

Husbandry and breeding of the Red-footed tortoise

Geochelone carbonaria

at the National Zoological Park, Washington

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Geochelone carbonaria, the Red-footed tortoise, is found from Panama south to Paraguay and Brazil excluding Amazonian Peru. Habitats are predominantly savanna except in Panama where they are found in deep forests. *G. carbonaria* is distinguished from its close relative *G. denticulata* by its black to dark brown carapace with a yellow area on each carapace scute. Colour on the head and legs varies from red to yellow depending on their geographic origin (Pritchard, 1967).

BREEDING GROUP

The breeding group at the National Zoological Park consists of two ♂♂ and four ♀♀, all of which were purchased or donated between October 1972 and September 1975. The ♂♂ and one of the ♀♀ arrived as juveniles and have since attained adult size. The group at present ranges in weight from 2.3–3.9 kg with an average of 3.2 kg. The ♂♂ average 2.7 kg while the ♀♀ are larger with a 3.5 kg average. Straight line carapace lengths and widths average 26.0 cm (23.0–27.2 cm) and 15.5 cm (13.4–17.0 cm). Again ♂♂ are smaller than ♀♀ in both measurements.

HUSBANDRY

In the past five years the group has been housed in three different but similar cages, each measuring 3 × 2 × 3 m high with a glass front and screen top. Pea gravel was used as a substrate but is now being changed to larger gravel (see Feeding). A depression in the floor, 1.0 × 0.5 × 0.5 m, is filled with peat and sand (3 : 1) for egg-laying. Rocks and rock planters with plants are used as cage decorations.

Temperatures are the same as building temperatures, averaging 28°C all year round. Relative humidity is that natural for the Washington, DC, area; dry in winter and humid in summer, although slight fluctuations occur when plants

are watered or the laying area is misted. The only light source is a skylight and no artificial photoperiods are used.

Hatchlings and young are housed either off-exhibit in 60 × 60 × 20 cm metal bins or on exhibit in a 70 × 40 × 40 cm three-sided plexiglass cage which is attached to the front glass of the adults' cage. The most recent hatchlings are placed in this tank where the public can compare them with the adults.

Tortoise diets at the zoo consist of chopped oranges, bananas, apples, sweet potatoes, carrots, hard-boiled eggs, lettuce, kale and parsley in amounts that can be eaten by the six animals in 20 minutes. They are fed every Monday and Thursday. The 'salad' is supplemented with powdered Pervinal and bone meal, and on Thursday feline diet is added. Newborn mice are occasionally given and are readily devoured. We have noticed our *G. carbonaria* eating gravel, sand and faeces and Auffenberg & Weaver (1969) have reported wild tortoises eating tortoise and rabbit faeces. We have recently been forced to remove the animals from the pea gravel substrate because of excessive gravel eating. Rarely do the tortoises refuse to feed, but ♀♀ will do so occasionally when they are gravid. Beltz (1954) noted reduced feeding during egg-laying in captive *G. denticulata*. A large crock 25 cm in diameter provides drinking water.

BREEDING BEHAVIOUR

A considerable amount of activity occurs in the breeding group. This may vary from simple investigation to more complex sexual and encounter behaviours. The animals are very inquisitive and investigate everything new in the cage. Most behaviour is associated with breeding and this takes place the year round. During courtship a ♂ approaches another tortoise from the side and slowly works his way posteriorly. The cloacal region is then investigated

and apparently sniffed. If the animal is a ♀ the ♂ may mount her. During a mount both vocalisation and head movements may occur. A rhythmic pulsation of the throat of the ♂ is seen during mounting. This has also been described in *G. denticulata* (Snedigar & Rokosky, 1950) and is not necessarily associated with the production of sounds, which are made by the breathing apparatus (Auffenberg, 1977), and consist of a group of about seven notes. The first three notes are longer and lower than the last four or five which are faster and run together. While mounting there may be five or six groups vocalised in a minute, although sometimes only parts of the group are heard. Vocalisation during courtship has also been reported in other tortoises and is somewhat similar to that of *G. carbonaria* (Campbell & Evans, 1967, 1972). Mounting may occur for a few to several minutes with periods of 'rest'. Males will either continue to pursue the same ♀ or wander off to rest by themselves.

Auffenberg (1965) states that 'in these tortoises (*G. carbonaria* and *G. denticulata*) sex and species discrimination is accomplished by means of a simple two-phase behavioural pattern'. The first is visual involving head movements by the adult ♂♂ and the second the scent discrimination identifying the ♀♀. The visual aspect occurs either during breeding or a challenge. During a challenge the head is moved through a horizontal arc of 76–80° with a series of 'stops' which may vary in number. *G. denticulata* has a similar challenge but without the 'stops'. Challenges in *G. carbonaria* are always face to face and it appears that the size and colour of the head play an important role (Auffenberg, 1965; Eglis, 1962). Head movements during breeding are quite similar to those during challenge.

Another behaviour that often occurs before mounting is biting. It is believed that this forces the ♀ to withdraw her legs, making it easier for the ♂ to mount (Auffenberg, 1965, 1977; Eglis, 1962).

LAYING, EGGS AND INCUBATION

It is not known how long after copulation the ♀♀ lay the eggs. This is especially difficult to determine since courtship and copulation occur frequently throughout the year. Laying occurs from June to December with clutch sizes of four

	INFERTILE NO. %	FERTILE NO. %	HATCHED NO. %
1975	2 29	5 71	0 0
1976	22 76	7 24	2 6
1977	19 49	20 51	17 44

Table 1. Fertility and hatching success of eggs laid by Red-footed tortoises *Geochelone carbonaria* at the National Zoological Park, Washington, between 1975–1977.

or five eggs. There were no eggs before 1975 but since then more than 75 have been laid. Although 58% of these were infertile, both the total numbers and fertility have been increasing yearly (Table 1). It may be that prior to 1975, the tortoises were not sexually mature.

A particular area of the cage is used for egg deposition. The ♀♀ dig alternating their hind feet and while digging urinate in the hole. It is believed that this helps to loosen the soil and make it adhere to the 'club-like' feet for easy removal (Auffenberg & Weaver, 1969). After laying, the 8–10 cm deep hole is covered and the ♀ leaves the area. Occasionally no nest is dug and the eggs are laid on top of the soil. Usually laying is unobserved and the keepers routinely search for clutches which are removed for artificial incubation. On one occasion a nest was missed completely and baby turtles were found emerging from the site.

At a depth of 5 cm, soil temperature in the nest area varies from 25–30°C and is usually about 1–2°C cooler than the air temperature. Through trial and error, we have found a relatively successful way to hatch *G. carbonaria*. Methods such as setting the eggs on sand, sand and peat or paper towels proved unsuccessful especially with temperatures ranging from 28–31°C. In 1976 we began putting the eggs in 500 ml jars half filled with moist Baccto peat. These are placed in 38 litre aquaria with heat tapes coiled under them. The aquaria rest on thin wooden sticks and can be raised or lowered to adjust the temperature. Although the shells are more calcified than most reptile eggs, they still require some humidity and we have opened eggs that have apparently dried up and died. If the peat begins to dry out more water is added or it may be replaced with fresh moist peat. Temperatures during incubation are now maintained at

FOUND/LAID	HATCHED	INCUBATION PERIOD (days)	WEIGHT (g)	LENGTH (mm)	WIDTH (mm)
6 Jul 76	19 Dec 76	165	36.5	47.0	34.4
13 Sep 76	29 Jan 77		not recorded		
5 Jun 77	5 Jun 77		30.7	41.3	35.3
	14 Jul 77		32.8	46.0	35.1
	5 Jun 77				
16 Jul 77	5 Jun 77				
17 Aug 77	18 Jan 78	185	38.0	48.3	36.5
	19 Feb 78	185	38.4	44.6	36.4
29 Aug 77	18 Feb 78	184	37.7	44.4	36.0
	4 Feb 78	170	38.8	45.0	36.0
	17 Feb 78	172	41.5	46.9	39.7
	2 Nov 77	121	37.5	43.0	36.0
25 Nov 77	25 Mar 78	145	37.1	43.0	40.0
	21 Mar 78	141	37.5	41.5	38.0
	8 Jan 78		31.0	40.0	34.3
	5 Feb 78		36.3	44.1	39.0
	12 Dec 77	3 Mar 78		33.3	43.5
	22 Mar 78		35.4	43.8	37.4

Table 2. Incubation periods and egg sizes for 19 live hatchlings. The clutch recorded on 5 June 1977 was not discovered until the first three hatchlings began to emerge from the nest site in the adults' enclosure. The remainder were artificially incubated. Incubation periods of less than 170 days were probably for eggs which were not recovered immediately after laying. Where this was known to be the case incubation periods were not recorded.

HATCHING DATE	HATCHING			APRIL 1978			AGE (days)
	WEIGHT (g)	LENGTH (mm)	WIDTH (mm)	WEIGHT (g)	LENGTH (mm)	WIDTH (mm)	
29 Jan 77				235.0	104.0	73.0	430
5 June 77	17.8	40.0	36.7	149.5	89.0	67.2	303
	22.2	41.3	40.6	105.5	77.7	60.9	303
	23.0	48.1	38.0	114.3	82.1	60.1	303
14 Jul 77	22.6	42.7	36.5	77.7	71.4	52.1	264
8 Jan 78	21.0	39.1	32.3	45.8	58.3	46.1	86
18 Jan 78	24.0	43.0	40.6	44.9	60.2	49.3	76
4 Feb 78	26.0	44.2	42.9	48.9	61.8	51.5	60
5 Feb 78	27.3	39.1	32.3	38.8	56.5	46.3	59
17 Feb 78	24.3	42.6	37.9	36.5	55.3	45.9	45
18 Feb 78	25.1	45.2	36.1	44.5	59.0	50.0	44
19 Feb 78	26.3	44.8	38.2	41.5	57.5	49.5	43
1 Mar 78	26.6	45.6	42.0	39.2	57.3	46.5	35
3 Mar 78	21.5	42.7	38.1	27.9	49.5	41.5	33
21 Mar 78	26.3	45.5	42.8	31.5	49.5	45.8	15
22 Mar 78	26.1	45.0	38.7	28.9	49.8	42.7	14

Table 3. Weight and carapace measurements of 16 young tortoises at hatching and at 4 April 1978

26–27.5°C and hatching success has improved (Table 1). At this temperature two eggs have incubated for 185 days. Since many of the eggs are not found immediately after laying most of the incubation periods are unknown but those

found soon after ♀♀ were observed digging hatched at 170 days or more (Table 2).

All hatchlings have emerged from the eggs with a yolk sac of about 1 cm. The incubation period for *G. radiata* has been recorded as 212

days with hatchlings having a very small yolk sac (Burchfield, 1975) and 150 days with larger yolk sacs (Peters, 1969). The tortoises are left in the incubator for three to five days after hatching by which time the yolk sac has been absorbed. They are then placed in another 38 litre incubator to 'run free' for two to three days before being given their first meal. The diet is the same as for adults. After a few more days they are put in holding cages with other hatchlings.

Only two of the 19 hatchlings have died, one of which had a congenital defect. The remaining 17 are doing well. At birth hatchling weights ranged from 17.8–27.3 g with an average of 24.1 g. Straight line carapace lengths and widths averaged 43.3 mm (39.1–48.1 mm) and 38.3 mm (32.3–42.9 mm) respectively (Table 3).

PRODUCTS MENTIONED IN THE TEXT

Baccto Peat Potting Soil: manufactured by Michigan Peat, Houston, Texas 77006, USA.

Feline Diet: manufactured by Central Nebraska Packing Co., North Platte, Nebraska 69101, USA.

Pervinal Powder: vitamin/mineral supplement manufactured by St Aubrey/Division of 8 in 1 Pet Products Inc., New York 11717, USA.

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