

Variation in Shell Morphology and Adult Specimen Weight in Three Varieties of a Commercially Important Gastropod *Turbinella Pyrum* (Linnaeus, 1767) From Southeast Coast of India

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Abstract

Using morphological traits including weight, the genetic group effect in three varieties of *Turbinella pyrum* was determined. A total of 300 *T. pyrum* individuals (100 per variety) were used. The morphometric analysis showed that the shell outer lip thickness and operculum width were found to be significantly different in between the three varieties of *T. pyrum*. The study also showed that the shell length, body whorl length and operculum length significantly differed in between G1 (var. *obtusa*) and G2 (var. *acuta* synonymous *T. rapa*) and shell width differed significantly in between G2 (var. *acuta*) and G3 (var. *globosa*). The effect of genetic group on the shell depth and adult animal weight were found to be non-significant. The observed mean length, width and depth in G1 genetic group (var. *obtusa*) supports its higher market value in comparison to the other two genetic groups studied. This variety has moderate lip thickness, which may be another reason for its higher demand in bangle industry than the other two genetic groups. The G2 (var. *acuta*) and G3 (var. *globosa*) genetic groups although comparatively larger, have a disproportionate body size then G1 (var. *obtusa*). The standardized shell morphological characters in present study are helpful to draw primary guidelines for identification of three *T. pyrum* varieties studied. The present morphometry data on *T. pyrum* varieties also plays key role for species description and also for their domestication.

Keywords: *Turbinella pyrum* varieties; Shell; Operculum; Morphometrics

Introduction

Varieties of species of *Turbinella pyrum* with their succulent meat have been harvested since time immemorial. This remarkable gastropod species is fished mostly for shell which is used for making fine pieces of handicrafts and ethnic jewelry like bangles in India [1]. The shell craft cottage industries and shell trade form a major business in several regions of India especially Tamil Nadu, West Bengal, Gujarat and the Andaman and Nicobar Islands. In India shell ash and flesh of this gastropod is also used in indigenous medicinal practices for treating several diseases [2-5]. By considering the divergences in external form and color pattern of normal individuals, five pseudo-species/ varieties described by Hornell namely var. *obtusa*, var. *acuta* synonymous *rapa* (Lamarck, 1816), var. *fuscus*, var. *globosa* and var. *comorinensis* under the species *T. pyrum* have been described [6]. All of these five forms have their own particular geographical distribution (Figure 1) and also physical and biological environmental characteristics [7]. The species is confined to Indian waters with exception of the adjacent coasts of Sri Lanka and occurs nowhere else in the Asian region [8-10].

Shells of gastropods contain a rich source of taxonomic information that can be used to interpret evolutionary relationships among taxa and shell morphological characters are also used as primary guidelines for species identification [11]. Preliminary observations of *T. pyrum* varieties revealed wide variations in shell size and shape [6], but this has never been standardized before. Increased awareness of the value and importance of three chank genetic resources i.e., *T. pyrum* var. *obtusa*, *T. pyrum* var. *acuta* and *T. pyrum* var. *globosa* (Figure 2) has turned attention back to their current taxonomic position further arousing the need to have scientific base on their shell morphological characteristics. The results of morphometric analyses might directly reflect the importance and effect of each character in chank industry.

In this study, we determined the genetic group effect on morphological traits including weight in three varieties of *Turbinella pyrum* i.e., var. *obtusa*, var. *acuta* and var. *globosa*. The major aim of the present study was to provide a detailed description of their phenotypic variability.

Materials and Methods

Source of data and sample collection

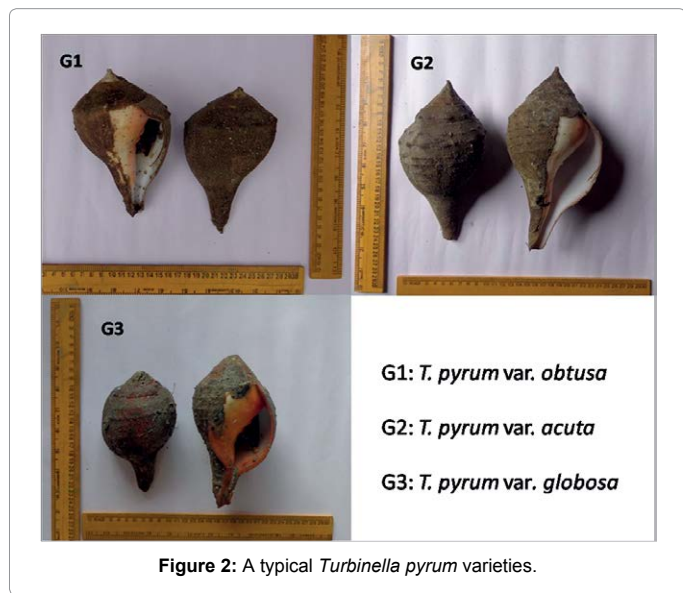
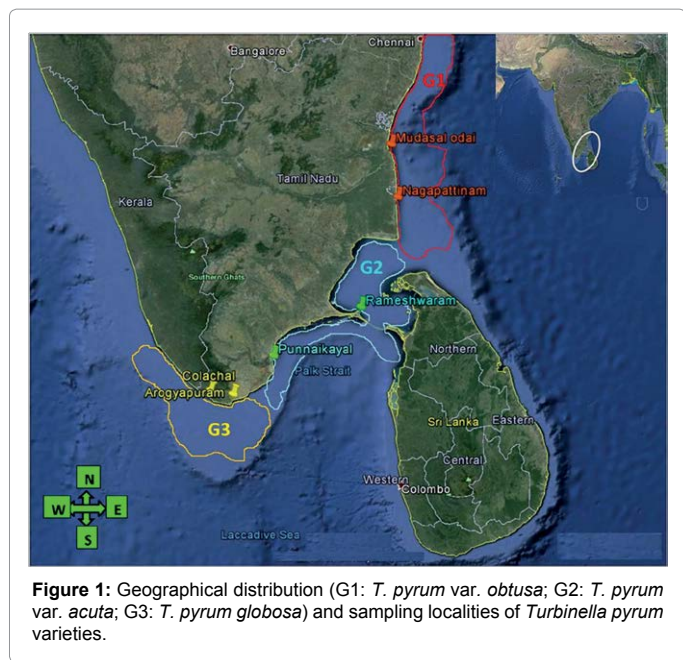
Fresh specimens of three *T. pyrum* varieties were randomly collected from commercial catch of fish landing centers at different localities of southeast coast of India covering a total length of 600-700 km of coastal belt (Figure 1). A total of 100 specimens belonging to each of the three *T. pyrum* varieties were utilized in the present study. The samples were collected between December 2012 and July 2014. Immediately after collection, the samples were first preserved in a 30 liter capacity ice flask and transferred to the laboratory than fixed in seawater with 10 per cent formalin, and kept at -20°C till further analysis. Locality descriptions, acronyms of varieties and number of chanks sampled are listed in Table 1.

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Selection of traits

The effectively useful traits for identification were selected based on the available taxonomic descriptions on class gastropoda from the literature [12-15]. A total of 8 traits were adopted for continuous measurements i.e., shell length (SL), shell width (SW), shell depth (SD), shell outer lip thickness (SOLT), body whorl length (BWL), operculum length (OL), operculum width (OW) and adult animal weight (AAW).

Classification and standardization of data

Samples of *T. pyrum* were classified into different genetic groups, i.e., G1: *T. pyrum* var. *obtusa*; G2: *T. pyrum* var. *acuta*; G3: *T. pyrum* var. *globosa*. Adult stage was recognized according to the shell length (120-140 mm) [16]. The morphological traits of shell were measured using digital vernier caliper at an accuracy of 0.01 mm and adult body weights were measured by electronic balance (accuracy: 0.01 g).

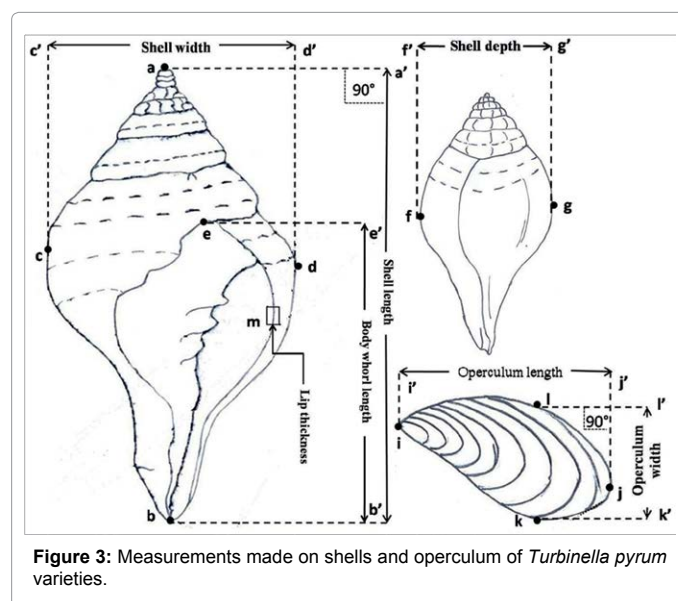
The continuous shell and operculum measurements were standardized as shown in Figure 3. The shell length was measured in centimeter as along an axis passing through the apex (a) to the bottom of the shell (b). The shell width was measured in centimeters as the maximum width perpendicular to the shell length distance (c'-d'). Shell depth was measured in centimeter as the distance from the point (f) to the point (g) of the shell as shown in Figure 1. The lip thickness was measured in millimeters along the flared outer lip of the posterior half of the aperture and three quarters the way along from the siphonal canal at the point (m). The length of columellar plicae was measured in centimeter as the distance from the start point of columellar plicae (e) to the bottom of the shell (b). The length of the operculum was measured in centimeters from the tip of narrowest point (i) to the rounded base (j) of the operculum. Width of the operculum was measured in centimeters across the widest section of the operculum at 90° to the operculum length (k'-l'). The individual adult body weight was recorded in grams. Only the individuals having an apparent apical portion were considered for morphometric measurement in order to avoid measurement bias and all measurements were conducted by single handedly to avoid user bias.

Statistical analysis

The mean and standard deviation (SD) for each of the recorded seven morphological traits and the weight of three *T. pyrum* varieties were computed. Critical difference (CD) of these traits among three varieties of *T. pyrum* were then determined. Analysis of variance (ANOVA) was used to evaluate genetic group effect on these traits

<i>T. pyrum</i> varieties	Locality	Latitude and longitude	Number of samples
<i>var. obtusa</i>	Mudasal Odai	11°29'07.74" N 7946'28.10" E	43
	Nagapattinam	10°45'37.94" N 79°50'57.82" E	57
<i>var. acuta</i>	Rameshwaram	9°16'49.46" N 7919'02.44" E	77
	Punnaikayal	8°38'15.20" N 78°07'13.63" E	23
<i>var. globosa</i>	Arogyapuram	8°07'10.76" N 7733'32.25" E	40
	Colachel	8°10'20.67" N 7714'56.42" E	60
Total			300

Table 1: Summary of locality and number of chanks sampled.



including weight. All statistical analyses were performed with the SPSS software for Windows (SPSS 13.0; SPSS, Chicago, IL, USA).

Results and Discussion

In general biomass of an animal is dependent on the body length, width and depth. Morphometric traits in terms of shell length (SL), shell width (SW), shell depth (SD), shell outer lip thickness (SOLT), body whorl length (BWL), operculum length (OL) and operculum width (OW) including adult animal weight (AAW) were good predictors for identification of three *T. pyrum* varieties. Critical differences between means of various morphometric traits in three *T. pyrum* varieties are furnished in Table 2.

In the present study the average SL at adult age was recorded as 10.148 ± 0.222 cm, 11.037 ± 0.189 cm and 10.745 ± 0.241 cm for G1, G2 and G3 genetic groups respectively. The effect of genetic group on the length of chanks was found to be significant (Table 3). The SL of G2 (*var. acuta*) group (11.037) was significantly longer than the SL of G1 (*var. obtusa*) group, however, was similar to that of G3 (*var. globosa*) group. The average SW was obtained as 5.476 ± 0.118 cm, 5.676 ± 0.099 cm and 6.259 ± 0.141 cm for the genetic groups G1, G2 and G3 respectively. Analysis of variance revealed that the difference in SW due to genetic group was highly significant (Table 3). The mean SW of G3 (*var. globosa*) group was largest and was significantly different from the mean SW of the other two genetic groups. The mean SW of G1 (*var. obtusa*) and G2 (*var. acuta*) were similar. Earlier findings have reported the average SL and SW in *S. canarium*, *S. urceus*, *S. marginatus succinctus* and *S. vittatus vittatus* as 55.24 ± 0.32 mm and 35.13 ± 0.19 mm, 56.62 ± 0.60 mm and 24.53 ± 0.37 mm, 48.44 ± 1.32 mm and 24.66 ± 0.43 mm; and 83.74 ± 5.6 mm and 25.53 ± 3.38 mm respectively [17]. Shell length (SL) in the Viviparid snail, *Cipangopaludina chinensis* ranged between 2.80 ± 0.36 cm and 4.02 ± 0.69 cm and SW varies between 2.80 ± 0.36 cm to 4.02 ± 0.69 cm at different localities in Taiwan [11]. They opined that the SL and SW is an effective descriptor to study the interspecies variation.

The averages of SD in present investigation did not differ significantly (Table 3) between genetic groups i.e., G1 (3.050 ± 0.076 cm), G2 (3.001 ± 0.051 cm) and G3 (3.092 ± 0.069 cm). Contrary to the present findings significant difference in SD was detected between male (24.71 ± 1.63 mm) and female (26.17 ± 1.57 mm) of *S. canarium* [Gastropoda, Stromboidea] at Merambong Shoal, Malaysia [18].

The mean SOLT for the animal of G1 (*var. obtusa*) group was found to be 1.703 ± 0.036 mm, for G2 (*var. acuta*) group 1.191 ± 0.020 mm and 2.215 ± 0.050 mm for G3 (*var. globosa*) group. The analysis of variance revealed that there was highly significant difference in SOLT due to the effect of genetic group (Table 3). The means showed that animals in all genetic groups differed significantly from one another in respect to SOLT. Significant difference in SOLT was also detected between *S. canarium* (3.26 ± 0.11 mm) and *S. urceus* (2.74 ± 0.13 mm) [17].

Trait	Genetic group		
	G1	G2	G3
	(Mean ± SE)	(Mean ± SE)	(Mean ± SE)
SL (cm)	10.148 ^a ± 2.22	11.037 ^b ± 1.89	10.745 ^{ab} ± 2.41
SW (cm)	5.476 ^a ± 1.18	5.676 ^{ab} ± 0.99	6.259 ^b ± 1.41
SD (cm)	3.050 ^a ± 0.76	3.001 ^a ± 0.51	3.092 ^a ± 0.69
SOLT (mm)	1.703 ^a ± 0.36	1.191 ^b ± 0.20	2.215 ^c ± 0.50
BWL (cm)	5.117 ^a ± 1.11	6.149 ^b ± 1.06	5.147 ^a ± 1.15
OL (cm)	3.050 ^a ± 0.76	3.580 ^b ± 0.62	3.070 ^a ± 0.74
OW (cm)	1.897 ^a ± 0.42	1.595 ^b ± 0.26	1.698 ^c ± 0.38
AAW (gm)	552.30 ^a ± 120.92	560.65 ^a ± 95.72	574.16 ^a ± 129.09

AAW: Adult animal weight; SL: Shell length; SW: Shell width; SD: Shell depth; SOLT: Shell outer lip thickness; BWL: Body whorl length; OL: Operculum length; OW: Operculum width. Mean values in the same row with different superscripts differed significantly (P<0.05).

Table 2: Critical differences between means of various morphometric traits in three *T. pyrum* varieties.

Variation in the BWL due to genetic group was highly significant as revealed in the analysis of variance (Table 3). The mean BWL for the animal of G1, G2 and G3 were obtained as 5.117 ± 0.111 cm, 6.149 ± 0.106 cm and 5.147 ± 0.115 cm respectively. The BWL of G2 (*var. acuta*) group (6.149) was significantly longer than the other two genetic groups, however, was similar between G1 (*var. obtusa*) and G3 (*var. globosa*) genetic groups. Similar to the present findings significant difference in BWL means range was obtained between 2.33 ± 0.35 cm and 3.23 ± 0.55 cm for *Cipangopaludina chinensis* at different localities in Taiwan [11].

In the present investigation the mean OL and OW was found to be 3.050 ± 0.076 cm and 1.897 ± 0.042 cm, 3.580 ± 0.062 cm and 1.595 ± 0.026 cm; and 3.070 ± 0.074 cm and 1.698 ± 0.038 cm for G1, G2 and G3 genetic groups respectively. The effect of genetic group on the OL and OW of chanks was found to be highly significant (Table 3). The OL of G2 (*var. acuta*) group was significantly longer than the other two genetic groups, however, was similar between G1 (*var. obtusa*) and G3 (*var. globosa*) genetic groups while the means showed that animals in all genetic groups differed significantly from one another in respect to OW. Similar significant difference in OL and OW was reported by various researchers [11,19,20].

The average adult animal weight (AAW) for G1, G2 and G3 genetic groups were found to be 552.30 ± 120.92 gm, 560.65 ± 95.72 gm and 574.16 ± 129.09 g respectively. There was no significant difference between the three genetic groups studied in respect to adult animal weight (Table 3). Earlier findings reported mean weight in male and female *S. canarium* as 5.54 ± 1.59 g and 6.60 ± 1.52 g respectively at Merambong Shoal, Malaysia and opined that the effect of sex on AAW is significant [18].

In the present study the mean length, width and depth in G1 genetic group (*var. obtusa*) supports to its higher market value in comparison

Sources of variation	d.f	MSS							
		SL	SW	SD	SOLT	BWL	OL	OW	AAW
Between genetic group	2	20.535 [*]	16.555 ^{**}	0.207 ^{NS}	26.214 ^{**}	34.498 ^{**}	9.023 ^{**}	2.357 ^{**}	12168.37 ^{NS}
Error	297	4.77	1.453	0.437	0.14	1.229	0.503	0.128	13482.52

d.f: Degrees of freedom; MSS: Mean sum of square; SL: Shell length; SW: Shell width; SD: Shell depth; SOLT: Shell outer lip thickness; BWL: Body whorl length; OL: Operculum length; OW: Operculum width; AAW: Adult animal weight.

*P<0.01; **P<0.05; NS: Not significant.

Table 3: ANOVA showing the effect of genetic group on various morphometric traits.

to the other two genetic groups studied. This variety has moderate lip thickness, which may be another reason for its higher demand in bangle industry than the other two genetic groups. The G2 (var. *acuta*) and G3 (var. *globosa*) genetic groups although comparatively larger in size but has a disproportionate body size then G1 (var. *obtusa*). The standardized shell morphological characters in present study are helpful to draw primary guidelines for identification of three *T. pyrum* varieties studied. However, phenotypic characterization alone may not be feasible to describe a species because it cannot detect the genetic variation [21].

Conclusion

The current study supports with the earlier taxonomic description based on external morphological characters in *T. pyrum*. The present morphometry data on *T. pyrum* varieties also plays key role for species description and also for their domestication. Further, in depth molecular taxonomical studies using mitochondrial DNA markers in these varieties of *T. pyrum* are necessary to strengthen the present findings and confirm the variation levels among the *T. pyrum* varieties. The study calls for further investigation to identify and understand the evolutionary lineages between these *T. pyrum* varieties.

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