2:489-493.

PLUMMER, M.V. AND SHIRER, H.W. 1975. Movement patterns in a river population of the softshell turtle, *Trionyx muticus*. Mus. Natur. Hist. Univ. Kansas, Occ. Papers 43:1-26.

SAJWAJ, T.D. AND LANG, J.W. 2000. Thermal ecology of Blanding's turtle in central Minnesota. Chelonian Conservation and Biology 3:626-636.

SPOTILA, J.R., FOLEY, R.E., SCHUBAUER, J.P., SEMLITSCH, R.D., CRAWFORD, K.M., STANDORA, E.A., AND GIBBONS, J.W. 1984. Opportunistic behavioral thermoregulation of turtles, *Pseudemys scripta*, in response to microclimatology of a nuclear reactor cooling reservoir. Herpetologica 40:299-308.

STURBAUM, B.A. 1982. Minireview: Temperature regulation in turtles. Comp. Biochem. Physiol. 72A:615-620.

U.S. ENVIRONMENTAL PROTECTION AGENCY. 1979. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, OH.

WEBB, R.G. 1962. North American recent soft-shelled turtles (Family Trionychidae). Univ. Kansas, Publ. Mus. Nat. Hist. 13:429-611.

WILLIAMS, T.A. AND CHRISTIANSEN, J.L. 1981. The niches of two sympatric softshell turtles, *Trionyx muticus* and *Trionyx spiniferus*. J. Herpetology 15:303-308.

WILLIAMSON, L.U., SPOTILA, J.R., AND STANDORA, E.A. 1989. Growth, selected temperature and CTM of young snapping turtles, *Chelydra serpentina*. J. Thermal Biology 14:33-39.

Received: 30 August 1999
Reviewed: 4 February 2001
Revised and Accepted: 23 March 2001

Chelonian Conservation and Biology, 2001, 4(1):165–170

Husbandry, Behavior, and Captive Breeding of the Nama Padloper, *Homopus bergeri*, from Southwestern Namibia

ALFRED SCHLEICHER[1] AND VICTOR J.T. LOEHR[2,3]

[1]*P.O. Box 30566, Windhoek, Namibia [Fax: 264-61-243827; E-mail: kidogo.safaris@gmx.net];*
[2]*Homopus Research Foundation, Nipkowplein 24, 3402 EC IJsselstein, Netherlands [Fax: 31-20-8821392; E-mail: loehr@homopus.org; Web Site: www.homopus.org];*
[3]*Corresponding Author for Reprint Requests*

The Nama padloper (currently referred to *Homopus bergeri*) is the least known species of the southern African tortoise genus *Homopus* (Fig. 1). Published information about the species is limited to taxonomic comments and opinions (Siebenrock, 1909; Mertens, 1955; Loveridge and Williams, 1957; Greig and Burdett, 1976; Branch, 1992) and some very brief and speculative notes about the biology of the species (Müller and Schmidt, 1995; Bonin et al., 1996; Branch, 1998). To date, confusion exists about the taxonomy of this species of *Homopus*. The holotype of *H. bergeri* has been identified as *Psammobates tentorius verroxii* (Branch, 1992). Therefore, *H. bergeri* should be considered a synonym of *P. t. verroxii*, unavailable as a name for the *Homopus* species. Branch reported in 1992 that a new name for the species is in preparation.

The Nama padloper is endemic to southwestern Namibia. The known area of distribution of the species is limited to the vicinity of Aus and areas in the adjacent *Sperrgebiet* (area with restricted access due to diamond mining activities) between Aus and Lüderitz (Branch, 1998). However, this does not necessarily mean that the species does not occur elsewhere; this is a very secretive species inhabiting rocky habitat and, according to farmers in the Aus region, active only after rare thunderstorms (Müller and Schmidt, 1995; Bonin et al., 1996). The habitat is characterized as semi-desert and receives an average rainfall of between 10 and 100 mm per year, depending on the exact location, with a peak in February–June (Richter, 1983; Müller and Schmidt, 1995). Low temperatures in the area during that time of the year can cause the precipitation to fall as snow (Müller and Schmidt, 1995; J. Swiegers, *pers. comm.*). Further climatic data are shown in Fig. 2. Due to the cold Benguela Current along the coast of Namibia, much of the area is frequently subjected to nightly fog. Average maximum temperatures increase inland, due to the decreasing influence of the Benguela Current.

In 1995 a captive study was initiated, in order to gather information about the biology of the Nama padloper, and to investigate the feasibility of captive reproduction. The restricted natural range of the species emphasizes its fundamental vulnerability. Therefore, gathering information for developing sound management programs, and creating *ex situ* insurance colonies, may be considered useful.

Materials and Methods. — A group of 5 *H. bergeri* was obtained on 24 March 1995 for husbandry and breeding purposes: 3 males (initial straight carapace length [CL] 73 mm [mass 59 g], 73 mm [mass 60 g], and 88 mm [mass 80 g]) and 2 females (initial CL 95 mm [mass 146 g] and 105 mm [mass 192 g]). The tortoises had been obtained from P. Berger (Aus outdoor school) and the Namibian Ministry of Environment and Tourism,

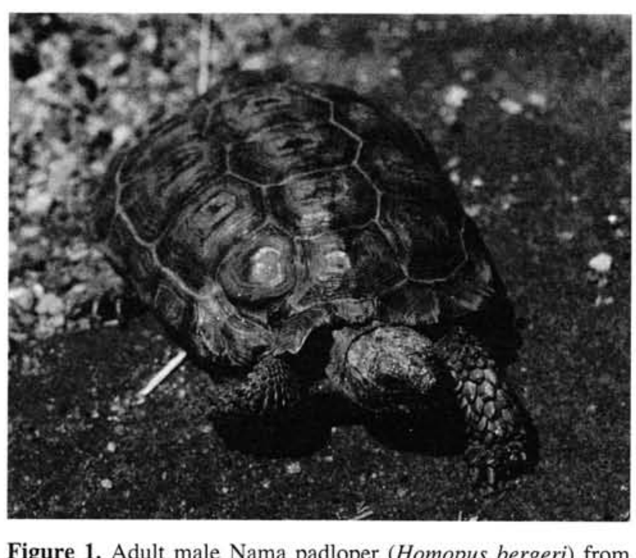

Figure 1. Adult male Nama padloper (*Homopus bergeri*) from Namibia. Photo by VJTL.

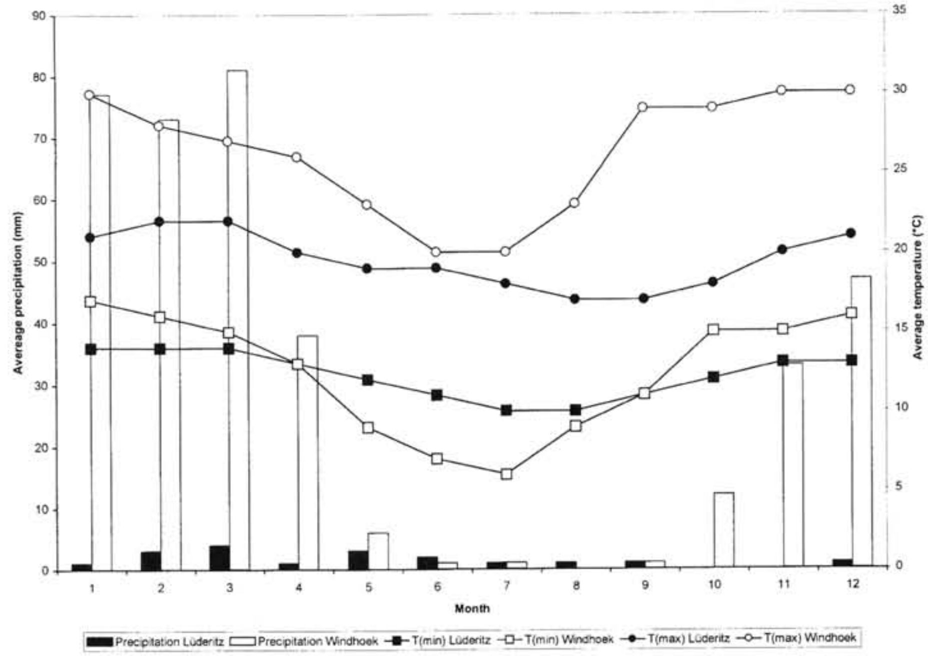

Figure 2. Monthly average maximum and minimum temperatures and precipitation in Lüderitz (natural range) and Windhoek (study site) (Richter, 1983)

and were originally collected in the direct vicinity of Aus, Namibia.

The largest male died on 28 March 1995, possibly as a result of overheating. The tortoise appeared to have been stuck between two rocks in the enclosure when found. In the beginning of September 1997, a third female (initial CL 90 mm) was obtained, and added to the existing group. At the end of September 1997 a wild-caught juvenile was added. These two specimens also originated from the Aus region. Adult specimens were occasionally measured with calipers during the study period, and weighed on a spring balance with an accuracy of 2 g.

The tortoises were released in an outdoor enclosure measuring 2.5 x 3.4 m in Windhoek, Namibia, constructed in such a way as to mimic their natural topography and habitat as much as possible. The enclosure provided both shade and sun at all times of day. Approximate air temperature and relative humidity in the enclosure were measured occasionally, by means of standard household equipment. Piles of rocks provided shelter, and 20% of the enclosure was protected against heavy rain by the wall of the adjacent house. This area of the enclosure remained dry. Plants indigenous to the natural range of the Nama padloper, such as *Aloe* spp., other succulents and grasses, were planted in the enclosure. The substrate consisted of a mixture of sand and fine gravel. The enclosure was positioned in such a way that qualitative observations on diurnal activities of the tortoises could be made from the house.

Tortoises were kept outside throughout the year, and experienced Windhoek's climatic conditions, including rains peaking earlier in the year (November–April), higher rainfall, and generally higher day temperatures compared to the Lüderitz region which is in the natural range of the species (Fig. 2). However, in order to imitate southwestern Namibia late rains, the enclosure was sprayed twice weekly, or when the hygrometer showed values below 40% relative humidity, during the Windhoek dry winter season (May–September). To ensure access to water at all times a water bowl was maintained. Also, during dry spells in summer, the enclosure was sprayed twice weekly by means of a misting system, in order to imitate the desert fog normally present in southwest Namibia.

Throughout the year, the tortoises were presented a herbivorous diet three times weekly, consisting of grasses, succulents, grape leaves, clover, small amounts of endive, lettuce, dried grasses, and flowers. Additionally, soaked chicken starter was provided (Growing Mash, Foodmaster, Windhoek, Namibia), which is composed of chopped oats, wheat, sunflower and cotton seeds, field hay, bran, maize, etc.). Food was offered in the morning (0900–1100 hrs, before sunlight reached the enclosure). Occasionally, dried fallen leaves from trees and shrubs (*Schinus terebinthifolius*, *Brunfelsia pauciflora*, *Sambucus candensis*, *Streptosolen jamesonii*, *Tecoma stans*, Vitaceae sp., and *Portulacaria afra*) in the vicinity of the enclosure were available to the tortoises, as were small quantities of maize porridge. Furthermore, five times per month cucumber, zucchini, yellow beet, and pumpkin were offered.

Within a maximum of six days after oviposition, eggs were transferred from the outdoor enclosure to a wet-type incubator (temperature fluctuating between 28–32.5°C during incubation (depending on outdoor weather conditions), relative humidity 80-90%), as described by Budde (1980). Eggs were placed in separate open plastic containers on top of dry vermiculite to optimize gas exchange. Air temperature and relative humidity were constantly measured. Incubation period was defined as the period of time between transferring eggs to the incubator and hatchlings leaving the eggs.

Table 1. Successful breeding results of captive *H. bergeri* between 1995 and 2000.

Hatchling number	Oviposition date	Hatching date	Incubation period[2]	Size hatchling (mm)	Mass hatchling (g)
1	15-07-1995	29-10-1995	106	27.0 x 27.0 x 21.0	9
2	29-05-1997[1]	18-09-1997	112	38.0 x 33.0 x 18.0	12
3	04-09-1997[1]	12-12-1997	99	40.0 x 33.0 x 18.0	12
4	28-03-1998[1]	29-06-1998	93	37.0 x 33.0 x 18.0	12
5	05-07-1998[1]	17-10-1998	104	36.0 x 31.0 x 22.0	10
6	28-09-1998[3]	12-12-1998	–	33.5 x 29.5 x 17.5	10
7	21-10-1998[1]	01-02-1999	103	37.0 x 34.0 x 19.0	14
8	10-01-1999[1]	07-04-1999	87	36.0 x 33.0 x 22.0	10
9	20-07-1999[1]	14-11-1999	117	34.5 x 26.5 x 20.5	10
10	31-08-1999[1]	21-12-1999	112	38.0 x 34.5 x 28.5	12
11	16-09-1999[4]	17-12-1999	92	38.0 x 33.0 x 22.0	12
12	24-10-1999[1]	01-02-2000	100	36.0 x 33.0 x 20.0	12
13	26-10-1999[3]	21-12-1999	–	36.0 x 32.0 x 18.0	10
14	26-10-1999[1]	06-02-2000	103	36.0 x 33.0 x 18.0	11
15	18-07-2000[1]	14-11-2000	119	41.5 x 36.0 x 21.5	12
16	05-08-2000[1]	30-11-2000	117	36.0 x 33.0 x 19.0	12
17	27-09-2000[1]	08-01-2001	103	36.0 x 33.0 x 20.0	10
18	29-09-2000[1]	02-01-2001	95	35.0 x 29.0 x 19.5	8

[1] Estimated date of oviposition (± 6 days)
[2] Incubation period defined as the number of days between oviposition (± 6 days) and the hatchling leaving the egg
[3] Egg located in enclosure > 6 days after oviposition
[4] Two egg clutch with one deformed egg

Hatchlings were transferred from the incubator when no yolk sac was discernible. They were kept individually in indoor enclosures (40 x 45 x 50 cm) on newspaper during the first two weeks. The habitat was enhanced with wood and stones, arranged so that a rock crevice was present as a hiding place. The hatchling enclosures were illuminated by two 18 Watt fluorescent lights (Osram Lumilux) and an 80 Watt spot light (Osram Concentra PAR) (with dimmer) providing a local heat source. A shallow water bowl was always present. The enclosures were misted daily. Straight carapace length of tortoises was measured monthly with calipers and mass on a spring balance with an accuracy of 2 g. Hatchlings were transferred to the outdoor enclosure of the adults for 1–2 hours per day, where they were protected within a mesh wire cage (78 x 48 x 30 cm) having several shaded sites. Diet was similar to that of the adult tortoises, although a calcium/vitamin additive (Calsup and Beefee Powder, Sanvet (Pty) Ltd., Silverton, South Africa) was added approximately once a month. When hatchlings were four to six months old (depending on season; never in winter),

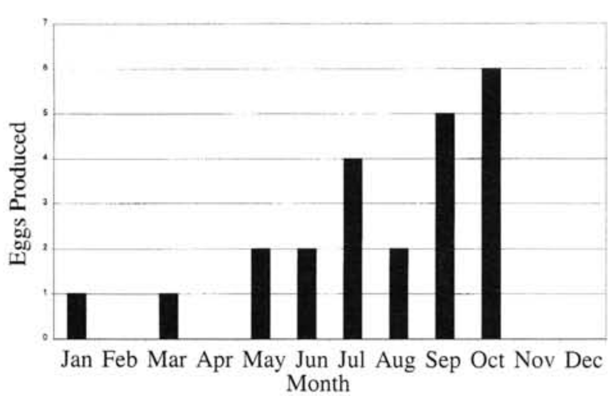

Figure 3. Oviposition by month in the captive population of the Nama padloper between June 1995 and January 2001.

they were transferred to the enclosure of the adult tortoises permanently, and received the same care. Prior to reaching sexual maturity, they were removed again to prevent inbreeding, and were housed in largely shaded outdoor enclosures, measuring 130 x 80 x 40 cm (habitat with wood and stones to form hiding places). From February 2000, all captive-bred specimens kept outdoors were housed in these enclosures, rather than in the enclosure of the adults.

Growth curves were fitted through the growth data of hatchlings with an age of 1000 or more days, and 10 or more data points, using CurveExpert 1.34 (Hyams, Starkville, USA).

Results. — It was observed that the padlopers hid in rock crevices when inactive. Tortoises fed during activity periods in the morning at feeding time, and in the late afternoon. Several tortoises (male/male and male/female assemblages) shared retreats. Fighting among males has never been noticed during permanent daytime observation of the colony. Shortly after placing the specimens in captivity, they began to feed on the prescribed diet. Straight carapace length, carapace width, and shell height of the females on 18 February 1999 were respectively 111.5 x 89.0 x 47.0 mm (mass 260 g) (female 1), 110.0 x 85.0 x 44.5 (mass 230 g) (female 2) and 96.5 x 78.5 x 41.0 mm (mass 158 g) (female 3). In summer (November–April), general activity levels were highest during cloudy days and daytime thunderstorms. In winter (end of May to mid-August) activity decreased, although the tortoises did not become completely inactive. Tortoises remained in their shelters (rock crevices) during the day, when temperatures during the night dropped below 0°C and when day temperatures did not rise above 20°C.

When the enclosure was misted in winter, in order to imitate southwestern Namibian late rains, the activity level of the tortoises increased. Despite presence of a

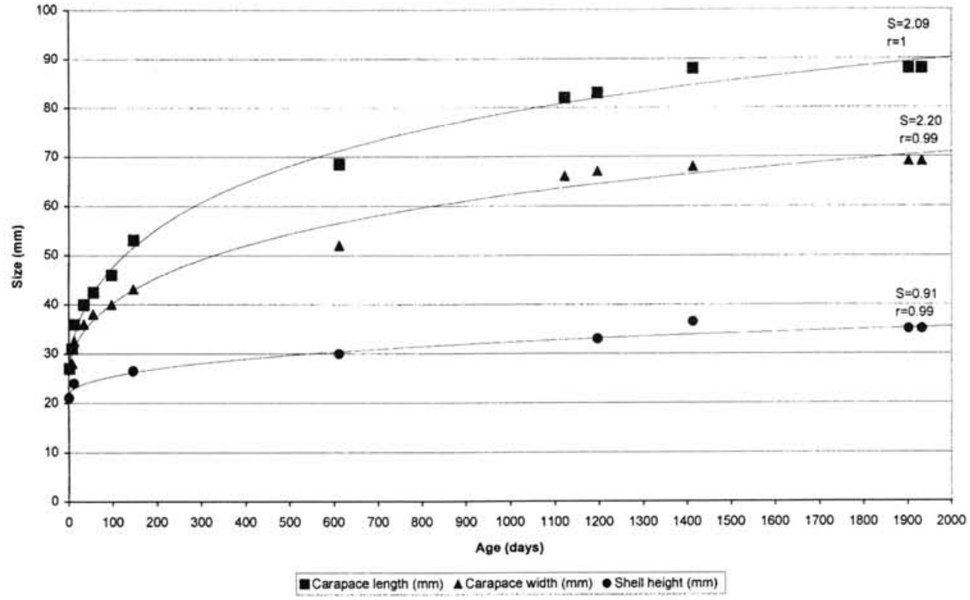

Figure 4. Size increase of the oldest captive bred Nama padloper (hatchling number 1); S = standard error, r = correlation coefficient.

water bowl in the enclosure, the tortoises also drank rain water as it collected in shallow depressions.

Immediately after the tortoises were released in the enclosure on 24 March 1995, nearly continuous mating behavior was observed during both the morning and late afternoon activity periods. Mating behavior was similar to that of *H. s. signatus* as reported by Loehr (1999), although in the Nama padlopers only head bobbing by males was observed. After a period of intense mating activity, one of the males showed signs of exhaustion and was treated with a 33% electrolyte solution (Electrona, Lagamed (Pty) Ltd., Kelvin, South Africa) by means of a stomach tube, in a dosage of 10–20 ml/kg body weight, for three times on alternate days (Gabrisch and Zwart, 1986). Throughout treatment, the male remained in the original enclosure, and continued the mating activity.

The second-largest female (female 2) was observed active under an exposed overhanging rock slab on 2 June 1995 at 1500 hrs. At 1700 hrs she was weighed and her mass was found to have decreased from 241 to 210 g. The cloaca was slightly wet. The site under the rock slab was inspected for eggs, but unfortunately the single egg that was found was broken. A few days later copulation between one of the males and the same female was observed.

On 15 July 1995 (43 days later) another abrupt weight reduction of the same female was noticed, and under the same overhanging rock slab a freshly laid single hard-shelled egg (Table 1) was discovered in a

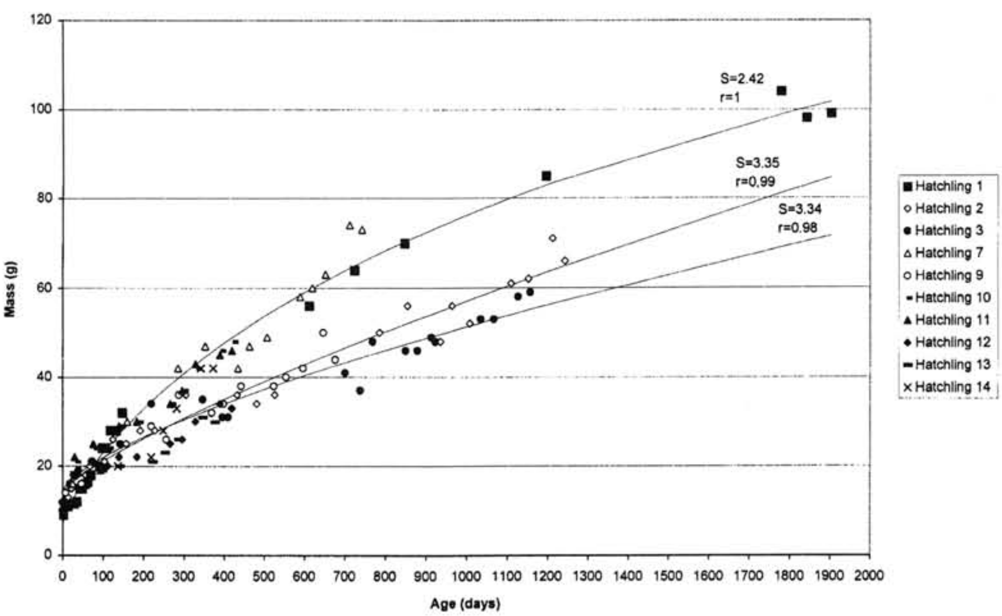

Figure 5. Mass increase and fitted curves of the three oldest captive bred Nama padlopers (hatchling numbers 1, 2 and 3); S = standard error, r = correlation coefficient.

humid nest having a diameter of approximately 9 cm. The depth of the nest was 6 cm, and the surface was covered with some dried grasses. During the time period between the nesting episodes the adult female had not been observed feeding, but drank regularly. The egg pipped in the incubator on 29 October 1995. The hatchling left the egg (retaining a small yolk sac) 106 days after oviposition, on 31 October 1995.

Additional breeding results are summarized in Table 1. Both adult females produced up to six clutches, always of only a single egg per year, with peak frequency in May–October (Fig. 3). All but one of the 24 clutches were buried at sites under overhanging rock slabs (9), in hollow rocks (7), or under small shrubs (7). The remaining egg was dropped on bare soil. Three viable eggs measured 37.0 x 26.0 mm, 41.0 x 28.0 mm, and 37.5 x 28.5 mm, all with a mass of 18 g. The egg that was deposited on bare soil and two other eggs, that remained buried in the enclosure for more than 20 days, failed to develop during incubation. Two additional embryos died of unknown causes after 9 and 7 weeks of incubation (embryo donated to National Museum of Namibia, NMWN-R-6687). Incubation period averaged 104 days (n = 16, SD = 9.6), and observed time-span between oviposition of two eggs with known oviposition dates and the hatchlings leaving the eggs were 104 and 124 days. Hatching success was 75% (18 of 24). Average hatchling straight carapace length was 36.2 mm (SD = 2.97), carapace width 32.0 mm (SD = 2.51), and shell height 20.1 mm (SD = 2.61) (n = 18). Average hatchling mass was 11.0 g (n = 18, SD = 1.46).

Growth data of the hatchlings is presented in Figs. 4 (size) and 5 (mass). Curves of the growth model $y = (ab+cx^d)/(b+x^d)$ were found to describe the growth patterns of the three oldest specimens most adequately. At age 2 yrs and 2 months (July 1997), the first courtship behavior of the oldest male (CL 68.5 mm, mass 56 g) was observed. Hatchlings 2 and 3 showed slower growth, compared to the oldest hatchling. Hatchling 4 died after 108 days, presumably from overheating, after it had become stuck between rocks in the enclosure. Also hatchlings 5 and 6 died from this cause, after 265 and 211 days. After these incidents all remaining captive-bred tortoises were transferred to the shaded outdoor enclosures in February 2000, to successfully prevent further deaths from overheating. Hatchling 9 never showed any growth, and died 466 days after hatching.

Discussion. — Highest general activity level of the captive group of Nama padlopers was observed between November–April, corresponding to the rainy (summer) season in Windhoek (Fig. 2). Precipitation in Windhoek is not the same as that in the natural range of the Nama padloper, which receives highest precipitation later in the year, extending into winter (Fig. 2). Because plant growth in the natural habitat depends heavily on the sparse rains (Walter et al., 1984), foraging activity of the species in the wild may extend into the winter season. The suggestion of *in situ* winter activity in the natural habitat is supported by the fact that in Windhoek spraying the enclosure could also induce winter activity. Average maximum winter temperatures are similar in both Windhoek and Lüderitz (Fig. 2), and can be expected to be higher (more favorable) further inland within the range of the padloper.

Branch reports that mature specimens are 100–150 mm in straight carapace length (Branch, 1998). In this study both females and males were reproductively active and successful at smaller sizes. Egg laying occurred throughout the year, although peaking in May–October, and was not confined to a limited period as in captive *H. s. signatus* (spring) (Palmer, 1994; Loehr, 1997, 1999). Year-round egg production may be characteristic of wild populations of the Nama padloper as well, but it may also have been induced by favorable environmental conditions in the enclosure throughout the year, such as relatively high (natural or artificial) precipitation and food availability.

Ovipositional behavior was remarkably similar to that of captive *H. s. signatus*, both species preferring sites protected by rock slabs (Palmer, 1994; Loehr, 1997, 1999), and it has also been noticed in captive *Malacochersus tornieri* (*pers. obs.*). In the case of *H. s. signatus* it also occurs in the wild (*pers. obs.*). These sites may conceal vulnerable females during oviposition and may protect the eggs from direct sun. A period of anorexia between two consecutive clutches has been noticed in *H. s. signatus* (Loehr, 1999), and in female 2 in the present study.

All normal clutches contained single eggs. The relatively large size of the eggs suggests that the species in the wild may also lay single eggs. The only multiple egg clutch contained two eggs, one of which was deformed in shape and reduced in size (31.5 x 25.0 mm, mass 12 g). Average incubation period was 102 days. This period is shorter than that found in eggs of captive *H. s. signatus*, incubated at a diurnal temperature cycle of 26°C (12 hrs) and 32°C (12 hrs) (116 days; Loehr, 1999), and eggs of *H. areolatus* from southern South Africa, when incubated at 26.1–27.2°C (139 days; Barzyk, 1994). The shorter period found in the Nama padloper may have been caused by incubation temperatures that were higher than average. Alternatively, a relatively short incubation period could be considered an adaptation to a habitat that provides conditions suitable for incubation only during a limited period of the year, although eggs of other southern African tortoise species (for instance *Geochelone pardalis*) are known to survive unfavorable periods, in order to hatch the following year (Boycott and Bourquin, 1988). The hatching success of the eggs (75%) was higher than recorded for captive *H. s. signatus* (67%, n = 12, Loehr, 1999).

The cause of the much slower growth of the second and third Nama padloper hatchlings is not clear. The three oldest hatchlings experienced the same season at approximately the same age (they were all born in October–December), and were housed in indoor enclosures, although experiencing different weather conditions after the age of 100 days.

Acknowledgments. — We would like to thank M. Griffin and the Ministry of Environment and Tourism in Namibia for supplying *H. bergeri* for the study and for issuing the permit (no. 29284). Also, we thank Jim Buskirk and Monika Schleicher for help preparing the manuscript. Nicolas Bayoff, Anders Rhodin, Peter Pritchard, and an anonymous reviewer are thanked for their valuable comments on the manuscript.

LITERATURE CITED

BARZYK, J.E. 1994. Husbandry and captive breeding of the parrot-beaked tortoise (*Homopus areolatus*). Chelonian Conservation and Biology 1:138-141.

BONIN, F., DEVEAUX, B. AND DUPRÉ, A. 1996. Toutes les tortues du monde. Lausanne: Delachaux et Niestlé, 254 pp.

BOYCOTT, R.C. AND BOURQUIN, O. 1988. The South African Tortoise Book, a Guide to South African Tortoises, Terrapins and Turtles. Johannesburg: Southern Book Publishers, 148 pp.

BRANCH, B.R. 1992. *Homopus 'bergeri'* - a wrong name for a new tortoise from southern Namibia. Journal of the Herpetological Association of Africa 40:11.

BRANCH, W.R. 1998. Field Guide to the Snakes and Other Reptiles of Southern Africa. Cape Town: Struik Publishers, 399 pp.

BUDDE, H. 1980. Verbesserte Brutbehälter zur Zeitigung von Schildkröten-Gelege. Salamandra 16:177-180.

GABRISCH, K. AND ZWART, P. 1986. Krankheiten der Heimtiere (Second edition). Hannover: Schlütersche Verlagsanstalt.

GREIG, J.C. AND BURDETT, P.D. 1976. Patterns in the distribution of southern African terrestrial tortoises (Cryptodira: Testudinidae). Zoologica Africana 11:249-273.

LOEHR, V.J.T. 1997. *Homopus s. signatus*, Namaqualand speckled padloper, captive breeding. African Herp News 26(July):23-24.

LOEHR, V.J.T. 1999. Husbandry, behavior, and captive breeding of the Namaqualand speckled padloper (*Homopus s. signatus*). Chelonian Conservation and Biology 3:468-473.

LOVERIDGE, A. AND WILLAMS, E.E. 1957. Revision of the African tortoises and turtles of the suborder Cryptodira. Bulletin of the Museum of Comparative Zoology 115:163-557.

MERTENS, R. 1955. Die Amphibien und Reptilien Südwestafrikas: aus den Ergebnissen einer im Jahre 1952 ausgeführten Reise. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 490:33-39.

MÜLLER, V. AND SCHMIDT, W. 1995. Landschildkröten. Münster: Natur und Tier-Verlag, 191 pp.

PALMER, M. 1994. The speckled tortoise, *Homopus signatus*, in captivity. Tortuga Gazette 30:1-5.

RICHTER, G. 1983. Handbuch Ausgewählter Klimastationen der Erde. Trier: Universität Trier.

SIEBENROCK, K.F. 1909. *Homopus bergeri* Ldh., eine *Testudo*-Art aus der *Geometrica*-Gruppe. Zoologischer Anzeiger 34:623-625.

WALTER, H., GIESS, W., SCHOLZ, H., VON SCHWIND, H., SEELY, M.K., AND WALTER, E. 1984. The Namib Desert. In: GOODALL, D.W., EVENARI, M., AND NOY-MEIR, I. (Eds.). Ecosystems of the World, Hot Deserts and Semi Arid Shrublands. V12A.

Received: 11 September 1999
Reviewed: 4 February 2001
Revised and Accepted: 20 March 2001

Chelonian Conservation and Biology, 2001, 4(1):170–172

Mycoflora Identified From Failed Green (*Chelonia mydas*) and Loggerhead (*Caretta caretta*) Sea Turtle Eggs at Heron Island, Australia

ANDREA D. PHILLOTT[1], C. JOHN PARMENTER[1], AND COLIN J. LIMPUS[2]

[1]*School of Biological and Environmental Sciences, Central Queensland University, Rockhampton, Queensland 4701, Australia [E-mail: phillota@cqu.edu.au];*
[2]*Queensland Environmental Protection Agency, P.O. Box 155, Albert Street, Brisbane, Queensland 4001, Australia*

Mortality during the early stages of sea turtle embryonic development is relatively high (Richardson and Richardson, 1982). Excavations of emerged nests indicate a significant proportion of eggs fail to hatch (Bustard, 1972; Fowler, 1979; Whitmore and Dutton, 1985) in both natural and artificial nests. This is usually attributed to beach erosion, depredation, plant root invasion, excessive rainfall, tidal inundation, pathogenic infection, and developmental abnormalities. Movement-induced mortality may occur in relocated nests (Limpus et al., 1979; Limpus, 1980; Parmenter, 1980; Blanck and Sawyer, 1981; Whitmore and Dutton, 1985). Some eggs are classified as infertile (Bustard, 1972; Fowler, 1979; Stancyk et al., 1980; Whitmore and Dutton, 1985). However, because unhatched eggs are not identified as such until after the normal incubation time has passed, early embryonic death and subsequent decomposition in the intervening time may be inappropriately interpreted as "infertility" (Parmenter, 1980; Wyneken et al., 1988). Parmenter (1980) suggested use of the term "undeveloped" to include all eggs that show no macroscopic signs of development after a full term interval. Microscopic examination of undecomposed eggs is the only process that may prove lack of embryonic development.

Excavation of emerged nests at various sea turtle rookeries often results in the detection of fungal growth on the shell exterior and in the contents of unhatched eggs. Microbes (including fungi) have been described from the exterior and/or embryonic tissue of eggs of several species of sea turtle including the loggerhead, *Caretta caretta* (Ragotzkie, 1959; McGehee, 1975; Wyneken et al., 1988; Peters et al., 1994); green, *Chelonia mydas* (Bustard and Greenham, 1968; Solomon and Baird, 1980; Whitmore and Dutton, 1985); leatherback, *Dermochelys coriacea* (Whitmore and Dutton, 1985; Solomon and Tippett, 1987; Eckert and Eckert, 1990), and olive ridley, *Lepidochelys olivacea* (Mo et al., 1990). Most observations are of "black" eggs, or those showing discolored