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Phenotypic Differences in Pacific Whiteleg Shrimp (*Litopenaeus vannamei,* Boone 1931) Reared in Different Types of Culture Ponds-Statical Approach

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Abstract: The aquafarming of shrimp is booming with updated innovations to produce successful and profitable crop of whiteleg shrimp *L. vannamei* which is major stocking species in aquaculture and also in highly demanded among seafoods. Present study was conducted to assess the phenotypic differences or morphometric variations of shrimp. The shrimps (*Litopenaeus vannamei*) were randomly collected during summer crop (2021) from earthen and polyethylene culture ponds located at Bhimpore, Surat (Gujarat-India). The morphometric parameters (16) were measured from 500 shrimp specimens from each pond to describe the morphological variations among the shrimp population of different culture ponds. The actual total length and partial total length of shrimp in earthen pond and polyethylene lined pond are positively and significantly correlated to each other. PCA shows that shrimp (*L.vannamei*) population variability is denoted by the three groups of variables in earthen pond (EP) while in polyethylene lined pond (PELP) it was donated by only one group of morphometric variables. The graphical presentation of PCs were depicted that separate cluster of shrimp population from earthen ponds and polyethylene lined pond which subsequently confirm and conclude that morphological structure of shrimp (*L. vannamei*) population of EP and PELP were entirely different from each other.

Keywords: Shrimp (*L. vannamei*), Different culture pond, Morphometric parameter, Correlation matrix, PCA, Cluster plot

The whiteleg shrimp, *Litopenaeus vannamei* (Boone 1931) is native of eastern Pacific Ocean from Mexican state of northern Peru and belongs to the phylum Arthropoda which having joined appendages and hard exoskeleton or cuticle (Bailey-Brock and Moss 1992). The post larvae of this shrimp is easy to available, specific pathogen free, specific pathogen resistance, fast growth rate, high export rate so far culture of whiteleg shrimp is globally disseminated and production increased in many folds from 0.01 MMT (1970) to 4.5 MMT since 2021 that contributing about 80% of the cultured shrimp in global aquaculture (FAO 2021P, Prajapati and Ujjania 2021). Indian scenario shows that it contributing about 0.81 MMT in cultured shrimp production (https://mpeda.gov.in). Hence, shrimp aquaculture vibrantly took a part to produce nutrient rich aquatic food as well as increase significantly in economy of India. Improvements in innovations of culture methods like spreading polyethylene liners on earthen pond come around to enhance the production and meet the global market demand. The phenotypic or morphometric a tool are used in multidisciplinary approaches for stock identification, separating various species and population, determine sexual dimorphism and relate population, classify the evolutionary connections among fish fauna and to identify biogeography and phenotypic plasticity (Deesri et al 2009, Hopkins and Thurman 2010, Silva et al 2010, Hirsch et al 2013). Furthermore, use of geometric morphometrics are principally apt due to the accurate identification of homologous landmarks on the hard exoskeleton (Rufino et al 2006). Gujarat is one of the dominant state in shrimp production and limited reviews are available on this aspects, so the current study was taken up to discriminate the shrimp (*L. vannamei*) cultured in two different types of culture ponds (earthen and polyethylene) which would be helpful for farmers and researchers to assess the growth and health status of shrimp.

MATERIAL AND METHODS

The 500 specimens of *L. vannamei* was randomly collected during summer crop of 2021 from each earthen and polyethylene lined culture ponds at Bhimpore, Surat (Gujarat). Morphometric variables of *L. vannamei* including 14 morphometric lengths and 2 circumferences (Fig. 1) were measured (Lester, 1983) with the help of digital vernier caliper (accuracy ±0.02 mm). The morphometric versions of the shrimp were described based on statistical tools i.e., principal components analysis (PCA), principal components (PCs), Eigen value, cumulative percentage, components matrix and rotated component matrix by SPSS (v26).

RESULTS AND DISCUSSION

Correlation coefficient (r): The correlation coefficient (r) shows that significance of inter-relationship of two different variables and in present study the range of correlation coefficient (r) was directly propose net between actual total length (ATL) and different morphological parameters and it was maximum (0.938) in between ATL and PTL, minimum (0.198) in between PAC and FoSL morphometric variables of shrimp population in earthen pond. Similarly, the range of “r” was directly proposing net between ATL and different morphological parameters of shrimp population in polyethylene lined pond and maximum (0.938) in between ATL and PTL and minimum (0.222) in between PAC and TSL variables of shrimp (Table 1 and Fig. 1). The observed correlation coefficient values shows that actual total length (ATL) and partial total length (PTL) of shrimp in earthen pond and polyethylene lined pond are strongly, positively, and significantly correlated to each other while morphometric variables PAC v/s FoSL and PAC v/s TSL of shrimp in earthen pond and polyethylene lined pond are positively and weakly correlated to each other. Vincent et al (2014) reported maximum correlation coefficient value (0.960) between PCL and TLW morphometric measurements of the shrimp (*P. monodon*) and concluded positive and strong correlation of

Table 1. Correlation matrix of *L. vannamei* morphological parameters

		ATL	PTL	CW	PCL	CD	FSL	SSL	TSL	FoSL	FiSL	SiSL	SSD	EnUL	EUL	PAC	AAC
ATL	EP	1.000															
	PELP	1.000															
PTL	EP	0.938	1.000														
	PELP	0.938	1.000														
CW	EP	0.431	0.449	1.000													
	PELP	0.740	0.690	1.000													
PCL	EP	0.755	0.729	0.476	1.000												
	PELP	0.893	0.872	0.684	1.000												
CD	EP	0.580	0.569	0.853	0.655	1.000	.										
	PELP	0.764	0.709	0.937	0.738	1.000											
FSL	EP	0.659	0.668	0.470	0.604	0.633	1.000										
	PELP	0.722	0.703	0.639	0.723	0.751	1.000										
SSL	EP	0.591	0.592	0.363	0.526	0.480	0.718	1.000									
	PELP	0.715	0.690	0.638	0.693	0.744	0.834	1.000									
TSL	EP	0.615	0.617	0.317	0.492	0.379	0.604	0.635	1.000								
	PELP	0.270	0.433	0.221	0.313	0.240	0.383	0.400	1.000								
FoSL	EP	0.452	0.444	0.287	0.225	0.259	0.343	0.408	0.647	1.000							
	PELP	0.748	0.742	0.653	0.756	0.769	0.758	0.784	0.429	1.000							
FiSL	EP	0.509	0.481	0.268	0.328	0.281	0.488	0.442	0.592	0.791	1.000						
	PELP	0.509	0.481	0.268	0.328	0.281	0.488	0.442	0.592	0.791	1.000						
SiSL	EP	0.665	0.654	0.327	0.536	0.404	0.638	0.576	0.712	0.509	0.671	1.000					
	PELP	0.750	0.761	0.559	0.725	0.659	0.679	0.701	0.338	0.734	0.752	1.000					
SSD	EP	0.679	0.696	0.331	0.618	0.517	0.685	0.619	0.499	0.249	0.368	0.639	1.000				
	PELP	0.737	0.700	0.534	0.726	0.636	0.688	0.724	0.303	0.735	0.738	0.729	1.000				
EnUL	EP	0.627	0.649	0.341	0.568	0.413	0.594	0.456	0.540	0.436	0.430	0.550	0.628	1.000			
	PELP	0.765	0.711	0.576	0.699	0.662	0.653	0.679	0.343	0.682	0.709	0.664	0.622	1.000			
EUL	EP	0.647	0.655	0.465	0.572	0.526	0.570	0.502	0.492	0.477	0.444	0.527	0.580	0.771	1.000		
	PELP	0.813	0.749	0.617	0.784	0.718	0.745	0.713	0.260	0.724	0.727	0.725	0.706	0.843	1.000		
PAC	EP	0.625	0.570	0.172	0.480	0.428	0.495	0.403	0.273	0.198	0.338	0.399	0.477	0.296	0.327	1.000	
	PELP	0.693	0.672	0.531	0.614	0.576	0.666	0.635	0.222	0.651	0.607	0.679	0.578	0.527	0.667	1.000	
AAC	EP	0.616	0.613	0.201	0.545	0.367	0.465	0.365	0.442	0.316	0.375	0.456	0.432	0.394	0.375	0.519	1.000
	PELP	0.732	0.722	0.623	0.668	0.655	0.633	0.689	0.284	0.713	0.638	0.629	0.580	0.607	0.670	0.584	1.000

*Correlation is significant at the 0.01 level. EP for Earthen Pond and PELP for Polyethylene Pond the variables. Rafael et al (2022) reported maximum correlation coefficient value (0.94) between 6SL and WAE morphometric measurements of the shrimp (*Penaeus schmitti*) and concluded positive and strong correlation of the variables.

Principal component analysis (PCA): PCA was conducted and range of eigenvalues 0.05-8.72 and 0.03-11.02, variance (%) 0.33-54.54 and 0.18-68.89 were observed in EP and PELP respectively (Table 2, Fig. 1). The component matrix (CM) shows 3 groups of principal components with cumulative variance 71.90% and eigenvalue 8.72, 1.56, 1.20 were in EP while only 1 group with cumulative variance 68.89% and eigenvalue 11.02 were in PELP (Table 2 and Fig. 2). Furthermore, rotated component matrix (RCM) denoted the major components of first group (PAC, ATL, PTL, AAC, SSD, PCL, FSL, SSL), second group (FoSL, FiSL, TSL, SiSL, EnUL) and third group (CW, CD, EUL) containing factor loading 4.65, 3.78, 3.06 and cumulative variance 29.10, 52.74, 71.90 % , respectively in shrimp population of EP whereas all morphometric variables (ATL, PTL, FoSL, PCL, FiSL, EUL, SSL, CD, FSL, SiSL, SSD, EnUL, AAC, CW, PAC, TSL) containing factor loading 11.02 and cumulative variance 68.89% were observed in shrimp population of PELP (Table 2, 3, Fig. 1). These finding shows that shrimp (*L. vannamei*) population variability is contributed by the three groups of variables while in PELP it was contributed by only one group of morphometric variables. Geometrically, the principal component (PC-1) explains most of variables in data set and assumed to lie parallel with the largest axis in the

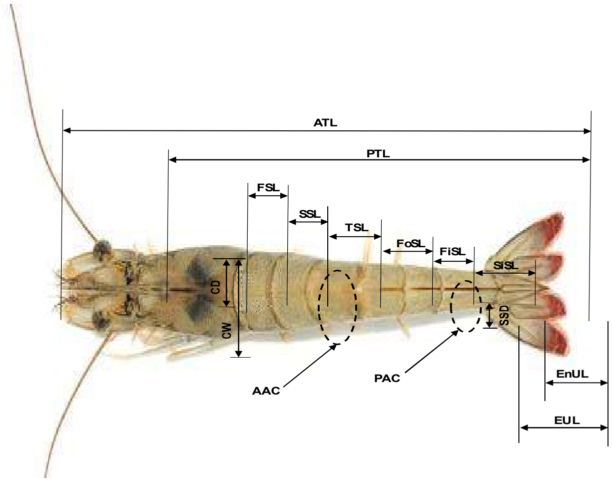

Fig. 1. Morphometric parameters [Actual total length (ATL), Partial total length (PTL), Carapace width (CW), Partial carapace length (PCL), Carapace depth (CD), First segment length (FSL), Second segment length (SSL), Third segment length (TSL), Forth segment length (FoSL), Fifth segment length (FiSL), Sixth segment length (SiSL), Sixth segment depth (SSD), Endopod of uropod length (EnUL), Exopod of uropod length (EUL), Posterior abdomen circumference (PAC) and Anterior abdomen circumference (AAC)] of shrimp (*L. vannamei*)

Table 2. Principal components analysis for Eigenvalue, loadings and percentage (Variance and cumulative) of various components for shrimp (*L. vannamei*)

CP	Eigenvalues		Variance (%)		Loadings		Variance (%)		Cumulative (%)	
	EP	PELP	EP	PELP	EP	PELP	EP	PELP	EP	PELP
1	8.72	11.02	54.54	68.89	4.65	11.02	29.10	68.89	29.10	68.89
2	1.56	0.97	9.80	6.09	3.78		23.64		52.74	
3	1.20	0.69	7.55	4.36	3.06		19.15		71.90	
4	0.87	0.57	5.48	3.57						
5	0.77	0.51	4.81	3.19						
6	0.54	0.44	3.42	2.78						
7	0.43	0.40	2.71	2.52						
8	0.40	0.34	2.49	2.16						
9	0.29	0.27	1.82	1.69						
10	0.28	0.22	1.76	1.38						
11	0.24	0.17	1.51	1.06						
12	0.23	0.12	1.49	0.77						
13	0.16	0.08	1.05	0.55						
14	0.10	0.08	0.67	0.50						
15	0.07	0.03	0.48	0.23						
16	0.05	0.03	0.33	0.18						

CP for Component, EP for Earthen Pond and PELP for Polyethylene lined Pond

Table 3. Principal component analysis and major components of *L. vannamei*

Component Matrix						Rotated Component Matrix			
Morphological variable		Component				Morphological characters	Component*		
EP	PELP	EP*			PELP**	EP	1	2	3
		1	2	3	1				
ATL	ATL	0.894			0.919	PAC	0.791		
PTL	PTL	0.889			0.898	ATL	0.761		
FSL	FoSL	0.826			0.894	PTL	0.739		
SiSL	PCL	0.794			0.890	AAC	0.728		
PCL	FiSL	0.784			0.876	SSD	0.683		
SSD	EUL	0.780			0.875	PCL	0.679		
EUL	SSL	0.764			0.863	FSL	0.574		
TSL	CD	0.756			0.862	SSL	0.479		
EnUL	FSL	0.748			0.857	FoSL		0.900	
SSL	SiSL	0.744			0.843	FiSL		0.853	
CD	SSD	0.704			0.818	TSL		0.743	
FiSL	EnUL	0.653			0.817	SiSL		0.651	
AAC	AAC	0.634			0.793	EnUL		0.474	
PAC	CW	0.593			0.782	CW			0.922
FoSL	PAC		0.649		0.753	CD			0.865
CW	TSL			0.648	0.414	EUL			0.509

*Three components extracted, ** one components extracted, EP for earthen pond and PELP for polyethylene lined pond

hyperdimensional cloud of data though, principal component (PC-2) is independent of PC-1 and its lies perpendicular to the axis of PC-1 and explains the second largest component of variation in the data set. Each PC is linear combination of the variables and defined by vector (an eigen vector) of coefficients and eigenvalue (Vincent et al 2014). The distance dimensions were further subjected to sheared PCA and the PCs were plotted on a graph with PC-1 and PC-2 on X and Y axes respectively. The shrimp population of earthen ponds formed separate cluster from shrimp population of polyethylene lined pond which shows that the morphological outlines of studied shrimp (*L. vannamei*) population of EP and PELP were entirely different from each other (Fig. 3). Ujjania and Kohli (2011) observed intra species variability in major carp during their study while in contrast Vincent et al (2014) reported no significantly different in *P. monodon* population.

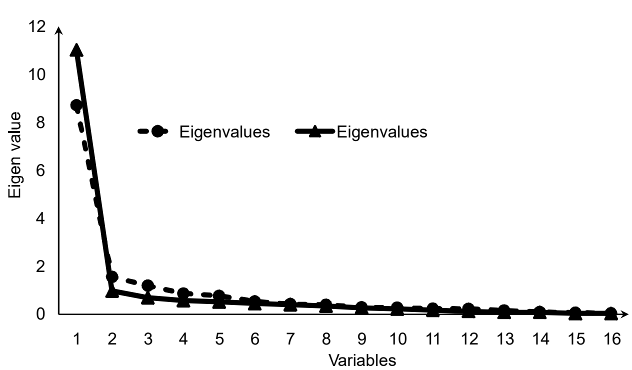

Fig. 2. Eigen value plot of morphometric parameters for different cultured ponds populations of shrimp (*L. vannamei*)

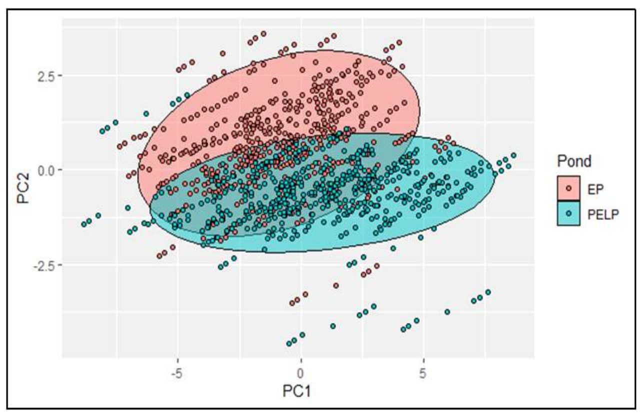

Fig. 3. Scatter plot with sheared PC scores of morphometric parameters for different cultured ponds populations of shrimp (*L. vannamei*)

CONCLUSION

The present study was elucidated the morpho geographical structure of the shrimp which help to determine the shape, size and structure of the shrimp's body. The findings help to conclude that all phenotypic variables are positively corelated in both the water body. It is also concluded that sharing PCs scores were successfully applied in discriminating the stocks of *L. vannamei* of earthen and polyethylene lined ponds. Eventually, the population of EP and PELP were not similar from each other. This simple technique provide a greater number of segregate characters.

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