ACKNOWLEDGEMENTS

I would like to thank Professor D. M. Guthrie for providing facilities in the Department of Zoology at Manchester, Manchester University Estates Department and Mr. and Mrs. Hamilton for permission to collect on their land, Dr. J. H. Kennaugh for identifying the parasites and Dr. D. W. Yalden for his advice during this study and for reading and commenting on the manuscript.

REFERENCES

Cott, H. B. (1940). *Adaptive Colouration of Animals*. Methuen, London.

Cox, F. E. G. (1971). Parasites of British Amphibians. *Journal of Biological Education* **5**, 35-51.

Frazer. J. F. D. (1983). *Reptiles and Amphibians in Britain*. Collins, London.

Lescure. J. (1964). L'alimentation du Crapaud Commun, *Bufo bufo*. *Vie et Milieu* **15**, 757-764.

Mathias, J. H. (1971). *The Comparative Ecologies of two species of Amphibia* (B. bufo and B. calamita) *on the Ainsdale Sand Dunes National Nature Reserve*. Ph.D. Thesis, Manchester.

Mazure, T. (1966). Preliminary studies on the composition of Amphibians food. *Ekologia Polska* **14**, 309-319.

Smith, M. (1954). *The British Amphibians and Reptiles*. Collins, London.

Tatner, P. (1983). The diet of urban Magpies *Pica pica*. *Ibis* **125**, 90-107.

Wheater, C. P. (1984). *The Ecology of some surface active Coleoptera*. M.Sc. Thesis, Manchester.

Wheater, C. P. (1985). Size increase in the Common Toad (*Bufo bufo*) from Cheshire. *Herpetological Journal* **1**, 20-22.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 66-70 (1986)

MORPHOMETRY IN THE CHELID TURTLE, *PLATEMYS PLATYCEPHALA*

CARL H. ERNST* AND JEFFREY E. LOVICH†

* *Department of Biology, George Mason University, Fairfax, Virginia 22030, U.S.A.*
†*Institute of Ecology, University of Georgia, Athens, Georgia 30602 U.S.A.*

(Accepted 7.5.85)

ABSTRACT

A study of growth of the shell and its scutes was conducted on 121 *Platemys platycephala* (Testudines: Chelidae). Straight-line carapace length, width and height increase at approximately the same rate as the straight-line plastron length, and are highly correlated to plastron length. Similar trends were noted for increases in bridge length and the width of both the anterior and posterior plastral lobes in relation to plastron length. Unequal growth rates occur in the vertebral scutes which may be correlated with development of carapacial curvature. The femoral scute grows faster than the other six plastral scutes. Development of the middorsal groove, plastral concavity in males, and loss of the juvenile scute rugosities are also discussed.

INTRODUCTION

The relative growth of a part in relation to the entire organism, has been studied in various turtles. These studies have compared either changes in the mass or weight of the turtle with growth of the shell, or the growth of the shell scutes or other body parts in relation to increases in shell length. Cryptodiran turtles in the families Chelydridae (Lagler and Applegate, 1943; Mosimann and Bider, 1960), Kinosternidae (Moismann, 1956, 1958; Hulse, 1976), Emydidae (Mosimann, 1958; Jolicoeur and Mosimann, 1960; Graham, 1971; Brown, 1971; Rouault and Blanc, 1978; Meek, 1982), and Testudinidae (Grubb, 1971; Bourn and Coe, 1978; Jackson, 1978, 1980; Hirth and Abdel Latif, 1981; Meek, 1982) have been previously studied. Pritchard and Trebbau (1984) summarized what little growth data have been published on South American pleurodirans, but until now no serious study has been reported. We here report the results of such a study on the neotropical chelid turtle, *Platemys platycephala*.

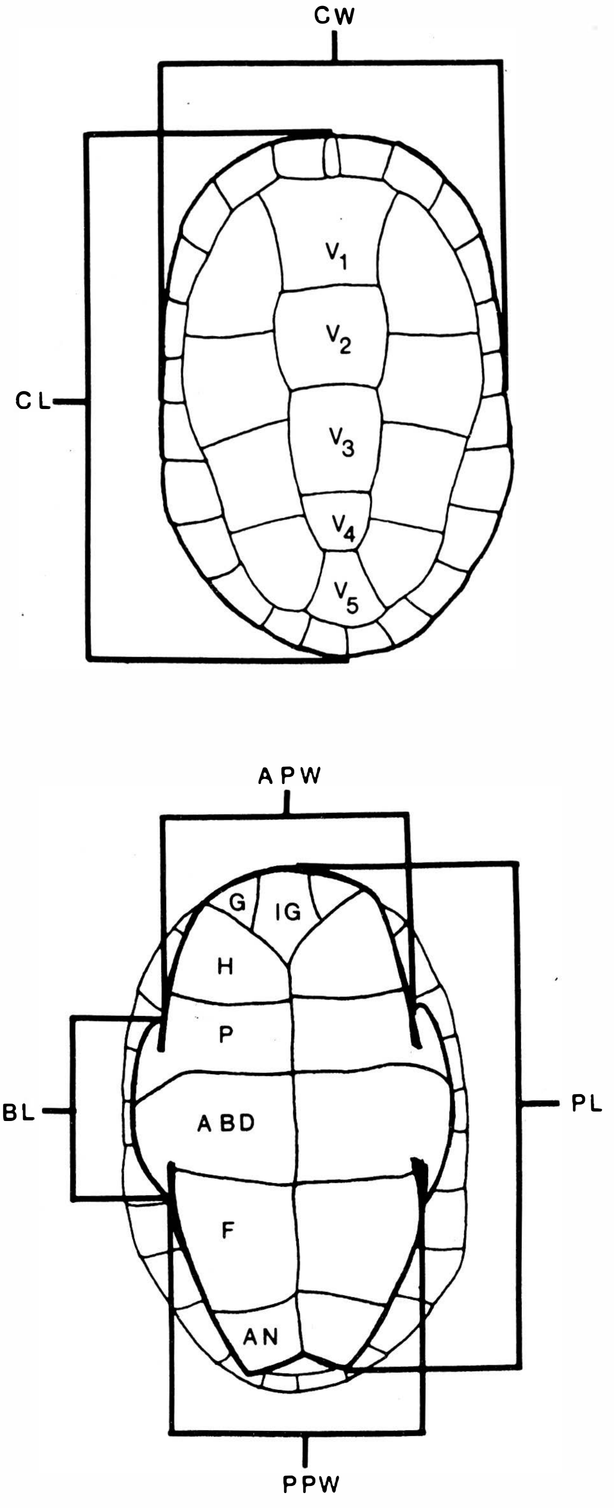

Fig. 1 Shell characteristics selected for measurement; see text for explanation of abbreviations. Carapace height (CH) is not shown, but was measured from the dorsal surface of the carapace to the ventral surface of the plastron at the level of the seam separating vertebral scutes 2 and 3. Drawings adapted from Pritchard and Trebbau (1984).

METHODS

One hundred and twenty-one preserved *Platemys platycephala* were examined (Ernst, 1984). Each specimen was sexed, and straight-line measurements were taken with dial calipers (accurate to 0.1mm) of the greatest carapace length (CL), carapace width (CW), and carapace height (CH) at the level of the seam between vertebrals 2 and 3, the greatest plastron length (PL), greatest width of the anterior plastral lobe (APW), greatest width of the posterior plastral lobe (PPW), greatest bridge length (BL), greatest width and length of all five vertebral scutes, and the medial seam length (as medial length of the intergular scute) of all plastral scutes (Fig. 1). Scute and bone designations used are those of Zangerl (1969).

All data were entered into a computer, and statistical tests and procedures, including regression analysis and correlation were performed using the Minitab computer package (Ryan, *et al*, 1982). All variables were tested and found to be normally distributed. Regression equations were calculated for best-fit using the method of least squares. In all relationships plastron length (PL) was used as the independent variable due to its relatively straight growth, as a straight-line carapace measurement includes much hidden growth masked in its curvature (Ernst, 1977). Mosimann (1956) has noted that there is no independent variable in the turtle's shell, but it is assumed, for example, that the lengths of the plastral scutes are more dependent upon the length of the plastron than the converse.

Data in several morphometric studies have been first converted to logarithms (Lagler and Applegate, 1943; Graham, 1971; Meek, 1981), but not in others (Mosimann, 1956; Brown, 1971; Hulse, 1976; Rouault and Blanc, 1978). According to Bailey (1959), if the relationship is a straight line and not curved, the use of logarithms is not necessary. Regional plots of our data clearly showed their relationships to be linear, and so logarithmic conversions were not used.

RESULTS AND DISCUSSION

Fig. 2 illustrates the relationships of growth in carapace length, width and height to plastron length. Pearson's correlation coefficients (r) for the three variables show thier growth to be highly correlated with lengthening of the plastron ($P<0.001$). As expected, the carapace had the greatest relative rate of growth, as it lengthened at almost the same rate as the plastron. *Platemys platycephala* has a flattened carapace, and this is indicated by the slightly greater growth rate in width than in height. No significant sexual difference in shell lengths occurs in *P. platycephala* (Ernst, 1984), and growth in shell proportions is almost constant, although overall growth slows with age, as it does in other turtles. The smallest juvenile examined was 46.4mm in carapace length, while the largest adult measured was 168.1mm.

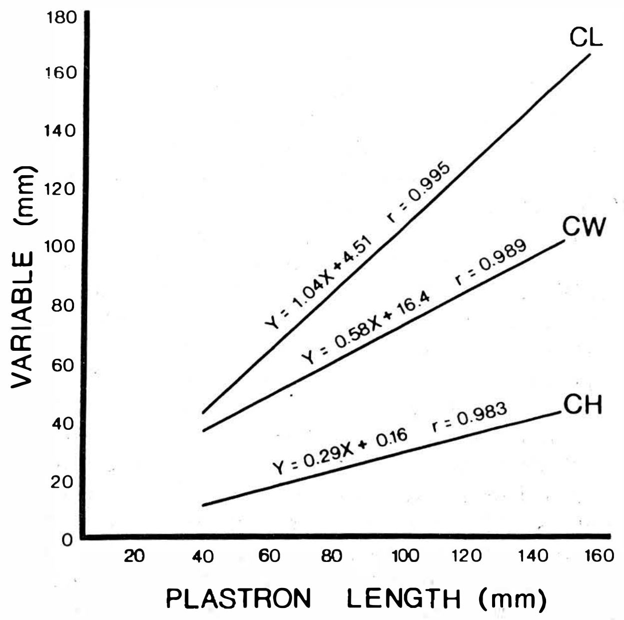

Fig. 2 Relationships of carapace length (CL), carapace width (CW), and carapace height (CH) to plastron length (PL) in *Platemys platycephala*, N = 121.

Shells of *Platemys platycephala* exhibit a well-developed middorsal groove in adults extending from the posterior portion of the first vertebral scute to the anterior portion of the fifth vertebral scute. However, this groove is poorly developed in hatchlings. As the carapace lengthens, increases in height are greatest in a pair of longtitudinal keels that lie along the dorsal portions of the pleural scutes and lateral portions of each vertebral scute and the underlying costal bones. The midportion of the five vertebral scutes does not increase in height at as fast a rate as do these keels, resulting in the lower middorsal groove. *Platemys platycephala* usually lacks neural bones, and middorsal growth is achieved by increases in width of the underlying costal bones which meet at the carapacial midline.

The vertebral scutes increase in length at different rates (Table 1). All five had a greater width to length ratio in hatchlings. The first remains broader than long throughout the life of *Platemys platycephala*, but the width to length ratio seems to increase with age. Vertebrals two to four show a steady growth in length as opposed to width; the third eventually becomes more long than it is wide (width/length <1.00). This also occurred in the fourth vertebral of 17 (25.4 per cent) of 67 *P. platycephala* over 120mm carapace length. Vertebral five showed the most variation in proportional growth; while that of most specimens remained broader than long, 12 (17.9 per cent) of 67 turtles over 120mm had this vertebral longer than broad. As in other species of turtles, the carapace of this chelid becomes slightly depressed both anteriorly and posteriorly with age and some carapacial growth is masked in the development of this curvature. Vertebrals two to four, and especially three, cover that area of the carapace not greatly involved in this progressive curvature, and perhaps their greater increases in length versus width reflect this as opposed to those of the first and fifth vertebrals which are directly involved in the curvature. It is interesting that the third vertebral should lengthen faster than the other four, since most theories on scute growth are based on the premise that all scutes grow at equal rates and retain the hatchling proportionality throughout life (Sergeev, 1937). Obviously, this is not always true.

						Vertebrals										
		One			Two			Three			Four			Five		
Carapace Length	N	L	W	W/L	L	W	Mean W/L	L	W	W/L	L	W	W/L	L	W	W/L
40 —	1	12.0	13.7	1.14	8.2	14.1	1.72	8.3	12.7	1.53	5.6	9.0	1.61	7.3	7.7	1.05
50 —	8	14.8	17.4	1.18	9.5	18.2	1.91	9.3	15.9	1.70	7.4	10.4	1.41	8.0	8.5	1.06
60 —	20	15.9	19.3	1.22	10.5	20.1	1.84	10.5	17.2	1.64	8.7	11.7	1.35	9.7	9.8	1.01
70 —	3	19.0	21.3	1.15	13.4	20.0	1.49	12.4	17.5	1.41	10.3	13.6	1.32	11.5	12.1	1.05
80 —	8	19.8	25.0	1.25	15.4	23.4	1.99	15.1	19.9	1.32	13.8	14.6	1.05	13.5	16.3	1.20
90 —	8	22.3	26.9	1.22	16.6	22.7	1.37	16.6	20.2	1.22	12.5	14.9	1.19	14.7	17.3	1.17
100 —	2	23.6	30.7	1.31	17.9	25.6	1.43	18.3	21.4	1.17	14.2	15.8	1.11	14.2	16.4	1.15
110 —	4	24.4	31.0	1.27	19.5	25.5	1.31	22.1	22.5	1.02	17.4	17.3	0.99	20.0	24.3	1.21
120 —	15	27.1	33.7	1.24	22.5	27.2	1.21	24.5	24.4	0.99	17.5	19.1	1.09	21.1	23.3	1.10
130 —	13	28.8	35.4	1.23	23.1	27.1	1.17	28.0	24.7	0.88	17.4	20.1	1.15	23.2	24.4	1.05
140 —	19	30.2	38.2	1.26	25.3	27.8	1.10	29.7	25.3	0.85	21.2	21.1	0.99	30.1	27.2	0.90
150 —	13	30.6	40.2	1.31	29.9	30.6	1.10	30.6	27.1	0.88	21.3	21.9	1.02	28.8	30.2	1.05
160 —	7	33.8	43.9	1.30	29.8	30.2	1.01	29.2	28.5	0.98	23.4	23.8	1.02	33.1	34.0	1.03

TABLE 1: Proportional changes of vertebral scutes in *Platemys platycephala*; all measurements in mm.

Upon emerging from the egg, the carapacial scutes of *P. platycephala* are covered with small rounded rugosities. These start to disappear (possibly due to abrasion) at about 100mm carapace length, but may still be present in 120mm individuals (2/12 = 16.7 per cent).

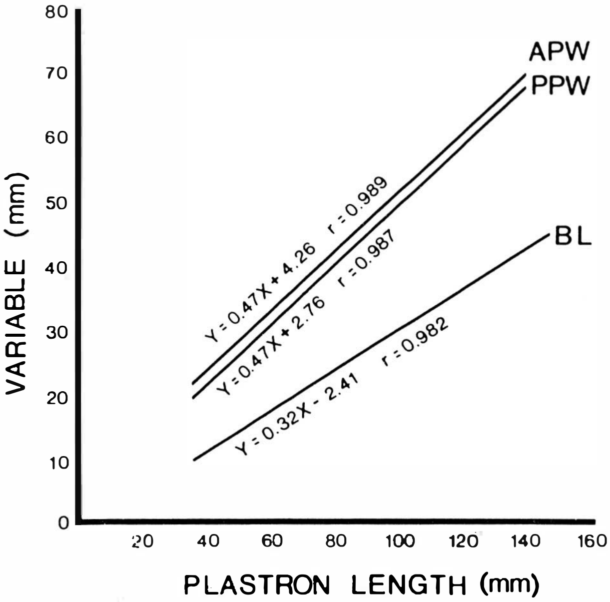

Fig. 3 Relationships of the width of the anterior plastral lobe (APW), width of the posterior plastral lobe (PPW), and bridge length (BL) to plastron length (PL) in *Platemys platycephala*, N = 121.

Fig. 3 illustrates the relationships of growth in length of the bridge, and growth in width of the anterior and posterior plastral lobes in comparison to plastron length. Growth in these three variables was highly correlated ($p<0.001$) with plastron length, and all three grew at approximately the same rate as did the plastron. This is especially true of the increases in width of the two plastral lobes, which had almost identical growth rates. In juvenile *P. platycephala*, the posterior plastral lobe is usually slightly narrower than the anterior lobe, and this relationship remains nearly constant with plastron growth. As in some other species of turtles, the anterior plastral lobe becomes slightly recurved with age in *P. platycephala.* This upturning is first noticeable in both sexes at about 115mm plastron length. Pritchard and Trebbau (1984) reported that male *P. platycephala* also have a slight but consistent difference in the shape of the posterior projections of the anal scutes, which curve dorsal in adult females.

Variable	Plastron
IGL	Y = 0.14X + 6.34 r = 0.89
GL	Y = 0.10X + 2.98 r = 0.93
HL	Y = 0.11X - 0.57 r = 0.88
PECT	Y = 0.11X - 0.29 r = 0.89
ABD	Y = 0.21X - 1.46 r = 0.97
FEM	Y = 0.22X - 3.07 r = 0.98
ANL	Y = 0.12X + 2.05 r = 0.92

TABLE 2: Relationship between plastron length and plastral scutes in *Platemys platycephala*. IGL = intergular length; GL = gular length; HL = humeral length; PECT = pectoral length; ABD = abdominal length; FEM = femoral length; ANL = anal length. Correlation coefficients are all significant ($p<0.0001$).

Plastron Length	N	Mean Length IGL	GL	HL	PECT	ABD	FEM	ANL
30 —	1	8.1	4.8	4.7	3.9	7.6	6.6	3.4
40 —	5	12.3	6.8	4.7	4.7	9.5	8.0	6.9
50 —	18	13.7	8.1	5.4	5.8	10.4	9.5	8.0
60 —	8	15.8	9.4	5.9	6.6	11.8	10.7	9.4
70 —	8	18.1	10.3	6.9	7.8	15.2	13.3	11.4
80 —	8	19.5	11.6	8.9	8.9	16.4	15.8	13.1
90 —	3	20.5	11.6	9.8	8.9	17.9	17.8	14.2
100 —	2	23.4	13.9	10.3	11.3	21.5	22.5	13.2
110 —	12	23.2	14.4	11.0	12.1	21.6	21.8	16.7
120 —	12	24.4	15.0	12.7	14.3	23.5	24.3	16.9
130 —	27	26.5	15.2	14.1	14.7	27.1	27.6	18.2
140 —	14	28.1	17.1	15.1	14.2	30.4	29.7	19.0
150 —	3	28.4	16.8	15.2	15.7	33.6	30.4	22.2

TABLE 3: Changes in length of plastral scutes in *Platemys platycephala*; all measurements in mm.

Adult male *P. platycephala* have concave plastrons, but adult females retain the flat juvenile plastron. The male concavity is first noticeable at about 114mm plastron length, and this probably indicates that male maturation occurs at a plastron length of 110-120mm.

Tables 2-3 show the changes in length of the seven plastral scutes with increasing plastron length. All increased at a relatively steady rate in comparison with plastron growth, but the femoral scute grew at a faster rate than the other six. This can best be seen by comparing its length in any size class with those of the abdominal and intergular scutes. In the smaller juvenile size classes, both the abdominal and intergular were longer than the femoral, but the femoral became longer than the abdominal in the 100-109mm size class, and it finally passed the intergular in the 130-139mm size class. Perhaps this relative lengthening of the femoral has some reproductive significance.

ACKNOWLEDGEMENTS

We thank the many persons who allowed us to borrow or examine specimens of *P. platycephala* in their care (see Ernst, 1984 for a list of specimens examined). Our special thanks go to Drs. Donald T. Gantz and John J. Miller, George Mason University, and to Dr. Barbara Nelson Young, University of Georgia, for assisting us with data analysis. Evelyn M. Ernst prepared the shell drawings, and Cathy Morice typed the manuscript.

REFERENCES

Bailey, N. T. J. (1959). *Statistical methods in biology.* London: English University Press.

Bourn, D. and Coe, M. (1978). The size, structure, and distribution of the giant tortoise population of Aldabra. *Philosophical Transactions of the Royal Society of London* B, **282,** 139-175.

Brown, W. S. (1971). Morphometrics of *Terrapene coahuila* (Chelonia: Emydidae), with comments on its evolutionary status. *Southwestern Naturalist* **15,** 171-184.

Ernst, C. H. (1977). Biological notes on the bog turtle, *Clemmys muhlenbergii. Herpetologica* **33,** 241-246.

Ernst, C. H. (1984). Geographic variation in the neotropical turtle, *Platemys platycephala. Journal of Herpetology* (1983) **17,** 345-355.

Graham, T. E. (1971). Growth rate of the red-bellied turtle, *Chrysemys rubriventris,* at Plymouth, Massachusetts. *Copeia* **1971,** 353-356.

Grubb, P. (1971). The growth, ecology and population structure of giant tortoises on Aldabra. *Philosphical Transactions of the Royal Society of London* B, **260,** 327-372.

Hirth, H. F. and Abdel Latif, E. M. (1981). Morphometrics of the spurred tortoise, *Geochelone sulcata,* in the Sudan. *Journal of Herpetology* **15,** 120-121.

Hulse, A. C. (1976). Growth and morphometrics of *Kinosternon sonoriense* (Reptilia, Testudines, Kinosternidae). *Journal of Herpetology* **10,** 341-348.

Jackson, O. F. (1978). A method of assessing the health of European and North African trotoises. *British Veterinary Zoological Society* **1978,** 25-26.

Jackson, O. F. (1980). Weight and measurement data on tortoises (*Testudo graeca* and *Testudo hermanni*) and their relationship to health. *Journal of Small Animal Practice* **21,** 409-416.

Jolicoeur, P. and Mosimann, J. E. (1960). Size and shape variation in the painted turtle, a principle component analysis. *Growth* **24,** 339-364.

Lagler, K. F. and Applegate, V. C. (1943). Relationship between the length and weight in the snapping turtle *Chelydra serpentina* Linnaeus. *American Naturalist* **77,** 476-478.

Meek, R. (1982). Allometry in chelonians. *British Journal of Herpetology* **6,** 198-199.

Mosimann, J. E. (1956). Variation and relative growth in the plastral scutes of the turtle *Kinosternon integrum* LeConte. *Miscellaneous Publications, Museum of Zoology, University of Michigan* **97,** 1-43.

Mosimann, J. E. (1958). An analysis of allometry in the chelonian shell. *Revue Canadienne de Biologie* **17,** 137-228.

Mosimann, J. E. and Bider, J. R. (1960). Variation, sexual dimorphism, and maturity in a Quebec population of the common snapping turtle, *Chelydra serpentina. Canadian Journal of Zoology* **38,** 19-38.

Pritchard, P. C. H. and Trebbau, P. (1984). *The turtles of Venezuela.* Society for the Study of Amphibians and Reptiles.

Rouault, J. and Blanc, C. P. (1978). Notes sur les reptiles de Tunisie: V. — Characteristiques biometriques de *Mauremys caspica leprosa* (Schweigger, 1812) (Reptilia: Emydidae). *Archives de Institute Pasteur,* Tunis 55, 337-357.

Ryan, T. A., Joiner, B. L. and Ryan, B. F. (1982). *Minitab reference manual.* University Park, Pennsylvania: Pennsylvania State University.

Sergeev, A. (1937). Some materials to the problem of the reptilian post-embryonic growth. *Zoology Journal, Moscow* **16,** 723-735.

Zangerl, R. (1969). The turtle shell. In *Biology of the Reptilia,* Volume I, 311-339. Gans, C., Bellairs, A. d'A. and Parsons, T. S. (Eds). London: Academic Press.