CALCULATION OF THE COEFFICIENT OF VARIATION FROM THE DIAMETER MEASUREMENTS OF SNAIL SHELLS

by Aydin Örstan*)

Abstract: There are different ways of measuring the diameters of the shells of globose land snails. The data obtained with *Helix aspersa* and *Neohelix albolabris* demonstrate that regardless of how the diameter is measured, one always obtains the same coefficient of variation for a given sample.
Key words: land snail, statistics, variability

The coefficient of variation (CV) is the ratio of the sample standard deviation to the sample mean. Usually one measures the heights and diameters of a sample of shells and calculates the CV for each data set. In land snail samples consisting of single species, for heights and diameters one usually obtains CVs of about 0.03 to 0.08 (Boycott, 1928; Welter-Schultes, 2000; Örstan & Yildirim, 2003). Therefore, a CV larger than ~0.09 for an unbiased and sufficiently large sample would strongly indicate that the sample is a mixture of the specimens of two sympatric species of different mean dimensions. Expectedly, the CV is helpful to settle taxonomic disputes in cases where species are distinguished from each other mainly by shell dimensions (Welter-Schultes, 2000; Örstan, 2001).

In most cases, the height of a shell is unequivocally defined as the distance between the apex and the bottom edge of the lip along the axis of coiling (columella). In contrast, if one is measuring a globose shell with a descending body whorl, such as that of *Helix aspersa* Müller (Pulmonata: Helicidae), what one designates to be the diameter requires clarification. As Boycott (1928) noted, a *H. aspersa* shell has two diameters (Fig. 1): the maximum diameter (D_m) is measured from the outermost edge of the lip to the diagonally opposite edge of the body whorl, while the perpendicular diameter (D_p) is measured perpendicular to the columella. The measurement of the latter requires the careful positioning of the shell to keep the columella parallel to the caliper jaws. This is easier said than done and consequently, the measurements of D_p are usually less reproducible than those of D_m (Fig. 2). One faces an additional complication when the adult shells have reflected lips: should the edge of the lip be included in the diameter or not? From experience I know that the measurement of the diameter that includes the reflected edge of the lip (D_+) is more reproducible than the measurement of the diameter excluding the edge of the lip (D_-). This is because during the measurement of the latter where one should place the caliper jaw behind the edge of the lip is determined somewhat arbitrarily.

I will argue that regardless of which diameter one measures, one always obtains the same CV for a sample.

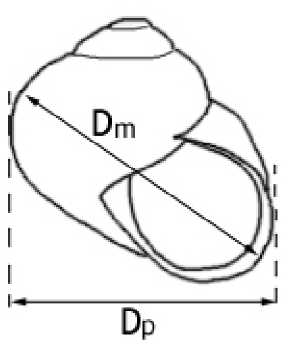

Figure 1. The two diameters of a *Helix aspersa* shell. See text for details.

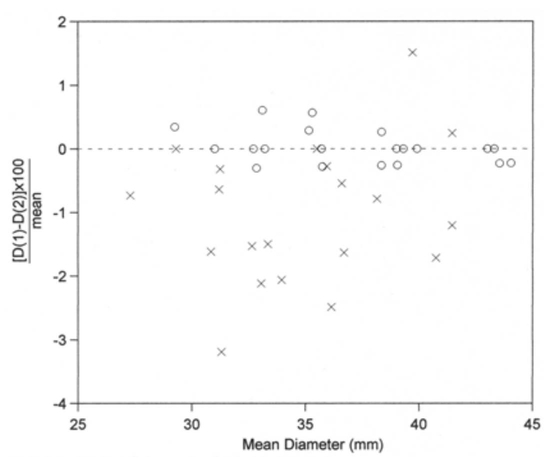

Figure 2. Relative deviations from the mean of the differences between the values of D_m (o) and D_p (x) from two sets of measurements of 20 adult *Helix aspersa* shells.

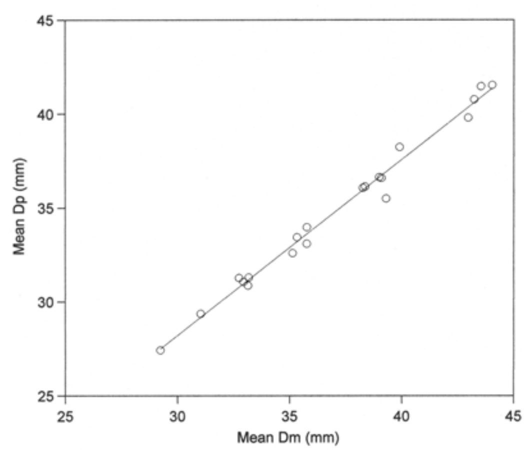

Figure 3. The relationship between the two diameters, D_m and D_p, of 20 adult *Helix aspersa* shells.

Consider a sample of shells whose mean diameter and the standard deviation are m_1 and s_1, respectively, and the CV is s_1/m_1. If the diameter of every shell in the sample is multiplied by a constant, k, the new diameters, D(2)s, will be related to the original ones, D(1)s, by the linear equation, D(2) = k D(1). One can show by simple mathematical manipulation that the mean and standard deviation of the new data set will be km_1 and ks_1, respectively, but, the CV will still be s_1/m_1 (Baird, 1962:65; Lewontin, 1966). This means that if two sets of diameters of a sample of shells, for example, D_m and D_p, are linearly related to each other, both sets will have the same CV.

To test the applicability of these arguments to land snail shells, I have measured the D_m and D_p of 20 adult *H. aspersa* shells (from various locations in southwestern Turkey) to the nearest 0.1 mm (including the reflected lip). I measured the two diameters of each shell in triplicate, and to prevent bias, at different times over a 24-h period without comparing the measurements until the end. The comparison of the relative differences between the diameters measured in the first and the second sets (Fig. 2) shows that the differences between the values of D_p in the first and second sets were in general larger than the differences between the values of D_m (similar results were obtained between the measurements in the pair-wise comparisons of other sets). Also, despite my attempts to avoid bias, most values of D_p measured during the second set were larger than those measured during the first set. These results illustrate the difficulty in accurately measuring the D_p.

To determine the relationship between D_m and D_p, I used the means of the three measurements of each diameter of each shell. Since the common sense dictates that when D_m is zero D_p should also be zero, the fitted line was forced to go through the origin. As shown in Fig. 3, there was a linear relationship between the mean values of D_m and D_p ($D_p = 0.94D_m$, r = 0.993). And as expected from the mathematical arguments presented above, the CVs for D_m and D_p were identical (0.118). However, I note that this CV has no biological meaning, because the measured sample was artificially compiled to have as wide a range of diameters as possible.

I have also measured the maximum diameters of 100 empty adult specimens of *Neohelix albolabris* (Say) (Pulmonata: Polygyridae), collected from one location in Maryland, USA. In this case, the diameter of each shell was measured once including the reflected lip (D_+) and once excluding the lip (D_-) to the nearest 0.1 mm. The two diameters were linearly related ($D_- = 0.938D_+$; r = 0.991) and the CVs for D_+ and D_-, 0.0494 and 0.0512, respectively, were not significantly different (F-test, P= 0.36). It is interesting that the slopes obtained in the two linear relationships given above are, perhaps coincidentally, almost identical.

These results suggest that linear relationships will also be obtained between the different diameters of other species of land snails that have shells shaped like those of *H. aspersa* or *N. albolabris*. I conclude that the measurement of the more reproducible maximum diameter, including the reflected lip if present, is preferable when the main interest is the determination of the CV of a sample.

Acknowledgement
I thank Drs. Tim Pearce and Francisco Welter-Schultes for helpful comments on the manuscript.

References

Baird, D.C. 1962. Experimentation: An Introduction to Measurement Theory and Experiment Design. - Prentice-Hall, New Jersey, 189 pp.

Boycott, A.E. 1928. Conchometry. Proceedings of the Malacological Society, 18:8-31.

Lewontin, R.C. 1966. On the measurement of relative variability. Systematic Zoology, 15:141-142.

Örstan, A. 2001. A revision of *Mastus carneolus* (Mousson 1863) from Istanbul, Turkey. Schriften zur Malakozoologie, 17:65-70.

Örstan, A. & Yildirim, M.Z. 2003. Conchological and genitalic comparisons of *Jaminia loewii* populations in Turkey. Zoology in the Middle East, 28:67-76.

Welter-Schultes, F. 2000. Spatial analysis of shell parameters suggests low species number of *Mastus* (Gastropoda: Pulmonata: Enidae) in central and eastern Crete. Folia Malacologia, 8:151-160

*)Aydin Örstan, Research Associate, Section of Mollusks, Carnegie Museum of Natural History, 4400 Forbes Ave., Pittsburgh, PA, 15213 U.S.A. Correspondence address: 13348 Cloverdale Place, Germantown, MD 20874 U.S.A. E-mail: pulmonate@earthlink.net

Note: The version of this paper that appeared in the Triton was in a slightly different format. I had to change the formatting in this Adobe Acrobat version to get it to fit on two sheets of U.S. letter size paper. AÖ