Proc. Tenth Intern. Malacol. Congr. (Tübingen 1989) 1991

COMPARATIVE ANATOMY OF POPULATIONS OF *OXYCHILUS (DROUETIA) ATLANTICUS* (MORELET ET DROUET, 1857) (PULMONATA: ZONITIDAE) FROM SAO MIGUEL ISLAND, AZORES

António M. de Frias Martins

ABSTRACT

The morphology of the reproductive system of *Oxychilus (Drouetia) atlanticus* (Morelet & Drouët, 1857) representing of eight populations from the type locality, Sĩo Miguel Island, Azores was compared. Variation in the relative proportion of the various organs was observed intrapopulationally, either natural or as an artifact due to differential contraction of the animal when preserved. Interpopulational variability was observed, marked in one case, but additional information is needed to justify a taxonomic separation. Shell morphology was observed to vary, some eastern populations showing a more depressed spire.

INTRODUCTION

Since the work of Morelet & Drouët (1857), the Zonitidae of the Azores remained untouched until Riedel (1964), based on anatomical features, recognized a series of new taxa of the genus *Oxychilus* Fitzinger, 1833. Riedel called attention to the endemic subgenus *Drouetia* Gude, 1911, which, pending availability of suitable material, he felt should yield several new species. Indeed four new species have been added since then (Martins, 1981, 1989; de Winter, 1989), and material from several islands is being worked upon, suggesting the addition of more new species (Martins, in preparation). Although in certain cases shell characters are diagnostic (Martins, 1981), the new taxa are based mostly on the anatomy of the reproductive system. However, the variability observed among the populations from Terceira Island (Martins, 1989) prompted this study on material from Sao Miguel Island in order to assess: (1) the variability of the type species, *Oxychilus* (*Drouetia*) *atlanticus* (Morelet et Drouët, 1857), previously known to exhibit two "forms" (Riedel, 1964); (2) the reliability of using proportional dimensions of the various organs of the reproductive system as the main character for taxonomic decisions.

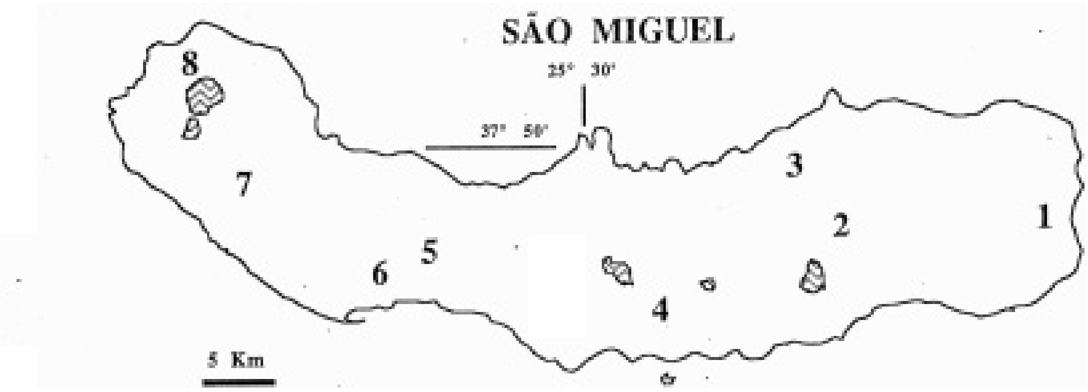


FIG. 1. Location of the stations.

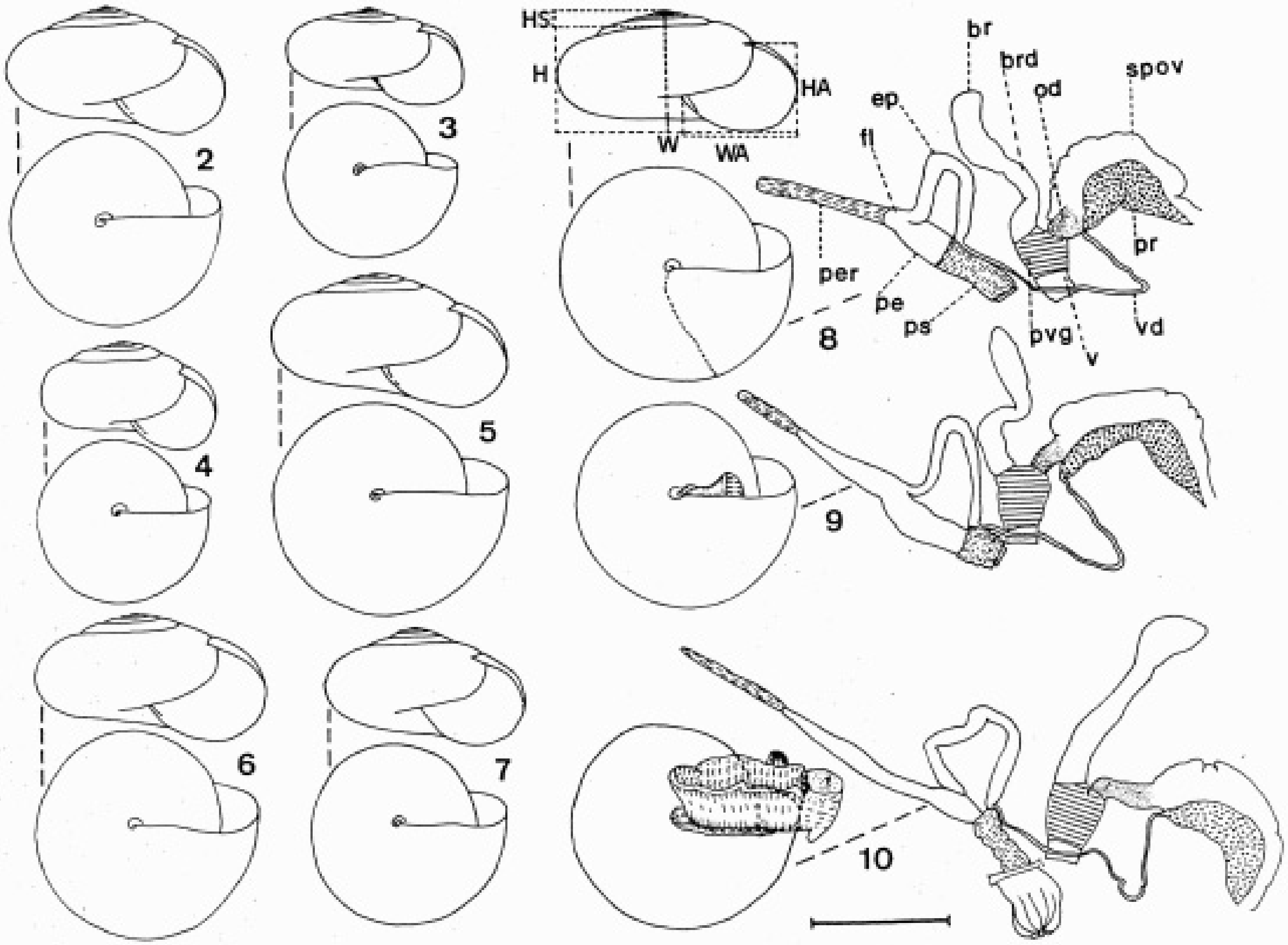
MATERIAL AND METHODS

Eight stations in Sao Miguel were selected, ordered from East to West as follows (Fig. 1):

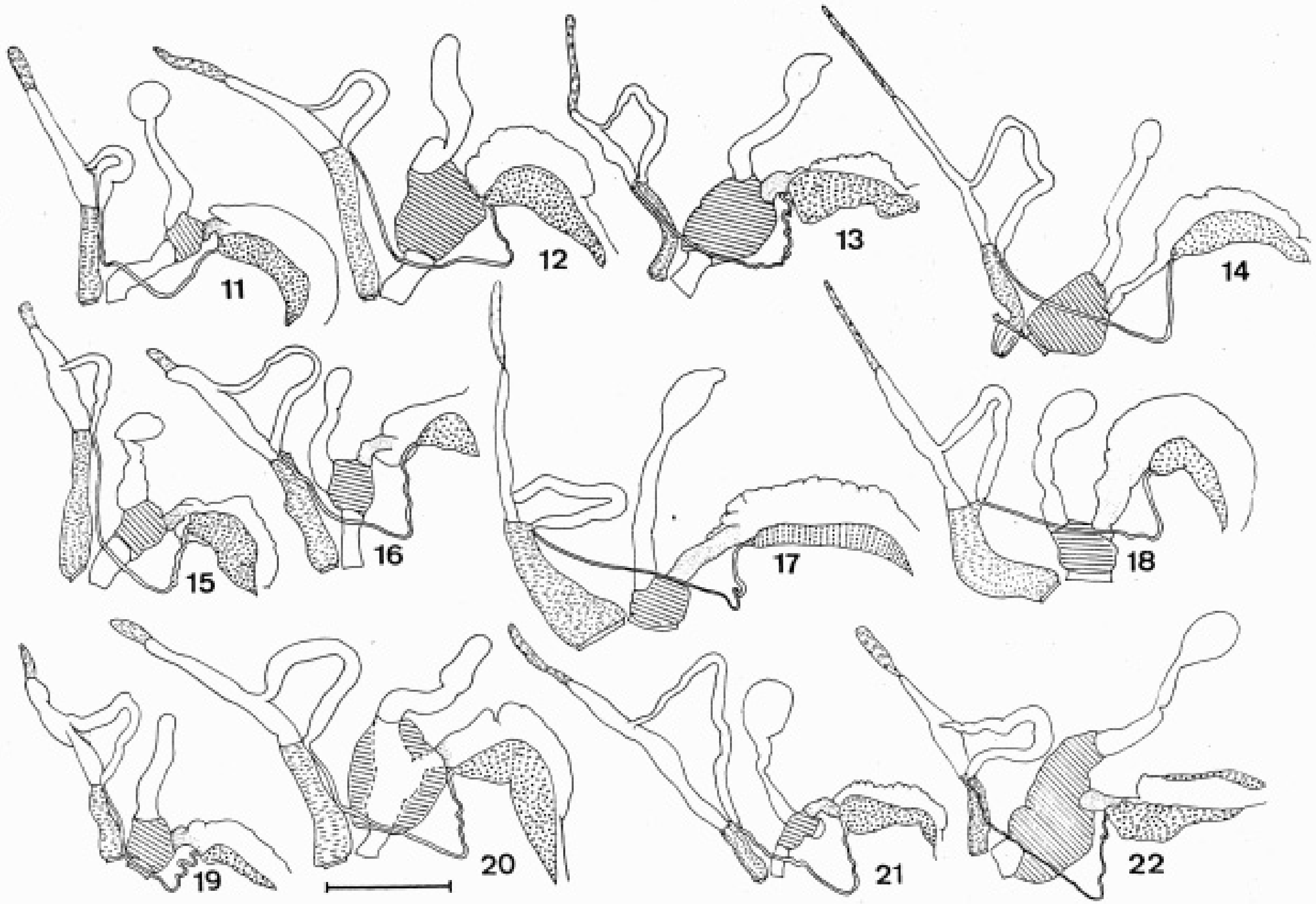
Sta 1 - Ribeira do Tosquiado, EN 1, N of Ponta da Madrugada, Nordeste. 03-08-1989 [RT].
Sta 2 - Cumieira, Pedras do Galego, Furnas. 15-03-1989 [PG]; 03-08-1989 [PGa].
Sta 3 - Ribeira dos Carneiros, EN 1. 20-03-1989 [RC]; 06-08-1989 [RCa].
Sta 4 - Rosário, Vila Franca do Campo. 23-09-1970 [Ros].
Sta 5 - Pico do Fogo, Livramento. 06-03-1984 [PF]; 26-07-1989 [PFa].
Sta 6 - Abelheira, Fajĩ de Baixo. 27-02-1988 [Ab]; 26-07-1989 [Aba].
Sta 7 - Curral da Achada, Covoada. 10-04-1988 [CA].
Sta 8 - Caldeira das Sete Cidades. 20-06-1989 [7C].

TABLE 1. Measurements (mm) of various parameters of the shell and genitalia of *Oxychilus (Drouetia) atlanticus*. #W, number of whorls; * penis everted. For symbols of other parameters see Fig. 8; for symbols of specimens see list of stations.

SPEC.	H	W	HS	HA	WA	#W	ps	pe	fl	ep	v	pvg	brd	br	od	vd
RT-1	3.9	7.1	0.6	2.8	3.6	5.3	1.6	1.2	0.5	3.4	0.6	1.7	2.5	1.0	0.7	5.2
RT-4	4.6	8.1	0.7	3.3	3.9	5.8	2.2	1.3	0.6	3.3	0.9	1.6	2.2	1.3	0.6	6.6
RT-5	4.4	7.7	0.5	3.4	3.8	5.6	1.8	1.5	1.1	5.3	0.4	1.7	2.9	0.9	1.7	6.9
RT-7	4.6	7.9	0.5	3.5	4.0	5.6	1.9	1.1	0.8	3.3	1.2	1.2	2.9	0.8	0.7	5.1
RT-8	3.9	7.0	0.5	2.9	3.6	5.2	*2.1	1.1	2.4	4.1	0.5	1.4	2.3	1.6	1.2	5.5
RT-9	3.9	6.9	0.6	3.0	3.6	5.2	---	---	---	---	---	---	---	---	---	---
RT-12	4.4	7.4	0.6	3.3	4.0	5.7	2.2	1.4	3.1	4.4	0.4	1.1	2.7	1.5	1.6	5.7
RT-16	4.5	7.6	0.7	3.2	3.8	5.6	3.0	1.4	2.0	4.7	0.2	1.7	1.9	0.9	1.6	5.6
PG-1	4.3	6.7	0.7	3.1	3.6	5.6	1.7	1.0	1.9	2.9	1.4	1.0	2.6	1.2	0.7	4.7
PGa-1	5.3	9.0	0.8	3.8	4.8	5.6	2.3	0.5	0.9	2.7	0.9	1.0	1.4	0.6	5.4	5.5
PGa-3	4.0	6.7	0.7	2.9	3.2	5.7	1.8	0.7	1.8	2.4	1.7	0.7	2.1	0.8	0.6	4.0
PGa-4	4.0	6.8	0.6	2.9	3.4	5.5	1.3	0.4	1.4	2.8	0.9	0.8	1.8	0.9	0.3	4.4
PGa-5	4.0	6.8	0.5	2.9	3.5	5.4	1.1	0.5	1.0	1.7	0.6	0.8	1.7	0.8	0.5	5.0
PGa-6	5.0	8.5	0.7	3.6	4.3	5.6	2.3	0.7	1.4	3.3	0.9	1.7	1.3	2.0	0.2	5.5
PGa-7	3.9	6.6	0.6	2.9	3.5	5.5	1.6	0.4	1.4	2.7	0.9	0.9	1.6	1.4	0.6	4.1
PGa-8	4.9	8.7	0.7	3.6	4.6	5.7	3.0	1.1	1.6	3.3	1.2	1.6	1.6	1.6	0.2	5.5
PGa-9	4.3	8.0	0.6	3.3	4.2	5.4	*2.7	1.1	1.1	3.5	1.4	0.9	0.6	1.2	0.2	5.4
RC-1	3.6	6.4	0.4	2.8	3.4	5.4	2.1	2.0	0.9	2.8	0.9	0.8	1.3	0.9	1.0	4.3
RC-2	3.6	6.4	0.5	2.7	3.4	5.5	2.4	1.9	0.9	4.6	1.2	0.9	1.6	0.9	0.9	5.4
RC-3	3.7	6.3	0.6	2.8	3.2	5.6	2.5	1.9	1.4	4.0	0.9	0.7	1.3	0.8	0.6	4.4
RC-4	3.2	5.9	0.3	2.7	3.1	5.4	---	---	---	---	---	---	---	---	---	---
RC-5	3.5	6.2	0.5	2.9	3.2	5.6	---	---	---	---	---	---	---	---	---	---
RC-6	3.4	6.2	0.4	2.7	3.1	5.3	2.2	1.5	0.9	2.4	0.8	0.8	1.0	0.9	0.5	4.0
RC-7	3.6	6.4	0.5	2.8	3.3	5.6	---	---	---	---	---	---	---	---	---	---
RC-8	3.1	5.6	0.5	2.3	2.8	5.4	2.7	1.8	1.0	2.5	0.6	1.0	1.7	0.9	0.8	5.0
RC-9	3.5	6.3	0.5	2.7	3.3	5.3	2.8	1.3	1.0	2.5	1.0	0.9	1.4	0.9	0.5	5.1
RC-10	3.4	5.9	0.5	2.7	3.1	5.4	---	---	---	---	---	---	---	---	---	---
RC-11	3.7	6.5	0.5	2.8	3.5	5.7	---	---	---	---	---	---	---	---	---	---
RC-12	3.7	6.7	0.6	3.0	3.5	5.6	2.7	1.9	0.8	2.9	0.9	1.0	1.6	0.9	0.7	4.9
RC-13	3.7	6.3	0.5	2.9	3.2	5.8	---	---	---	---	---	---	---	---	---	---
RC-14	3.8	6.3	0.4	3.0	3.4	5.7	---	---	---	---	---	---	---	---	---	---
RC-15	3.5	6.4	0.4	2.9	3.2	5.6	---	---	---	---	---	---	---	---	---	---
RC-16	3.6	5.9	0.4	2.8	3.2	5.4	---	---	---	---	---	---	---	---	---	---
RCa-1	4.2	7.5	0.6	3.1	3.8	5.7	*2.7	---	---	---	0.5	0.9	1.9	1.3	1.6	5.5
RCa-2	4.2	7.3	0.6	3.1	3.7	5.3	*2.2	---	---	---	0.5	1.0	1.2	1.3	2.0	6.1
RCa-3	4.4	7.7	0.8	3.0	3.9	5.8	*2.2	---	---	---	0.5	0.9	1.4	1.3	1.1	4.8
RCa-4	4.5	7.6	0.6	3.2	3.8	5.7	---	---	---	---	---	---	---	---	---	---
RCa-5	3.7	6.3	0.4	2.8	3.3	5.3	---	---	---	---	---	---	---	---	---	---
RCa-9	3.6	6.4	0.6	2.7	3.2	5.7	*2.0	1.7	0.7	2.9	1.2	0.6	2.6	0.5	1.5	5.6
Ros-1	4.9	8.0	0.9	3.2	4.0	5.7	0.8	3.1	1.4	4.3	0.6	1.0	1.9	1.5	1.8	4.4
Ros-2	4.8	8.3	0.8	3.3	4.3	5.8	3.0	0.3	2.5	3.8	0.4	1.3	2.7	1.5	0.6	5.7
Ros-3	5.0	8.2	1.0	3.2	4.2	5.8	2.8	0.4	3.3	3.4	0.2	0.9	2.4	1.5	1.4	5.8
Ros-4	5.0	8.2	1.0	3.2	4.2	5.7	---	---	---	---	---	---	---	---	---	---
Ros-6	4.8	7.9	1.0	3.0	3.9	5.6	1.2	2.1	2.5	4.1	0.5	0.7	2.8	1.6	2.2	4.9
Ros-8	4.5	7.9	0.6	3.2	4.1	5.6	1.3	2.1	3.0	4.1	0.4	0.7	2.0	1.1	1.3	5.5
Ros-9	4.6	8.2	0.7	3.3	4.2	5.6	2.8	0.5	2.6	4.5	0.1	1.0	3.3	1.6	1.6	6.5
Ros-10	5.1	8.1	0.9	3.4	4.0	6.0	1.7	2.9	3.4	4.6	0.2	0.9	3.0	1.7	1.7	5.4
Ros-12	4.7	7.8	0.9	3.0	4.0	5.7	2.8	1.2	2.0	3.9	0.2	0.8	1.9	1.2	1.4	5.2
Ros-13	4.8	7.9	0.9	3.0	4.0	5.8	0.8	2.0	2.6	3.4	0.3	1.1	2.4	1.4	1.0	6.6
Ros-23	4.8	8.1	0.8	3.1	4.1	5.9	2.3	1.4	2.6	3.6	0.3	1.0	2.4	1.4	0.5	5.8
PF-1	3.7	6.4	0.5	2.9	3.4	5.3	---	---	---	---	---	---	---	---	---	---
PF-4	3.2	5.3	0.4	2.5	3.1	5.3	---	---	---	---	---	---	---	---	---	---
PF-7	4.3	7.2	0.8	3.0	3.8	5.7	1.1	1.2	1.5	4.2	0.7	0.4	1.5	0.7	0.6	3.3
PF-8	4.1	6.8	0.6	3.0	3.7	5.4	---	---	---	---	---	---	---	---	---	---
PF-10	3.6	6.4	0.5	2.8	3.3	5.4	---	---	---	---	---	---	---	---	---	---
PF-13	3.9	6.6	0.6	3.0	3.7	5.6	---	---	---	---	---	---	---	---	---	---
PF-14	3.9	6.6	0.5	2.9	3.6	5.5	---	---	---	---	---	---	---	---	---	---
PFa-1	5.0	8.3	0.9	3.4	4.3	6.4	*1.7	0.9	1.9	4.5	0.3	1.6	1.0	1.3	0.5	7.0
PFa-2	4.2	6.9	0.7	3.0	3.6	5.5	1.6	1.2	1.0	4.2	0.4	1.2	1.4	0.9	0.4	5.0
PFa-3	5.1	8.6	0.7	3.5	4.5	6.0	1.6	1.0	1.3	4.6	0.6	1.7	2.8	1.4	1.2	5.8
PFa-4	4.6	8.0	0.6	3.4	4.0	5.7	2.0	1.7	2.3	5.9	0.5	2.1	2.2	1.2	0.6	6.9
PFa-5	5.7	9.0	1.0	3.8	4.2	6.1	2.0	1.5	2.2	5.4	0.4	1.8	1.4	1.4	0.5	6.4
PFa-6	5.0	8.4	0.8	3.6	3.9	6.4	*1.9	1.4	1.7	5.4	0.8	2.1	0.9	1.1	1.0	6.4
Ab-1	4.7	8.0	0.9	3.2	4.1	6.1	1.5	1.3	0.8	3.9	0.5	1.0	1.4	1.1	1.1	5.2
Ab-2	4.8	8.3	0.8	3.0	4.2	6.1	1.7	1.7	1.5	5.1	0.4	0.8	2.2	1.2	1.8	5.0
Ab-4	4.8	8.1	0.9	3.2	4.0	5.8	2.1	0.4	2.2	4.5	0.2	0.8	1.6	1.4	2.2	5.7
Ab-6	4.7	8.2	0.9	3.0	4.2	6.3	1.8	1.8	3.1	6.1	0.4	2.4	1.9	1.7	1.1	4.8
Ab-7	4.3	7.6	0.9	2.8	4.8	5.8	1.9	1.1	1.8	4.9	0.3	0.6	2.7	0.8	1.0	4.2
Ab-8	4.6	8.0	0.7	3.0	4.0	6.0	1.7	0.3	2.0	5.1	0.2	1.3	1.8	1.2	1.9	4.7
Ab-9	4.2	7.7	0.7	2.9	4.1	5.6	2.1	1.6	1.9	5.1	0.3	0.9	2.0	1.1	1.8	4.8
Aba-1	4.7	8.4	0.6	3.3	4.4	5.8	1.1	1.4	0.8	3.9	0.4	0.7	1.2	1.0	0.8	5.7
Aba-2	4.8	8.5	0.7	3.3	4.4	5.8	2.3	0.4	0.9	3.9	0.3	0.8	1.2	1.0	0.9	5.8
Aba-3	4.6	8.8	0.6	3.3	4.3	5.8	1.4	0.9	0.4	3.3	0.5	0.6	2.5	0.9	0.7	4.6
Aba-4	4.2	8.2	0.5	3.3	4.2	5.7	0.8	1.7	2.4	4.3	0.3	1.2	2.2	1.2	0.7	4.6
Aba-5	4.1	7.5	0.6	2.9	3.7	5.7	1.1	1.9	2.9	3.6	0.5	0.6	1.6	1.1	1.1	4.2
Aba-6	4.3	7.4	0.8	3.0	3.5	5.8	*1.5	---	2.4	3.5	0.4	0.8	1.7	1.2	1.0	4.5
Aba-7	4.9	8.1	0.8	3.3	4.1	5.7	1.7	1.8	2.6	3.8	0.3	1.1	2.0	1.2	0.6	5.0
Aba-8	4.8	8.3	0.6	3.2	4.0	6.0	*1.1	---	3.0	4.3	0.3	0.9	1.3	1.8	1.1	4.8
Aba-9	4.8	8.2	0.8	3.4	4.0	6.2	*1.1	0.3	3.6	4.7	0.5	1.1	2.8	1.5	1.3	5.2
Aba-10	4.7	8.2	0.8	3.2	8.2	6.0	*2.1	---	2.1	3.4	0.3	0.9	1.5	1.4	2.4	5.5
Aba-11	4.8	8.3	0.7	3.3	4.1	6.0	*1.8	---	3.4	4.3	0.4	0.7	2.7	0.9	1.8	5.5
CA-1	5.3	8.5	0.9	3.5	4.5	5.8	1.9	1.4	1.8	5.0	0.3	0.9	2.0	1.0	1.7	6.1
CA-2	4.5	7.9	0.6	3.3	4.3	5.7	1.5	1.3	1.3	3.3	0.3	0.6	1.7	0.6	0.8	4.8
CA-3	5.1	8.7	1.0	3.4	4.4	5.7	2.5	1.5	2.9	5.0	0.9	1.3	2.2	1.3	0.5	6.6
CA-4	4.7	8.4	0.6	3.5	8.4	5.6	2.4	1.2	2.4	5.7	0.6	2.0	1.6	1.3	0.7	6.2
CA-5	5.0	8.6	0.8	3.5	4.4	5.8	2.4	0.9	2.1	4.1	1.0	1.0	1.2	1.7	0.7	5.7
CA-10	4.4	7.6	0.7	3.3	4.0	5.3	2.1	0.9	2.3	3.6	0.8	1.5	1.0	2.3	0.8	5.8
CA-12	4.7	8.0	0.7	3.6	4.1	5.6	1.5	1.2	2.2	4.0	0.7	1.2	0.7	0.8	0.8	5.5
SC-1	4.2	7.5	0.6	3.1	4.0	5.5	---	---	---	---	---	---	---	---	---	---
SC-2	4.4	7.3	0.6	3.2	3.8	5.5	0.7	3.2	2.0	6.8	0.8	0.5	2.6	1.3	1.0	4.8
SC-6	4.3	7.4	0.6	3.2	3.8	5.4	1.4	3.4	2.8	9.8	0.7	1.1	2.8	1.9	1.2	5.5
SC-8	4.5	7.4	0.8	3.2	3.9	5.7	1.4	3.2	1.0	7.5	0.9	1.1	2.6	2.2	0.8	4.8
SC-11	5.1	8.6	0.7	3.6	4.5	5.7	*1.4	3.8	1.8	8.9	0.5	1.3	3.7	1.9	1.1	6.1



FIGS. 2-10. Shell and reproductive organs of *Oxychilus (Drouetia) atlanticus*. 2, RT-4; 3, RC-2; 4, PGa-3; 5, PGa-8; 6, CA-4; 7, SC-2; 8, Aba-3, the dotted line showing how far the animal was retracted into the shell; 9, Aba-4; 10, Aba-9. (Specimen symbols as in Table 1). H, height of the shell; HA, height of the aperture; HS, height of the spire; W, width of the shell; WA, width of the aperture; br, bursa; brd, bursa duct; ep, epiphallus; fl, flagellum; od, oviduct; pe, penis; per, penial retractor; pr, prostate; ps, penial sheath; pvg, perivaginal gland; spov, spermoviduct; v, vagina; vd, vas deferens. Scale bar = 5 mm for the shells and 2.5 mm for the reproductive organs.



FIGS. 11-22. Reproductive system of *Oxychilus (Drouetia) atlanticus*. 11, PGa-3; 12, PGa-8; 13, RT-4; 14, RT-5; 15, RC-9; 16, RC-2; 17, Ros-9; 18, Ros-12; 19, CA-2; 20, CA-4; 21, SC-2; 22, PFa-3. (Specimen symbols as in Table 1). Scale bar = 2.5 mm

The material was killed by drowning overnight and preserved in 70% alcohol. The animals were extracted from their shells, or the shells were broken after having been drawn under camera lucida; the reproductive systems were dissected out and drawn under camera lucida in their natural position and with the organs gently separated. The measurements of the various parameters (Fig. 8; Table 1) were done on such drawings.

RESULTS

Shell shape showed some interpopulational differences and specimens that could be referred to the smaller and larger forms of Riedel (1964) were identified (Figs. 3, 4, 7). Although shell shape was fairly constant intrapopulationally, both shell forms were found together (Figs. 4, 5), to which some differences in reproductive morphology seemed to correspond (Figs. 11, 12). Populations from Stas. 1-3 showed a more depressed spire (Figs. 2-5), whereas a more conical profile was found in the western half of the island (Figs. 6-8).

The reproductive system was found to vary greatly. An important factor accounting for a fair amount of variability of the proportional dimensions of the reproductive system is the position in which the animals die and are preserved (Figs. 8-10). Fully contracted animals showed a significant size reduction of the penial retractor, flagellum and, to a lesser degree, oviduct, whereas partially retracted or fully extended animals did not show noticeable differences in these aspects.

Intrapopulational variability was found for almost every character: sizes of the vagina and the perivaginal gland, (Figs. 11-12), of the flagellum, vagina and oviduct (Figs. 13-14), of the epiphallus (Figs. 15-16), and shape of the penis and oviduct (Figs. 17-18).

Geographically close populations (Stas. 7 and 8; 5 and 6) surprisingly were found to diverge greatly, namely in the size of the epiphallus and arrangement of the root of the bursa duct (Figs. 19-21) or the shape of the perivaginal gland (Figs. 8-10, 22).

CONCLUSIONS

Oxychilus (Drouetia) atlanticus shows a great amount of variation in shell and reproductive morphology, either natural or resulting from the preservation of the animals. Meier-Brook (1976) documented the influence of the latter as a source of variability in *Planorbis*. Caution, then, should be exercised when utilizing proportional dimensions of the reproductive organs where a taxonomic decision depends primarily on these characters.

Although the conchological forms identified by Riedel (1964) were found to diverge in the morphology of the genitalia in Sta. 2, the divergence noted here does not coincide with the differences noted by that author; also, there is a great amount of overlap when other populations are considered. A final taxonomic conclusion must await a more thorough study. A similar decision on the population of Sta 8 is not warranted at the moment, for only a small sample from one site was studied.

Presently a complementary study on molecular genetics is in progress at the University of the Azores to survey enzyme variability in these populations.

ACKNOWLEDGEMENTS

I want to thank Regina Cunha and Carlos Brito for assisting in the collection.

LITERATURE CITED

MARTINS, A. M. F., 1981. *Oxychilus (Drouetia) agostinhoi* new species (Stylommatophora: Zonitidae) from the Azores Islands, its anatomy and phylogenetic relationships. *Occasional Papers on Mollusks, Museum of Comparative Zoology, Harvard University*, 4(59): 245-265.

MARTINS, A. M. F., 1989. Espécies novas do género *Oxychilus* (Gastropoda: Zonitidae) na Ilha Terceira. *Açoreana*, 7(1): 55-71.

MEIER-BROOK, C., 1976. The influence of varied relaxing and fixing conditions on anatomical characters in a *Planorbis* species. *Basteria*, 40: 101-106.

MORELET, A. & H. DROUET, 1857. Conchologiae Azoricae prodromus novarum specierum diagnoses sistens. *Journal de Conchyliologie*, 6(2.e série, vol. 2): 148-153.

RIEDEL, A., 1964. Zonitidae (Gastropoda) der Azoren. *Boletim do Museu Municipal do Funchal*, 18(Art. 66): 5-60.

WINTER, A. J. DE, 1989. Remarks on the non-marine molluscan fauna of the Azores. 3. A new species of *Drouetia* from the Isle of Sïo Miguel (Pulmonata: Zonitidae). *Basteria*, 53: 63-67.

ANTONIO M. DE FRIAS MARTINS
Departamento de Biologia
Universidade dos Açores
P-9502 Ponta Delgada (Codex)
Sao Miguel - Açores -
PORTUGAL