MORPHOMETRY IN RELATION TO GENETIC VARIATION

Resume of literature:

Organisms occur more or less in distinct or discrete population or stocks. Stock has to be defined as a group or population of a species maintaining one or more common characteristics depending on the type of environment of domicile. (Kutkuhn 1981). Two or more unit stocks can be satisfactorily demonstrated by applying any of the following techniques such as biochemical, immunological, serological, behavioural, morphometric, meristic, mark recapture, electrophoretic etc.

Morphological variation in Zoarces viviparus was observed by Schmidt (1917a, 1918) from 61 different locations. The characters are heritable and are reported to have direct environmental influence (Schmidt 1917a, 1917b; 1918, 1920 1921a; 1921b). Morphological variation was analysed in three races of kokanee Oncorhyncus nerka (Vernon 1957), in mountain white fish Prosopium williamsoni (Holt 1960), in three sympatric Arctic cod fishes of the genera Arctogadus and Gadus (Boulva 1972) in Upeneus sulphureus (Cuvier) from Maharashtra coast (Musharraf Ali 1978) in Sardinella sirmwal from Andaman Sea (Abidi et al.,1978-79), in Lactarius lactarius

(Choudhary and Dwivedi 1980-81), and in pink salmon Oncorhynchus gorbuscha (Beacham 1985). Morphometric technique has been used for stock separation in several species of fishes including Salmo salar (Lear and Misra 1978; Riddell and Leggett 1981), Mallotus villosus (Sharp et al.,1978), Salvelinus malma (Morrow 1980) and Coregonus spp. (Casselman et al.,1981, Ihssen et al.,1981; Todd et al.,1981). The main advantage of this method is that it effectively isolate shape differences than most of the other traditional methods (Ihssen et al.,1981).

In crustaceans also some work has been done using morphological characters for stock delineation. Metric variation in populations of Carcinus maenas (William and Needham 1941) and geographic morphometric variation in American lobster Homarus americanus (Templetson 1935; Saila and Flowers 1969) were noticed.

Geographical variation using morphological characters was seen in the genus Nematocelis (Crustacea:Euphausidae) by Gopalakrishnan (1974), in isopod Sphaeroma rugicauda by Heath (1975), in Western Atlantic population of Gammarus oceanicus segerstrale (Amphipoda) by Croker and Gable (1977), in the dwarf cray fish by Chambers et al.,(1979), in Sphaeroma serratum (Isopoda) by Consiglio and Argano (1968)

and in Pontinella dara (Copepoda) by Fleminger and Hulsemann (1974).

Morphological variance was used in prawns to find intra species variation in Macrobrachium rosenbergii de man by Lindenfelser (1980), to analyse specific variation in fresh water prawn M. niloticum in lake chad and Lake Rudolf by Williamson (1972) in Penaeus semisulcatus by Morgan (1982) and P. vannamei and P. stylirostris by Lester (1983). Lui (1979) after measuring and statistically testing the morphological variables in Macrobrachium australiense disapproved Rick's (1951) suggestion of possible subdivisions.

Morphological relationship of Penaeus semisulcatus Metapenaeus affinis and Parapenaeopsis stylifera was found out by Farmer (1986). Besides morphometry in some organisms electrophoresis also gained momentum to identify different stocks as seen in Cynoglossus bilineatus from Bombay waters (Kasinathan et al.,1972), in rainbow trout Salmo gairdneri (Gjedrem and Skjesvold 1972), in four population of Menidia (Mickevich and Johnson 1976) in Gasterosteus aculeatus (Bell 1976), in fiddler crab Uca (Selander et al.,1971; Salmon et al. 1979) in Chthamalus montagui (Crustacea: Cirripedia) in the Adiatric (Dando et al.,1979) and in Atlantic show crab (Davidson et al.,1985).

Several causative agents like environmental factors play crucial role in the speciation process as seen in Malaysian prawn Macrobrachium rosenbergii (de man) reared in earthern ponds in South Carolina (Smith et al.,1978). Particularly salinity variation and diet cause differences in M. carcinus from Barbados and Jamaica (Choudhury 1971) and in species of M. rosenbergii, M. javanicum and M. pilimanum (Johnson 1960) and in laboratory population of brown shrimp Penaeus aztecus (Venkataramiah et al.,1975). Maturation and spawning was found to exhibit difference between costa Rican and Maxican P. stylirostris (Brown et al.,1980).

Results:

Univariate and Multivariate analysis were carried out for the 3 geographical population (Cochin, Tuticorin and Madras) of P. indicus (Table No.79,- 81 & 83-85) and 2 geographical population (Cochin and Bombay)of P. stylifera (Table No. 82, 86 & 87).

Table 79: Comparison of morphometric variables of *Penaeus indicus* samples from Cochin and Tuticorin

Character	Sampling Location	Sample size range	Mean value	S.D.	't' value
SSL	Cochin	9-15 mm	11.2639	1.3065	3.3498*
	Tuticorin	10-15 mm	12.278	1.262	
FSL	Cochin	6-14 mm	8.3889	1.4595	2.4501*
	Tuticorin	6-14 mm	9.361	1.881	
PCL	Cochin	19-32 mm	22.1667	2.3115	1.4761
	Tuticorin	18-29 mm	23.056	2.779	
CW	Cochin	10-18 mm	11.4028	1.553	0.4303
	Tuticorin	8-15 mm	11.569	1.72	
FLF	Cochin	3.5-7 mm	5.0556	0.8348	1.3871
	Tuticorin	6-11 mm	5.333	0.862	
SSD	Cochin	7-14 mm	9.0139	1.2506	0.4705
	Tuticorin	6-11 mm	9.153	1.258	
SAD	Cochin	10-16 mm	11.3611	1.3764	0.1526
	Tuticorin	8-15 mm	11.417	1.713	
AAC	Cochin	34-54 mm	39.5833	3.9668	0.3451
	Tuticorin	31-49 mm	39.944	4.858	
PAC	Cochin	25-41 mm	30.0556	2.8977	1.439
	Tuticorin	20-36 mm	28.917	3.76	
TW	Cochin	7-28 gm	13.1111	11.2282	0.0168
	Tuticorin	7-19 gm	13.078	3.656	
TL	Cochin	101-150mm	115.0000	9.2921	0.6397
	Tuticorin	90-140mm	116.667	12.574	

* Significant at 5% level.

Table 8.0: Comparison of morphometric variables of *Penaeus indicus* samples from Cochin and Madras

Character	Sampling Location	Sample size range	Mean Value	S.D.	't' Value
SSL	Cochin	9-15 mm	11.2639	1.3065	4.8557*
	Madras	10-15 mm	12.681	1.166	
FSL	Cochin	6-14 mm	8.3889	1.4595	6.216*
	Madras	8-14 mm	10.472	1.383	
PCL	Cochin	19-32 mm	22.1667	2.3115	4.133*
	Madras	17-29 mm	24.458	2.392	
CW	Cochin	10-18 mm	11.4028	1.5530	3.6058*
	Madras	8-15 mm	12.667	1.419	
FLF	Cochin	3.5-7mm	5.0556	0.8348	2.8325*
	Madras	4-7 mm	5.611	0.829	
SSD	Cochin	7-14 mm	9.0139	1.2506	2.8624*
	Madras	12-18 mm	9.889	1.342	
SAD	Cochin	10-16mm	11.3611	1.3764	4.4192*
	Madras	9-14.5mm	12.778	1.344	
AAC	Cochin	34-54 mm	39.5833	3.9668	3.8073*
	Madras	32-52 mm	43.0000	3.641	
PAC	Cochin	25-41 mm	30.0556	2.8977	1.4759
	Madras	20-39 mm	31.083	3.008	
TW	Cochin	7-28 gm	13.1111	11.2282	1.16
	Madras	5.3-20.5gm	15.375	3.326	
TL	Cochin	101-150mm	115.0000	9.2921	1.4752
	Madras	110-142mm	120.683	21.165	

* Significant at 5% level.

Table 81: Comparison of Morphometric variables of Penaeus indicus samples from Tuticorin and Madras.

Character	Sampling Location	Sample size range	Mean Value	S.D.	't' value
SSL	Tuticorin	10-15 mm	12.278	1.262	1.4074
	Madras	10-15 mm	12.681	1.166	
FSL	Tuticorin	6-14 mm	9.361	1.881	2.8552*
	Madras	8-14 mm	10.472	1.383	
PCL	Tuticorin	18-29 mm	23.056	2.779	2.2942*
	Madras	17-29 mm	24.458	2.392	
CW	Tuticorin	8-15 mm	11.569	1.72	2.9546*
	Madras	8-15 mm	12.667	1.419	
FLF	Tuticorin	6-11 mm	5.333	0.862	1.3947
	Madras	4-77 mm	6.611	0.829	
SSD	Tuticorin	6-11 mm	9.153	1.258	2.4007*
	Madras	12-18 mm	9.889	1.342	
SAD	Tuticorin	8-15 mm	11.417	1.713	3.7505*
	Madras	9-14.5mm	12.778	1.344	
AAC	Tuticorin	31-49 mm	39.944	4.858	3.0203*
	Madras	32-52 mm	43.0000	3.641	
PAC	Tuticorin	20-36 mm	28.917	3.760	2.699*
	Madras	20-39 mm	31.083	3.008	
TW	Tuticorin	7-19 gm	13.078	3.656	2.7885*
	Madras	5.3-20.5gm	15.375	3.326	
TL	Tuticorin	90-140mm	116.667	12.574	0.9788
	Madras	110-142mm	120.683	21.165	

* Significant at 5% level.

Table 82: Comparisons of morphometric variables of *Parapenaeopsis stylifera* samples from Cochin and Bombay.

Character	Sampling location	Sample size range	Mean value	S.D.	't' value
SSL	Cochin	8-11 mm	9.7778	0.7215	1.4461
	Bombay	9-11 mm	9.5139	0.8236	
FSL	Cochin	4-9 mm	6.5000	0.94111	5.8919*
	Bombay	6-9 mm	7.7222	0.8145	
PCL	Cochin	20-29 mm	23.8611	2.8601	1.2023
	Bombay	18-29 mm	23.0278	3.0189	
CW	Cochin	9-15 mm	11.5556	1.5389	0.6055
	Bombay	10-16 mm	11.7639	1.3757	
FLF	Cochin	4-6 mm	5.1667	0.5606	0.5247
	Bombay	3-7 mm	5.2500	0.7700	
SSD	Cochin	7-11 mm	9.3611	1.0185	3.3655*
	Bombay	7-10 mm	8.5278	1.0820	
SAD	Cochin	8-12 mm	10.3889	0.9344	1.3219
	Bombay	8-12 mm	10.0694	1.1094	
AAC	Cochin	23-40 mm	31.8611	3.4654	0.7885
	Bombay	26-37 mm	31.2778	2.7735	
AAC	Cochin	22-30 mm	26.1667	2.3845	1.9530*
	Bombay	21-30 mm	25.0833	2.3223	
TW	Cochin	4.1-10gm	6.1111	1.6039	0.5892
	Bombay	4-9 gm	6.3333	1.5959	
TL	Cochin	86-116mm	97.75	8.1744	0.0129
	Bombay	82-117mm	97.7222	10.0046	

* Significant at 5% level.

Table 83: Matrix of correlation coefficient among eleven morphological variables in *Penaeus indicus* collected at Cochin.

	SSL	FSL	PCL	CW	FLF	SSD	SAD	AAC	PAC	TW	TL
SSL	1.0000										
FSL	0.5365	1.0000									
PCL	0.7608	0.6916	1.0000								
CW	0.7666	0.7861	0.8981	1.0000							
FLF	0.6411	0.5680	0.6910	0.6324	1.0000						
SSD	0.8589	0.7248	0.8665	0.9054	0.6697	1.0000					
SAD	0.7240	0.7103	0.7529	0.8456	0.6783	0.8352	1.0000				
AAC	0.7881	0.6851	0.7946	0.8536	0.6327	0.8996	0.8185	1.0000			
PAC	0.7092	0.6568	0.7685	0.8552	0.5243	0.8591	0.7757	0.8521	1.0000		
TW	-0.0298	0.2222	0.1371	0.1633	-0.0037	0.0380	0.1230	0.1066	0.1746	1.0000	
TL	0.7849	0.7163	0.8327	0.8811	0.6704	0.9220	0.8511	0.9054	0.8425	0.1235	1.0000

Table 84 : Matrix of correlation coefficient among eleven morphological variables in *Penaeus indicus* collected at Tuticorin.

	SSL	FSL	PCL	CW	FLF	SSD	SAD	AAC	PAC	TW	TL
SSL	1.000										
FSL	0.751	1.000									
PCL	0.828	0.776	1.000								
CW	0.692	0.774	0.924	1.000							
FLF	0.779	0.726	0.803	0.745	1.000						
SSD	0.755	0.743	0.864	0.902	0.676	1.000					
SAD	0.711	0.701	0.835	0.877	0.619	0.884	1.000				
AAC	0.846	0.793	0.893	0.848	0.769	0.876	0.792	1.000			
PAC	0.806	0.760	0.881	0.845	0.820	0.882	0.746	0.895	1.000		
TW	0.732	0.732	0.930	0.958	0.776	0.878	0.892	0.823	0.847	1.000	
TL	0.813	0.771	0.896	0.899	0.778	0.898	0.871	0.895	0.856	0.909	1.000

Table 85: Matrix of correlation coefficient among eleven morphological variables in Penaeus indicus collected at Madras.

	SSL	FSL	PCL	CW	FLF	SSD	SAD	AAC	PAC	TW	TL
SSL	1.000										
FSL	0.645	1.000									
PCL	0.833	0.736	1.000								
CW	0.650	0.679	0.909	1.000							
FLF	0.518	0.626	0.709	0.609	1.000						
SSD	0.561	0.483	0.699	0.734	0.435	1.000					
SAD	0.450	0.473	0.686	0.716	0.446	0.421	1.000				
AAC	0.872	0.743	0.879	0.755	0.573	0.623	0.593	1.000			
PAC	0.765	0.656	0.842	0.753	0.655	0.692	0.535	0.814	1.000		
TW	0.709	0.676	0.912	0.943	0.658	0.779	0.721	0.755	0.769	1.000	
TL	0.495	0.270	0.425	0.315	0.186	0.325	0.293	0.544	0.378	0.315	1.000

Table 86: Matrix of correlation coefficient among eleven morphological variables in *Parapenaeopsis stylifera* collected at Cochin.

	SSC	FSL	PCL	CW	FLF	SSD	SAD	AAC	PAC	TW	TL
SSL	1.0000										
FSL	0.1683	1.0000									
PCL	0.3861	0.5679	1.0000								
CW	0.3459	0.5721	0.8879	1.0000							
FLF	0.4473	0.4332	0.4782	0.4857	1.0000						
SSD	0.6177	0.4918	0.7828	0.7980	0.5421	1.0000					
SAD	0.6828	0.4224	0.6623	0.6403	0.6364	0.8990	1.0000				
AAC	0.1587	0.4775	0.7533	0.7757	0.4535	0.6056	0.5378	1.0000			
PAC	0.2546	0.4711	0.6906	0.6592	0.5985	0.5392	0.4959	0.7394	1.0000		
TW	0.4441	0.5981	0.7521	0.8193	0.5444	0.7163	0.7101	0.7791	0.7443	1.0000	
TL	0.4844	0.5589	0.8295	0.8472	0.4645	0.6975	0.6715	0.7300	0.6486	0.8436	1.0000

Table 87: Matrix of correlation coefficient among eleven morphological variables in *Parapenaeopsis stylifera* collected at Bombay.

	SSL	FSL	PCL	CW	FLF	SSD	SAD	AAC	PAC	TW	TL
SSL	1.0000										
FSL	0.6447	1.0000									
PCL	0.7065	0.5028	1.0000								
CW	0.6460	0.3732	0.8960	1.0000							
FLF	0.5125	0.4783	0.5009	0.5428	1.0000						
SSD	0.6809	0.4953	0.7914	0.7003	0.5573	1.0000					
SAD	0.7259	0.5278	0.8184	0.7411	0.4808	0.8969	1.0000				
AAC	0.6487	0.5790	0.8419	0.8264	0.5954	0.7876	0.8107	1.0000			
PAC	0.6641	0.5563	0.7251	0.7665	0.5473	0.6643	0.7795	0.8347	1.0000		
TW	0.7256	0.4799	0.8852	0.8765	0.5743	0.7871	0.8257	0.8635	0.7933	1.0000	
TL	0.6628	0.4811	0.8810	0.8462	0.4952	0.7451	0.7998	0.8647	0.8360	0.8588	1.0000

Discussion:

Various population parameters and physiological, behavioral, morphometric, meristic, calcareous, biochemical and cytogenetic characters have been used to identify fish stocks. Population measures are useful primarily for the recognition of punitive stocks at the practical management level. Application of morphometric and meristic characters in stock identification is complicated by the fact that phenotypic variation in these characters has not been directly related to particular differences in the genome (Clayton, 1981). Effects of physiological and epigenetic constraints on morphology is directly related to certain environmental parameters such as temperature and oxygen (Martin 1949, Gould 1977, Stanley 1979 and Todd et al, 1981). The number of serially repeated characters alters with the environmental changes associated with attitude (Taning 1952; McGlade 1981).

Morphological (morphometric) characters represent a series of measured variables and represent the synergism between shape and size. Using these morphological characters differenciation of stocks is likely to be subtle as seen in most fish species since it is affected by allometry (Gould 1966, Sweet 1980).

Fish stocks appear to develop as a result of complex interaction between genetic (biochemical level), organismic (level of morphology, physiology and behaviour) and ecological factors (Lindsey 1981; Clayton 1981).

Multivariate comparisons of morphological measurement among closely related group of organism reflect some biological variables such as growth rate or sexual dimorphism (e g. Eyles and Blackith 1965) According to the present study a large portion of morphometric variation among stocks is probably due to difference in growth rates in the stocks. As per the present results, morphometric data of Penaeus indicus differentiates Tuticorin-Madras, Cochin-Madras stocks completely and the resulting relationships among the stocks did not appear to resemble the relationships obtained from the biochemical electrophoretic data. But Cochin-Tuticorin geographical populations of P. indicus and Cochin-Bombay geographical populations of P. stylifera showed significant variation only for few morphological variables. Kirkpatrick and Selander (1979) found out speciation occurs in sympatric stocks of white fish with only minor changes in the allelic frequencies measured by electrophoresis.

Lester (1983) found out that different variables analysed in each species data set have quite distinct

correlations despite their appearance of morphological similarity among penaeid species. In the commercial mariculture operation of prawns any reduction of the size of the maturation tanks, hatchery tanks and growout ponds will affect behaviour and survival (Lester 1983), and consequently size.

Phenotypic differences observed between prawn species P. indicus samples of Tuticorin-Madras, Cochin-Madras, may be due to morphological differentiation in response to environmental factors during the ontogeny when these prawns enter the back waters and lakes for larval development as seen in snow crabs (Davidson et al.,1985). P. indicus can withstand wide range of salinity, especially in younger stages. To some extent the species is eurythermal, as seen from wide gradient of temperature of its natural habitats. Thus they are faced with relatively heterogeneous environments. The magnitude of larval exchange between areas would be affected by oceanographic patterns and proportional to the distance between areas and velosity of surface currents (Davidson et al.,1985).

As they grow larger they move to the sea and thus have a relatively homogeneous adult environments. Then tend to converge in their morphological attributes as seen in snow crab (Davidson et al.,1985).

Invertebrates such as crustacean generally exhibit little morphological change in relation to short-term changes in their environments. Their rigid exoskeleton often allows for more precise morphometric measurements compared with soft bodied vertebrates (Davidson et al.,1985). This proves that morphological comparison of crustacean population may provide useful evidence for delineating stocks. But it is often difficult to distinguish between genetic and environmental effects on phenotypic characters (Booke 1981). But majority of the phenotypic variability (Morphovariance) observed between areas would be due to the notion that structural genes evolution (measured by electrophoresis) proceeded independently at a different rate from evolution at more complex phenotypic levels (King and Wilson 1975, Wilson, Maxson and Sarich 1974; Wilson, Sarich and Maxson 1974). Besides these rate of protein evolution appears to be proportional to time (Ayala 1976; Carson 1976). This is probably the reason why some morpho variance is noticed in specimen from different areas, although biochemically they appear to belong to the same population.