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BIVARIATE AND MULTIVARIATE SIZE ALLOMETRY OF THE NILE FISH, (Chrysichthys auratus (Ceoffroy Saint-Hilaire, 1809) FROM THE NILE AT EGYPT

(With 6 Table & 2 Fig.)

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الألومتري الحجمي ثنائي والمتعدد المتغيرات لسمكة الزمـــــار

امام مكـــاوي

قدر في هذا البحث الالومتري الحجمي ثنائى المتغير لسمكة الزمار Chrysichthys auratus بتطبيق معادلة هوكسلى Huxley (1932) علي بعض الخصائص المورفورمترية بدلالـــة بارامتيرات هذه المعادلة · ولقد طور المفهوم الألومتري ثنائي المتغير كي يشمل البيانـــات متعددة المتغيرات باستخدام طريقة جوليكر Jolicoeur's (1963) التعميم متعدد المتغيـــرات للألومتري · ولقد سجل وجود الألومتري متعدد المتغيرات فى الذكور والاناث والجنس المختلـــط لسكة الزمار (٩٥-٢٠٦ ملليمترا) التي جمعت من النيل بمحافظتي أسيوط والجيزة باستخـــدام اختبار اندرسون Anderson (1963) ولقد حددت ونوقشت أيضا الطبيعة الألومترية للمعامـــلات المورفومترية لسمكة الزمار النيلية · وطبقا لانماط الالومتري ثنائى المتغير ومتعدد المتغيـــرات التى ظهرت تم تقدير الفروق بين ذكور واناث وأصناف الزمار المدروسة وزيادة علي ذلـــك تم اختبار المفهوم متعدد المتغيرات للألومتري بمقارنته بنتائج المفهوم ثنائي المتغير · ونتيجـــة لذلك استنتج أن طريقة جوليكر للألومتري متعدد المتغيرات تعطي تقديرات فعالة لانمـــاط الألومتري الحجمي ·

SUMMARY

The bivariate size allometry of Chrysichthys auratus was estimated by the application of the power function equation of HUXLEY (1932) on certain-morphometric characters in terms of its parameters. The bivariate allometric concept was expanded for multivariate data by JOLICOEUR'S (1963) approach and the presence of multivariate allometry was revealed by ANDERSON'S (1963) test. Also, the allometric nature in the morphometric indices of the species studied was determined and discussed. According to the patterns of bivariate and multivariate allometry exhibited, sexual dimorphism and racial differences in Chrysichthys auratus were evident.

INTRODUCTION

In animals, shape changes during ontogeny and phylogeny are the rule rather than the exception. Such situations are termed allometry. Some attempts to extend the allometry concept to more than two dimensions simultaneously have been made in the past. These attempts include some based on factor analysis (BAKER, 1954 and HAMMOND, 1957), multiple regression (REYMENT, 1960), and the use of the first principal component of the correlation matrix of logarithms (TEISSIER, 1960). Because the results of such attempts have not met with general acceptance, the multivariate generalization of allometry suggested by JOLICOEUR (1963) has served as the basis for most subsequent work in this area. Although JOLICOEUR'S (1963) approach has been applied to numerous data sets, many questions about the multivariate generalization of allometry equation persists (SHEA, 1985). One of these questions relates to whether JOLICOEUR'S technique does, in fact, provide an effective multivariate generalization of bivariate allometry.

GOULD (1966), having in mind the bivariate sense, defined allometry, in its broadest sense, to designate the differences in proportions correlated with changes in absolute magnitude of the total organisms or of the specific parts under consideration. BROWER, et al. (1978) interpreted this definition to indicate that for multivariate case, more than one source of allometry might exist. This means that, for example, during the ontogeny of a single species one source of allometry might be attributed to overall size increase; certain dimensions could provide a second source of allometry and so on. In the present investigation, using certain morphometric characters, it is intended to estimate the bivariate and multivariate size allometry of the sexes and certain races of Chrysichthys auratus from the Nile in Egypt. Moreover, the multivariate generalization of allometry will be cross-cheked against the bivariate results in order to test the accuracy of JOLICOEUR'S (1963) approach.

MATERIAL and METHODS

The present study is based on the examination of random samples of Chrysichthys auratus (95-206 mm in standard length) which were collected from the Nile at Assiut (Latitude 27ºN) and Giza districts (LATITUDE 30ºN) through the period December 1989-December 1990.

The morphometric measurements were recorded from fresh adult specimens following the work of MEKKAWY (1987) as a guide for the choice of measurements. The morphometric measurements of each fish examined were made on the left side up to the nearest millimeter using a divider and a measuring board. The morphometric measurements recorded for each specimen are diagramatically represented in Fig. 1; each character is given a number.

In the present investigation, the simple power function or allometric equation of HUXLEY (1932):

$$y = aX^{b},$$

was used, where y and X are dependent and independent variables respectively and a and b, the allometric coefficient, are constants. The parameters (a & b) of this equation were estimated by fitting a linear equation to the logarithmic transformations of y and x according to the least square method. This yields an equation of the form:

$$\log y = \log a + b \log x.$$

Moreover, the type of allometry was determined by estimating the confidence limits of the allometric coefficients, i.e. whether growth reveals isometry (I), negative allometry (-) or positive (+) allometry.

According to JOLICOEUR (1963), the most suitable manner to generalize the bivariate allometric equation is to use the first principal component (PCI) of the covariance matrix of logarithms. In the present investigation, JOLICOEUR'S (1963) approach was taken into consideration and the presence of multivariate allometry in the first vector of the log-transformed morphometric characters considered was testified by ANDERSON'S (1963) test. This means that if such a vector was equal to:

$$\left(\frac{1}{\sqrt{P}}, \frac{1}{\sqrt{P}}, \ldots, \frac{1}{\sqrt{P}} \right),$$

where p is the number of variables considered in each set, all proportions of the fish would remain constant as its size increased.

The sources of allometry in the morphometric indices (relative to standard length) were discovered by comparing the results of principal component analysis of such indices with those of bivariate allometry. DAVIS (1973) computer programs of linear regression and principal componnet analysis (PCA) were modified by the author to fulfil the requirments of the present investigation. These programs were executed on VME 2900 computer system in the Computer Centre of Assiut University.

RESULTS

The parameters (a & b) of the power function equations and the confidence limits of the allometric coefficients are given in Tables 1-4. Tables 1-3 show that at 0.05 level of significance the isometric characters outnumbered the allometric ones in all cases except in the combined sexes of Assiut and in the combined samples (Assiut + Giza). However, if the significance level decreases to 0.01, the isometric characters

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BIVARIATE AND MULTIVARIATE SIZE ALLOMETRY

Table 1: The allometric coefficient of males and females of Chrysichthys auratus of Assiut (Egypt) derived by the bivariate power equation (b) and multivariate approach (m). The lower (CL1) and upper (CL2) confidence limits of b and the types of allometry (I : isometry; +: positive allometry; -: negative allometry) were also given, R = correlation coefficient between m & b.

Morphometric characters*	Males				Females			
	m	b			m	b		
		b	CL1	CL2		b	CL1	CL2
SL	1.10	1.07 I	0.88	1.26	1.19	1.15 +	1.08	1.22
ED	0.57	0.58 -	0.37	0.78	0.63	0.62 -	0.55	0.70
PrOL	1.21	1.20 +	1.06	1.35	1.07	1.04 I	0.98	1.09
HL	1.11	1.10 I	0.99	1.22	1.01	0.99 I	0.95	1.03
IOW	0.94	0.92 I	0.63	1.20	1.12	1.08 I	0.99	1.16
INW1	1.10	1.08 I	0.79	1.38	1.07	1.01 I	0.88	1.13
INW2	0.87	0.85 I	0.68	1.02	1.02	0.97 I	0.88	1.05
PrDL	1.21	1.19 I	0.92	1.47	1.03	1.02 I	0.99	1.05
PrDL	1.07	1.06 I	0.98	1.14	1.05	1.03 +	1.01	1.06
PrVL	1.14	1.13 +	1.06	1.20	1.06	1.05 +	1.02	1.07
PrAL	1.10	1.10 +	1.04	1.16	1.00	1.00 I	0.97	1.03
P[illegible]L	1.07	1.06 +	1.02	1.11	1.02	1.02 +	1.01	1.03
PrPVL	1.06	1.05 I	0.92	1.19	1.10	1.09 +	1.03	1.15
PrANL	1.01	1.02 I	0.80	1.24	1.02	1.01 I	0.93	1.09
BH1	0.72	0.70 -	0.41	0.98	1.23	1.18 +	1.09	1.28
BH2	0.61	0.61 -	0.29	0.93	1.20	1.15 +	1.06	1.24
CL	0.85	0.85 I	0.69	1.01	0.93	0.92 -	0.87	0.97
CD	0.77	0.76 -	0.53	0.99	1.04	1.00 I	0.93	1.06
ML	1.32	1.27 I	0.95	1.58	1.16	1.13 +	1.03	1.24
VL	0.90	0.91 -	0.83	0.98	0.98	0.97 I	0.94	1.00
HD	0.95	0.92 I	0.70	1.14	1.11	1.07 I	0.99	1.14
HL	1.27	1.23 +	1.03	1.43	1.12	1.08 +	1.03	1.13
DADL	0.85	0.87 I	0.71	1.03	0.83	0.81 I	0.61	1.00
ML	0.52	0.48 -	0.15	0.80	0.93	0.88 I	0.75	1.01
OBAL	0.94	0.93 I	0.53	1.33	0.95	0.91 I	0.81	1.01
I[illegible]L	1.02	1.00 I	0.62	1.37	0.96	0.92 I	0.80	1.04
PTDL	0.91	0.91 -	0.85	0.97	0.93	0.93 -	0.90	0.95
PTLL	1.21	1.20 +	1.03	1.37	1.07	1.05 +	1.01	1.09
PTDCL	0.95	0.96 I	0.89	1.02-	0.96	0.96 -	0.93	0.98
AL L	0.83	0.83 I	0.65	1.01	0.72	0.72 -	0.66	0.79
DBL	1.02	0.98 I	0.80	1.16	1.04	1.01 I	0.96	1.06
ADBL	1.25	1.19 I	0.87	1.51	1.08	1.03 I	0.94	1.13
AFD	1.27	1.16 I	0.64	1.69	1.12	1.07 I	0.98 -	1.17
DL	0.94	0.71 -	0.47	0.95	0.82	0.80 -	0.72	0.87
DL	0.82	0.78 I	0.46	1.09	1.39	1.31 +	1.16	1.46
PL	1.04	1.02 I	0.75	1.28	0.95	0.92 I	0.85	1.00
VL	0.73	0.69 -	0.40	0.99	0.99	0.96 I	0.88	1.05
R	0.986				0.992			

* See Fig. 1.

Table 2: The allometric coefficients of males and females of <u>Chrysichthys auratus</u> of Giza (Egypt) derived from the bivariate power equation (b) and multivariate approach (m). The lower (CL1) and upper (CL2) confidence limits of b and the types of allometry (I : isometry; +: positive allometry; -: negative allometry) were also given, R = correlation coefficient between m & b.

Morphometric characters*	Males				Females			
	m	b			m	b		
		b	CL1	CL2		b	CL1	CL2
SNL	1.02	1.00 I	0.82	1.18	1.12	1.10 I	0.95	1.25
ED	0.82	0.79 I	0.52	1.06	0.80	0.79 -	0.61	0.96
PTOL	1.12	1.09 I	0.95	1.23	1.04	1.03 I	0.93	1.14
HL	1.06	1.04 I	0.95	1.13	1.01	1.01 I	0.94	1.07
IOW	1.07	1.02 I	0.78	1.27	1.12	1.12 I	0.94	1.30
INW1	1.17	1.11 I	0.80	1.42	0.96	0.95 I	0.76	1.13
INW2	0.93	0.90 I	0.68	1.13	0.65	0.65 -	0.51	0.78
PRDL	1.04	1.02 I	0.95	1.10	1.03	1.02 I	0.96	1.09
PTDL	1.02	1.01 I	0.95	1.07	1.03	1.02 I	0.98	1.07
PRVL	0.96	0.96 I	0.89	1.03	1.02	1.02 I	0.96	1.07
PRAL	1.03	1.03 I	0.99	1.08	1.01	1.01 I	0.97	1.05
PTAL	1.02	1.01 I	0.98	1.05	0.99	0.99 I	0.94	1.04
PTPVL	1.02	1.03 I	0.84	1.21	1.02	1.03 I	0.89	1.17
PVANL	0.99	0.99 I	0.78	1.20	1.06	1.06 I	0.93	1.19
BD1	0.99	0.92 I	0.48	1.36	1.18	1.17 +	1.01	1.21
BD2	0.77	0.74 -	0.53	0.96	1.07	1.05 I	0.91	1.21
CPL	0.84	0.83 -	0.71	0.95	0.88	0.88 I	0.74	1.02
CPD	0.79	0.75 -	0.59	0.90	1.01	1.00 I	0.84	1.16
MW	1.35	1.31 I	0.98	1.63	1.27	1.26 +	1.09	1.44
VCL	0.94	0.93 I	0.86	1.01	0.98	0.98 I	0.92	1.05
HD	1.08	1.06 I	0.86	1.26	1.05	1.04 I	0.91	1.17
HW	1.13	1.10 I	0.98	1.23	1.14	1.13 +	1.02	1.24
DADL	1.02	1.01 I	0.80	1.24	1.08	1.06 I	0.87	1.26
MBL	0.90	0.86 I	0.52	1.21	1.26	1.22 I	0.99	1.45
OMAL	0.88	0.84 I	0.56	1.13	1.17	1.13 I	0.86	1.39
IMAL	0.93	0.90 I	0.58	1.21	1.47	1.44 +	1.11	1.77
PTDOL	0.90	0.90 -	0.84	0.97	0.96	0.96 I	0.91	1.02
PTEL	1.10	1.09 I	1.00	1.18	1.10	1.09 I	1.00	1.18
PTDEL	0.84	0.82 -	0.67	0.96	0.96	0.96 I	0.91	1.01
ADCL	0.89	0.86 I	0.63	1.08	0.97	0.97 I	0.77	1.16
DFBL	0.92	0.91 I	0.75	1.07	1.04	1.03 I	0.91	1.15
ADFBL	0.83	0.80 I	0.50	1.10	0.91	0.90 I	0.66	1.14
ADFD	1.24	1.18 I	0.86	1.50	1.23	1.21 I	0.94	1.48
DFSL	0.83	0.80 I	0.56	1.05	0.72	0.71 -	0.50	0.91
DFRL	1.31	1.23 I	0.90	1.56	1.19	1.13 I	0.70	1.55
PFSL	0.87	0.84 I	0.60	1.08	0.77	0.77 -	0.57	0.97
VFSL	1.00	0.97 I	0.78	1.16	1.05	1.02 I	0.79	1.24
R	0.990				0.997			

* See Fig. 1.

Table 3: The allometric coefficients of combined sexes of Chrysichthys auratus of Assiut and Giza, Egypt, derived from the bivariate power equation (b) and multivariate approach (m). The lower (CL1) and upper (CL2) confidence limits of b and the types of allometry (I : isometry; + : positive allometry; -: negative allometry) were also given, R = correlation coefficient between m & b.

Morphometric characters*	Assiut				Giza				Assiut + Giza			
	m	b			m	b			m	b		
		b	CL1	CL2		b	CL1	CL2		b	CL1	CL2
SNL	1.17	1.12 +	1.05	1.19	1.09	1.08 I	0.96	1.19	1.14	1.10 +	1.04	1.16
ED	0.62	0.61 -	0.54	0.68	0.80	0.80 -	0.64	0.95	0.65	0.64 -	0.58	0.71
PTOL	1.07	1.04 I	0.98	1.09	1.09	1.07 I	0.99	1.16	1.07	1.03 I	0.99	1.08
HL	1.02	0.99 I	0.96	1.03	1.04	1.03 I	0.98	1.08	1.02	1.00 I	0.97	1.03
IOW	1.09	1.05 I	0.97	1.13	1.11	1.10 I	0.95	1.24	1.09	1.05 I	0.98	1.12
INW1	1.06	0.98 I	0.86	1.10	1.08	1.04 I	0.86	1.23	1.03	0.96 I	0.85	1.06
INW2	0.99	0.93 I	0.85	1.02	0.80	0.78 -	0.64	0.92	0.92	0.87 -	0.80	0.95
PRDL	1.05	1.04 I	0.99	1.08	1.04	1.03 I	0.99	1.08	1.04	1.03 I	1.00	1.06
PTDL	1.05	1.03 +	1.01	1.06	1.03	1.02 I	0.99	1.06	1.04	1.03 +	1.01	1.05
PRVL	1.06	1.06 +	1.04	1.08	1.00	1.00 I	0.95	1.04	1.05	1.04 +	1.02	1.06
PRAL	1.01	1.01 I	0.98	1.03	1.02	1.02 I	0.99	1.05	1.02	1.01 I	0.99	1.03
PTAL	1.02	1.02 +	1.01	1.03	1.00	1.00 I	0.97	1.03	1.02	1.01 +	1.01	1.03
PTPVL	1.10	1.09 +	1.03	1.14	1.01	1.03 I	0.92	1.14	1.08	1.07 +	1.02	1.12
PVANL	1.02	1.01 I	0.94	1.09	1.02	1.03 I	0.92	1.15	1.02	1.02 I	1.96	1.08
BD1	1.18	1.14 +	1.04	1.23	1.10	1.07 I	0.86	1.28	1.17	1.12 +	1.04	1.21
BD2	1.14	1.09 +	1.01	1.18	0.95	0.93 I	0.80	1.06	1.09	1.05 I	0.98	1.12
CPL	0.92	0.91 -	0.86	0.96	0.86	0.87 -	0.78	0.96	0.91	0.90 +	0.86	0.94
CPD	1.01	0.96 I	0.89	1.03	0.92	0.90 I	0.79	1.01	0.97	0.92 +	0.87	0.98
MW	1.16	1.10 I	0.98	1.22	1.38	1.33 +	1.07	1.59	1.18	1.13 +	1.01	1.24
VCL	0.97	0.96 -	0.94	0.99	0.96	0.97 I	0.92	1.01	0.97	0.97 -	0.94	0.99
HD	1.09	1.04 I	0.97	1.11	1.06	1.06 I	0.95	1.17	1.08	1.05 I	0.99	1.11
HW	1.11	1.08 +	1.02	1.13	1.15	1.13 +	1.05	1.22	1.11	1.08 +	1.04	1.13
DADL	0.84	0.82 -	0.65	0.99	1.05	1.05 I	0.90	1.19	0.89	0.86 I	0.75	1.01
MBL	0.88	0.82 -	0.70	0.94	1.11	1.08 I	0.88	1.28	0.93	0.88 -	0.78	0.98
OMAL	0.94	0.89 -	0.79	0.99	1.06	1.02 I	0.83	1.21	0.96	0.91 -	0.82	0.99
IMAL	0.96	0.90 I	0.79	1.02	1.26	1.22 I	0.98	1.45	1.01	0.96 I	0.85	1.06
PTDOL	0.93	0.93 -	0.91	0.95	0.93	0.94 -	0.90	0.98	0.93	0.93 -	0.91	0.95
PTEL	1.08	1.06 +	1.02	1.10	1.10	1.10 +	1.04	1.16	1.08	1.06 +	1.03	1.10
PTDEL	0.96	0.96 -	0.94	0.98	0.91	0.90 -	0.82	0.97	0.95	0.94 -	0.92	0.97
ADCL	0.73	0.73 -	0.67	0.80	0.94	0.93 I	0.78	1.07	0.78	0.78 -	0.72	0.84
DFBL	1.03	1.00 I	0.95	1.05	0.98	0.98 I	0.89	1.08	1.01	0.98 I	0.94	1.03
ADFBL	1.09	1.04 I	0.95	1.13	0.88	0.87 I	0.68	1.05	1.02	0.98 I	0.89	1.06
ADFD	1.12	1.07 I	0.96	1.17	1.24	1.21 +	1.01	1.41	1.14	1.08 I	0.99	1.17
DFSL	0.81	0.78 -	0.71	0.85	0.75	0.75 -	0.59	0.91	0.80	0.77 -	0.71	0.83
DFRL	1.33	1.26 +	1.12	1.40	1.19	1.16 I	0.86	1.46	1.29	1.22 +	1.10	1.35
PFSL	0.96	0.93 -	0.85	0.99	0.81	0.80 -	0.65	0.96	0.92	0.90 -	0.83	0.96
VFSL	0.97	0.93 I	0.85	1.01	1.02	1.00 I	0.86	1.15	0.97	0.94 I	0.87	1.01
R	0.985				0.994				0.959			

* See Fig. 1.

Table 4: The constant, a, of the allometric power function equation ($y = a x^b$) of Chrysichthys auratus of Assiut and Giza, Egypt.

Morphometric characters*	Male Assiut	Female Assiut	Male Giza	Female Giza	Combined sexes Assiut	Combined sexes Giza	Combined sexes Assiut+ Giza
SNL	0.082574	0.052610	0.112286	0.065181	0.061397	0.076473	0.069173
ED	0.580241	0.458056	0.196177	0.201984	0.488000	0.194183	0.417075
PTOL	0.046972	0.101010	0.079720	0.102565	0.102503	0.085166	0.104306
HL	0.177430	0.299968	0.239193	0.276595	0.297508	0.245275	0.257755
IOW	0.165982	0.071117	0.097599	0.056475	0.084983	0.066001	0.085050
INW1	0.039172	0.049504	0.034814	0.070090	0.057443	0.045420	0.066224
INW2	0.170417	0.088830	0.134854	0.441591	0.106442	0.236892	0.145485
PRDL	0.136192	0.328318	0.321706	0.318805	0.301890	0.308565	0.308913
PTDL	0.357375	0.403627	0.452992	0.425067	0.406407	0.428824	0.421329
PRVL	0.278043	0.412125	0.653292	0.477731	0.397465	0.534215	0.429071
PRAL	0.438366	0.720338	0.609263	0.673730	0.685634	0.637726	0.670146
PTAL	0.600111	0.752443	0.766104	0.872199	0.741813	0.815693	0.765277
PTPVL	0.238191	0.206350	0.279468	0.282421	0.208610	0.275401	0.227428
PVANL	0.183914	0.200058	0.216828	0.153383	0.198815	0.172201	0.188111
BD1	0.796331	0.077032	0.263951	0.077214	0.096595	0.128405	0.101671
BD2	1.131552	0.081763	0.629393	0.130115	0.107231	0.248119	0.135333
CPL	0.378610	0.281056	0.434196	0.332730	0.293022	0.356842	0.302443
CPD	0.299638	0.092483	0.334266	0.094208	0.111366	0.157165	0.134770
MW	0.039888	0.061420	0.033018	0.032197	0.075262	0.025493	0.067385
VCL	0.772565	0.574318	0.687995	0.539073	0.589415	0.582720	0.578500
HD	0.210155	0.102587	0.099649	0.113608	0.116352	0.103343	0.112913
HW	0.066029	0.130374	0.120946	0.104677	0.132185	0.102488	0.130367
DADL	0.447633	0.626405	0.204785	0.169681	0.592699	0.180649	0.430582
MBL	2.213974	0.285949	0.311277	0.051291	0.382293	0.105977	0.283962
OOMAL	0.161756	0.167508	0.237464	0.056375	0.184646	0.098373	0.168129
IMAL	0.083084	0.111889	0.129517	0.008344	0.122055	0.025485	0.093827
PTDOL	0.925569	0.889288	0.974868	0.731529	0.880944	0.827616	0.852311
PTEL	0.081579	0.169525	0.141477	0.139921	0.162221	0.133087	0.159104
PTDEL	0.656352	0.674652	1.325626	0.653938	0.663467	0.890161	0.706881
ABCL	0.313608	0.542634	0.280243	0.159555	0.521469	0.193765	0.415264
DFBL	0.140366	0.121077	0.193636	0.112100	0.129422	0.139075	0.136108
ADFBL	0.049805	0.106472	0.373539	0.220444	0.104543	0.265252	0.145798
ADFD	0.030157	0.045507	0.026454	0.022037	0.047674	0.022269	0.043768
DFSL	0.605928	0.391325	0.371027	0.628773	0.422215	0.501707	0.446751
DFRL	0.671653	0.051124	0.070082	0.135999	0.064988	0.108082	0.077318
PFSL	0.137100	0.219683	0.315932	0.467316	0.217796	0.389665	0.247196
VFSL	0.517858	0.134816	0.124010	0.101792	0.162592	0.107456	0.153076

* See Fig.1.

Table 5: The first two principal components (PCI & PCII) and their variances derived from principal component analysis carried out on the covariance matrix of certain log-trans-formed morphometric characters of Chrysichthys auratus from Egypt. Chi-square (x^2) values to testidy the presense of multivariate allmoetry were given. (coefficient × 1000).

Morphometric characters*	Sex separated								Combined sexes					
	Male Assiut		Female Assiut		Male Giza		Female Giza		Assiut		Giza		Assiut + Giza	
	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII
SL	163	000	157	010	162	-007	155	-028	159	033	158	- 010	160	- 025
SNL	180	083	187	-007	166	009	174	-097	186	- 063	173	051	183	078
ED	094	-118	098	048	133	-241	123	076	098	054	126	036	104	015
PTOL	198	-014	168	022	182	-025	162	-056	170	- 028	172	051	170	088
HL	182	-010	159	009	172	-044	157	-035	161	- 025	164	027	163	054
IOW	154	157	175	-061	173	061	174	-217	173	- 079	176	107	173	063
INW1	179	134	169	-037	190	-176	149	-176	168	- 207	171	262	165	333
INW2	143	094	160	-005	151	-100	101	-057	157	- 081	126	163	148	151
PRDL	197	157	162	016	169	025	160	-033	167	039	164	- 018	167	- 031
PTDL	175	004	165	002	166	016	160	-025	166	013	162	- 031	166	- 017
PRVL	185	-001	166	009	156	018	158	-063	169	023	158	013	167	- 009
PRAL	180	-020	153	-000	167	-017	157	-073	161	020	161	006	162	- 010
PTAL	174	-006	160	017	165	-015	153	-053	162	031	158	- 001	162	- 011
PTPVL	172	-012	173	006	165	102	159	-107	175	036	160	- 041	172	- 039
PVANL	164	-145	160	-004	161	-114	164	-089	161	049	162	004	163	- 040
BD1	117	360	194	-054	162	580	184	-094	188	074	173	- 234	187	- 274
BD2	100	387	189	-089	126	158	166	-082	182	014	150	- 021	174	- 124
CPL	138	032	146	-003	136	055	136	001	146	059	136	- 058	145	- 098
CPD	126	-110	164	-060	128	023	157	-129	160	- 032	145	- 014	155	- 011
MW	216	-230	183	-039	219	-383	197	-094	184	- 226	218	509	189	- 551
VCL	147	008	153	-012	152	-018	152	002	154	034	152	- 023	155	- 053
HD	154	208	174	-072	176	083	162	-070	172	- 032	167	- 076	173	- 088
HW	207	-088	174	-002	184	-019	177	-066	177	- 056	181	075	178	113
DADL	139	-113	131	960	166	043	168	-083	133	868	165	- 100	143	- 181
MBL	085	-184	146	-111	145	-313	195	186	140	- 145	176	074	149	077
OMAL	153	-394	149	-035	143	.188	181	172	149	- 152	167	049	153	185
IMAL	167	-429	151	009	151	-201	229	060	152	- 158	199	200	161	301
PTDOL	149	003	146	022	146	035	148	-051	147	059	146	- 048	149	- 063
PTEL	197	048	168	009	179	043	170	-077	171	017	174	- 011	172	- 002
PTDEL	155	002	151	020	137	010	148	-040	152	057	143	- 021	151	- 053
ADCL	136	033	113	-023	144	-018	150	103	116	019	148	- 005	124	- 031
DFBL	166	110	164	-029	150	065	162	059	164	- 004	155	- 077	162	- 055
ADFBL	204	194	169	-062	134	-073	141	025	172	- 037	139	075	163	030
ADFD	206	-116	176	-128	201	-056	191	007	178	- 137	196	013	182	- 001
DFSL	121	085	130	-031	135	226	112	197	129	028	119	- 277	127	- 178
DFRL	134	-113	218	-089	212	214	185	814	211	077	188	- 590	206	- 409
PFSL	169	107	150	020	142	221	120	117	152	066	127	- 221	147	- 167
VFSL	120	019	157	047	163	113	162	013	153	- 008	161	- 084	156	- 100
Variance	135	009	207	008	139	010	165	008	196	008	151	011	185	009
%Variance	75 339	5 153	81 097	3 315	74 343	5 548	80 146	4 109	79 267	3.064	75.352	5.384	77.863	3.589
x^2	1194.9		417.5		4828.7		564.3		622.8		231.3		567.1	

*See Fig.1.

Table 6: The first two principal components (PCI & PCII) and their variances derived from principal component analysis carried out on the covariance matrix of certain morphometric indices (relative to standard length) of Chrysichthys auratus of Egypt (coefficient x 1000).

Morphometric indices	Sex separated								Combined sexes					
	Male Assiut		Female Assiut		Male Giza		Female Giza		Assiut		Giza		Assiut++ Giza	
	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII	PCI	PCII
SNL	065	064	058	089	004	-031	-002	101	041	121	-025	-007	014	123
ED	-082	-044	-034	-028	-026	024	015	-018	-028	-034	008	-048	-013	-031
PTOL	125	-001	028	018	022	062	-007	081	009	075	015	-042	-001	089
HL	163	018	041	081	304	069	-001	109	010	173	-017	-082	-003	186
IOW	019	091	030	085	018	-022	-059	059	023	094	-058	020	-008	095
INW1	008	021	024	010	-023	013	-022	057	009	039	-046	-029	-011	074
INW2	-046	036	029	020	-033	-007	-012	-033	022	032	-047	-031	-002	057
PRDL	216	624	038	128	086	067	023	099	037	172	031	-002	034	155
PTDL	180	039	084	152	078	-005	035	042	067	213	053	032	058	194
PRVL	287	-011	058	297	106	-187	-058	261	041	299	-046	109	006	256
PRAL	372	-021	-046	585	-088	-032	-110	272	-069	472	-087	045	-083	289
PTAL	303	017	-002	312	-035	024	-077	245	-025	310	-042	021	-034	252
PTPVL	088	021	093	368	134	-289	-107	452	083	270	-010	274	044	223
PVANL	105	-163	-080	208	-138	042	-029	035	-084	108	-030	-068	-068	004
BD1	-210	338	167	036	756	-042	-006	-024	192	-079	207	524	196	-131
BD2	-217	340	151	109	082	-294	002	027	156	-001	-011	187	096	003
CPL	-144	036	002	-146	060	-091	007	-222	012	-170	022	113	020	-169
CPD	-039	-024	050	011	018	-055	-021	-032	041	003	-008	051	023	012
MW	221	-175	012	072	-138	224	-017	222	-044	226	-199	-349	-102	355
VCL	-175	061	-025	-088	-045	-005	056	-252	-011	-164	029	-054	008	-185
HD	-033	170	070	028	040	-037	-004	-071	070	017	016	077	047	-009
HW	244	-101	042	076	040	146	-028	200	015	162	-036	-078	-006	197
DADL	-116	-204	-091	-251	057	060	-033	199	-060	-255	062	148	-007	-338
MBL	-271	-215	050	-067	-102	155	125	229	058	-068	035	-299	054	005
OMAL	-003	-294	-004	040	-020	-011	062	095	-020	061	014	-004	-009	068
IMAL	047	-154	004	008	-012	003	017	158	-011	050	-013	-101	-012	069
PTDOL	-158	-018	-058	-177	049	-265	-071	-121	-025	030	024	-291	-001	-296
PTEL	214	054	026	116	066	065	-018	097	009	149	008	011	006	136
PTDEL	-145	-028	-046	-154	169	-513	-036	-094	-025	-216	040	346	004	-271
ADCL	-133	038	-076	-133	040	003	045	-087	-057	-154	029	-067	-021	-134
DFBL	-010	074	043	009	030	-087	047	023	049	017	040	023	046	024
ADFBL	020	076	069	035	-028	-043	008	-062	070	037	-023	-060	040	093
ADFD	-033	-065	040	004	003	016	023	003	043	007	008	-037	031	021
DFSL	-177	107	045	-053	109	-106	116	-288	062	-071	146	132	093	-103
DFRL	-193	-146	930	-126	485	551	951	154	932	-025	918	-245	946	084
PFSL	-016	084	035	-044	133	-011	071	-202	043	-028	117	089	070	-070
VFSL	-111	023	052	-015	042	-005	015	129	059	-019	032	029	052	-023
Variance	17.19	11.99	21.11	10.70	23.96	11.60	29.05	7.57	19.48	11.36	25.65	10.57	20.60	10.20
%Variance	22.44	15.66	24.22	12.27	26.25	12.71	36.84	9.59	21.87	12.75	27.88	11.49	22.55	11.16

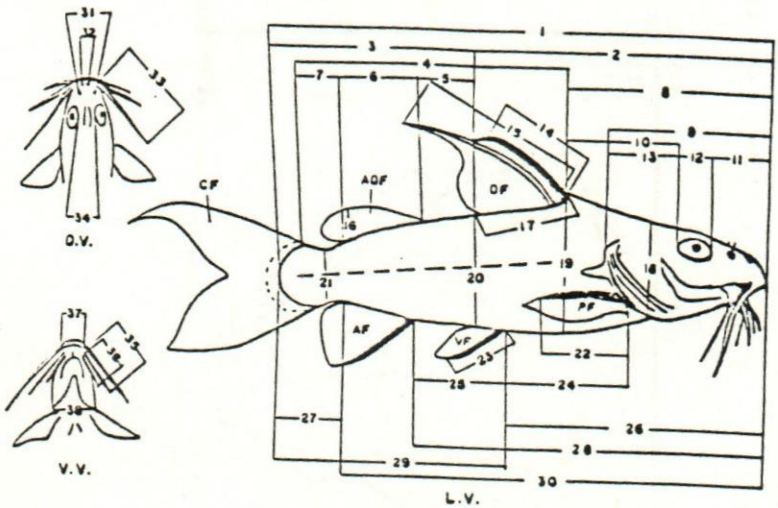

Fig. 1: Schematic illustration of the measurements taken on the body of *Chrysichthys auratus*. ADF, Adipose dorsal fin; AF, anal fin; CF, caudal fin; DF, dorsal fin; PF, pectoral fin; VF, ventral fin. L.V.: lateral view; D.V.: dorsal view; V.V.: ventral view.

1. Standard length (SL). 2. Postdorsal length (PTDL). 3. Postdorsal end length (PTDEL). 4. Postdorsal origin length (PTDOL). 5. Dorsal adipose length (DADL). 6. Adipose fin base length (ADFBL). 7. Adipose caudal length (ADCL). 8. Predorsal length (PRDL). 9. Head length (HL). 10. Posteye length (PTEL). 11. Snout length (SNL). 12. Eye diameter (ED). 13. Postorbital length (PTOL). 14. Dorsal fin spine length (DFSL). 15. First dorsal fin soft ray length (DFRL). 16. Adipose fin depth (ADFD). 17. Dorsal fin base length (DFBL). 18. Head depth (HD). 19. Body depth 1 (BD1). 20. Body depth 2 (BD2). 21. Caudal peduncle depth (CPD). 22. Pectoral fin spine length (PFSL). 23. Ventral fin spine length (VFSL). 24. Pectoral pelvic length (PTPVL). 25. Pelvic anal length (PVANL). 26. Preventral length (PRVL). 27. Caudal peduncle length (CPL). 28. Preanal length (PRAL). 29. Ventral caudal length (VCL). 30. Postanal length (PTAL). 31. Internasal width 2 (INW2). 32. Internasal width 1 (INW1). 33. Maxillary barbel length (MBL). 34. Interorbital width (IOW). 35. Outer mandibular barbel length (OMAL). 36. Inner mandibular barbel length (IMAL). 37. Mouth width (MW). 38. Head width (HW).

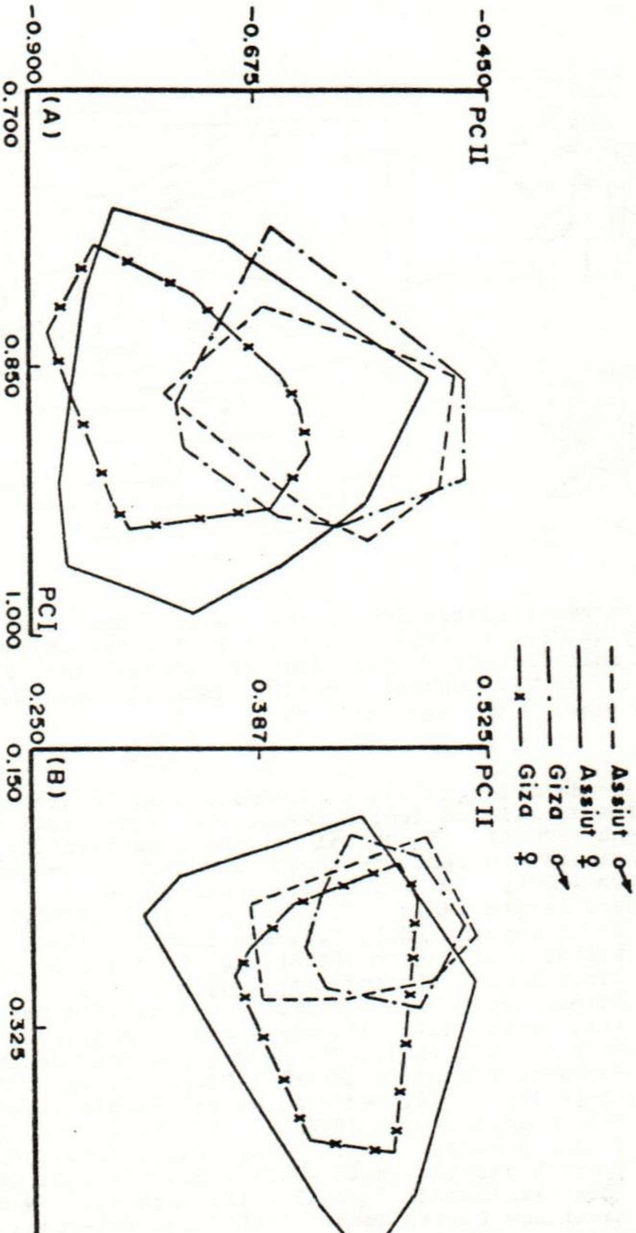

Fig. 2 : Plots of scores of PCI and PCII derived from PCA carried out on log-transformed morphometric data (A) and indices (B) of *Chrysichthys auratus* of Assiut and Giza, Egypt.