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A NOTE ON THE BIOMETRY AND REPRODUCTION OF *PODOCNEMIS SEXTUBERCULATA* (TESTUDINES, PELOMEDUSIDAE)

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ABSTRACT

Weight-length relationship, relative shell weight, and egg and clutch biometry data are given for the turtle Podocnemis sextuberculata.

INTRODUCTION

During the months of October to December, 1977, the boats "Lindolpho R. Guimarães" and "Garbe" travelled on the Rio Japurá, as part of the program of the Exposição Permanente da Amazônia (EPA), maintained by this Museum, by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) and by the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus.

One of the objectives of the trip was the collection of data on the reproductive biology of Amazonian chelonians, pursuing leads from previous work (Vanzolini, 1977). Unfortunately, the season was a bad one, as the level of the river stayed practically stationary, very few beaches being available for laying. We saw no specimens, and were offered none, of *Podocnemis unifilis* ("tracajá"), usually the commonest turtle in the valley, a valued food resource and a highly interesting animal. Of *P. expansa* ("tartaruga") we were offered by a Colombian itinerant trader, for an outrageous price, a few young ("tartarugotas") and sickly-looking females. The only species we were able to obtain, both by purchase and by direct collecting, was the "iaçá", *Podocnemis sextuberculata* (Cornalia).

MATERIALS AND METHODS

The river Caquetá, where it enters Brasil from Colombia, at the mouth of the tributary Apaporis (01°23′S, 69°25′W), has its name

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changed to Japurá and flows down to the Solimões, which it enters at 03°08′S, 64°46′W. It has no meanders, but even so touches "terra firme" (land above seasonal flood level) at remarkably few places.

We obtained turtles at the following localities:

1. Ilha de São José, 01°43′S, 66°01′W. There we bought freshly caught turtles on two occasions, November 2 and December 5. Of 8 specimens, 5 had eggs.

2. Costa da Altamira, 01°47′S, 66°32′W. This is a hamlet on the right bank of the river. On a beach directly across from it we collected on the stormy night of December 2 four females that had come ashore to lay.

3. La Pedrera, 01°18′S, 69°43′W. From the Colombian trader mentioned above we purchased, on December 1, five specimens from around La Pedrera in Colombia; three had eggs. The man did not know for how long they had been in captivity when originally bought, which was allegedly 3-4 days before meeting us.

4. Taboleiro Inda Nova, 03°50′S, 62°25′W. On our way from Manaus to the Japurá we stopped at this long sand bar in the Solimões, protected by the Instituto Brasileiro de Desenvolvimento Florestal (IBDF, the federal agency in charge of wild life) during the turtle season. There, on October 23 we obtained two females, one with eggs, caught the night before.

Thus we know that the specimens from Inda Nova, Altamira and Ilha de São José were healthy females, come ashore to lay, and that their eggs were not injured by prolonged captivity. We are not sure about the La Pedrera specimens, although they looked to us, and to our sailors, normal enough.

The animals were kept alive on board from one to three days. They were weighed alive, to the nearest 50 grams, in a spring balance, and killed by decapitation by our cook. The bridge was sawed through, the plastron removed, the eggs carefully collected, washed, individually measured with calipers to the nearest millimeter, and weighed in a spring balance to the nearest gram. The shell was scraped clean and weighed, after removal of the vertebrae, to the nearest 5 grams. This measurement contains an element of error: the pelvic girdle was not removed, but often broke unevenly when the plastron was detached from the carapace. The maximum difference thus produced (estimated by weighing some bone fragments) should be around 5-10 grams, irrelevant to this broad search for relationships.

The heads, fixed in formalin and kept in alcohol, and the dry shells are in the museum turtle collection, with the MZUSP numbers cited in Table 1.

Besides the direct measurements made on board (live weight, shell weight and individual egg diameters and weights), we obtained arithmetically some other ones. By adding the weight of all eggs we got "clutch weight". The difference between live weight and the weight of the clutch we call here "body weight". Body weight minus shell weight we call provisionally "naked weight", until a better name is proposed. For each egg we calculated the volume, the density and the

TABLE 1 — RAW DATA

MZUSP	Locality	pl	lwt	swt	cl	cwt
2944	Inda Nova	255	2500	—	0	—
2945	”	280	3150	—	21	378
2968	Ilha de S. José	219	1900	600	11	170
2969	”	230	1950	650	0	—
2970	”	234	1750	575	15	272
2971	”	230	1800	645	10	191
2972	”	220	1350	—	0	—
2973	”	232	1850	675	13	256
2985	Costa da Altamira	232	1900	670	10	196
2986	”	220	1700	565	7	113
2987	”	227	1950	710	12	226
2988	”	220	1450	485	10	140
2975	La Pedrera	230	1800	685	0	—
2976	”	236	2000	655	9	142
2977	”	223	1700	650	7	123
2978	”	232	2000	670	7	142
2979	”	233	1850	670	0	—

pl, plastral length, mm; lwt, live weight, grams; swt, shell weight, grams; cl, number of eggs; cwt, clutch weight, grams.

eccentricity, according to Vanzolini (1977). No direct measurements of egg volume were made.

This was the first time we registered in the field the weight of the turtles; we had not thought of shell weights when we got the Inda Nova specimens, at the begining of the trip, and this turned out to be a grievous omission, as one of them is the only large female obtained, and responsible for the significance of several regressions, as discussed below.

For the characters not involving turtle weight, we use, without further mention, in addition to the present ones the data of Vanzolini (1977).

A NOTE ON BODY PROPORTIONS

When one studies, in non-experimental situations, the dependence of any measurement on a general body size parameter, one has a composite of at least two elements: the regression within individual age classes and the evolution in time of age class averages (Kavanagh & Richards, 1942). Both phenomena are individually important and not necessarily correlated. In practice it is not always possible to discern between them, but frequently a distribution with a broad range, and in which all size classes are evenly distributed, will afford information on the latter issue; bunched up distributions on the former.

The specimens we have so far studied constitute a sample very strongly biased towards small sizes, a consequence perhaps of intensive human predation. This asymmetry is noticeable in our previous samples (for which no weights of the animals are available), but is really extremely marked in the case of the present materials. Eleven females have plastral lengths between 219 and 236 mm, and only one gravid female has a 280 mm plastron. The former are probably just-matured females. We are thus in a position to get a fair idea of intra-class regressions in the range of small mature females, and an indication of the eventual presence (but not a good quantitative estimate) of over-all regression. Since the data are uneven (not all measurements were performed on all animals), mention will be made of relevant points in each case.

Body weight relationships

To study the regression of body weight on plastral length (Graph 1, Table 2) we have data from 17 females, ranging from 219 to 280 mm in plastral length, 15 among them measuring 236 mm or less. The regression in this "small" group is significant at the 5% level; it shows that a relationship exists, but the coefficient of determination (0.30) is low and the equation poorly predictive.

Adding the two large females, 250 and 280 mm in plastral length, the regression of course improves much ($r^2 = 0.78$), but still affords only poor predictions, given the biased distribution of lengths. It seems evident that improved samples will afford better average estimates, but that the variability will remain high.

Since it is to be expected that body weight will be correlated with body length, and the correlation may be in some animals extremely high (e.g. 0.996 for the joint distribution of caimans of two different genera, Vanzolini & Gomes, 1978) we think emphasis should be placed on the poorness of the fit rather than on the presence of regression.

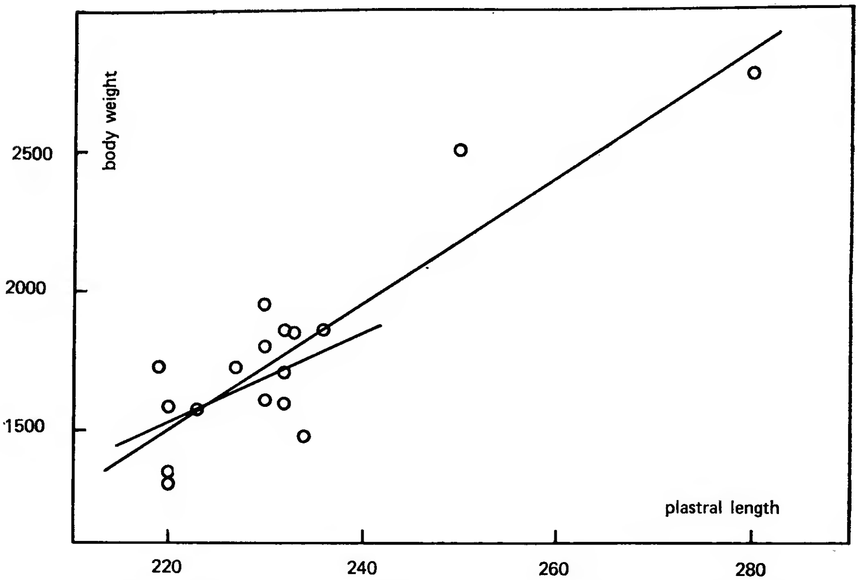
The next step is to study the regression of naked weight and of shell weight on plastral length. For these relationships we have only 14 specimens of the "small" group. The regression of naked weight on plastral length is not significant. That of shell weight on plastral length is significant at the 5% level (Table 2); the fit is rather poor ($r^2 = 0.32$), and this fact again should deserve emphasis rather than the presence of a correlation. Finally, the regression of shell weight on naked weight is not significant at the 5% level ($r^2 = 0.22$).

It seems thus that the weight of the iaçá is extremely variable, and the partition of body mass between shell and animal rather irregular.

Data on reproduction

Epoch of reproduction

Vanzolini (1977) called attention to the differences in laying season of Amazonian turtles in different rivers. For *P. sextuberculata* he cited



Graph 1. Regression of body weight on plastral length; lines corresponding to the "small" and to the general group.

June-July in the Purus, and August-September in the Trombetas. Now we have October-November for the lower Solimões and late October--December for the Japurá.

TABLE 2 — DATA ON REGRESSIONS

	N	R	b	s_b	a	r^2
on plastral length						
body weight, "small"	15	219-236	16.64	7.406	-2127 (ns)	0.30
general	17	219-280	22.61	3.063	-3472**	0.78
shell weight	14	219-236	5.95	2.519	-723*	0.32
clutch, 1977	11	230-279	0.06	0.0344		0.25
general	24	219-280	0.17	0.0297	-27.1***	0.59
clutch volume	16	219-280	3.14	0.616	-5.56**	0.65
clutch weight	12	219-280	3.87	0.871	-703**	0.66
on body weight						
clutch weight	12	1310-2770	0.14	0.0522	-39.5 (ns)	0.40

N, specimens in the sample; R, range of the independent variable; b, coefficient of regression; s_b, its standard deviation; a, regression constant; r^2, coefficient of determination; ns, not significant at the 5% level; *, **, ***, significant respectively at the 5%, 1% and 0.1% level of significance; "small", specimens up to 236 mm plastral length; "clutch 1977", corrected data of Vanzolini, 1977.

It must be explained that the Solimões sends up to the Japurá a long, contorted but very vigorous arm, the Auatí-Paraná, that leaves the mother river at 67°23'W and reaches the Japurá at 65°37'W. The latter is thus divided into two sections: above the mouth of the Paraná the river has its own regime in the dry season and is dammed by Solimões water at flood; below the mouth of the Paraná it follows strictly the Solimões. All our Japurá specimens are from the upper segment, and seem to breed later than the Solimões populations. In these geographical comparisons the scale is of a few hundred kilometers.

It is obvious that a tagging program is in order, not only to obtain natural history data, but also to check the fidelity of individual turtles to their native rivers or even beaches, with the consequent restrictions to gene flow. This may well be important for conservation. Tagging itself, whether of adults or hatchlings, is not much of a problem, but the return of tags is another thing. In spite of all prohibitions, poaching will continue, and, passim, justifiably so. (A ban on commerce and surveillance of the main beaches constitute enough protection, and this nutritious food resource should not be denied to local inhabitants). Thus a tagging program can count almost only on the returns to protected beaches, the tags from poached animals (caught on other beaches) being discarded and thus biasing the results. Even so the program is indispensable.

Number of clutches

We found no evidence of two clutches in the specimens autopsied.

Biometry of the egg

The matters of egg volume and weight are here approached by starting from intra-locality clutch variability and working up to broader correlations. From the measurements and weights obtained in the field we have calculated egg volume, density and eccentricity; and projected these secondary parameters, plus egg weight proper, against measures of turtle size.

Egg volume

Vanzolini's (1977) four clutches showed marked differences in central tendency and variability of the distributions of the egg volume. The present sample of 12 clutches confirms those findings. In Table 3 the clutches are arranged geographically, and it is to be seen that the several local distributions are similar. There is the possible exception of Inda Nova, but it is impossible to say whether this is a geographic effect or due to the large size of the only female available. It should be noted that in Table 3 the classes are "10 to less than 11" and so forth, so the columns are not capped by the midpoint of the class. In the analysis we used the originally computed data, with three decimal places.

Trying to link this intra-locality variation with other recorded features of the animal, we tested graphically the regressions of mean

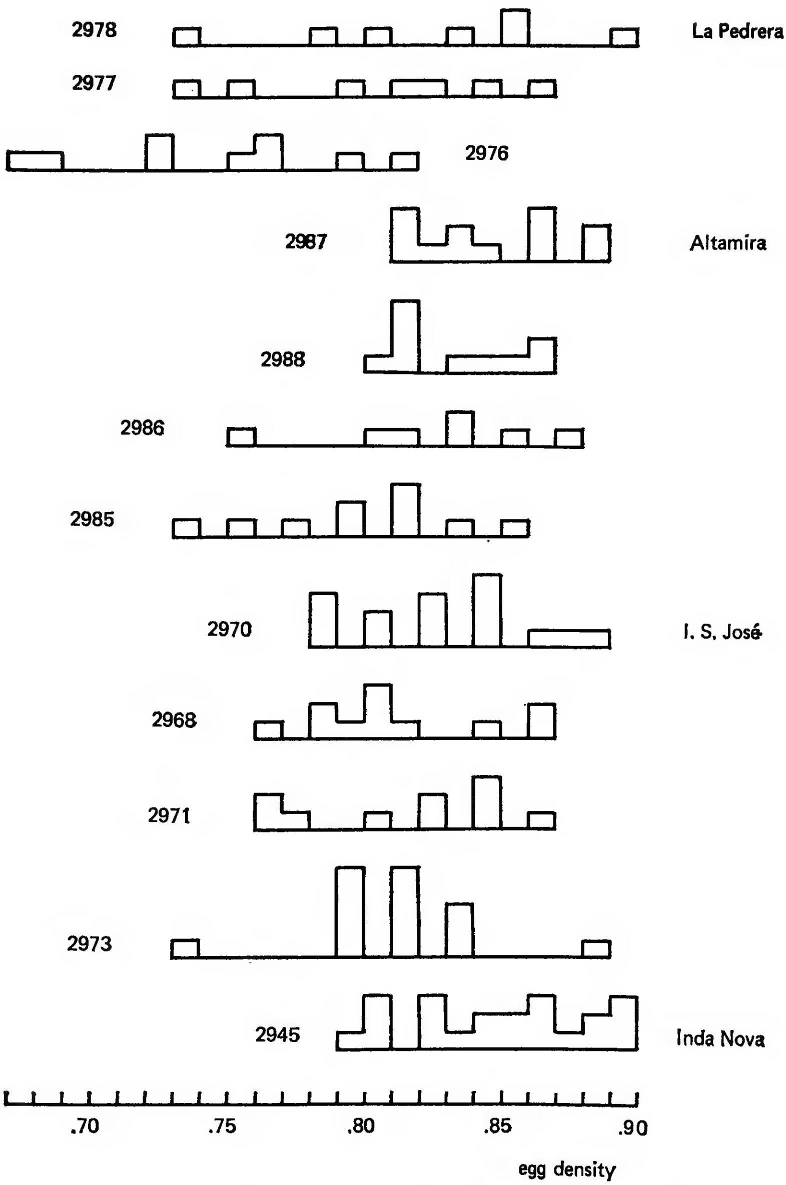
TABLE 3 — DISTRIBUTIONS OF FREQUENCIES OF THE EGG VOLUME

		Egg volume, cm3								
Locality	Specimen	10	11	12	13	14	15	16	17	18
La Pedrera	2976	2	3	4						
	2977				3	3	1			
	2978						3	2	1	1
Costa da Altamira	2988	1	6	3						
	2986			3	2	2				
	2985					2	5	3		
	2987					1	6	5		
Ilha de São José	2968		3	4	4					
	2970				1	7	4	3		
	2971					2	4	4		
	2973					2	6	3	2	
Inda Nova	2945								10	11

TABLE 4 — DISTRIBUTIONS OF FREQUENCIES OF THE EGG WEIGHT

		Egg weight, g								
Locality	Specimen	13	14	15	16	17	18	19	20	21
La Pedrera	2976			2	7					
	2977					3	4			
	2978							1	3	3
Costa da Altamira	2988	2	6	2						
	2986			1	4	2				
	2987						4	6	2	
	2985							4	6	
Ilha de São José	2968			6	5					
	2970					2	9	4		
	2971						2	5	3	
	2973						1	4	6	2
Inda Nova	2945					5	11	5		

egg volume on plastral length, on clutch size, on body weight and on naked weight. No significant patterns were found; on the contrary, the graphs are beautiful examples of random distributions, both in the "small" and in the total ranges. In the specific case of the



Graph 2. Histograms of the distributions of frequencies of egg density.

regression of mean egg volume on plastral length this confirms Vanzolini's (1977) data, based on fewer specimens.

Egg weight

The study of egg weight is strictly analogous to that of egg volume, in methods and results. From Table 4 it is evident that there is much intra-locality variation. We tried the regressions of mean egg weight on plastral length, on body weight and on naked weight, and none was found to be significant.

Egg density

Vanzolini (1977) presented data from the literature on the density of the eggs of *P. vogli* and *P. expansa*. It was seen that the density of *vogli* eggs taken from several nests constituted a coherent distribution, except for a few very light eggs, supposed to be infertile. The data for *expansa* were very meager.

The present data (Graph 2) show high intra-locality heterogeneity for the eggs of *sextuberculata,* even in the case of the Costa da Altamira specimens, caught together on the same beach and killed practically simultaneously. The averages for all samples vary from 0.74 to 0.85, much lower values than those found for *expansa* (0.98) and *vogli* (1.08). The only suspect densities are the very low ones of specimen 2976, from La Pedrera, that we do not know for how long had been in captivity before the autopsy. All other distributions seem quite reasonable. The question remains whether these are real interspecific differences or due to normal dehydration of *vogli* eggs in the nest.

We found no correlates of egg density.

Shape of the egg

Vanzolini (1977), on the basis of four clutches, noted that the shape of the egg of *sextuberculata* (represented by the eccentricity of the generating ellipse) showed variability, not correlated with egg volume or turtle size. On the other hand, in *P. unifilis* the oblateness of the egg was clearly related to its volume, i.e., increase in egg volume was achieved by progressive roundness. The egg of *P. dumeriliana,* the second largest species, has not been described, but it seems that a tendency toward spherical eggs is a size-trend in the family.

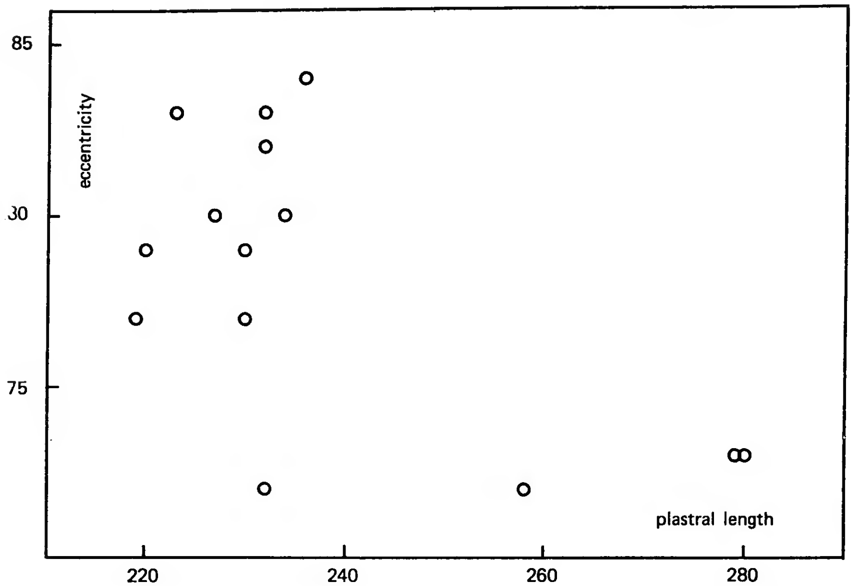
The present sample confirms the great intraspecific variability of egg shape (Table 5) and the lack of correlation between egg eccentricity and volume within clutches, as well as between mean eccentricity and mean volume. It is not quite conclusive with regard to the regression of mean egg eccentricity on plastral length (Graph 3). There would be an inverse relationship similar to that of *unifilis* if one inconvenient specimen were omitted, a seemingly usual situation in this species.

Clutch

Vanzolini (1977) found no correlation between the number of eggs (clutch size) and plastral length. The data in his Table 3 are

TABLE 5 — DISTRIBUTIONS OF FREQUENCIES OF THE ECCENTRICITY

	La Pedrera			Costa da Altamira				Ilha de São José				Inda Nova
	2978	2977	2976	2987	2988	2986	2985	2970	2968	2971	2973	2945
.65					1							1
.66					—							—
.67					—							—
.68					—							3
.69					—							—
.70				1	—							1
.71				—	—							1
.72				—	—							3
.73				—	—				1			1
.74				—	—				1			3
.75				—	—				2			1
.76				—	—	1			—			3
.77				—	—	1		2	1	3		1
.78				—	3	—		—	2	2		—
.79				4	1	1		5	2	1	1	3
.80				—	2	2		4	2	3	1	
.81		2		4	—	1	1	4		1	2	
.82	2	1	1	3	1	—	6				5	
.83	2	1	2		2	1	2				2	
.84	1	1	3				1				2	
85	2	2	2									
.86			1									



Graph. 3 Regression of egg eccentricity on plastral length.

wrong, due to a computational error, but the revised data (Table 2 of this work) confirm this conclusion.

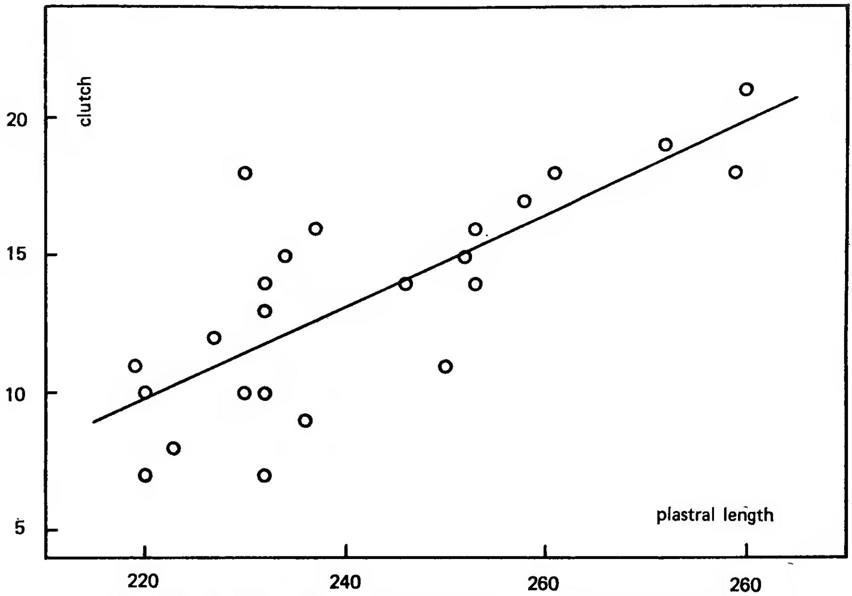
Using the same range of "small" plastral lengths as done for body weight, we find no correlation between clutch size and plastral length ($r^2 = 0.11$). Extending the analysis to all specimens available (Graph 4, Table 2) we now have a moderately good fit ($r^2 = 0.59$). These facts should be interpreted according to the concepts discussed in the section on body proportions: there is no relationship between number of eggs and turtle size within any given age class, but each individual female lays more eggs as she grows.

Taking into account that clutch size is related to plastral length, and that the intra-clutch variability of egg volume and egg weight is relatively small, one should expect dependence of clutch volume and clutch weight on the measures of general body size.

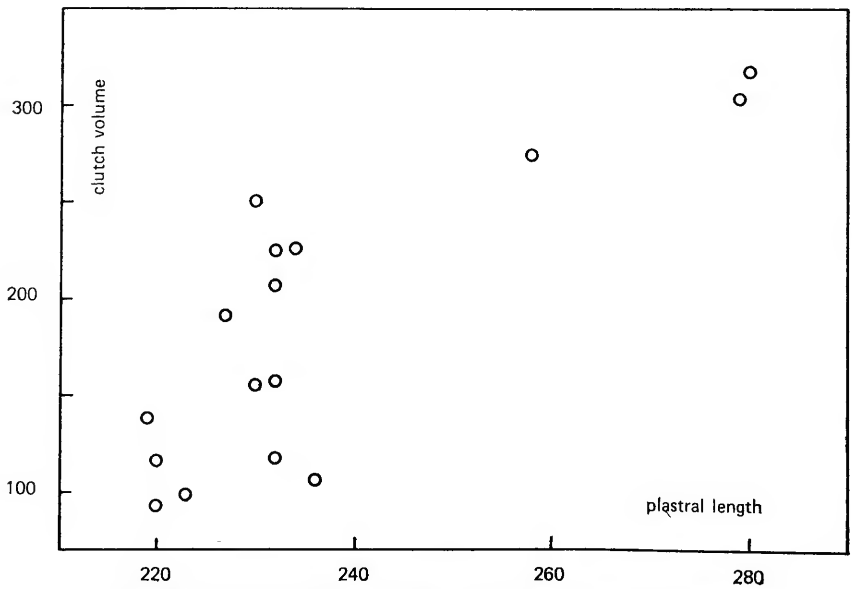
Clutch volume is indeed related to plastral length (Graph 5 and Table 2) when the whole range is taken ($r^2 = 0.65$); for the "small" group the regression is not significant. The regressions of clutch volume on body and naked weight are not significant; in fact the distributions are wildly random.

Clutch weight is dependent on plastral length and on body weight (Table 2), but not on naked weight. The respective graphs closely resemble that for clutch volume on plastral length and need not be published. All regressions within the "small" range are not significant.

The conclusion to be reached is then that the investment of female *Podocnemis sextuberculata* in the clutch is not proportional



Graph. 4. Regression of clutch size on plastral length.



Graph 5. Regression of clutch volume on plastral length.

to the individual's size within its age class, but is proportional to the average body size of the age class. Intra-class variability is vey high in all aspects investigated.

Comments

It is an interesting result of this investigation that weight-length relationships are statistically so poor. In this respect intra-age class correlations are the more relevant, and we see that the only significant regressions (body weight x plastral length and shell weight x plastral length) are the obvious ones and should have been much better. That naked weight is uncorrelated with other parameters is unexpected and should be confirmed.

Great variability was also found in the parameters of the individual eggs, volume, weight, shape and density. This variability cannot be ascribed to heterogeneity of the materials, as it is evident among females caught together and treated identically. So far we have no correlates for any of it. The case with density is particularly interesting, given the broad range of variation and the differences from data available on other species.

The data for clutch size, volume and weight seem to indicate a clear pattern, i.e., no relationship with body size within age classes, but an average increase as the animal grows. It is again impressive that no relationship with naked weight is significative.

Acknowledgements

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APPENDIX - DATA ON EGGS

ld	sd	wt
	2945	
40	26	17
41	27	18
39	27	17
37	28	17
38	26	17
40	28	19
38	28	18
40	27	18
39	27	18
40	26	18
38	28	18
40	27	18
42	26	18
39	28	18
38	28	18
38	27	18
40	26	17
42	27	19
40	27	19
42	26	19
42	26	19
	2968	
40	25	16
40	24	15
39	26	16
37	25	15
39	25	16
39	24	15
38	26	16
38	24	15
40	24	15
39	24	15
39	26	16

ld	sd	wt
	2970	
42	26	18
43	26	18
42	26	18
42	27	19
43	26	19
42	27	19
44	27	19
42	26	18
43	25	18
43	25	18
43	26	18
44	26	18
42	25	17
43	25	18
42	26	17
	2971	
41	26	19
42	27	19
43	27	20
44	26	20
42	27	19
43	26	18
43	26	20
42	26	18
43	26	19
43	27	19
	2973	
44	26	19
46	26	20
46	27	21
46	25	19
45	25	18

ld	sd	wt
46	25	19
45	27	21
44	27	19
45	26	20
45	25	20
45	26	20
45	26	20
46	26	20
	2985	
46	25	20
46	26	20
45	26	19
46	26	20
45	26	20
45	26	20
45	25	19
45	25	20
46	26	19
44	26	19
	2986	
40	24	16
39	25	15
42	25	17
43	24	16
43	25	16
40	26	17
41	25	16
	2987	
44	26	18
45	26	19
44	26	19
44	26	19

ld	sd	wt
46	26	20
44	26	18
44	27	19
44	27	20
45	26	19
42	26	18
39	28	18
43	27	19
	2988	
33	25	13
43	24	15
40	24	15
41	23	14
40	24	14
39	24	14
38	24	14
38	24	14
38	24	14
40	23	13
	2976	
40	22	15
41	23	15
43	22	16
44	23	16
43	24	16
42	24	16
42	23	16
42	23	16
	2977	
44	26	18
44	25	17
45	25	18

ld	sd	wt
44	24	18
45	24	17
45	24	18
43	25	17
	2978	
49	27	21
48	25	20
47	26	20
47	27	21
47	25	19
47	27	21
48	26	20

ld, larger diameter; sd, smaller diameter; wt, weight.