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MULTIVARIATE ANALYSIS OF THE MORPHOMETRIC AND MERISTIC CHARACTERISTICS OF THE NILE CHARCOID FISH, ALESTES NURSE (RUPPEL, 1832) FROM THE NILE AT EGYPT

(With 8 Tables & 6 Figs.)

By
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تحليل متعدد المتغيرات لبعض الخصائص المورفومترية
والعددية لسمكة الراية من نيل مصـــــر

إمــــام مكـــــاوي

Alestes nurse
تم اكتشاف بعض أشكال مورفومتيريه وعددية فى سمكه الرايه
المتحصل عليها من النيل عند أسيوط وأسوان وذلك باستخدام تحليل المكونات الاساسيــــة
Principal components analysis وهذا التحليل قد ساعد ايضا على استنتاج حقيقــــة
أخرى وهى أن المكان المتغير للزعنفة الظهرية يؤثر على شكل *Shape* هذا النوم . وعلـــى
ذلك تم اكتشاف ثلاث أشكال غير مرتبطة بالنمر *Shape forms* وباستخدم ام *Canonical*
variate analysis بالاضافة لهذا التحليل قد أمكن تحليل اختلافات جنسية وصنفيــة
racial and sexual variations فى هذا النوم فى مصر . وبمقارنة الصفات العددية لعشائر هـــذا
النوم فى مصر مع مثيلها فى مناطق أفريقية أخرى لوحظ وجود اختلافات جغرافية أو صنفيـــة
فى هذا النوم ولم توجد أى علاقة واضحة بين هذه الاختلافات وخطوط العرض وبالتالى الحرارة .

SUMMARY

The principal component analysis (PCA) of certain raw morphometric and meristic characters of Alestes nurse from the main course of th Nile at Aswan (latitude 24º) and Assiut (latitude 27º), Egypt led to the presence of certain size morphometric forms and meristic forms. Moreover, by such an analysis, it is concluded that the relative variable position of the dorsal fin led to the recognition of three morphometric shape forms. By the application of PCA and canonical variates analysis on certain shape characters in addition to the above ones, racial and sexual variations of Alestes nurse were revealed. Moreover, the racial variations in the meristic characters of that species from different African areas were compared.

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INTRODUCTION

A wide range of certain individual biological, morphometric and meristic characters was found in Alestes nurse (SVENSSON, 1933; DAGET, 1954, 1961; BLACHE, 1964; ROMAN, 1966; REIZER, et al. 1972; KOUASSI, 1978; PAUGY, 1979-1980; MEKKAWY, 1980, 1990; KHALIL, et al. 1982, 1983 a,b). This was attributed to the prolonged spawning season of that species, and in turn the wide spectrum of environmental factors influencing its development. MEKKAWY (1980) emphasized on the variable position of the dorsal fin relative to the position of the other fins by studying the interrelationship between specially related characters such as predorsal, preventral and postdorsal origin lengths. Accordingly, A.nurse can be represented by different morphometric and meristic forms in nature. In the present work it is intended to study the morphometric and meristic characteristics of A.nurse in a multivariate sense in an attempt to detect the presence of certain morphometric and meristic forms, and to determine the nature of the relationship between the relative position of the dorsal fin and some of these morphometric forms exhibited. Moreover, the sexual and racial variations in A.nurse from the Nile at Egypt were evaluated and certain meristic characters of that species from different African areas were compared.

MATERIAL and METHODS

A total of 550 specimens of Alestes nurse (70-240 mm in total length) were randomly collected from Assiut fish markets during the period July 1987 - July 1989; also, 500 specimens of the same species (80-180 mm in total length) were randomly collected from Aswan fish markets during the same period. Both localities are 500 km apart.

For each fish, 19 morphometric measurements were made on the left side up to the nearest millimeter. Those morphometric measurements which are defined in KHALIL, et al. (1982) included the total length (TL), fork length (FL), standard length (SL), predorsal length (PRDL), postdorsal length (PTDL), preventral length (PRVL), preanal length (PRAL), postanal length (PTAL), body depth (BD), postdorsal origin length (PTDL), head length (HL), eye diameter (ED), snout length (SNL), postorbital length (PTOL), head depth (HD), interorbital width (IOW), internasal width (INW), caudal peduncle length (CPL), and caudal peduncle depth (CPD).

Certain meristic counts of 263 specimens collected from the Nile at Aswan (84 males & 179 females) and of 323 specimens from Assiut District (167 males & 156 females) were recorded. These counts included lateral line scale (LLS), pectoral fin ray (PFR), anal fin ray (AFR), total vertebral (TV), anterior abdominal vertebral (AAV), posterior abdominal vertebral (PAV) and caudal vertebral (CV) counts.

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To detect the presence of morphometric and meristic fomrs of A.nurse, the principal component was carried out on the correlation matrices of raw morphometric characters, indices (related to TL), regression – adjusted characters (Type 1) according to MAcCRIMMON, et al. (1983), regression-adjusted characters (Type 2) according to MEKKAWY (1990 a) and meristic characters. Also, PCA was used to elucidate the racial and sexual variations of A.nurse. Moreover, such variations were revealed by the canonical variates analysis (CVA) which maximizes the between group variations in respect to the within group ones.

The programs of PCA (DAVIS, 1973) and CVA (BLACKITH and REYMENT, 1971) were modified to fulfil the aforementioned requirements. Such programs were executed on VME 2900 computer at Assiut University, Egypt.

RESULTS

PCI of raw data (92.37%) can be considered as a size vector containing some elements of shape. Such elements were contributed by ED, BD & INW. The size components of that vector included ontogenetic, sexual and racial ones which were contributed by all characters except the aforementioned ones Table 1. PCII & PCIII, accounting for 2.58 and 1.08% of the total variation respectively, are shape vectors. ED and INW have highest loadings on PCII and PCIII respectively Table 1.

Plots of PCI & PCII scores Fig. 1 a, reveal that in terms of size and shape, there were many morphometric forms of A.nurse. In each form, individuals of Assiut population were obviously differentiated from those of Aswan population. On the other hand, plots of PCI & PCIII scores Fig. 1 b, show that discrimination between Assiut and Aswan forms was possible with the presence of an intermediate group according to size component. No sexual dimorphism was recorded in this respect.

The shape in terms of PCI, PCII & PCIII of indices accounted for 29.21, 17,37 & 10.00% of the total variability respectively Table 1. Fig. 2 a, shows that shape sexual dimorphism and shape racial discrimination between Assiut and Aswan populations were possible on PCII. The discriminating power of such a component was contributed by HL, ED, HD acting against PTDOL, PTAL & INW. PCI & PCIII had no discriminating power. The characters on PCI gave different contributions and PCIII can be termed INW, IOW, CPD, SNL & PTOL versus PTDOL vector Table 1.

Table 1 and Fig. 2b show that conclusions similar to those of indices can be arrived at in PCA of regression-adjusted characters (Type 1). PCII of such shape characters was the important component which had a sexual and geographic discriminating power. It can be termed INW, SNL, PTOL,IOW & CPD versus ED, BD & HD vector.

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PCI of the regression-adjusted characters (type 2) is a size vector explaining 86.15% of the total variations. The size components of such a vector were sexual and racial; the ontogenetic components were excluded by these characters. The remainder components were shape vectors explaining few of the total variations Table 1. Fig. 2c shows that on PCI, sexual size differences of Assiut population were greater than those of Aswan population were greater than those of Aswan population; racial size differences between Assiut and Aswan populations were obvious.

For both males and females, the variance and loadings of characters of the principal components of PCA of PRVL, PRDL and PTDOL are given in Table 2. These characters contributed similar loading on the size vector PCI, whereas PRDL & PRVL acted against PTDOL on the shape vector PCII and PRDL acted against PRVL on PCIII. Fig. 3 shows that three morphometric forms can be identified accoriding to shape bases in males and females of Assiut population of A.nurse with overlapping in plots of PCI & PCII scores Fig. 3a,c and without overlapping in plots of PCI & PCIII scores Fig. 3b,d. Since the interrelationship between PRDL, PRVL and PTDCL reflects the variable position of the dorsal fin of A.nurse, the previously mentioned forms can be considered as an expression of the variable position of dorsal fin in a multivariate sense.

The size and shape CVI (86.72%) of raw data had a racial discriminating power Table 3 & Fig. 4a. It can be termed as INW versus ED vector. CVII (12.49%) and CVIII (0.79%) are shape vectors. CVII can be considered as INW, CPD & SNL versus PTOL vector. It had a sexual discriminating power Fig. 4a whereas CVIII showed no discriminating power.

CVI, CVII & CVIII of indices are shape vectors explaining 90.52, 8.68 and 0.90% of the total variations respectively Table 3. According to their discriminating powers, CVI and CVII can be considered as racial and sexual vectors respectively Fig. 4b. CVI, CVII and CVIII can be termed as ED versus INW, PTOL & SNL; INW, CPD & SNL versus ED, and SNL versus INW, ED, PRDL & CPD vectors respectively Table 3.

Table 4, shows ranges and means of the meristic characters studied. For each sex of Assiut and Aswan populations, PCA of these characters showed different meristic forms as regards plots of scores of the first three components Table 5 & Fig. 5. Fig. 5, shows only plots of score of males of Assiut population as an example identification of the above mentioned forms was achieved by all the meristic characters used. On the other hand, PCA of the meristic characters of Assiut and Aswan populations (all together) of A.nurse was unable to exhibit any meristic forms on plots of scores of PCI & PCII whereas differentiation of such forms was possible on plots of scores of PCII & PCIII Table 5 & Fig. 6. Discrimination between sexes and races was also emphasized on PCI & PCII. Except for PFR & CV, all characters were responsible of such discrimination.

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Roman, B. (1966): Les poissons des hauts bassins de la Volta. Ann. Mus. Roy. Afr. Centr., In 8, Sc. Zool.: 150–191.

Sokal, R.R. and Rohlf, F.J. (1981): Biometry. San Francisco: Freeman.

Svensson, G.S.O. (1933): Freshwater fishes from the Gambia River. Kungl. Sv. Vet. Akad. Handl., 12 (3): 1–102.

Table 1: The first three principal components (PCI, PCII and PCIII) derived from principal components analysis carried out on certain morphometric characters of *Alestes* nurse from Assiut and Aswan, Egypt (coefficient X 1000).

Morphometric characters	Raw data			Indices			Regression-adjusted character 1			Regression-adjusted character 2		
	PCI	PCII	PCIII	PCI	PCII	PCIII	PCI	PCII	PCIII	PCI	PCII	PCIII
TL	237	-076	-036	--	--	--	--	--	--	--	--	--
FL	237	-055	-095	362	-178	-179	366	-025	-255	251	-070	-141
SL	237	-055	-105	351	-205	-189	361	-033	-272	251	-070	-144
HL	235	023	024	198	425	078	251	087	276	246	023	-060
ED	177	944	180	138	458	-045	184	-250	320	129	978	-129
SNL	225	-123	178	121	-012	360	076	404	070	233	-029	013
PTDL	229	-088	141	079	161	315	036	389	129	238	-033	-100
PRDL	237	-065	-038	301	-133	152	257	291	-084	250	-044	-089
PTDL	236	-058	-086	279	-101	045	169	117	-117	233	-066	-141
PRVL	235	044	-139	332	195	-065	339	-175	153	246	007	048
PRAL	237	-021	-100	327	-120	-056	339	-030	-036	249	-025	-083
PTAL	237	-047	-093	333	-241	-087	356	010	-165	251	-053	-117
HD	230	106	-113	216	394	037	254	-167	356	235	049	322
BD	224	092	-255	226	191	091	231	-182	326	223	025	718
CPD	231	-058	055	138	-095	394	114	316	190	240	-015	182
CPL	226	-037	-236	160	184	-163	154	-034	-188	229	-082	-370
IOW	231	-056	121	120	-145	393	105	338	155	239	-026	097
INN	216	-161	825	-008	-230	458	-028	455	091	225	004	225
PTDOL	234	-090	-124	115	-248	-316	117	027	-501	244	-105	-253
Variance	17.55	0.49	0.21	5.26	3.13	1.80	5.50	2.41	1.77	15.51	0.77	0.30
% Variance	92.37	2.58	1.08	29.21	17.37	10.00	30.58	13.37	9.86	86.15	4.29	1.65

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Table 2: The first three principal components (PCI, PCII & PCIII) derived from principal components analysis carried out on certain raw morphometric characters of <u>Alestes nurse</u> from Assiut, Egypt. (coefficient X 1000).

Morphometric characters	Males			Females		
	PCI	PCII	PCIII	PCI	PCII	PCIII
PRDL	579	-348	-738	578	-403	-709
PRVL	578	-463	672	578	-411	705
PTDOL	575	815	067	576	818	055
Variance	2.920	0.050	0.030	2.924	0.046	0.030
% Variance	97.317	1.673	1.010	97.473	1.536	0.991

Table 3: Canonical variates (CVI, CVII & CVIII) derived from canonical variate analysis carried out on certain morphometric characters of <u>Alestes nurse</u> from Assiut and Aswan, Egypt (coefficient X 1000).

Morphometric characters	Raw data			Indices		
	CVI	CVII	CVIII	CVI	CVII	CVIII
TL	008	- 068	- 011	-	-	-
FL	- 033	059	029	031	- 096	- 061
SL	- 022	- 034	077	025	083	- 121
HL	- 195	171	116	241	009	- 084
ED	- 497	- 031	- 390	550	254	335
SNL	276	337	520	- 299	- 292	- 579
PTOL	329	- 263	- 137	- 338	195	136
PRDL	196	- 001	- 273	- 184	- 026	298
PTDL	017	- 013	099	- 014	016	- 064
PRVL	- 076	139	- 063	115	- 131	091
PRAL	048	108	- 029	- 039	- 093	043
PTAL	- 027	- 110	073	- 021	092	- 106
HD	- 282	139	- 140	294	- 106	116
BD	- 146	099	185	115	- 073	- 198
CPD	109	374	- 278	- 125	- 393	245
CPL	- 042	- 011	000	060	059	009
IOW	205	- 067	- 182	- 145	- 014	197
INW	559	739	- 526	- 486	- 761	483
PTDOL	109	- 068	- 049	- 093	072	098
Variance	3.721	0.536	0.034	4.423	0.424	0.039
% Variance	86.720	12.490	0.790	90.520	8.680	0.800

Table 4: The ranges and means $\pm$ standard deviations (in brackets) of certain meristic characters of Alestes nurse of Assiut and Aswan.

Meristic counts	Aswan			Assiut		
	Males	Females	Combined sexes	Males	Females	Combined sexes
LLS	27 - 32 (28.39±0.899)	26 - 33 (28.95±1.024)	26 - 33 (28.96±0.984)	28 - 34 (30.87±1.126)	27 - 34 (31.00±1.130)	27 - 34 (30.94±1.128)
PFR	12 - 15 (13.95±0.579)	12-- 16 (14.01±0.556)	12 - 16 (13.99±0.563)	12 - 16 (13.84±0.853)	12 - 16 (13.93±0.771)	12 - 16 (13.88±0.814)
AFR	15 - 17 (16.10±0.481)	34 - 18 (16.18±0.575)	14 - 18 (16.16±0.548)	15 - 19 (16.50±0.676)	12 - 18 (16.56±0.789)	12 - 19 (16.53±0.732)
TV	36 - 38 (37.26±0.583)	34 - 39 (37.19±0.755)	34 - 39 (37.21±0.705)	36 - 40 (38.09±0.579)	37 - 40 (38.43±0.634)	36 - 40 (38.25±0.629)
AAV	14 - 17 (15.70±0.655)	13 - 17 (15.34±0.657)	13 - 17 (15.80±0.659)	16 - 13 (17.44±0.617)	17 - 20 (17.76±0.644)	16 - 20 (17.60±0.649)
PAV	3 - 7 (4.55±0.751)	3 - 7 (4.65±0.729)	3 - 7 (4.62±0.737)	2 - 6 (4.19±0.673)	3 - 6 (4.23±0.654)	2 - 6 (4.21±0.663)
CV	15 - 18 (16.99±0.611)	14 - 18 (16.69±0.607)	14 - 18 (16.79±0.677)	15 - 18 (16.46±0.599)	15 - 18 (16.43±0.683)	15 - 18 (16.46±0.641)

Table 5: The first three principal components (PCI, PCII & PCIII) derived from principal component analysis carried out on certain meristic characters of _Alestes nurse_ from Assiut and Aswan (coefficient X 1000).

| Meristic characters | Aswan | | | | | | Assiut | | | | | | Assiut and Aswan populations (4 groups) | | |
| | Males | | | Females | | | Males | | | Females | | | | | |
	PCI	PCII	PCIII	PCI	PCII	PCIII	PCI	PCII	PCIII	PCI	PLII	PCIII	PCI	PCII	PCIII
LLS	011	579	-317	315	361	-080	192	537	-341	275	038	-568	505	-213	112
PFR	-138	-046	493	-054	380	-591	210	285	-126	075	418	315	-041	149	811
AFR	058	482	-067	155	542	-266	176	072	-139	052	-188	281	273	-095	288
TV	423	476	396	490	266	521	431	508	271	557	364	-282	495	096	226
AAV	540	054	-385	483	-335	019	540	-168	-489	436	-532	-219	582	-071	-168
PAV	-527	441	257	-394	489	549	-492	581	071	-409	475	-455	-291	-520	390
CV	479	-082	525	495	094	-028	410	-044	729	498	385	380	-022	799	124
Variance	1.892	1.438	1.241	2.079	1.339	1.084	1.780	1.424	1.194	1.757	1.509	1.259	2.503	1.309	1.078
% Variance	27.030	20.394	17.724	29.693	19.136	15.493	25.428	20.342	17.064	25.101	21.562	17.983	35.756	18.703	15.405

Table 6: Lateral line scale counts of _Alestes nurse_ from some African areas (underlined means were insignificantly different at 0.01).

Region	Sénégal	Gambie	Sassandra	Bandama	N'Zi	Comoë	Léraba	Bagoé	Niger	Tchad	Aswan Egypt	Assiut Egypt	Aswan Egypt	Assiut Egypt
Authors	Reizer Mattei Chevalier (1972)	Svensson (1933)	Paugy (1979-1980)	Paugy (1979-1980)	Paugy (1979-1980)	Paugy (1979-1980)	Paugy (1979-1980)	Paugy (1979-1980)	Daget (1954)	Blache (1964)	Khalil et al. (1983a)	Khalil et al. (1983a)	Mekkawy Present Work	Mekkawy Present Work
Counts														
24			5											
25			14	8	2	1	1				1		1	
26			17	39	5	6	4			14	1	3	7	
27		1	7	106	16	2	7	1	2	29	12	9	82	1
28	7	6	2	26	11	2	8	12	17	39	135	49	102	1
29	15	3		1		3	3	17	34	45	174	134	57	27
30	12					1	2	15	10	19	105	158	11	85
31	6					2	2	5	1	10	26	105	2	114
32	3							1			2	31	1	69
33											1	6		22
34														4
Number	43	10	45	180	34	17	27	51	64	156	457	495	263	323
Mean	29.605	28.200	25.711	26.850	27.059	28.588	27.815	30.275	29.859	29.359	29.002	30.826	28.962	30.935
Variance	1.292	0.400	1.028	0.542	0.724	4.007	2.311	1.123	0.599	1.780	0.989	1.472	0.968	1.272

Table 7: Branched and fin ray counts of Alestes nurse from some African areas (underlined means insignificantly different at 0.01).

Region	Sénégal	Gambie Niokol-okoba	Gambie	Sassandra	Bandama	Bandama Kossou	N'Zi	Comoé	Leraba	Bagoé	Niger	Volta	Tchad	Aswan Egypt	Assiut Egypt	Aswan Egypt	Assiut Egypt
Authors	Reizer Hattat Cheva-lier	Daget	Sven-sson	Paugy	Paugy	Kouessi	Paugy	Paugy	Paugy	Paugy	Daget	Roman	Blache	Mekkawy	Mekkawy	Mekkawy Present Work	Mekkawy Present Work
Counts	(1972)	(1961)	(1933)	(1979-1980)	(1979-1980)	(1978)	(1979-1980)	(1979-1980)	(1979-1980)	(1979-1980)	(1954)	(1966)	(1964)	(1980)	(1980)		
10	-						1						1				1
11	1			1			1				1		1				
12	5	17	2	2	16	1	5	4	11	2	35	20	24	1		15	8
13	43	2	8	46	182	5	39	26	28	56	28	1	91	23	23	202	164
14	1			2	28	98	1		4	1			34	381	262	43	143
15					2	17				1			5	85	185	3	6
16														6	13		1
18																	
Number	50	19	10	51	228	121	46	20	43	60	64	21	156	496	483	263	323
Mean	12.880	12.105	12.800	12.961	13.070	14.083	12.870	12.800	12.837	12.017	12.422	12.048	13.096	14.145	14.389	14.129	14.455
Variance	0.189	0.099	0.176	0.158	0.224	0.210	0.205	0.168	0.330	0.118	0.280	0.048	0.578	0.254	0.388	0.250	0.435

Table 8: Total vertebral counts of Alestes nurse from some African areas (underlined means were insignificantly different at 0.01).

Regions	Sassandra	Bandama	Bandama Kossou	Bagoë	Niger	Aswan Egypt	Assiut Egypt	Aswan Egypt	Assiut Egypt
Authors	Paugy (1979-1980)	Paugy (1979-1980)	Kouassi (1978)	Paugy (1979-1980)	Daget (1954)	Khalil et al. (1983 b)	Khalil et al. (1983 b)	Mekkawy Present Work	Mekkawy Present Work
Counts									
34						1		1	
35						7		3	
36	1		7			50		22	1
37	29	7	93	2		305	37	156	22
38	3	26	9	17	6	147	348	75	202
39		2		15	15	14	165	6	90
40				3			18		8
Number	33	35	109	37	21	524	568	263	323
Mean	37.061	37.857	37.018	38.514	38.714	37.206	38.289	37.212	38.253
Variance	0.121	0.244	0.148	0.535	0.214	0.512	0.399	0.497	0.395

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Fig. 1. Plots of scores of PCI, PCII & PCIII derived from PCA carried out on certain raw morphometric characters of Assiut (X : Males; △ : Females) and Aswan (▲ : Males; O : Females) populations of *Alestes nurse*. Such plots show different forms of *A. nurse*.
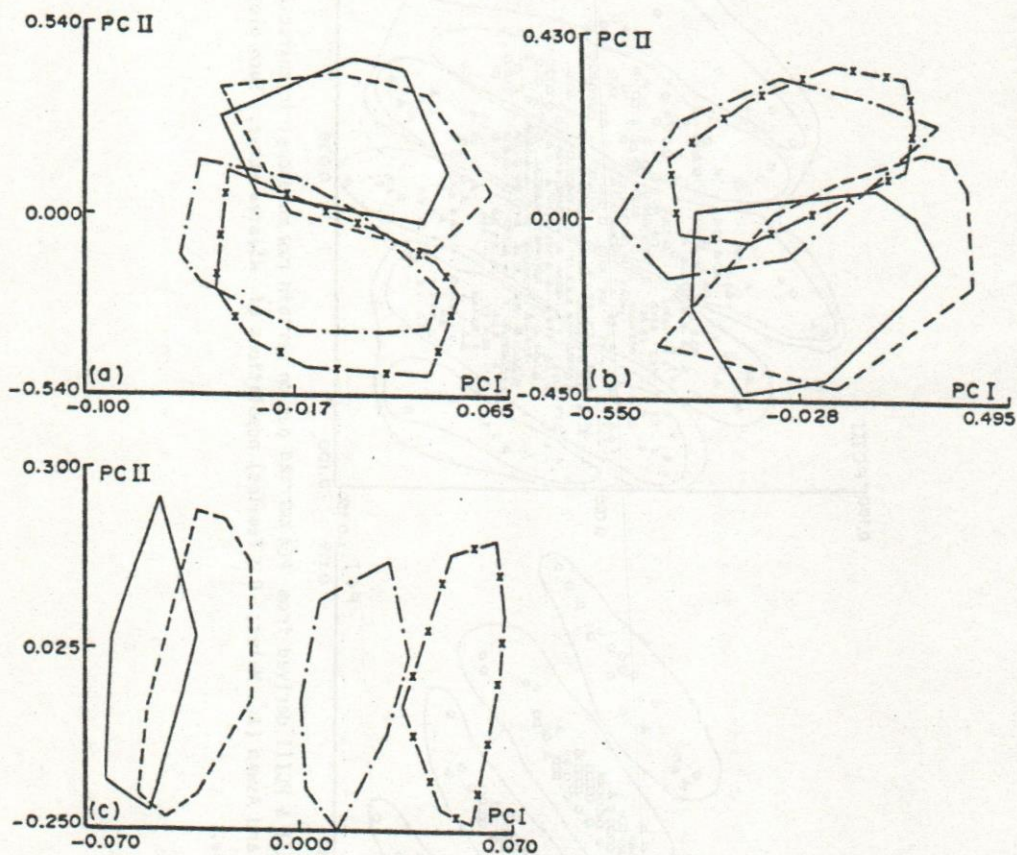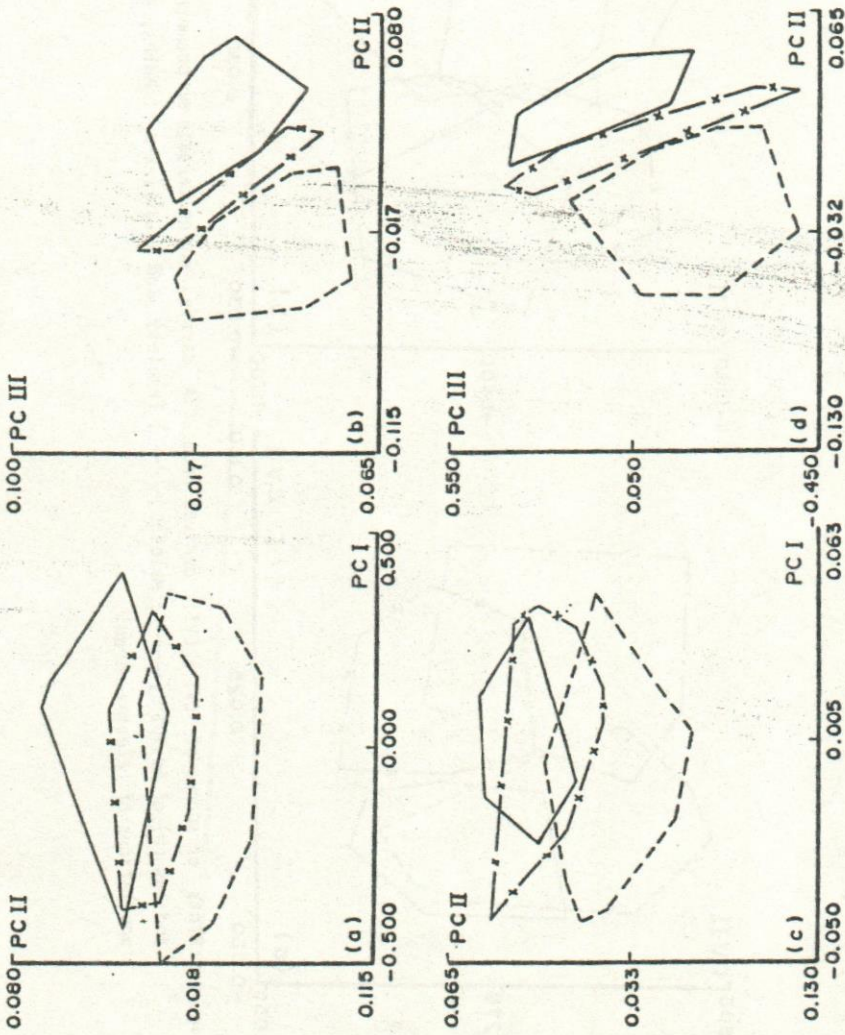
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Fig.2:Plots of scores of PCI & PCII derived from PCA's carried out on indices
(a), regression-adjusted characters-type 1 (b), and regression-adjusted
character-type 2(c), of Assiut (———— : Males; ---: Females) and Aswan
(-x-x-x:Males;-.-.-: Females) populations of *Alestes nurse*.

Fig. 3: Plots of scores of PCI, PCII & PCIII derived from PCA carried out on certain raw morphometric characters of males (a&b) and females (c&d) of Assiut population of *Alestes nurse*. Such plots show three forms: (1) individuals in which PRDL>PRVL(————),(2) individuals in which PRVL=PRDL(-x-x-) and (3) individuals in which PRVL > PRDL (------).
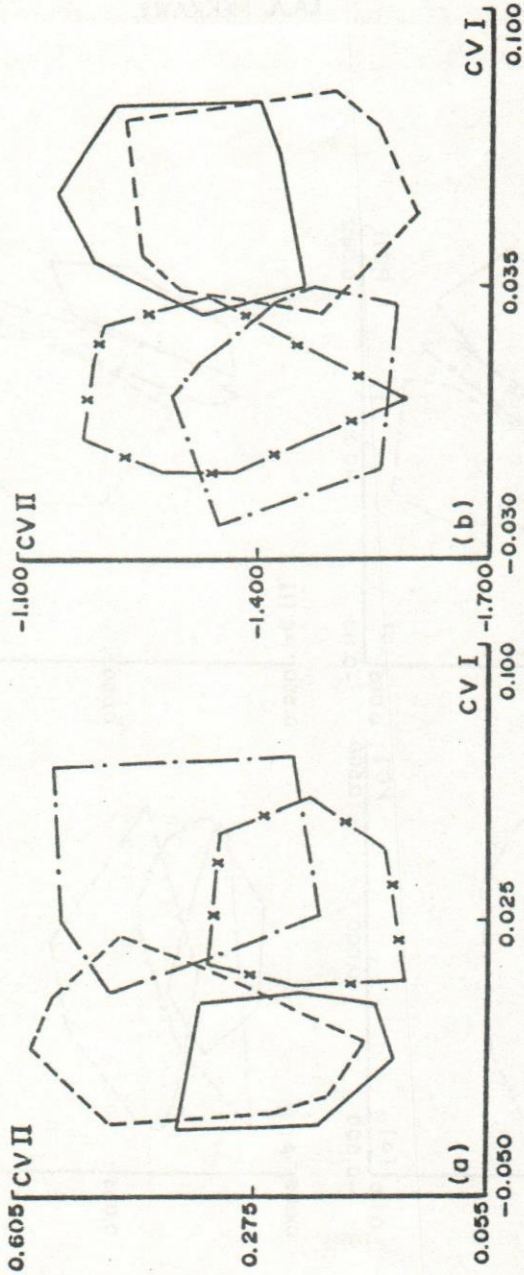
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Fig. 4. Plots of scores of CVI & CVII derived from CVA carried out on certain morphometric raw data (a)and indices (b) of Assiut (————— : Males; -----: Females) and Aswan (-x-x-: Males; -·-·-·-: Females) populations of *Alestes nurse*.
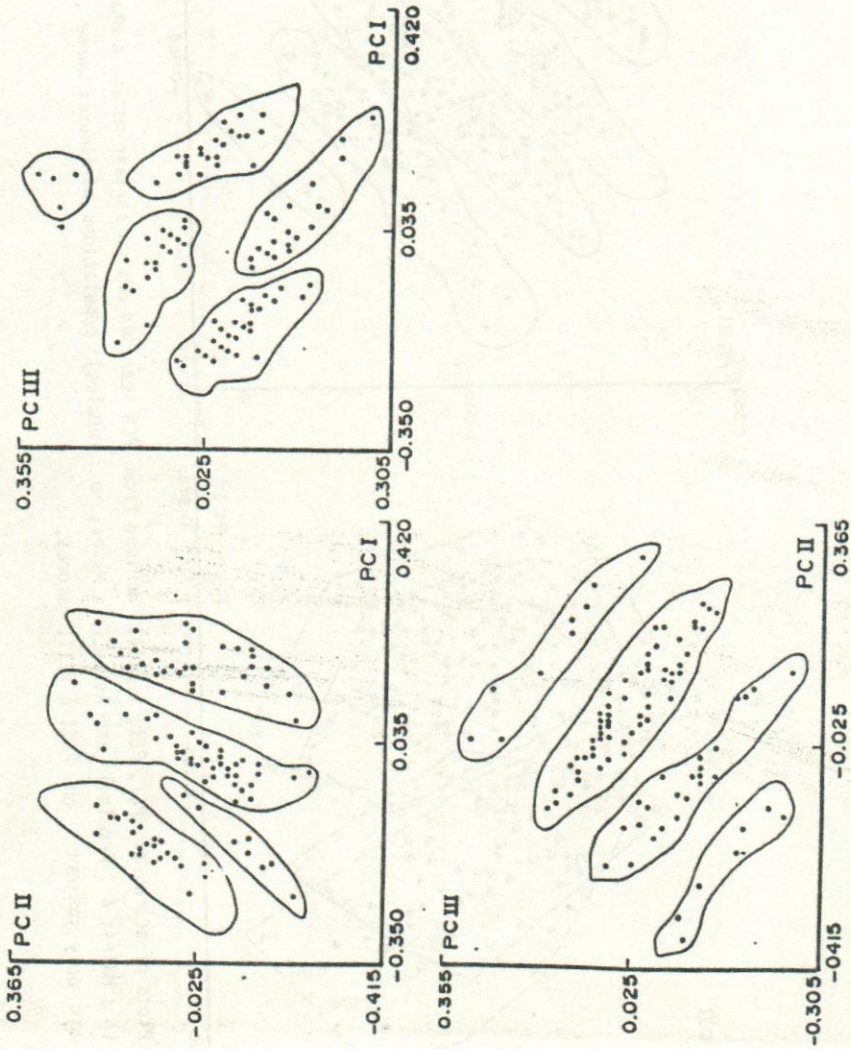
L.A.A. MEKKAWY

Fig. 5. Plots of scores of PCI, PCII & PCIII derived from PCA carried out on certain meristic characters of males of Assiut population of *Alestes nurse*. Such plots show different meristic forms.
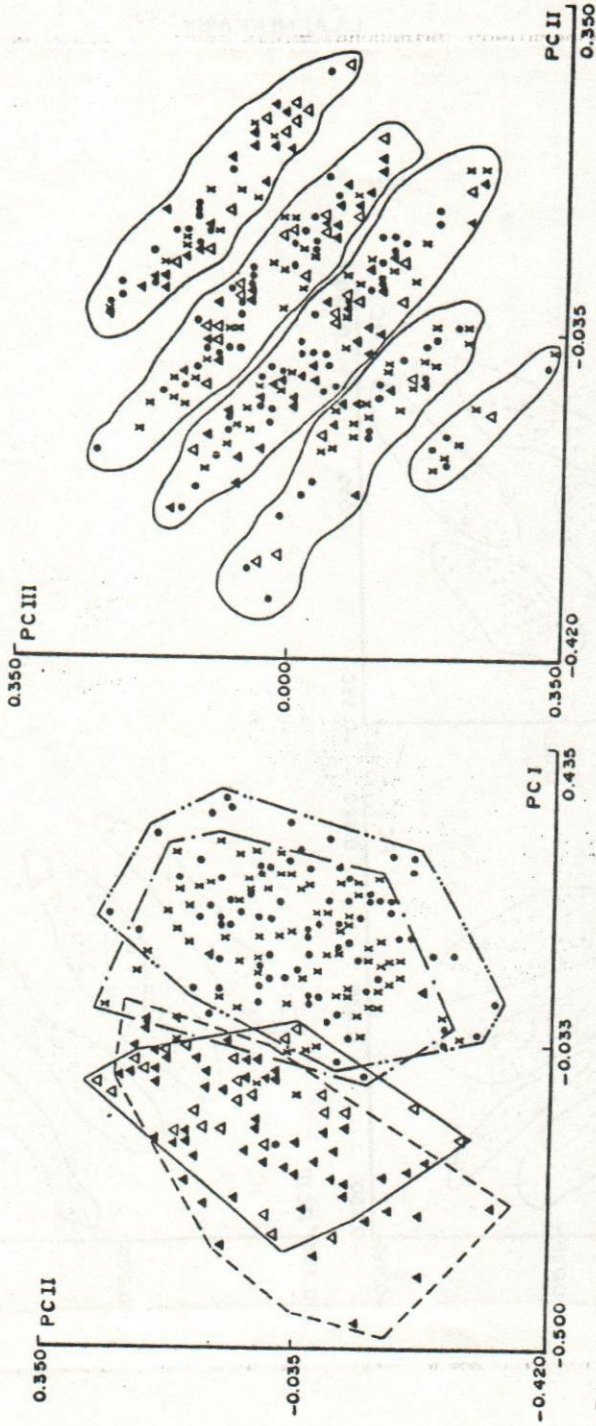
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Fig. 6. Plots of scores of PCI, PCII & PCIFI derived from PCA carried out on certain meristic characters of Assiut (Δ : Males; ▲ : Females) and Aswan (x : Males; o : Females) populations of *Alestes nurse* . Meristic forms are only present .on PCII & PCIII scores.