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The local forms of *Zootecus* (Gastropoda: Pulmonata: Subulinidae) of Pakistan: an archaeomalacological case study

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Abstract - In the past, several Asian subspecies and local forms of *Zootecus* have been described and some of them can be linked back to *Zootecus insularis.* Their collecting sites, shell shapes, dimensions and number of whorls have been listed in the past. In recent years, collections, observations and biometrics of dead shells have been carried out in five sites in Pakistan, in both Balochistan and Sindh, The samples have quite different dating; two of them come from archaeological excavations. The biometrics indicate that different shell shapes are locally present among the empty shells accumulated over the years; in the Siranda Lake they have floated from different of areas. A comparison between the *Zootecus* shells cited in the past literature and the shells from the five sites shows, that in these mounds of shells a variety of shapes exists, including those known as *Zootecus agrensis, Z. chion, Z. gracilor minor, Z. polygyratus* and *Z. pullus.* Given the ample polymorphism present in every sample, it is difficult to ascribe the specimens of Siranda Lake to one of the above taxa.

Key words: land snail, *Zootecus*, Pakistan, shell shapes, biometrics.

Riassunto - Le forme regionali di *Zootecus* (Gastropoda: Pulmonata: Subulinidae) del Pakistan: uno studio archeomalacologico.

In passato sono state descritte per alcune regioni asiatiche molte sottospecie e forme locali di *Zootecus*, alcune riportabili a *Zootecus insularis*. Sono noti le loro località di raccolta, le altezze e diametro della conchiglia ed il numero dei giri della conchiglia. In anni recenti sono state fatte raccolte, osservazioni e biometrie su conchiglie di *Zootecus* da cinque differenti località del Pakistan, in Balochistan e nel Sindh. Due campioni provengono da scavi archeologici. Le conchiglie accumulate nel tempo nei singoli siti hanno forme e dimensioni diverse, inoltre nel caso del Lago Siranda hanno tempi e zone di provenienza molto ampi. Sono state comparate le forme storicamente citate in letteratura con quelle raccolte nei cinque siti la cui antichità è differente e ove compaiono insieme alcune delle forme conchigliari citate per *Zootecus agrensis, Z. chion, Z. gracilor minor, Z. polygyratus* e *Z. pullus.* A causa del polimorfismo presente in ogni campione risulta difficile attribuire con certezza il materiale del Lago Siranda ad uno di detti taxa.

Parole chiave: gasteropodi terrestri, *Zootecus*, Pakistan, forme conchigliari, biometrie.

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INTRODUCTION

During the 2011-2013 annual surveys of the Italian Archaeological Mission to Las Bela, Balochistan (Pakistan), areas south of Uthal, around Lake Siranda, and near Miani Hor (Snead, 1966, 1967; Snead & Frishman, 1968; Dales, 1982) and the promontory of Puhari have been investigated (Biagi *et al.,* 2013a). In addition to the study of many prehistoric shell middens, several empty shells of the land snail *Zootecus* sp. were observed and collected. Much of the countryside is strewn with these small white shells, sometimes heaped up in thousands of specimens in restricted areas as also observed by other malacologists (Auffenberg, 1994; Lindauer *et al*., 2016). Due to the reduced length and small size of their shells, which were also observed in Arabia and in the Indian subcontinent (Pilsbry, 1906), they were at first ascribed by one of the authors (Biagi *et al*., 2013b) to *Zootecus chion* (Pfeiffer, 1856) although the question whether the application of the name *Z. chion* for the specimens from Pakistan is not resolved yet. Many taxa are present in the literature concerning Pakistan and the surrounding territory, described as *Zootecus insularis* (Ehrenberg, 1831), *Z. chion* (Pfeiffer, 1856) or *Z. insularis chion* (Haas, 1959; Akhtar, 1978; Solem, 1979). This may have been caused by pronounced variability of shape.

Pilsbry (1906) observed: «*A group of small, pupiform snails, largely eremitic in habits, generally occurring in large numbers, and varying within wide limits in size and degree of taper. Most gatherings from one place show shorter and longer individuals; the diameter remaining more constant for any one colony. The proportion of diameter to length is therefore individually variable*».

And Gude (1914) wrote: «*…the diameter remaining more constant for any one colony but the proportion of diameter to length is therefore individually variable. There is a good deal of local variation in size and texture, and hence a superabundance of names*».

The polymorphic species *Zootecus insularis* is widespread and can be found from the Cape Verde Islands to East Africa, Afghanistan, the north, central and southern Indian subcontinent, upper Burma, with several named forms (Pilsbry, 1906; Ramakrishna & Mitra, 2010).

The phylogenetic position of *Z. insularis* is known, as well as features of its metabolism, physiology and ecology; the species is parthenogenetic (Chaudhari & Kulkarni, 1993, 1994; Davison *et al*., 2005; Wade *et al.,* 2001; Fontanilla, 2010). *Z. insularis* produces an epiphragm during aestivation and comes out from deep in the ground only after periods of rain (Hora, 1928; Raut & Ghose, 1977); *Z. chion*, along with many invertebrates and vertebrates, forms part of the diet of *Varanus bengalensis* (Daudin, 1802) (Auffenberg, 1994).

Zootecus sp. is known as a Holocene fossil in the deserts of Libya, Egypt, Sudan (Mienis, 1979, 1992; Marinova *et al.,* 2008; Girod, 2008, 2010) and in the lacustrine deposits of Lake Assal, Djibuti (Van Damme & Gautier, 1994). The local populations of *Zootecus* in the region east of Iran are known by many names (Gude, 1914): *Z. agrensis* (Kurr. 1855), *Z. chion* (Pfeiffer, 1856), *Z. estellus* (Benson, 1857), *Z. gracilor minor* (Pfeiffer, 1856), *Z. pertica* (Benson, 1857), *Z. polygyratus* (Reeve, 1849), *Z, pullus* (Gray, 1834) (Tab. 1).

These taxa were identified and described solely on the basis of morphological characteristics of the shells but their anatomy is still unknown. A revision of the various species and subspecies assigned to *Zootecus* is urgently needed (Neubert, 1998). Louis Germain (1924: 26) suggested that a more detailed study of individuals from distant populations allows to group some forms and to accept that individual variability is very high in every population.

Aim of the research

Our research is geographically limited to five sites in Balochistan and Sindh and is restricted to morphometric aspects of the *Zootecus* sp. shells, with the aim to set out the difficulties to give the right taxon name to empty shells. It is important to examine again the assembly of shell-shapes observed on the bottom of Siranda Lake and to check if their past identification as *Z. chion* is correct (Biagi *et al*., 2013b). Only dead shells are available and this is a problem for the archaeomalacologists, because in many cases it not possible to collect living individuals so as to compare their anatomy with that known for *Z. insularis* or species like *Z. contiguus* (Reeve, 1849) in the South Arabian countries (Neubert, 2003). A similar problem has recently been observed in the Eastern United Arab Emirates (Lindauer *et al*., 2016).

The basin of Lake Siranda

Lake Siranda, some 14 km long and 3 km wide, and only 0.30-0.45 m above the present sea level, is located in the southernmost part of Las Bela Valley (Pakistan, Balochistan) (Fig. 1). Although fed by summer monsoon rains draining into the basin mainly by the Watto River, an easternmost branch of the Porali River, today the lake is often dry, depending on the seasonal precipitation (Akhtar, 2011). According to data from the 1950s, its maximum depth was 1.5 m in the winter and 3 m in the summer.

The bottom of the dry basin of Lake Siranda is covered by muddy and sandy sediments not suitable to the ecology of *Zootecus* because it is a petricolous genus, living on stony ground, under boulders, on hill and mountain slopes (Feulner *et al*., 2005); sometimes in moist agricultural soils (Al-Khayat, 2010).

Huge quantities of shells are floated into Lake Siranda from the hills and from the Holocene plain deposits by temporary rivers during the summer monsoon (Snead, 1966), producing a mixture of specimens derived from different areas. Such enormous accumulations of shells have been observed in other regions (Fowler, 2005; Lindauer *et al*., 2016).

Tab. 1 - Historical names, dimensions and whorl numbers of the *Zootecus* described from Afghanistan and Pakistan. AMNH, American Museum of Natural History; NHMUK, National History Museum, London; PZS, Proceedings of the Zoological Society of London.

Local taxa	**Collecting areas**	**H mm**	**D mm**	**H/D**	**Whorls**
1) *Zootecus pullus* Gray, 1834 - P.Z.S., 2 : 66	Balochistan, Quetta; Kutch; Bank of Ganges; Delhi; Uttar Pradesh	10	4	2.5	9-10
2) *Zootecus chion* (smaller form) *gracilior minor* (Pfeiffer, 1856)	Not specified	11	4	2.75	
3) *Zootecus insularis chion* (Solem, 1979, tab. IV: 30)	Afghanistan	11.8±0.15 (9.8-14.3)	5.66±0.071 (4.3-6.4)	2.279 2.234	7 3/4 + (7 1/8-9)
4) *Zootecus polygyratus* Reeve, 1849	Sindh (Rohri Hills); Baluchistan (Gwadar)	12	4	3	9
5) *Zootecus chion*, Pfeiffer, 1856	Afghanistan; Punjab; Sindh	12	0.5	2.4	7-8
6) *Zootecus chion* (#2), Pfeiffer, 1856	Samples from Hyderabad	14	6	2.333	
7) *Zootecus agrensis* Kur.r 1856 - Malakozoologische Blätter, 2: 107	India: Agra	16	6	2.666	9
8) *Zootecus estellus* Benson, 1857 - A.M.N.H. ser. 2, 19: 327	Punjab; Sindh; Rajasthan; Andhra Pradesh	18	6	3	8
9) *Zootecus pertica* Benson, 1857 - A.M.N.H. ser. 2, 19: 328	Sindh	20	5	4	10

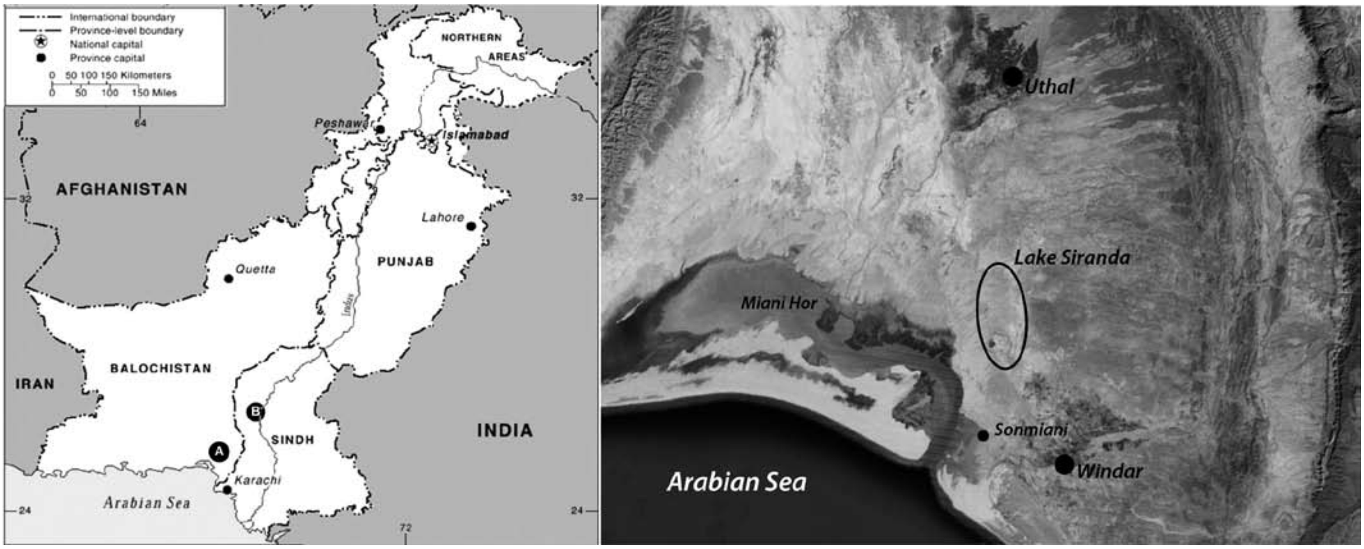

Fig. 1 - Left: map of Pakistan with the areas of the studied sites. A) Balochistan, sites WP16, WP 31, Uthal. B) Upper Sindh, Rohri Hills, site 59, site 480. Right: satellite view of the area of Balochistan, South of Uthal with location of the Lake Siranda and the lagoon of Miani Hor.

Shells of *Zootecus* are present in the Pleistocene dunes visible along the main road N25 to Karachi (Naseem *et al.,* 1996-1997). There are sub-fossil *Zootecus* shells in the old eroded dunes along the beach near Miani Hor lagoon; few shells dated to 5700±40 uncal. BP AMS ^{14}C (GrA-62258). Sub-fossil shells are also in the ancient exposed sediments along the beds of streams that flow into Lake Siranda (for example: N25 44.760 E66 37.190) (Fig. 2). Few living specimens of *Z. insularis,* in diapause with epiphragm, have been collected far away from the plain of Siranda on the hills around the River Windar, in the typical stony and dry environment of the species and sent abroad for a future anatomical study (Fig. 3).

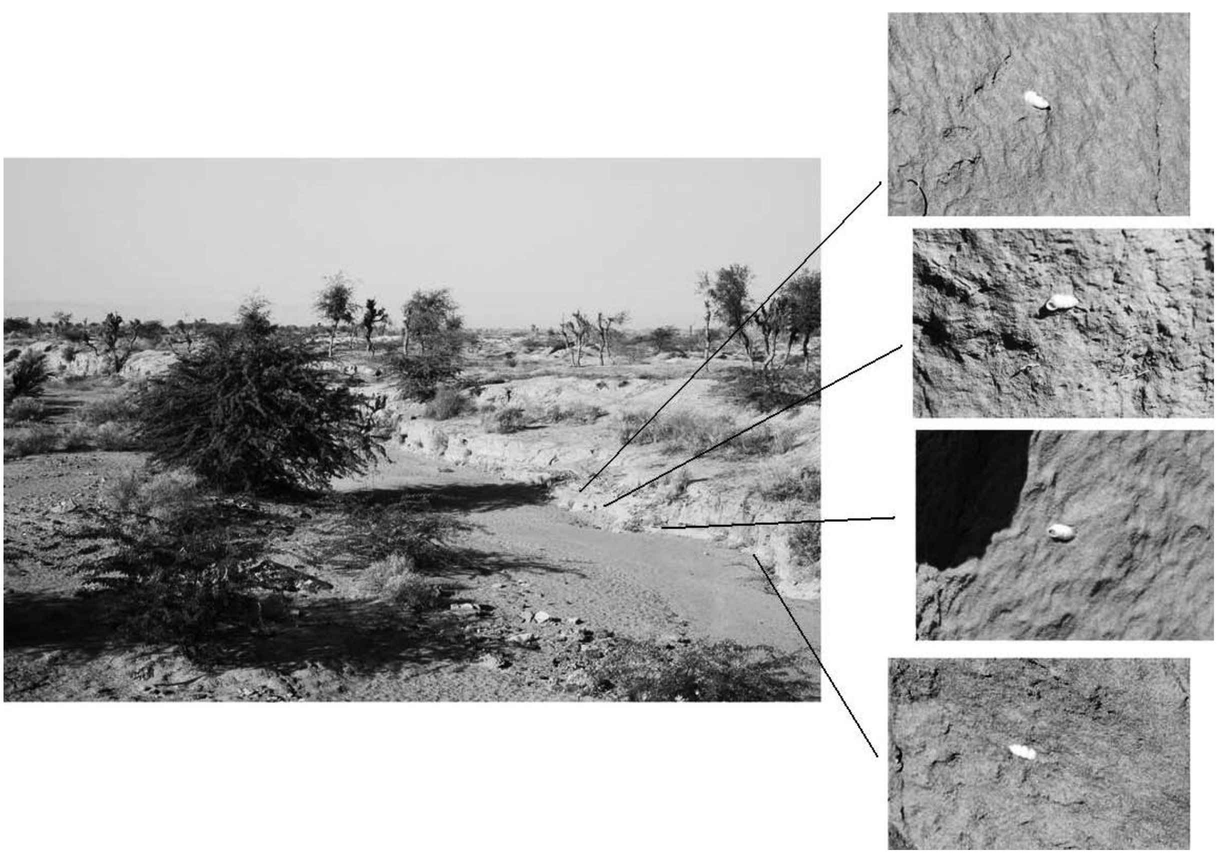

Fig. 2 - WP 199, N 25 44. 760 E 66 37.190 with *Zootecus* shells emerging from sediments (photo by P. Biagi, R. Nisbet, A. Girod).

Fig. 3 - Hills around the River Windar and some living specimens of *Zootecus* cfr. *insularis* (photo by A. Girod).

The erosion of hills and fossil dunes over centuries/millennia has resulted in the transport of *Zootecus* shells towards Lake Siranda. The floods and changes in the level of the lake release old shells buried in the muddy/sandy bottom and water movements push the empty shells of *Zootecus* and those of freshwater species all around the basin. Among the freshwater species, *Melanoides tuberculata* has been dated to 830±30 uncal. BP, AMS ^{14}C (GrA-57527), confirming the existence of a freshwater habitat in a historical period. In recent decades, after the rainy season Lake Siranda may become totally dry or change into a saline shallow-water pond.

MATERIALS AND METHODS

Five samples coming from different locations and dating were examined (Fig. 1):

i. WP 16, (Balochistan) central zone of Lake Siranda, eastern shore (N25° 32'108" E66° 37'274"). *Zootecus* empty shells are accumulated on the beach together with *Pupoides coenopictus* (Hutton, 1834) and the freshwater gastropods *Bellamya bengalensis* (Lamarck, 1822), *Melanoides tuberculata* (Müller, 1774), *Lymnaea acuminata* Lamarck, 1822, *Indoplanorbis exustus* (Deshayes, 1834), *Gyraulus* cf. *rotula* (Benson, 1850) and *Gyraulus euphraticus* (Mousson, 1874) (Fig. 4).
ii. WP 31, (Balochistan). Hundreds of shells are lying on ancient sandy sediments in a depression among two Holocene dunes near the western shore of Lake Siranda (N25° 32'671" E66° 35'406") (Fig. 4).
iii. Uthal, (Balochistan). We received the specimens from NHMGB (BMNH 1903.6.1. 4203, donation H. Godwin-Austen); they were collected at Camp Uthal by Capt. Tigle on 19th March 1897 (Biggs, 1962).
iv. Site RH 59, Rohri Hills (Upper Sindh), 1993 excavation (N 27°25'45.69" E 68°51'27.64"). We received the sample by P. Biagi. The prehistoric site is a mine with adjacent workshop dating to the 3rd millennium cal. BC, Mature Indus Civilisation (Fig. 32 in Biagi & Pessina, 1994; Biagi & Starnini, 2012). The subfossil shells (Fig. 5a) were in the pit at a depth of circa 110 cm under layer 2 of aeolian sand and 15 cm above the bedrock of layer 3 (Fig. 5). No other shells were found in the stratigraphy.
v. Site RH 480, Rohri Hills (Upper Sindh), 1994 excavation (N 27°25'17.9" E 68°51'11.1"). We received the sample by P. Biagi. The prehistoric site is recorded as bladelet workshop dating to the 3rd millennium cal. BC,

Fig. 4 - Left: view of shell heaps. WP 16, *Zootecus* sp. with fresh-water malacofauna. Right: WP 31, shells of *Zootecus* sp. only (photo by A. Girod).

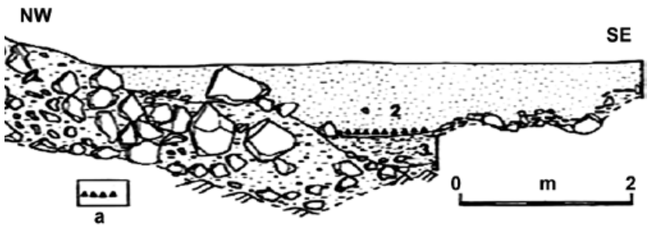

Fig. 5 - Rohri Hills, site 59. Section through the deposits: a) *Zootecus* sp. shells (modified from Biagi & Pessina. 1994).

Mature Indus Civilisation, located about 400 m south-east of Site 59 (Negrino & Starnini, 1995). The shells were only collected at the surface among stones.

Shell height and width (diameter) of the adult specimens were measured using a dial caliper accurate to a tenth of a millimetre (Fig. 6). Morphometric studies were based on classes of 0.1 mm amplitude. The maximum heights and diameters of specimens from the five sites were recorded (Fig. 7) and indices of roundness H/D were calculated (Fig. 8). For each sample the regression lines were elaborated (Fig. 9). These parameters are summarised in Tab. 2.

To evaluate the statistical difference between the five regression lines, the Analysis of Variance (ANOVA) with Fisher test was applied (Tab. 3).

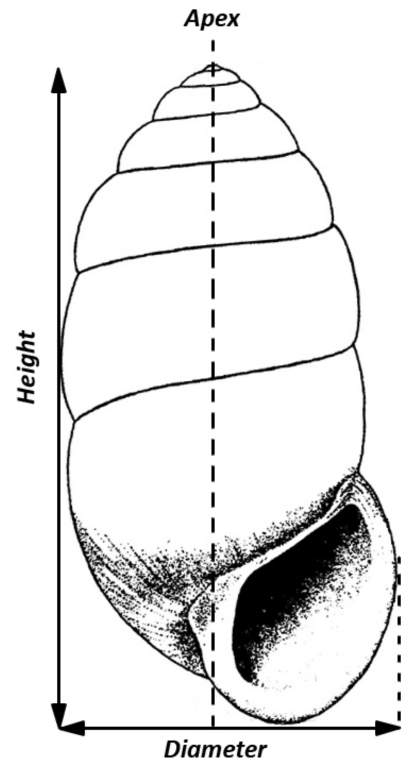

Fig. 6 - Shell measurements (drawn by Dael Sassoon).

Tab. 2 - Number of individuals, heights (H), diameters (D), means, roundness indices (H/D), whorl numbers and linear regression coefficient for *Zootecus* sp. of the five sites.

	WP 16	**WP 31**	**UTHAL**	**RH 59**	**RH 480**
Numbers of individuals	240	162	217	197	167
Mean H mm	10.75	11.40	11.57	11.97	10.70
Max H mm	13.50	13.30	14.85	17.00	12.90
Min H mm	8.00	9.50	8.30	10.00	8.50
Delta H mm	5.50	3.800	6.55	7.00	4.40
Mean D mm	4.69	4.85	4.80	4.19	4.87
Max D mm	6.00	5.60	5.50	4.85	5.60
Min D mm	3.80	3.90	4.10	3.70	3.50
Delta D mm	2.20	0.95	1.40	1.15	2.10
Mean roundness H/D	2.30	2.30	2.41	2.85	2.19
Whorl numbers	8	8	8 and 9	8 and 10	7 and 8
Linear regression equation	y = 0.2493x + 1.9771	y = 0.1606x + 3.0419	y = 0.302x + 1.1788	y = 0.10278x + 2.9634	y = 0.2122x + 2.5862

Tab. 3 - Results of ANOVA test. DF, degree of freedom; S^2, variance; F, variance ratio; P, significance level.

Source of variation	**Deviance**	**DF**	**S^2**	**F**	**P**
Within groups variance	107.8805	986			
Common regression slope	0.226133	1	0.226133	2.075882	<0.01
Between regression slopes	0.8000667	4	0.200017	1.836137	<0.05
Error for coefficient	106.8637	981	0.108933		

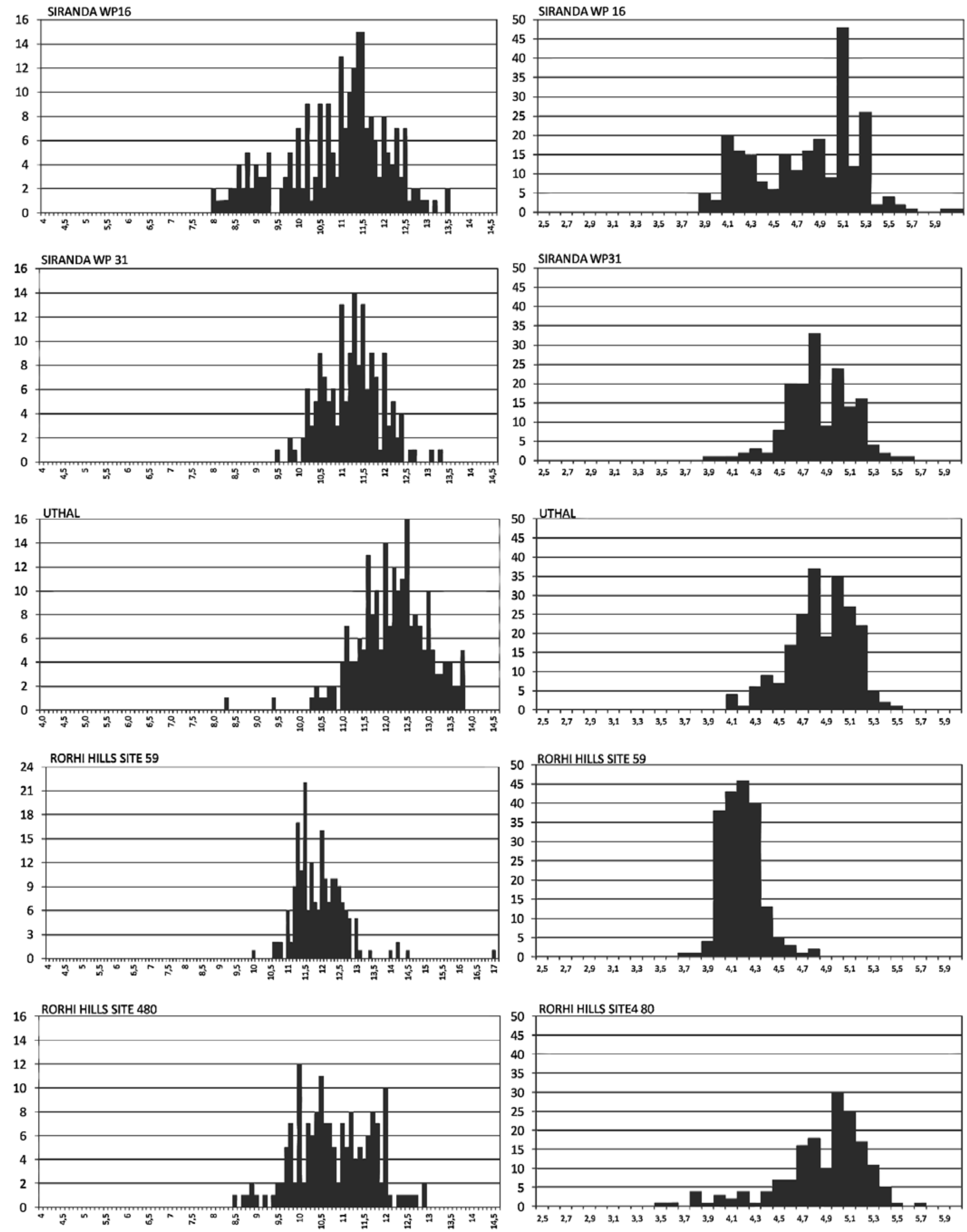

Fig. 7 - Distribution of 0.1 mm dimension classes of individuals from the five sites. On the left the shell height; on the right the shell diameter: x-axis = number of individuals, y-axis = dimension classes.

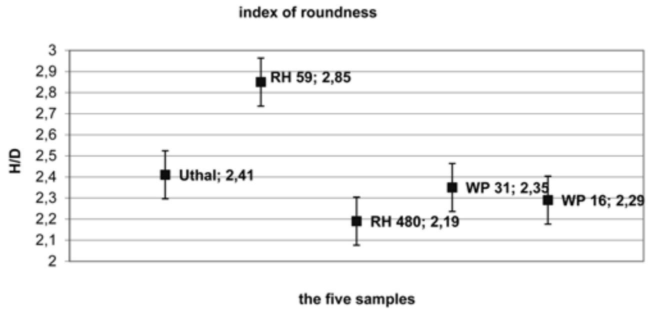

Fig. 8 - Shells index of roundness H/D of the five samples.

The analysis of variance to test the significance of differences between the regression coefficient regression is a F test with F k-1 and N-2k:

$$F_{k-1,\,N-2k} = \frac{S_b^2}{S_e^2}$$

It is obtained by the ratio between:

- the variance of the differences between the linear regression coefficients S_b^2 also called variance of deviation from regression;

- the variance of the residual around separate lines S_e^2 or error variance (Soliani, 2005).

The published critical values for F (Fowler & Cohen, 2010) are the following:

	$F_{1,\,\infty}$	$F_{1,\,\infty}$
P=0,05	254,31	5,6281
P=0,01	6365,9	13,463

For P=0.05 the critical value is much greater than the tabulated value therefore we can reject the null hypothesis and there is no common trend in the relationship between diameter and height. For P=0.01 the critical value is much greater than the tabulated value therefore we reject the null hypothesis and we can say that there is a difference between the angular coefficients. To verify the source of variation the Tukey test was applied to the ten possible data pair of angular coefficients (Tab. 4).

Four pairs of the angular coefficients have a value above the tabulated one and the differences are statistically significant: RH59-WP31, RH59-WP16, RH59-Uthal, WP31-Uthal. The pair RH59-RH 480 is not statistically different.

The average roundness indices H/D of the shells has been also compared (Fig. 8).

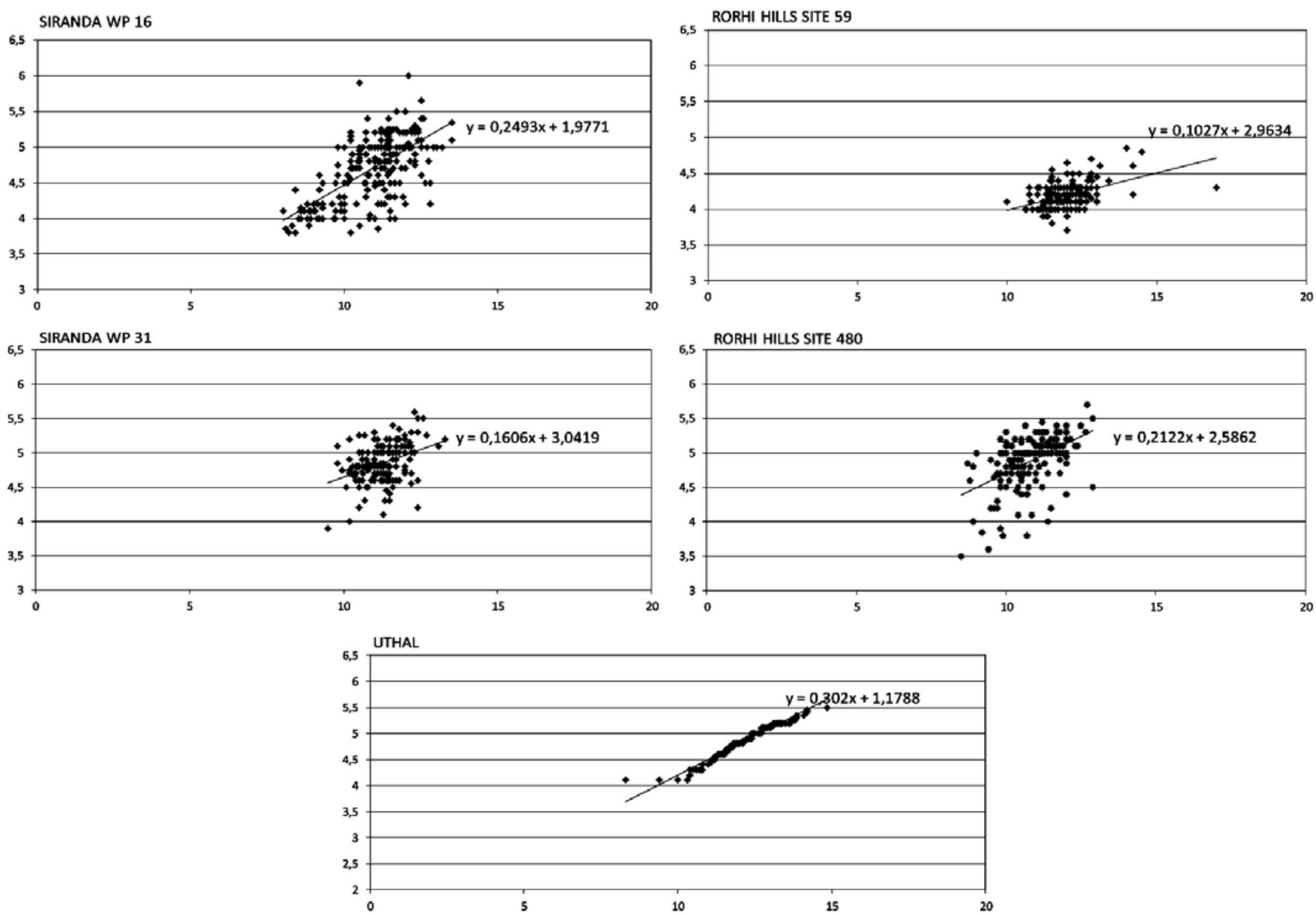

Fig. 9 - Linear regression analyses of the height - diameter relationships in the samples; x-axis = diameter in mm; y-axis = height in mm.

Tab. 4 - Values of *q* based on Tukey test. The pairs pointed out with asterisks (*) are significantly different.

Comparison of samples	**q**
RH59 - RH480	0.5853
RH59 - WP31 *	4.8001
RH59 -WP16 *	5.9384
RH59 - UTHAL *	6.402
RH480 - WP31	1.3343
RH480 - WP16	1.5047
RH480 - UTHAL	2.8947
WP31 - WP16	3.4168
WP31 - UTHAL *	5.4741
WP16 - UTHAL	2.2843

Siranda WP 16

On one hand, the graphical presentation of the height classes reveals some variability of the shell shape (Fig. 10A) confirmed by a fairly constant difference between maximum and minimum values, probably caused by the different origins of lake sediments and it illustrates a bimodal distribution centred on heights of 8.6 mm and 11 mm (Fig. 7). A similar distribution is shown by the diameter classes, with maxima at 4.1 mm and 5.1 mm (Fig. 7). Diameter and height thus seem correlated; this is confirmed by the ***b*** coefficient of the linear regression line, equal to 0.25, the highest value obtained in these analyses. The ***a*** coefficient 1.97 (Tab. 2; Fig. 9).

Siranda WP 31

Analysis of height classes shows a unimodal distribution in the heights and diameters, with respective peaks at 11.3 mm and 4.8 mm (Fig. 7). The lower differences between maximum and minimum values in comparison to WP 16 indicates that the WP 31 population shows less morphological variation (as would be expected for samples taken from a hollow between dunes) and this is confirmed by the scatter plot (Fig. 9) in which values are more closely grouped; although the average diameter is greater than at WP 16, the maximum value is inferior and the minimum value almost identical.

The ***b*** coefficient of the linear regression line is quite low (0.16), which indicates a lower correlation between height (the values of which are in this case generally elevated) and diameter. The ***a*** coefficient is equal to 3.0419 (Tab. 2; Fig. 9). The moderate roundness index (2.3) indicates that the greater number of specimens in the sample is not elongate (Fig. 10B).

Uthal

Analysis of the height classes reveals – with the exception of a few outliers – a unimodal height distribution with quite elevated values (centred on 12.5 mm), in accord with diameter measurements (Fig. 7). The scatter chart illustrates a distribution in which height increases linearly with increase in diameter (Fig. 9). The linear regression ***b*** coefficient of 0.3 is one of the highest found, confirming the strong correlation between height and diameter. The ***a*** coefficient, on the other hand, is the lowest of the samples studied (1.18) and the index of roundness (2.41) is fairly high (Tab. 2); these values correspond to shells distinguished by an averagely elongate shape in which, as height increases, the diameter increases in linear proportion. The presence of continuous variation among the specimens, without discontinuities, would be expected from a sample collected in a fairly restricted zone with a certain degree of internal variability (Fig. 10C).

Rorhi Hills site 59

Analysis of the height classes shows a modest spread in height measurements, with a modal value of 11.5 mm and the majority of the sample in the interval between 10.6 mm and 13.0 mm (Fig. 7). The distribution of diameter values, with a mode of 4.2 mm, likewise exhibits a modest dispersion (Fig. 7). The scatter chart (Fig. 9) reveals shells with little morphological variation, but with a consistent correlation between height and diameter confirmed by a linear regression line ***b*** coefficient of 0.1027, the lowest among the populations examined. The quite high ***a*** coefficient (2.96) and the highest roundness index found (2857), indicate generally elongated shells. However, this population contains a few individuals of different shape, as may be seen from the distribution of diameters (Fig. 7), which show more or less continuous variation between the extreme values (3.7-4.85 mm), but change little as height increases. Thus in a few individuals the height – and the H/D ratio is lower. The presence of a certain morphological variability is evident, given the considerable height range, one of the largest found in this study. On the contrary, the difference between maximum and minimum diameter values is not great (Tab. 2). The biostatistics evidence a certain uniformity of shape, as might be expected from subfossil shells lying in a limited archaeological surface at a depth of 110 cm (Fig. 10D).

Rorhi Hills site 480

Analysis of height classes reveals a distribution ranging between 8.5 mm and 12.9 mm, quite a small interval in which no modal class stands out clearly (the most frequent are 10 mm, 11 mm and 12 mm) (Fig. 7). The difference between maximum and minimum values is not large at 4.4 mm (Tab. 2). The distribution of diameter measurements is centred on 5 mm (Fig. 7). The ***b*** coefficient of the linear regression line (0.21) is high, demonstrating a strong correlation between height and diameter although the population is not widely spread (Fig. 9). The ***a*** coefficient is 2.6. The low roundness index (2.19) denote a sample distinguished by a rather squat shell shape (Tab. 2). The comparison with WP16, WP 31 and Uthal shows that this archaeological sample seems to come from a more uniform empty shells accumulation (Fig. 10E).

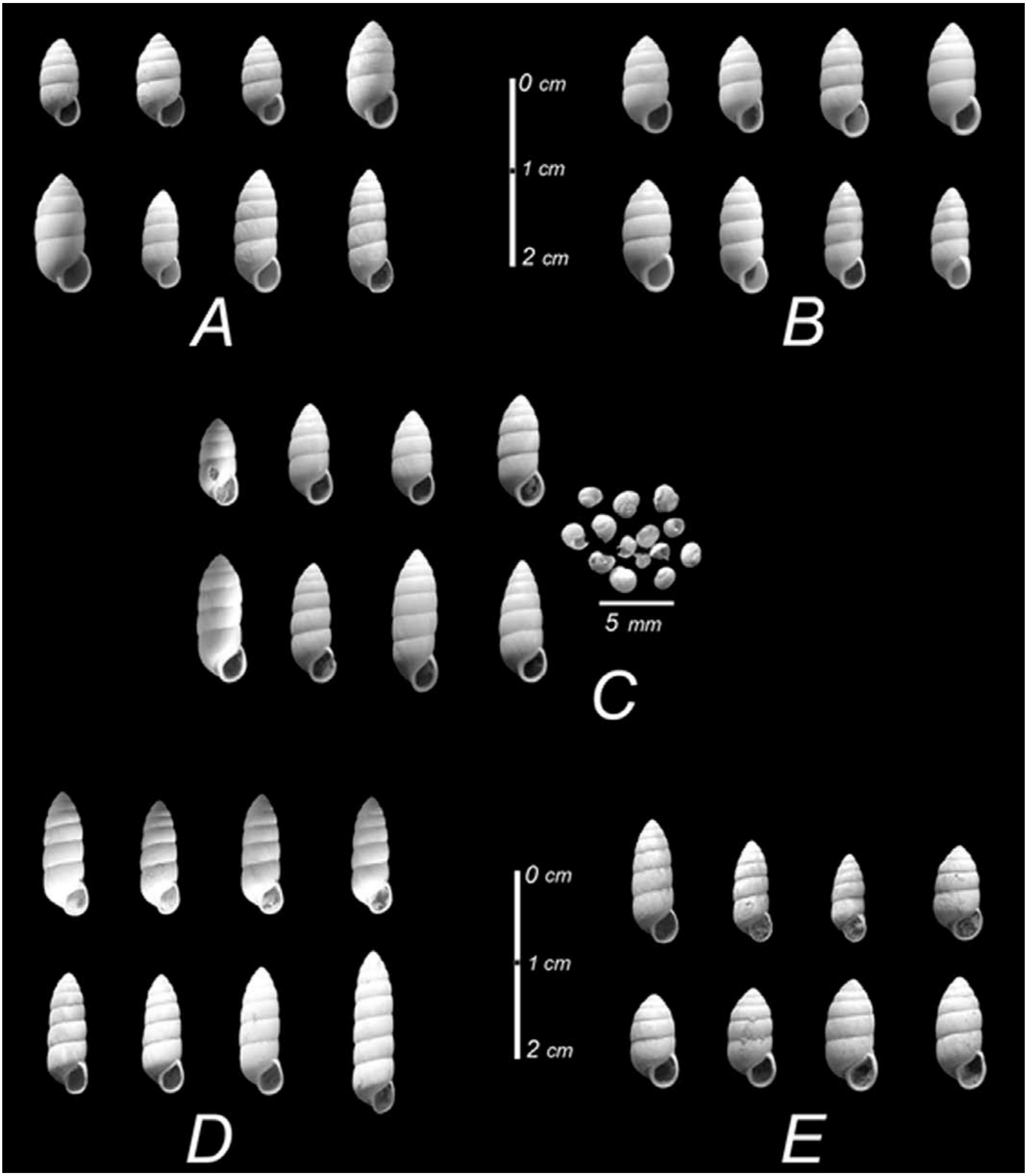

Fig. 10 - *Zootecus* sp.: Examples of different shell shapes. A) Siranda WP 16. B) Siranda WP 31. C) old collection from Uthal with some juvenile individuals. D) Rohri Hills site 59. E) Rohri Hills site 480 (photo A. Girod).

OBSERVATIONS AND CONCLUSIONS

On the basis of the biostatistical analysis of specimens from the five sites, it is clear that a large number of shapes in each sample is present. The heights, diameters and roundness indices are far from uniform and in each site the range of values is broad (Figs. 8, 10, 11). The subfossil shells of RH 59, extracted from a restricted archaeological area, have a more uniform elongate shape and diverge from the other samples (Fig. 8). The subfossil specimens of RH 480 have a low variability of shape too; they are small in size, with less whorls and a globular shape (Figs. 8 and 10E). The samples WP 16, WP 31 and Uthal, composed by shells dispersed on the soil surface, differ from RH 59 and RH 480. Their inhomogeneity is caused by the huge quantities of empty shells coming from unknown geographical area(s), periods of accumulation and chronology.

It was only possible to compare the linear regression of the five samples with the mean of the few diameter and height dimension of taxa described in the literature (Tab. 1). *Z. chion* from Hyderabad, *Z. agrensis* and Z. *estellus* differ from the shell shapes of the five samples which fall within the range of variability recorded for the taxa *pullus, chion gracilor minor, insularis chion*, *polygyratus, pertica* (Fig. 11). The description as *Z. chion* of the dead shells from the Lake Siranda is not wrong, giving the archaeomalacologist a partial answer because *Z. pullus* and *Z. polygyratus* have been also listed for Balochistan. The attribution of the right taxon name to the shells enclosed in the other samples is also uncertain.

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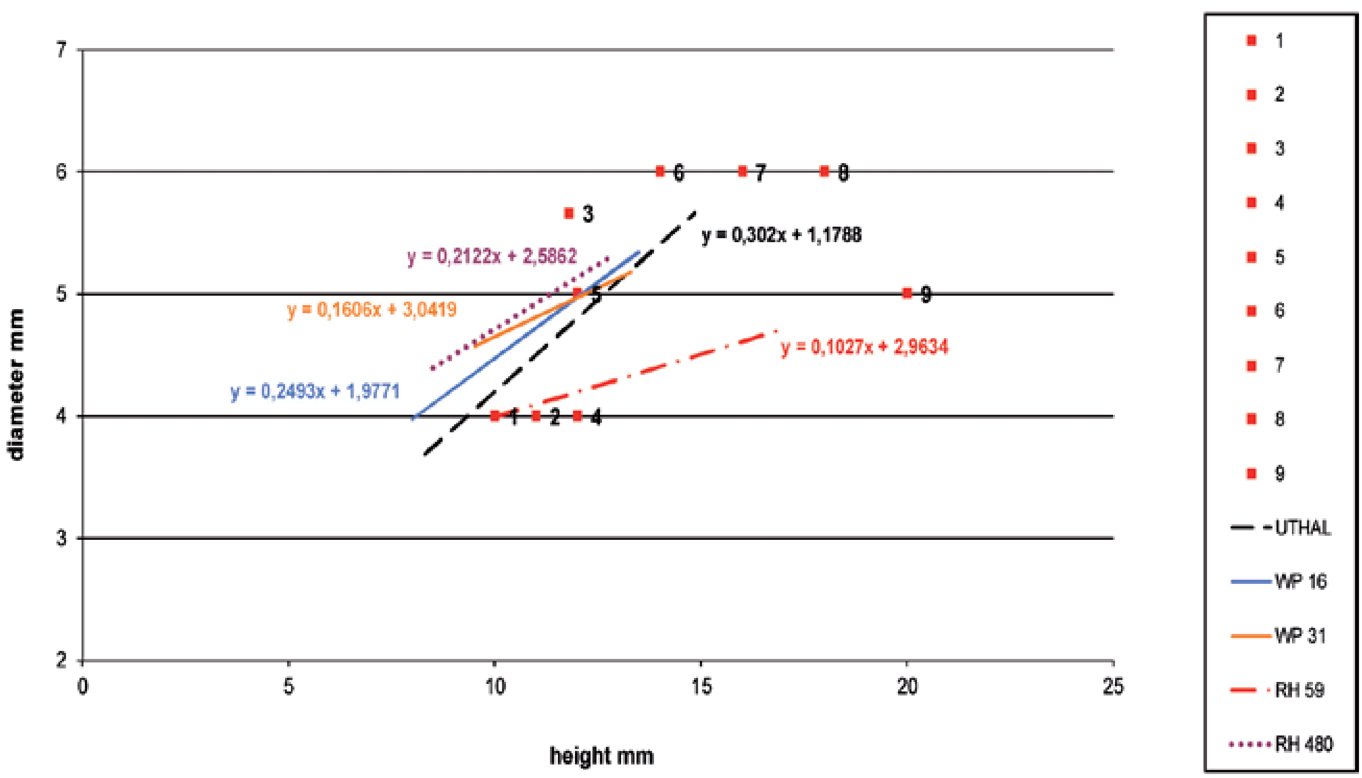

Fig. 11 - Comparison between the linear regression of the five samples and the shapes described in the past literature. 1) *Z. pullus*. 2) *Z. chion gracilor minor*. 3) *Z. insularis chion*. 4) *Z. polygyratus*. 5) *Z. chion*. 6) *Z. chion* from Hyderabad. 7) *Z. agrensis*. 8) *Z. estellus*. 9) *Z. pertica*.

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