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STATUS AND MANAGEMENT OF THE MEXICAN BOX TERRAPIN *Terrapene coahuila* AT THE JERSEY WILDLIFE PRESERVATION TRUST

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ABSTRACT: The vulnerability of the Mexican box terrapin *Terrapene coahuila* in the wild has made necessary the establishment of captive colonies that can serve as a safeguard for the species and may even provide terrapins to reinforce the natural populations through a release programme. The Jersey Wildlife Preservation Trust became involved in these efforts 10 years ago and maintains a well-established and reproducing colony. Analysis of animal records showed that the adult terrapins were active all year and could be active over the 24-hour period. Copulation occurred throughout the year and did not seem to be seasonal, although digging and oviposition were more frequent in May to August. The six founder terrapins (3.3) laid 156 eggs in 36 clutches; 86 were fertile and produced 46 individuals, 30 of them still in the collection. Six were removed to other facilities, and 10 died. Mortality was attributable to physical injuries and trauma rather than to diseases or parasites. Two terrapins hatched naturally in the exhibit. Infants developed well with good growth rates. The management regime has resulted in successful captive breeding and the techniques employed by the Trust can now be usefully implemented in Mexican scientific facilities where the species is kept. Early collaboration for *T. coahuila* conservation *in situ* is recommended.

KEY WORDS: Mexican box terrapin, *Terrapene coahuila*, captive breeding, growth and development, endemic reptile, threatened species

Introduction

The Mexican box terrapin *Terrapene coahuila* was first described by Schmidt and Owens in 1944. Mincley, in Brown (1974), reported this species, in 1969, as restricted to a semi-isolated inter-montane desert basin of about 800 km^2, just south and south-west of the Cuatrocienegas de Carranza village in the central part of Coahuila State, Mexico, where the terrapins occur principally in marshes. Milstead (1967) established that *T. coahuila* differentiated as a full species from *T. carolina putnami* in the late Pleistocene, due probably both to its isolation and to rigorous selective pressures, and Pritchard (1979) highlighted the aquatic habit of this species as a secondary, or even tertiary, adaptation, in contrast to the other members of the genus, which are entirely terrestrial.

Several field surveys on this terrapin have been conducted, principally those by Webb, Mincley and Craddock on habitats, habits and distribution (Brown, 1974).

Between 1964 and 1967, Brown (1974) conducted the first and most comprehensive field research on the ecology and reproduction of this endemic Mexican reptile. Brown's data have since been the main source of information for several attempts at breeding *T. coahuila* in captivity, and his work constitutes the major reference for field approaches.

T. coahuila has been listed as a "Vulnerable" species due to its restricted distribution and the drainage of its habitats (Groombridge, 1982). The interest and need to breed this species in captivity has grown over the last 10 years, although attempts at captive breeding were made earlier. In August 1970, an adult pair of *T. coahuila* was collected and kept at Dallas Zoo. Successful breeding was achieved when four individuals were hatched in September 1979 (Olney, 1980; Murphy and Mitchell, 1982; Tonge, 1987). Since then, a colony of this terrapin has been maintained and surplus individuals have been distributed to other facilities in order to establish more captive colonies (Murphy and Mitchell, 1982). On 20 March 1982, six individuals (3.3) from the Dallas Zoo were sent to the Gaherty Reptile Breeding Centre at the Jersey Wildlife Preservation Trust (JWPT) (Anon, 1982; Tonge, 1987), as part of the effort for sustaining captive populations as a safeguard for the species.

The purposes of the present paper are to summarise: 1) the captive management regime that has contributed to the successful breeding of *T. coahuila* at JWPT; 2) the behaviour, reproduction, development, health and other patterns shown by the terrapins in controlled conditions; and 3) the status of this species at JWPT up to February 1992.

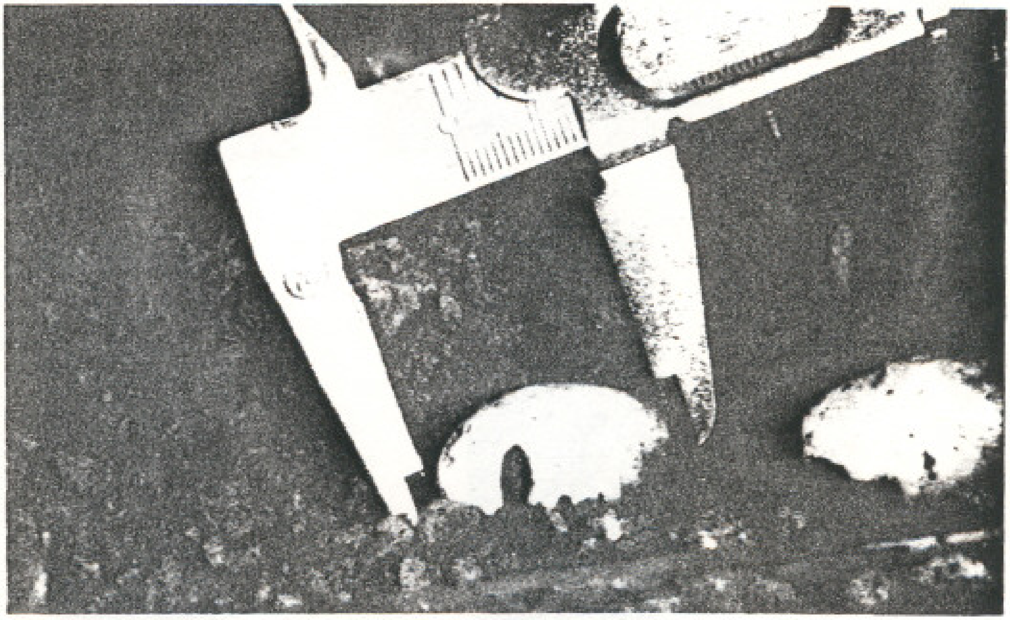

PLATE 1 — *QUENTIN BLOXAM*
Mexican box terrapin eggs *Terrapene coahuila* being measured.

The review of the JWPT's propagation efforts has become particularly necessary in relation to the possibilities for releasing surplus captive-born *T. coahuila* into the Cuatrocienegas basin, but more immediately for proper management ensuring long-term viability of this well-established captive population.

Materials and Methods

Animal Records System

The information on *T. coahuila* presented in this paper has been stored in the JWPT's Animal Records System (referred as ARS) since 11 October 1982 to date, compiled by the Curator of Reptiles, Quentin Bloxam, and the Reptile Department's Section Head, Simon Tonge, on a day-to-day basis since the arrival of the first six terrapins. The objectives and general organisation of the ARS have been described by Durrell (1964, 1974) and Hayes (1991).

A total of 438 relevant dates or entries in chronological order were registered in this system for all JWPT *T. coahuila* over 10 years.

The data required for this analysis (patterns of behaviour, reproduction, growth, health, management regime, infant rearing, etc.) were retrieved and organised for analytical treatment. Although Tonge (1987) reported the status and breeding of *T. coahuila* from 1982 to 1987, in the present paper all the individuals over a 10-year period have been reviewed.

Terrapins

Because of the large amount of data stored in the ARS, and because it was not always possible for staff to identify every single individual, especially when they were mating, digging and laying eggs (due in part because these activities occurred after working hours or in a semi-hidden position), this report deals mainly with the population as a whole, and only when it is possible, with single individuals.

The only data recorded by the authors directly from the current 36 live terrapins in the collection were carapace length, carapace width, shell height, and weights taken on 25 January 1992. Calipers and balance were used. The terrapins and their dates of acquisition are shown in Table I.

Additional data were provided by Quentin Bloxam and Simon Tonge; from personal experience both in the field and in captive collections in Mexico by Cerda; and from review of the literature.

Analytical Treatment

Computer programs were used for statistical treatment: Minitab for obtaining means, standard deviations, ranges and other, and Lotus 123 for graphs, ratios and regression analysis, especially on weight/age relationships. Means have been provided as a way to show general patterns of the captive population as well as to make predictions for future findings and management. When useful, "goodness of fit" X^2, Wilcoxon and Mann-Whitney tests were used.

Results

The characteristics and basic maintenance of the enclosure where the six founder terrapins were kept are the same as reported by Tonge (1987). The terrapins are still on exhibit (Table I) and share the enclosure with three adult Malagasy spiny-tailed lizards *Oplurus cuvieri*, which usually lie on branches and rocks. No interactions between the species have been seen.

The daily basic routine by staff starts at 08.00 hr with a general checking of enclosures and terrapins. Special attention is given to signs of nesting, eggs, mating and condition of the animals. The plants in the enclosure are then watered. Later, the pond is drained, washed and filled again so all remains of food and faeces are removed. The different ground substrates are also cleaned. If the terrapins are mating, or the females are laying or digging, the routine is not carried out to avoid disturbance, and the activities are recorded.

The terrapins received a diet consisting of dead pink mice (twice a week), crickets (once or twice a week), earthworms (once a week) and extra calcium in the form of cuttlefish bone powder (sprinkled on flat rock).

The terrapins were measured and weighed once or twice a year. None of them are marked individually. The identification of sexes in adult individuals is easy in the hand. No diseases or parasites have been detected.

TABLE I. INVENTORY OF *Terrapene coahuila* AT THE JWPT, JANUARY 1992.

Identification Number	Sex	Date of Arrival or Hatching
FOUNDERS		
R167A	Female	20/MAR/1982
R167B	Female	20/MAR/1982
R167C	Male	20/MAR/1982
R167D	Male	20/MAR/1982
R167E	Female	20/MAR/1982
R167F	Male	20/MAR/1982
JERSEY-BORN:		
R270B		27/SEP/1987
R270C		07/OCT/1987
R304B		02/AUG/1988
R304C		04/AUG/1988
R304D		10/AUG/1988
R304E		10/AUG/1988
R304F		31/AUG/1988
R304G		31/AUG/1988
R304H		11/SEP/1988
R304I		25/SEP/1988
R304J		27/SEP/1988
R304K		28/SEP/1988
R349A		01/AUG/1989
R349B		01/AUG/1989
R349C		01/AUG/1989
R349D		01/AUG/1989
R359A		28/AUG/1989
R359B		28/AUG/1987
R359C		29/AUG/1989
R358D		08/OCT/1989
R401A		09/AUG/1990
R401B		09/AUG/1990
R416A		22/OCT/1990
R416B		22/OCT/1990
R416C		22/OCT/1990
R416D		23/OCT/1990
R416A		22/OCT/1990
R416E		23/OCT/1990
R416F		26/NOV/1990
R416G		26/NOV/1990
R471		23/AUG/1991

The sex of Jersey-born animals is unknown.

Growth

On arrival in Jersey, when they were six months old, the terrapins had a mean weight of 10.6g (s.d. 3.44g). In February 1988 at 78 months old, the three females averaged 515g (s.d. 81.02g) and the three males 648.7g (s.d. 74.3g) (Tonge, 1987). In January 1992 at 125 months of age, these females had a mean weight of 543.6g (s.d. 74.1g) and the males 704.5g (s.d. 45.8g).

The mean increase of weight per individual in four years has been 28.6g (s.d. 7.41g) for females and 55.8g (s.d. 30.7g) for males, or 20.4mg/day (s.d. 5.29mg) and 39.0mg/day (s.d. 21.0mg) respectively. A general profile of growth based on weights from age 6 to 123 months is plotted in Fig. 1.

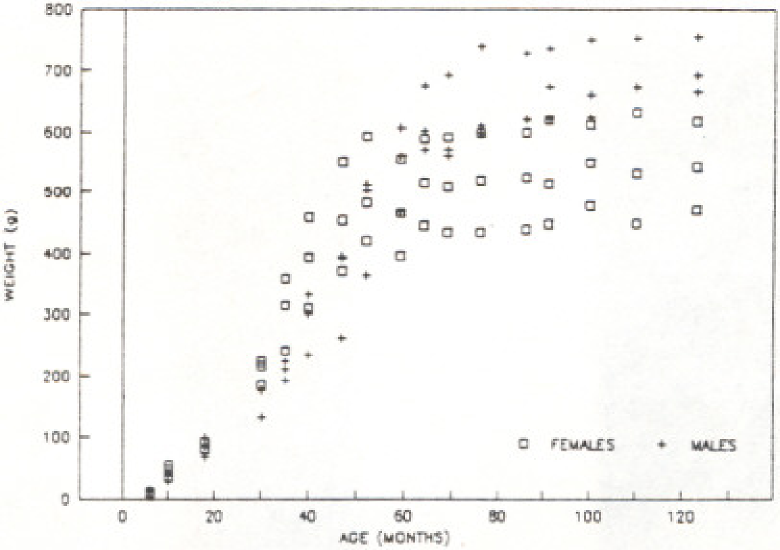

Fig. 1 General growth of six JWPT founder *Terrapene coahuila* from 1982 to 1992.

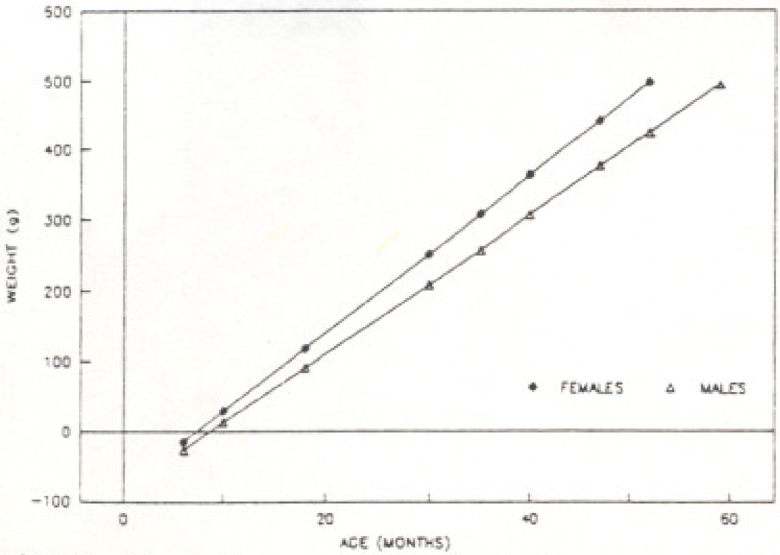

Fig. 2 Regression slopes of founder *Terrapene coahuila* from age 6 to 52 months (females) and from 6 to 59 months (males) at JWPT.

A comparison of the rates of growth of females versus males (from age 6 to 52 months for females and 6 to 59 months for males), as measured by their regression slopes (b), showed that the females grew at a significantly faster rate than males ($t = 7.21$, $df = 44$, $P < 0.001$) (Fig. 2). The males continued their growth for seven more months before reaching a higher plateau than the females. Both regressions were significant ($bf = 11.15$, $t = 15.9$, $n = 24$, $P < 0.001$; $bm = 9.82$, $t = 16.1$, $n = 26$, $P < 0.001$).

The 95% confidence limits of the regression slopes were calculated as a possible means of determining sex at an early age. However, the sample of known sex animals is small, with almost entire overlap in the 95% confidence limits of the two slopes.

From ages 59 (females) and 64 (males) to 123 months, when the terrapins were fully mature, the median values for weight (521.5g for females and 661.2g for males) were obtained. The median adult females' weight was significantly lower than that of males (Mann Whitney Test $w = 393.5$, $Nf = 26$, $Nm = 24$, $P < 0.001$). However, the extent of within-sex variation did not differ between males and females ($F = 1.31$, $P > 0.05$).

The individual adult terrapin measurements provided by Tonge (1987) have changed little in four years. Table II gives biometric data for March 1988 and January 1992. Age/linear measurement and weight/linear measurement relationships were not obtained due to the lack of an accurate data set on the five basic terrapin measurements, (carapace length (CL), width (CW) and height (CH); and plastron length (PL) and width (PW)).

TABLE II. BIOMETRIC DATA OF *Terrapene coahuila* FOUNDERS AT JWPT.

		JANUARY 1988				JANUARY 1992			
No.	Sex	CL	CW	SH	W	CL	CW	SH	W
R167A	F	125	91	62	433	128.7	96.6	64.5	470
R167B	F	142	101	72	595	145.9	103.5	75.6	618.1
R167C	M	145	107	66	598	152.5	108.7	66.5	665.7
R167D	M	152	113	69	734	153.1	112.3	67.1	692.8
R167E	F	135	99	67	517	135	100.3	75.6	242.6
R167F	M	150	108	66	614	159	114.5	73.1	755

F = Female; M = Male; CL = Carapace length (mm); CW = Carapace width (mm); SH = Shell height (mm); W = Weight (g).

The current set of adult measurements has also shown that in proportion to the sexes' size, the adult females' carapaces have grown more in height than in length and width (Percentage change – CL: m = 4.0%, f = 1.9%; CW: m = 2.5%, f = 3.3%; CH: m = 3.8%, f 7.3%). This increase in height is likely to provide more internal physical space for accommodation of eggs, but more data are required for statistical support of this difference.

Activity Patterns

1) Annual Cycle and Photoperiod

The captive Mexican box terrapins were found to be active all year. No annual changes in general activity were reported (*e.g.* definite hibernation or aestivation), although there was a seasonal rhythm to reproductive traits (copulation occurred all year but digging and oviposition occurred more during spring and summer; see Reproduction) and to food consumption (which usually decreased in the winter months). This seasonality could be related to photoperiod or temperature: the stimulus still requires investigation.

Some terrapins were recorded as "disappearing" at any time of the year (because staff "could not find the specimen"). Because of their irregularity, these disappearances were not considered signs of annual change of activity governed by photoperiod.

2) Circadian Cycle

Night: T. coahuila is active over the 24 hr period, at least in the peak of the breeding season. Numerous matings and agonistic behaviours have been observed during the morning and afternoon, whilst digging and oviposition appear to occur in hours of darkness.

Some of the terrapins' nocturnal activity patterns were studied by Divis (1989) during 40 days in June and July 1989. The females, in these months of high breeding intensity, reached their peaks of activity around 00.45 hr, approximately one hour before the males, and ceased around 06.00 to 07.00 hr.

Divis (1989) pointed out the disparity in the two sexes' activity levels: the females showed a greater variety of behaviour than males. Moreover, the females' moving behaviour alone was greater than the males' moving and pond activity combined, probably due in part to the digging and searching for nesting sites by the females.

Although both sexes were found in all the different areas, the favoured location was the gravel (Fig. 3), where the females stayed almost 70% of the time, whilst the males stayed about 40%. The males spent more time in the pond than the females (Divis, 1989).

Day: At the very beginning of their residence in the public exhibit, the terrapins tended to hide away from human presence. They were shy and used to hide in the many crevices in the rock-work, where each had its own preferred spot, or stayed in the pond (Tonge, 1987).

This wary behaviour changed. Divis (1989) reported that the females still preferred to stay in the crevices, but sometimes went under the spotlights. The males were less secretive and seen basking and sunbathing under the spotlights for long periods, or patrolling the enclosure at any time of the day. Moreover, the terrapins mated during the day: copulations have been observed 127 times from 08.00 to 11.00 hr over six years. It is not known if they also mated at night.

During January, February, March, April and June of 1988 a total of five fights between males was recorded. The fights occurred both in the pond and on land. At least two of these fights were coincident with observations of mating and patrolling activities (within a few hours). Some males were seen dominating the others and driving them out of the pond or pursuing them on land. The duration of three fights was 1 hr 40 min, 1 hr 10 min, and 10 min (in this last case, on the land, the fight continued into the pond for a few more minutes). In the fights, individuals were seen circling the opponent and lifting the rear of each other's carapace with the top of the head. Butting and biting were seen, as well as facing the rival and raising up on all four legs, then lunging and biting at each other's face, neck and forelimbs. The lunges were powerful, and the fight usually ended when one male was driven away on land or out of the water, or when he was flipped onto his side or back. These exhibitions of male aggression were recorded during the day.

The extreme carnivory of this species was observed when an unidentified individual was seen catching and eating a sick house gecko *Gehyra mutilata* one morning in January 1988. The day after, a Maria Island lizard *Cnemidophorus vanzoi* was found to have a large piece missing from its tail as a result of a terrapin bite.

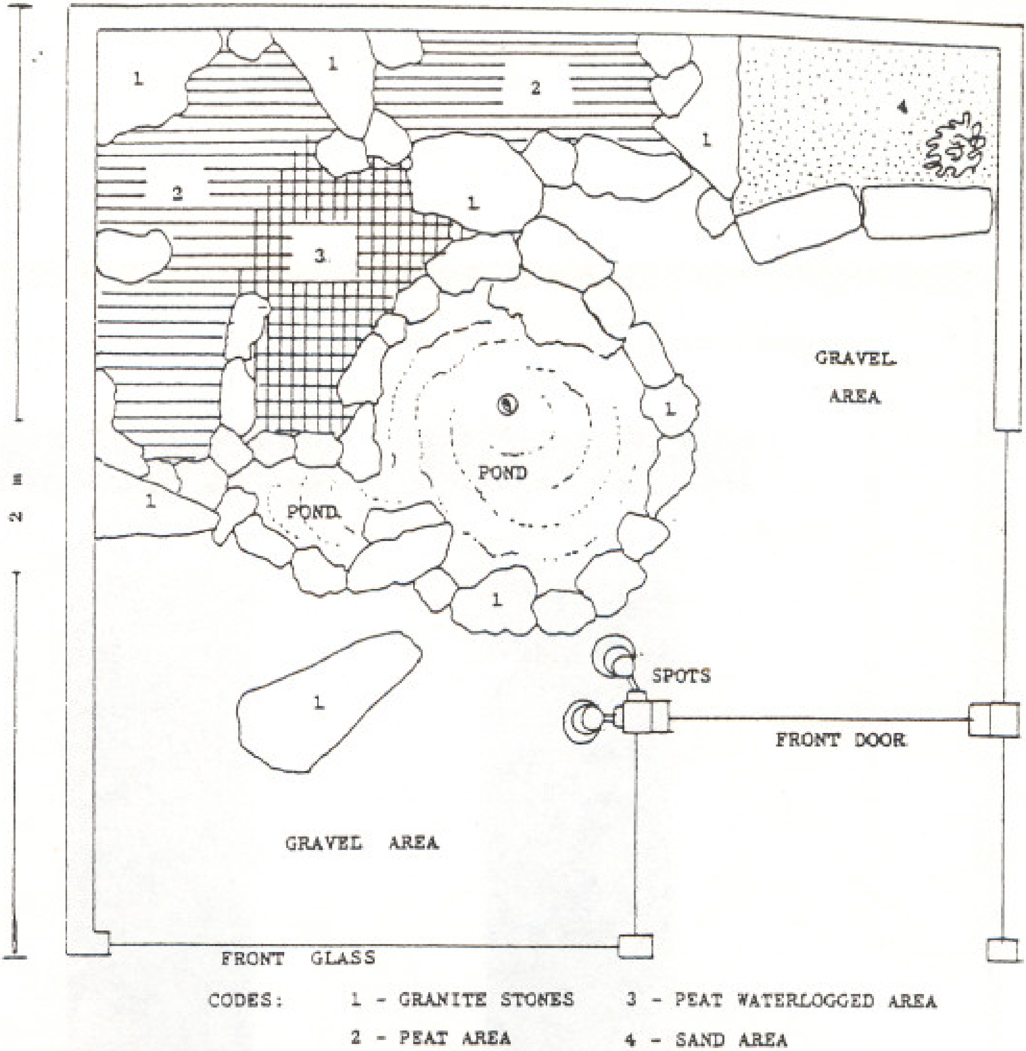

Fig. 3 Distribution of ground substrates in the *Terrapene coahuila* exhibit at JWPT.

Reproduction

1) Copulation

A total of 233 copulations was recorded from 13 March 1986 to date. The precise distribution of copulations during the six years is given in Fig. 4, and the totals per month in Fig. 5. Even though there appear to be peaks in March/April and September, this monthly distribution is not significantly different from an equal number per month (X^2 = 15.31; df =11; $P > 0.05$). All but 10 copulations (4.3%) occurred in the water. Twice (0.9%) the participants were found at the edge of the pond out of the water, and eight times (3.4%) copulation was on dry land. The mean duration of copulation from 58 observations was 61.3 min (s.d. 42.21). The terrapins copulated during all hours from 08.00 to 17.00 hr (staff working hours), but there was a preference for the morning

($X^2 = 293.67$; df = 9, $P < 0.05$). The mating behaviour observed at the JWPT is similar to that described by Brown (1974).

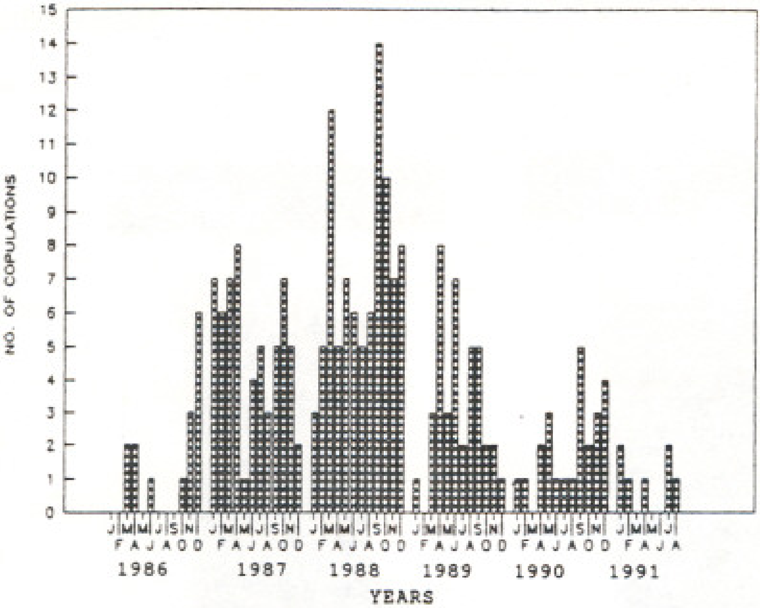

Fig. 4 Annual distribution of copulation of *Terrapene coahuila* at JWPT.

2) Digging

Approximately 50 digging events or signs were recorded. These few preliminary data show that the activity was concentrated principally from May to July (Fig. 5). Females appeared to prefer digging in hard substrates, and about 20 (40%) digging events or signs were observed in the gravel area (Fig. 3). The females dug at night. Divis (1989) recorded an average starting time shortly before midnight and a little after 01.00 hr. The duration of some observed digging events was 38–39 min. Typically, digging was carried out by the female with her back legs.

3) Oviposition

Between March 1986 and February 1992 (when the founder individuals were *c.* 4 and 10 years old respectively) a total of 36 clutches were found. Unfortunately, oviposition was not observed directly, and staff were unable to determine which clutches belonged to which female.

Clutches were laid in different substrates in the enclosure (Fig. 3). Fourteen clutches (38.9%) were found in the gravel area at the front and right sides of the enclosure. These clutches were laid on the gravel or in semi-excavated holes. Eight clutches (22.2%) were found in the sandy area in the back right corner of the enclosure. The eggs were found both in nesting holes excavated by females and on the sand. This area was particularly easy for recovering eggs because the females left marks of digging. Three clutches (8.3%) were laid on the waterlogged peat area at the back left side of the pond, and one clutch (2.8%) of three eggs was found in the pond. Ten more clutches (27.8%) were recorded as found in a "nesting hole", some with data on location.

The clutches were found between March and December during the six-year period, with a peak of oviposition in summer (June, July) and a decrease in the following months. No eggs were laid in January, February and April. This was significantly different from a random distribution ($X^2 = 16$; df = 8; $P < 0.05$) (Fig. 5).

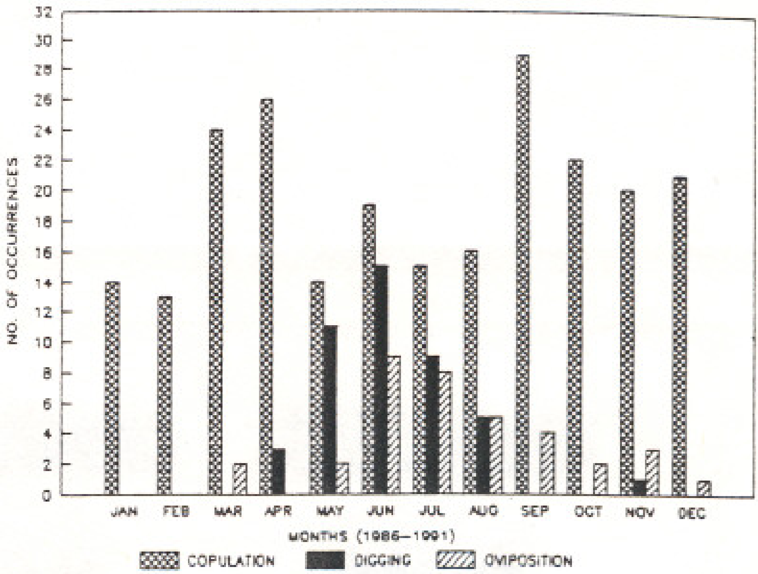

Fig. 5 Seasonal distribution of mating, digging and oviposition of *Terrapene coahuila* at JWPT, 1986–1992.

Given three females and 36 clutches, an average of 12 clutches were attributable to each female during the six years. The average number of clutches per year per female was thus 2 (1986), 1.3 (1987), 3 (1988), 1 (1989), 4 (1990) and 0.6 (1991).

4) Copulation/Oviposition Interval

As shown in Fig. 5, only copulations were registered during January and February, but from March digging activity and oviposition also occurred. This information is insufficient to estimate copulation to oviposition interval, and only accurate identification of females involved in copulation and egg laying will permit this determination. Some oviposition events were not preceded by digging activity, and the females laid eggs straight onto the substrate.

5) Eggs

From the 36 clutches, a total of 156 eggs were recovered, with a mean of 4.3 eggs per clutch (s.d. 1.57) and a median value of 4.0 (range 2–9 eggs). The average clutch sizes in different years were: 1986, 4.2 (s.d. 2.14); 1987, 3.8 (s.d. 1.29); 1988, 4.6 (s.d. 1.80); 1989, 5.0 (s.d. 0.0); 1990, 4.2 (s.d. 1.49); and 1991, 3.00 (s.d. 0.71). The frequency distribution of clutch size is shown in Fig. 6. The estimated average egg production per female per six years has been 52 eggs, or 8.7 per year.

Of the 156 eggs laid, 28 (17.9%) were discarded (because of damage), 43 (27.6%) were infertile, and 86 (55.1%) were fertile. The mean number of fertile eggs per clutch was 2.4 (s.d. 1.9), and mean infertile eggs 1.2 (s.d. 1.7), representing 55% and 27.7% of the mean clutch size, respectively (Fig. 7).

The large *T. coahuila* eggs have white or cream shells, which are brittle and easily deformed if they are carelessly handled. Most of the discarded eggs were broken or damaged due to their fragility. The measurements and weights taken from 88 eggs a few hours after laying were: mean length 30.4 mm (s.d. 3.25), mean width 19.4 mm (s.d. 3.13) and mean weight 6.43 g (s.d. 1.21).

Eighteen fertile eggs (with and without embryos) were fixed in neutral buffered formalin to be used in developmental series studies, plus two infertile eggs for reference.

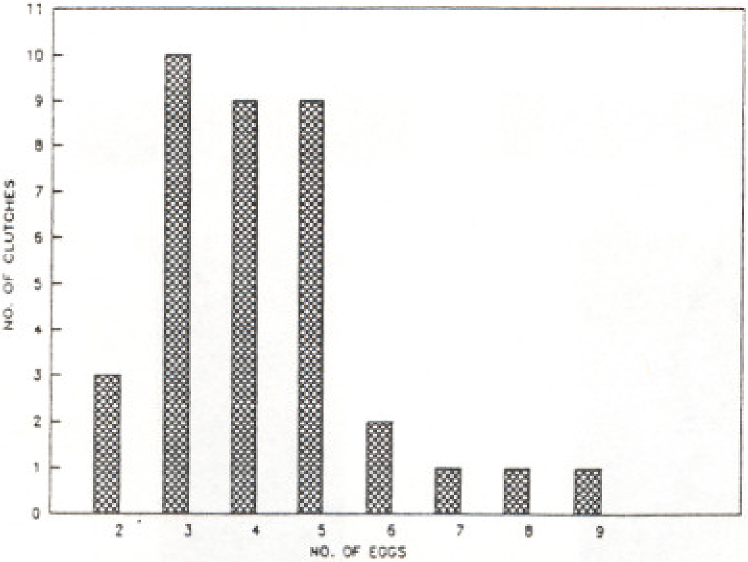

Fig. 6 Frequency distribution of clutch size of *Terrapene coahuila* at JWPT.

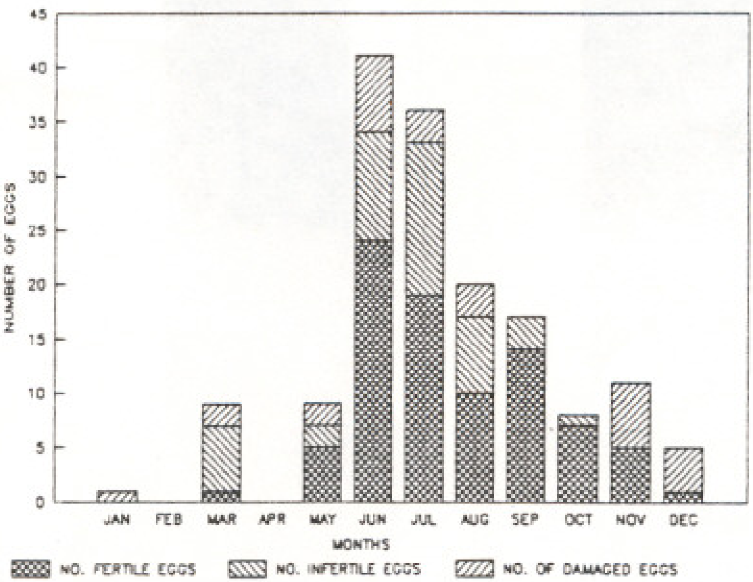

Fig. 7 Fertility/infertility of eggs of *Terrapene coahuila* at JWPT.

Infants/Juveniles

1) Incubation

Generally, as the eggs were discovered they were taken from the laying site and placed in a peat-filled plastic box with holes in the lid. The peat was moist to the touch and the eggs were buried with just a small area of the shell protruding above the substrate (Tonge, 1987). Then, they were put into an incubator and all incubated within the temperature range 29 to 31.5° C. Some eggs were candled to verify fertility and development of embryos, and those discovered to be infertile were removed, as were those that collapsed during incubation. The mean incubation period registered and calculated from 29 hatched and live specimens still in the collection was 46.3 days (s.d. 3.98).

2) Hatching

A total of 46 *T. coahuila* individuals have been hatched at JWPT, including two that hatched naturally in the exhibit. This number represents 29.5% of the total eggs produced, and 53.5% of the total fertile eggs. Of the 46, six were transferred to other facilities to establish other colonies, and 10 died. Thirty captive-born terrapins still remain in the collection (one born-in-exhibit infant is included).

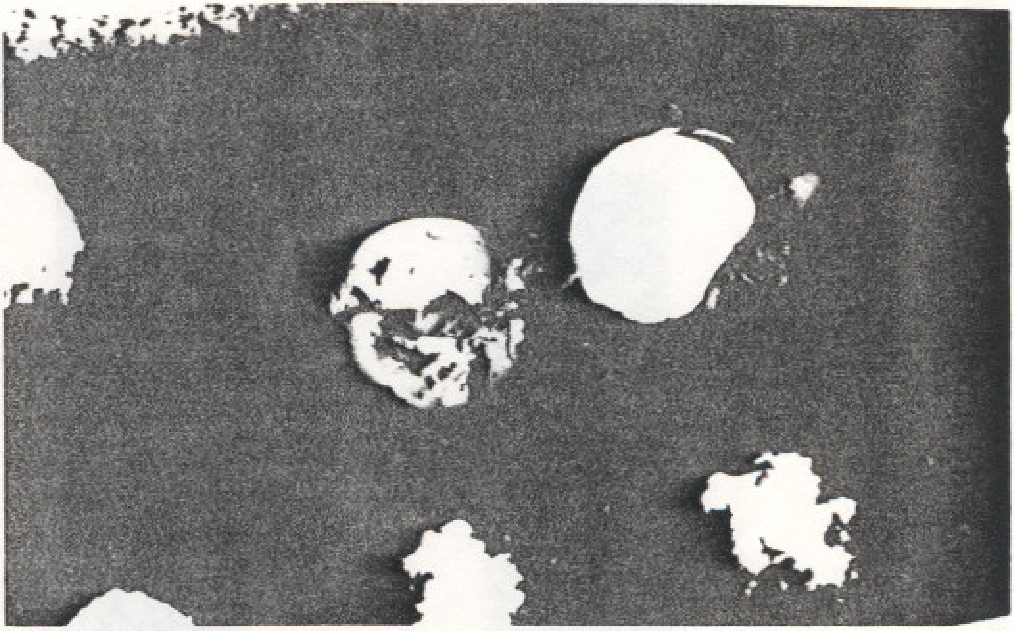

PLATE 2 QUENTIN BLOXAM
Mexican box terrapin eggs *Terrapene coahuila* hatching in the incubator.

The hatching event is preceded by the pipping and chipping of the egg shell by the infant. The period in which this occurs may vary from a few hours to one or two days. Almost all individuals hatched with a yolk sac of variable size and stayed from 1 to 4 days in the incubator until they had absorbed the yolk. The mean weight of 29 terrapins after removal from the incubator was 4.4 g (s.d. 0.73 g). On 23 August 1990 it was decided to scale down the commitment to breeding due to restricted holding facilities.

3) Management Regime

After hatching and absorption of the yolk sacs, the infants were transferred from the incubator to the rearing room, in which the temperature reaches 30° C. This room had numbered fixed tanks 90 x 40 x 20 cm height (6) and 260 x 90 x 25 cm height (2), of which the Jersey-born *T. coahuila* currently occupy five. The tanks are of semi water-proof wood covered by fibre-glass. In the central part they have plugs and joined drainage. The smaller tanks have two thirds shallow water (2.5 cm deep) with pieces of wood or stone to give refuge. The other part is covered with aquarium gravel. One of the largest tanks has two circular ponds (25 cm deep) at two levels (connected by slopes) and an area of peat. Each tank has natural plants to provide shade and a more naturalistic appearance. They also have movable spot lamps, and the temperature under these is 35 to 40° C.

The infants are shy and secretive, and are fed twice a week with chopped dead pink mice, and once a week with crickets and earthworms. Some of the individuals share the tank with other terrapin species' infants of similar body size.

4) Growth

The growth of all Jersey-born terrapins is plotted in Fig. 8. An analysis of the proportional body increase, as well as growth rates based on weights (average daily gain) are given in Table III. Evidently, they have grown at different rates, the single individual born-in-exhibit having the fastest and greatest growth rate. In general, during the first year the terrapins gained between 37 and 122 g, or from 50 to 334 mg/day, which represents a proportional increase that ranges from 863.5% to 3042.5% of the weight at birth. In the second year, their body mass increased between 64 and 81 g, or from 143 to 245 mg/day. Some individuals older than two years had reduced annual gain.

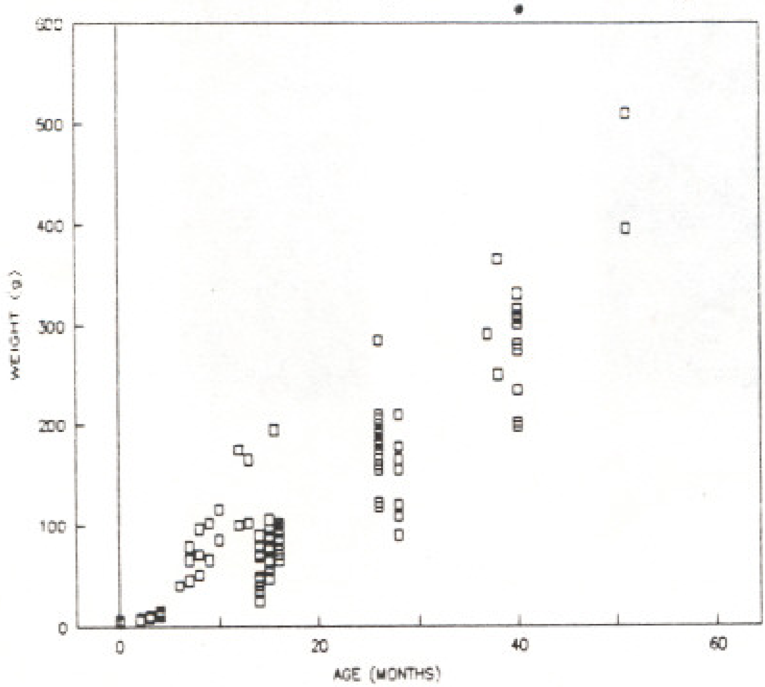

Fig. 8 Growth of Jersey-born *Terrapene coahuila*: data from 40 hatched terrapins.

Precise sex determination of the Jersey-born terrapins at an early age was not possible because of the lack of individual identification, an incomplete set of measurements, and also because of the lack of standards from the wild.

5) Mortality

Of the total of 86 fertile eggs produced, 18 (11.5%) which did not hatch showed varying embryonic development and nine collapsed naturally during incubation. Of the total of 46 hatchings, 10 (21.7%) terrapins subsequently died. The deaths were attributable to physical trauma rather than to diseases or parasites (Table IV).

TABLE III. PROPORTIONAL BODY INCREASE (% OF CHANGE) OF JERSEY-BORN INDIVIDUALS OF *Terrapene coahuila* ON THE BASIS OF WEIGHT (mg).

Ref. Number	Percentage of body change				Rate of increase mg/day	
	First Year	Second Year	Third Year	Fourth Year	First Year	Second Year
R401	863.5	—	—	—	88.0	—
R416	835.6	—	—	—	103.1	—
R359	852.3	154.4	—	—	89.2	143.9
R349	1111.9	130.3	—	—	156.2	207.2
R304	1482.2	113.9	—	—	158.8	244.2
R270	3042.5	78.0	41.5	28.9	333.4	269.2*

* Rate of increase in body mass: Third year = 254.8 mg/day.

TABLE IV. POST-HATCHING MORTALITY: AGE AND CAUSE OF DEATH IN *Terrapene coahuila* AT JWPT.

Ref. Number	Date of death	Age	Cause
R241	24/JAN/87	*c.* 6 months	Unknown
R241	01/MAR/87	*c.* 7 months	Unknown
R247	09/JUL/87	*c.* 1 year	Choked on food (earthworm)
R304A	23/JUL/88	1 day	Probably drowned
R304	15/AUG/90	*c.* 2 years	Probably drowned
R304	15/OCT/90	*c.* 2 years	Probably drowned
R304	25/JAN/92	*c.* 3 yrs 4 mths	Drowned
R416	21/OCT/90	1 day	Possible congenital problem
R416	29/APR/91	*c.* 5 months	Malnutrition

One specimen: identification and cause of death unknown.

Discussion

The main purposes of this research were to summarise the regime under which *T. coahuila* has been managed, and to document the general patterns of behaviour, activity, reproduction, growth and other aspects that the founders and the Jersey-born terrapins have shown in relation to captive conditions. The Animal Records System was the essential tool whereby these aims were achieved.

Adaption to Artificial Conditions

One of the most important results was to document the excellent adaptation of this species to the captive environment – all six founders are still alive and healthy, and the quantitative measurements of reproductive events are a positive indication of their good health status. Relevant to this adaptation however, is the fact that the Trust has made the effort to mimic the essential freshwater marsh characteristics of the terrapin's natural habitat in the captive accommodation, in addition to providing an appropriate and varied diet. That two individuals hatched naturally in the exhibit further supports the adequacy of the Trust's management of *T. coahuila*.

The founder animals reached full maturity and bred so successfully during six consecutive years, that it was decided by staff to scale down breeding of the species. This meant that the space available for this species was filled, and even temporarily exceeded, so some surplus terrapins were distributed to other facilities. Moreover, the Trust currently has surplus individuals for possible release and reinforcement of the wild population.

The Jersey-born terrapins are also well adapted in terms of their survivorship (78% of total hatchings), their pattern of development, their current state of health and their apparent strength and vigour.

PLATE 3 QUENTIN BLOXAM
Adult Mexican box terrapin *Terrapene coahuila*.

Biology and Reproduction in Captive Individuals

1) Growth

In defining the biological characteristics of the species, there is now a complete growth profile based on weight/age relationship (Fig. 1 and 2), but these data correspond to a sample of only six specimens of both sexes, limiting to some extent the general applicability of the results. However, this relationship can be the basis for future comparisons with data taken from the wild, and can be progressively supplemented with more data from captive animals. There are currently insufficient data for determining sex of individuals by growth rates on the basis of weights, or carapace and plastron linear measurements.

In the captive-bred terrapins, the differences in growth rates cannot be directly related either to the state and times at which the eggs were taken for incubation or to the infants' food consumption. Some eggs presented dimples when found and others probably had several days in the exhibit before being found. Since at least one specimen died of malnutrition, and because considerable food competition between the juvenile terrapins has been observed, it remains a possibility that food consumption has differed between the individuals, with resulting varying growth rates. This possible confounding effect between food consumption and sex requires more data on body measurements and food intake for resolution.

As stated above, one terrapin hatched naturally and it had the greatest growing rate. The success of this individual could be tested by attempting future natural incubation in the adult exhibits and also by investigating if the conditions of incubation (temperature and humidity) determine sex as in other closely-related species.

2) Activity

A more complete profile of diurnal (territoriality, copulation, basking) and nocturnal (digging, oviposition) activity patterns is now available. Brown (1974) made a partial report of the terrapins' diurnal activity and just a brief reference to the nocturnal. He cited other authors' records of the inactivity of this species after dark. Divis (1989) recorded the intense nocturnal activity of the species, at least in the most important reproductive months. Almost all the digging and oviposition events by the females were in hours of darkness, with statistically significant differences between females (temporarily marked for his study) in occupation of particular locations. Divis (1989) noted that once a female had laid eggs, she moved and thus no longer occupied an apparently prime egg-laying location. This change of location helped "show the contrast between a female which is in the process of egg laying and one that has probably finished". This statement is especially important when relating particular females to particular clutches. Thus, from the point of view of improved genetic management, more intensive monitoring (for example, using video) might enable staff to relate the finding of a clutch to individually marked female occupancy of the same location, even if the digging and oviposition events themselves were not directly observed.

3) Reproduction

Copulation has been frequently observed, but inter-individual comparison of frequencies was not possible due to identification difficulties. The activity involved in copulation can be now described, but a comprehensive sequence of courtship has yet to be defined. The reduced frequency of copulation in 1990 (24) and 1991 (7) is an artifact of diminished recording effort and probably not a real decline in this behaviour. The lack of an estimate of copulation to digging/oviposition intervals, due again to difficulties of individual identification, is currently a hindrance to determining the exact gestation period, the existence or not of delayed fertilisation, or even the laying of multiple clutches. It is of major interest to compare these, as well as clutch size and fertility, of individual captive females to individual females in the wild, especially with regard to possible reintroduction of captive-bred *T. coahuila*.

Oviposition was concentrated in the spring and summer months, and from the individual means (of eggs recovered from the exhibit) per month, it is probable that two or three females laid eggs in 1986; one or two in 1987; three in 1988; one in 1989, three in 1990, and one or two in 1991. In concordance with Divis (1989), these assumptions are made on the basis of the females' general activity.

The average egg production per female per year during the six years was 8.6, more than the 6.6 reported by Tonge (1987). The hatch rate was also greater: 53.6% and 17.5% respectively from the total number of fertile eggs. Thus, attempts to increase the females' fertility were successful, and management of eggs has improved since Tonge pointed out that "incorrect temperature or humidity during incubation or an inadequate adult diet are potential reasons" for the previous poor rate of hatching (Tonge, 1987).

Of the three different substrates in the adults' exhibit, the females preferred to locate nest sites in hard substrates. This might have an adaptive significance in the wild, possibly for protection of eggs against predators. However, in the case of eggs laid in the soft sandy substrates, subsequent development and hatching were good and more research on the effect of different substrates is recommended.

In terms of the *T. coahuila* breeding and development reported in this study, the Trust has provided the essential requirements for this species in captivity and is now in a position to conduct more complete and long term studies on behaviour, physiology and other aspects rather than just those of husbandry and maintenance. The well-established colony at the Gaherty Reptile Breeding Centre could contribute to the conservation of the species in the wild by releasing individuals currently considered as surplus and those that can be produced in the short term as a second generation. Particularly, the Trust can encourage other zoological collections to maintain *T. coahuila* for long-term viability of a captive population, and support a demographic and up-to-date field survey in the Cuatrocienegas basin, plus a Population and Habitat Viability Analysis, in line with IUCN guidelines (Stubbs, 1987), in order to establish the basis for the long-term conservation of *T. coahuila* in the wild.

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