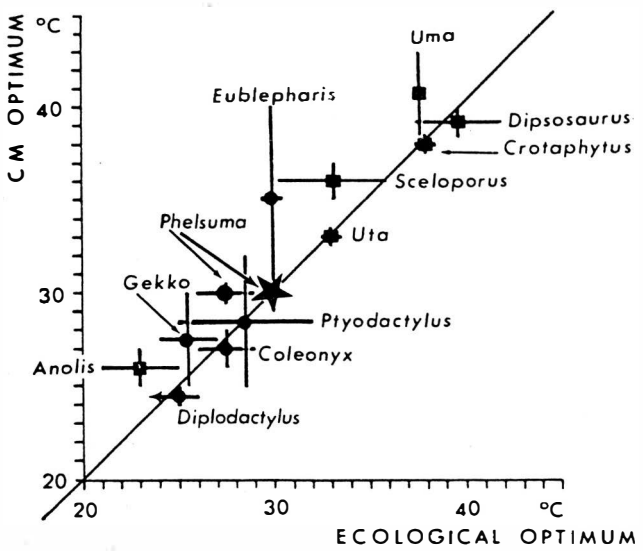

Fig. 1. The relation of the temperature optimum for the CM audiogram, to the ecological temperature optimum of the same species. Symbols (squares, iguanids; circles, gekkonids) are in the middle of respective ranges (bars); all these data from Werner (1983). Star, present correction for *Phelsuma madagascariensis*.

averages (≃ prefers) a body temperature of 29.9°C. Although admittedly both pieces of evidence are not too compelling, it does seem at present that the agreement between the two kinds of optimal temperature is even better in this case than previously thought (Fig. 1, star).

REFERENCES

Crawford, C. M. and Thorpe, R. S. (1979). Body temperatures of two geckos (*Phelsuma*) and a skink (*Mabuya*) in Praslin, Seychelles. *British Journal of Herpetology* **6**, 25-31.

Huey, R. B. (1982). Temperature, physiology, and the ecology of reptiles. In *Biology of the Reptilia*, Vol. 12, 25-91. Gans, C. and Pough, F. H. (Eds.). New York: Academic Press.

Werner, Y. L. (1972). Temperature effects on inner ear sensitivity in six species of iguanid lizards. *Journal of Herpetology* **6**, 147-177.

Werner, Y. L. (1976). Optimal temperatures for inner-ear performance in gekkonoid lizards. *The Journal of Experimental Zoology* **195**, 319-352.

Werner, Y. L. (1983). Temperature effects on cochlear function in reptiles: a personal review incorporating new data. In *Hearing and other Senses: Presentations in Honor of E. G. Wever*, 149-174. Fay, R. R. and Gourevitch, G. (Eds.). Groton: Amphora Press.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 37-39 (1985)

SHORT NOTE:

THE CALCIUM CYCLE OF FEMALE DAY-GECKOS *(PHELSUMA)*

ANDREW S. GARDNER

Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, U.K.

Present Address:
The Galton Laboratory, Department of Genetics and Biometry, University College London, Wolfson House, 4 Stephenson Way, London NW1 2HE, U.K.

(Accepted 24.10.84)

INTRODUCTION

Day-geckos of the genus *Phelsuma* Gray 1825 are widely distributed on the islands of the western Indian Ocean. Most species are diurnal, arboreal and coloured green or blue with red markings. In the granitic Seychelles, two species occur at high densities on most islands: *P. astriata* and *P. sundbergi* (Thorpe and Crawford, 1979; Gardner, 1984). During a study on *Phelsuma* evolutionary ecology in the Seychelles, several hundred specimens of both these species were examined, both during 15 months field work and subsequently in the laboratory after preservation in 70 per cent alcohol. It became apparent in the field that individual, reproductively active females pass through a calcium cycle involving the storage of calcium in the endolymphatic sacs (which are visible as whitish swellings on either side of the neck) and its subsequent deposition as egg-shell. Slightly gravid females (i.e. those with small, but externally visible oviducal eggs) almost always had large, well calcified endolymphatic sacs. Very heavily gravid females, with almost full

sized eggs, often had small sacs, as did those non-gravid females with soft, flabby abdomens, which had probably recently laid. The eggs of *Phelsuma*, as of other Gekkonine geckos, have a hard, well calcified shell with considerable ability to withstand dessication. While the calcium storage capacity of geckos endolymphatic sacs is widely appreciated (e.g. McKeown, 1984), these cyclic events have not been clearly shown in wild geckos. Reproduction of *Phelsuma* in the granitic Seychelles is both asynchronous and aseasonal (Gardner, 1984).

METHODS

Specimens were killed by thoracic injection of pentobarbitone sodium, and preserved in 70 per cent alcohol for up to two years prior to this study. The condition of the endolymphatic sacs was noted in 162 female *P. astriata* and 187 *P. sundbergi* from a range of 25 islands from the granitic Seychelles, scoring them as small (not externally visible), medium (slightly swollen) and large (considerable swellings on sides of neck). Also noted were the presence and size of externally visible oviducal eggs and the presence of a calcareous crust formed on the skin of the preserved specimen. This crust was a white or yellow deposit found particularly on the dorsal surface of the abdomen and around the vent. In addition, the stomach contents of 65 *P. astriata* and 32 *P. sundbergi*, of both sexes, from Praslin were examined, and the presence of any calcareous material was noted.

RESULTS

Table 1 gives the data on the condition of the endolymphatic sacs, oviducal eggs and the presence of a calcareous crust in the preserved specimens. The figures are generally similar for both species. In both *P. astriata* and *P. sundbergi* there was a highly significant association ($p>0.999$) between the condition of the endolymphatic sacs and the presence and size of externally visible oviducal eggs. (χ^2 4 d.f. = 25.4 *P. astriata*; 36.6 *P. sundbergi*). There was a tendency for females without externally visible oviducal eggs to have small endolymphatic sacs and for slightly gravid females to have large sacs. Heavily gravid females had small, medium or large sacs.

The development of calcareous skin crusts in the preserved specimens was strongly associated with the presence of large oviducal eggs. No non-gravid or slightly gravid females developed this crust whereas 60.7 per cent of heavily gravid *P. astriata* and 59.0 per cent of heavily gravid *P. sundbergi* did so. Moreover, amongst the heavily gravid females, there was a significant association ($p>0.999$) between the development of a skin crust and the condition of the endolymphatic sacs ($\chi^2 = 18.9$ 2 d.f. for both species pooled). A crust formed on many geckos with small or medium endolymphatic scas, but on very few specimens with large endolymphatic sacs.

On dissection, the heavily gravid females with small sacs fell into two categories. Most had developed calcareous skin deposits, and proved to have unshelled

(a) *P. astriata*

	ENDOLYMPHATIC SACS (SKIN CRUST)		
	small	medium	large
non-gravid	65 (0)	24 (0)	23 (0)
slightly gravid	2 (0)	5 (0)	15 (0)
heavily gravid	10 (9)	8 (7)	10 (1)

(b) *P. sundbergi*

	ENDOLYMPHATIC SACS (SKIN CRUST)		
non-gravid	72 (0)	36 (0)	20 (0)
slightly gravid	2 (0)	3 (0)	15 (0)
heavily gravid	24 (16)	7 (5)	8 (2)

TABLE 1. The condition of the endolymphatic sacs in preserved specimens of mature female *Phelsuma astriata* and *Phelsuma sundbergi*, together with the presence of externally visible oviducal eggs. Bracketed figures are the numbers of specimens in each category that developed a calcareous skin deposit on preservation.

oviducal eggs. Some, however had not developed skin deposits, and these were found to be carrying shelled eggs. Indeed some of these females contained a single egg, having already laid one. Heavily gravid females with large endolymphatic sacs did not develop a calcareous deposit and contained unshelled eggs.

Mineral matter was found in eleven of the stomachs examined, consisting of coral sand, land snail shells, fragments of marine mollusc shells and fragments of gecko egg-shell. The two land snails found had been eaten when dead as the shells contained sand and other debris. In ten of these cases, the gecko was an adult female, the exception being one sub-adult male containing some sand grains. All the matter found was calcareous. There was no obvious association between the presence of ingested calcareous material and the reproductive state of the gecko in this small sample.

DISCUSSION

The simplest interpretation of these observations is that individual reproductively active females pass through a calcium cycle. Females without visible oviducal eggs tend to store calcium in their endolymphatic sacs. As most slightly gravid females had large endolymphatic sacs, and some females with ingested calcareous material were not visibly gravid, most of the storage of calcium probably occurs before the eggs are visible externally. In heavily gravid females this stored calcium is mobilized from the sacs shortly before oviposition. Geckos preserved at this stage develop a calcareous deposit on the skin , and, hence, it is likely that the blood contains a large amount of calcium. The mobilized calcium is laid down as egg-shell, so that geckos with shelled eggs

have small endolymphatic sacs, and do not develop a skin deposit on preservation.

It is likely that the ingestion of calcareous material is intentional and normal in reproductively active females to replace the large amounts of calcium lost in the production of shelled eggs. Captive geckos are regularly fed cuttlefish and dietary supplements to replace their calcium, without which uncalcified, inviable eggs are produced or bone degeneration may occur (Demeter, 1976; Bloxam and Vokins, 1978; Howard, 1980). Deliberate ingestion of calcareous material by female geckos in the wild has not been previously reported, though Vinson (1975) did note the presence of coral fragments in the stomachs of two specimens of *Phelsuma guentheri* on Round Island, Mauritius. One of these was a female, but the sex of the other specimen was not given.

ACKNOWLEDGEMENTS

This study was carried out while I was the holder of a studentship from the Science Research Council at the University of Aberdeen. I wish to thank Dr. R. S. Thorpe for valuable advice and the staff of the Royal Scottish Museum for kindly allowing me the use of their research facilities.

REFERENCES

Bloxam, Q. and Vokins, M. (1978). Breeding and maintenance of *Phelsuma guentheri* (Boulenger 1885) at the Jersey Zoological Park. *Dodo. Journal of the Jersey Wildlife Preservation Trust* **15**, 82-91.

Demeter, B. J. (1976). Observations on the care, breeding and behaviour of the giant day-gecko *Phelsuma madagascariensis* at the National Zoological Park, Washington. *International Zoo Year Book* **16**, 130-133.

Gardner, A. S. (1984). The evolutionary ecology and population systematics of day-geckos (*Phelsuma*) in the Seychelles. Ph.D. thesis, University of Aberdeen.

Howard, C. J. (1980). Breeding of the flat tailed day gecko *Phelsuma laticauda* at Twycross Zoo. *International Zoo Year Book* **20**, 93-96.

McKeown, S. (1984). Captive maintenance and propagation of Indian Ocean day geckos (genus *Phelsuma*). *Bulletin of the Chicago Herpetological Society* **19**, 55-63.

Thorpe, R. S. and Crawford, C. M. (1979). The comparative abundance and resource partitioning of two green gecko species (*Phelsuma*) on Praslin, Seychelles. *British Journal of Herpetology* **6**, 19-24.

Vinson, J. M. (1975). Notes on the reptiles of Round Island. *Bulletin of the Mauritius Institute* **7**, 49-67.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 39-40 (1985)

SHORT NOTE:

GETTING INTO A PICKLE WITH PRESERVED SPECIMENS: FORMALIN AND DISTORTION IN THE SMOOTH NEWT, *TRITURUS VULGARIS*

PAUL A. VERRELL

Animal Behaviour Research Group, The Open University, Milton Keynes MK7 6AA, U.K.

(Accepted 19.11.84)

INTRODUCTION

In an interesting and highly relevant paper to herpetologists, Lee (1982) cautioned against the unguarded use of morphometric data collected from preserved specimens. In an analysis of 20 characters in the toad *Bufo marinus*, Lee found a number of significant effects of preservation when data from the 'fresh' and 'preserved' states of the same toads were compared using univariate statistics. One important point raised by Lee at the end of his paper concerned the species- and tissue- specificity of responses to a preserving fluid.

In an ongoing study of the reproductive biology of the smooth newt (*Triturus vulgaris*), I have collected and preserved several hundred specimens; but, can I be sure that the 10 per cent unbuffered formalin solution that I use for preservation does not distort the characters in which I am interested? In this report, I present data on the effects of preservation on several morphological characters which suggest little distortion when compared with the "fresh" state.

METHODS

The data presented below were derived from the analysis of 20 male and 20 female smooth newts obtained from ponds in the Oxford and Milton Keynes areas of southern England, between April 1982 and February 1984. Within one or two days of capture, the newts were sacrificed in m-aminobenzoate and scored