Therefore, the comparison of the results from the present investigations with the data of other

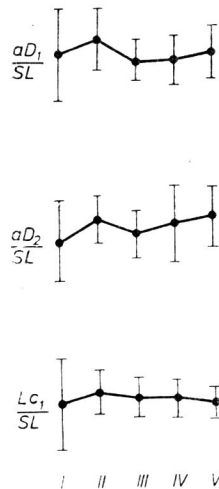
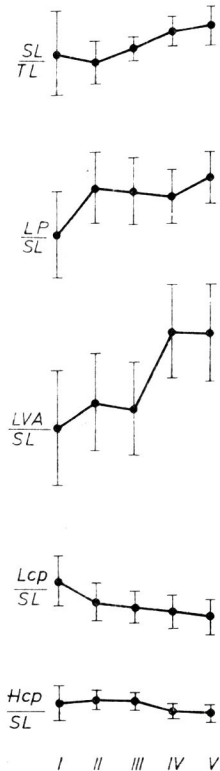


Fig. 3. Statistically little significant variations of body proportions in I—V TL groups of fishes (other data as in Fig. 2)

Fig. 4. Insignificant statistically variations of body proportions in I—IV TL groups of fishes (other data as in Fig. 2)

authors is impossible. The values of some proportions of the *Trematomus bernacchii* body may be found in the studies of DeWitt and Tyler (1960), Everson (1969) and other authors. In view of generally very approximate values of the corresponding proportions the considerably lower values of the $\frac{H}{SL}$ and $\frac{Lc1}{iO}$ proportions in this study are noteworthy. The values given by the above mentioned authors are in the range of about 0.125—0.300 and 0.110—0.227, respectively. Possibly fishes from the collections (mainly for the waters of the West Antarctic) had a more massive structure of the front part of the body.

4. Conclusion

1. Correlation between wet weight and total length indicates an allometric character of the growth of the *Trematomus bernacchii* fishes.
2. With the growth of the specimens the proportions of their bodies vary and the greater part of their characteristic features cannot be used in the taxonomy indiscriminately.
3. These variations are characterized by the lack of or a weak linear correlation of "inter-proportions", i.e. between the measured plastic features and head length ($Lc1$) or standard length (SL).
4. The unvarying proportions: $\frac{AD1}{SL}$, $\frac{AD2}{SL}$, and $\frac{Lc1}{SL}$, as well as $\frac{LV}{SL}$, $\frac{Lc1}{Hc}$ and $\frac{iO}{Lc1}$ may be good taxonomic features of denomination of the genus *Trematomus*.

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5. Summary

During the 1979 wintering at the USSR Antarctic Station Mirny (66°33' S, 93°01' E) measurements of 20 selected plastic features were conducted in 171 specimens of *Trematomus bernacchii*. (TL 110.2—265.0 mm). On the basis, statistically significant variation of the proportions of the body with the growth of the fishes was ascertained. Only three proportions were not subject to any variations and consequently making up good taxonomic indices in the descriptions of this species.

6. Резюме

Во время зимовки 1979 г. на советской станции Мирный (66°33' S; 93°01' E) проводились определения 20 избранных пластических свойств у 171 особи *Trematomus bernacchii* (TL 110, 2—265,0 mm). На основании полученных результатов была установлена статистически существенная изменчивость пропорций тела по мере роста рыб. Только три пропорции не подлежали никаким изменениям, являясь таким образом хорошими таксономическими показателями при описании этого вида.

7. Streszczenie

Podczas zimowania 1979, na radzieckiej stacji Mirny (66°33' S; 93°01' E) przeprowadzono pomiary 20 wybranych cech plastycznych u 171 osobników *Trematomus bernacchii* (TL 110,2—265,0 mm). Na tej podstawie stwierdzono statystycznie istotną zmienność proporcji ciała wraz ze wzrostem ryb. Tylko 3 proporcje nie ulegały żadnym zmianom, stanowiąc wskaźniki taksonomiczne w opisach tego gatunku.

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