Breeding the Galapagos Tortoise—Success Story

By Charles E. Shaw

The Curator of Reptiles at the San Diego Zoo describes a successful captive breeding programme—after a difficult start—with a highly endangered species. By the beginning of this century the huge slaughter of Galapagos tortoises, mostly by sailors in need of fresh meat on board ship, had dangerously reduced their numbers, and the destruction has been continued since by the predators introduced by settlers and visitors—rats, cats, dogs and pigs which preyed on the eggs and young, and goats which competed with the tortoises for food. The first successful hatching of tortoises at San Diego Zoo took place in October, 1958, but fertility is very low, and the author concludes that the tortoises have never reproduced in substantial numbers because, for various reasons, they do not need to do so, and that they are probably incapable of doing so.

ABOUT the beginning of the present century, many interested enough to care despaired over the decline of the Galapagos tortoise. The once teeming numbers of tortoises, whose name in Spanish, *galapago,* has been given to the archipelago, had dwindled alarmingly. From the 17th century into the 19th, buccaneers and whalers, as well as the ships of several navies of the world, made inroads into what appeared to be the inexhaustible tortoise populations of the several islands. In the days before refrigeration and tinned goods such a source of fresh meat was highly desirable for seafarers. Van Denburgh (1914) quotes Captain Benjamin Morrell, who was in the Galapagos in 1823 and again in 1825 and stated: "I have known whale ships to take from six to nine hundred of the smallest size of these tortoises on board when leaving the islands for their cruising grounds; thus providing themselves with provisions for six or eight months, and securing men against scurvy. They have been known to live on board some of our whaleships for 14 months under similar circumstances, without apparent diminution of health or weight." According to another captain, the tortoises could be stowed alive without the necessity of food and water for as long as 21 months before slaughter. C. H. Townsend (1926) examined the logbooks of seventy-nine New Bedford, Nantucket and Salem whalers, admittedly a comparatively small fraction of the total number of vessels to visit the Galapagos. These ships made 151 visits to the islands, and took a recorded total of 10,373 tortoises. Estimates of the total number of tortoises taken from the islands during the heyday of their exploita-

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tion as food for seafarers run as high as ten million.

In retrospect, it is possible that these early human predations had an even more serious long-term effect on the reproductive potential of the tortoises than might be caused by the simple random removal of specimens from the islands. There is a pronounced sexual difference in size, the males being much larger and heavier than the females in most if not all the island races, which once numbered fifteen. It would be logical to assume that, because of the rugged volcanic terrain of the tortoises' oceanic island habitat, and the consequent difficulty in traversing it in most instances, the majority of tortoises taken for food by the early voyagers were either immature individuals or females, as these weighed less and were therefore more easily handled. An exception to the difficulty of obtaining tortoises of a convenient size, and no doubt a seasonal one, is noted by Captain (later Admiral) David Porter, United States Navy, who visited James Bay, James Island, on August 4th, 1813. Captain Porter, as quoted by Van Denburgh, notes: "The most of those we took on board were found near a bay on the northeast part of the island, about eighteen miles from the ship. Among the whole, only three were male, which may be easily known by their great size, and from the length of their tails, which are much longer than those of the female. As the females were found in low sandy bottoms, and all without exception were full of eggs, of which generally ten to fourteen were hard, it is presumable that they came down from the mountains for the express purpose of laying. This opinion seems strengthened by the circumstances of there being no male tortoises among them, the few we found having been taken a considerable distance up the mountains." Some 152 years later Hendrickson (1965) confirmed Captain Porter's speculations concerning nesting migrations noting: "The smaller, lighter female tortoises make regular nesting migrations to the desert lowlands to lay their eggs. The damp, cool, often cloudy highlands are probably not suitable for incubation of the eggs in their subterranean nests. Large males have been found in the lowlands, but by far the major proportion of individuals encountered there are females and young specimens." Parenthetically, it should be noted here that because of this pronounced dimorphism in size, most zoos, understandably desiring very large specimens for show, have, perhaps unwittingly, furnished themselves with a nice collection of the most display-worthy of these plodding giants, but all of one sex—all male!

After the initial onslaught by seafarers, the tortoise populations of the Galapagos were allowed no reprieve, for the early visitors left as their legacy several hitherto absent mammalian predators such as rats, cats, dogs and pigs to prey upon the defenceless young and eggs. Prior to such introductions by man, the tortoises were presumed to have no enemies, although Darwin in his *Voyage of HMS Beagle* reported that: "The young tortoises, as soon as they hatched, fell prey in great numbers to the carrion-feeding buzzards," probably meaning the

Galapagos hawk *Buteo galapagoensis*. On many of the islands, and at various times, there were also left behind goats and cattle which competed with the tortoises for food. The final blow was offered in the form of oil-hunters who mercilessly slaughtered these reptiles for the oil which brought $9.00 per 100 pounds in Guayaquil, Ecuador. These hunters allegedly sought out the largest individuals, therefore the males, since they contained the greater amount of body fat. The oil-hunters obviously did not have the transportation problems that faced the sailors of an earlier day.

Collection for Captive Breeding

Nearly forty years ago, Dr. Charles H. Townsend, late Director of the New York Aquarium, set out for the Galapagos Islands in a commendable attempt to save from extinction some of the giant tortoises. His object was to obtain enough tortoises to establish breeding colonies in southern latitudes in the United States and other parts of the world. The expedition, which was sponsored by the New York Zoological Society, sailed on the steamer Albatross II of the United States Bureau of Fisheries, and brought back 180 young tortoises, all from the mountains of southern Albemarle Island.

Colonies were established at the Botanical Gardens, Panama Canal Zone; the San Diego Zoo; the Boyce Thompson Arboretum, Superior, Arizona; the Zoological Gardens of Houston and San Antonio, Texas, and New Orleans, Louisiana; the grounds of the Aquarium in Bermuda; the Honolulu Zoo, Hawaii, and the Taronga Park Zoo, Sydney, Australia. All the tortoises were very young but it was hoped that they would reach maturity and breed. Meanwhile, in their early captive years, they served to supply data on the growth rate in this species about which little was known at that time.

Breeding results in these captive tortoise colonies were slight and sporadic. Hatching of the eggs eventually occurred in Bermuda where five out of eight eggs were hatched in 1939; one in 1940 and one in 1941. At an unknown date, Miami, Florida, reported the hatching of two young and the Honolulu Zoo recorded the hatching of three—two out of twenty eggs in 1954 and one out of twenty eggs in 1956.

In the early 1930's the San Diego Zoo's collection of Galapagos tortoises numbered some 30 specimens. Subsequently, our collection of these giants was greatly augmented on several occasions by the Allan Hancock expeditions to the Galapagos Islands. Despite the increased size of the collection with a presumed better representation of females, the attempted incubation of tortoise eggs was without success, all eggs proving infertile upon examination.

Eventually, C. B. Perkins, late Curator of Reptiles at the San Diego Zoo, and I came to the conclusion that perhaps what was most lacking in the captive environment of our tortoises was a suitable area for copulation. The earth in our tortoise enclosure is what is known locally as adobe, which makes an extremely hard and unyielding surface. After many years of observation we felt that the primary reason

for the infertile eggs was simply the inability of the male tortoise to get the rear of his shell into the proper position to achieve copulation. In 1957, therefore, the San Diego Zoo modified the Galapagos tortoise enclosure. The entire upper end was dug out to a depth of about 40 inches with a bulldozer, and the earth thus removed replaced with river sand to provide a more yielding surface.

On February 16, 1958, one of our females laid 15 eggs, of which three were broken in the laying process, a not uncommon occurrence. The eggs, together with the moist sand in which they were deposited, were placed in a large crock and removed to one of the constantly-heated corridors of the reptile house. On October 21, 1958, 246 days after the eggs were laid, a scratching noise was heard emanating from the crock. Investigation showed five young tortoises on the sand surface. A sixth egg contained a dead embryo while the other six eggs that were incubated were found to be infertile. Thus, and omitting the three broken eggs that were not incubated, we had a 50 per cent fertility in this clutch of eggs. It should be pointed out here that the 246-day period does not represent an incubation period, but simply the elapsed time between laying and discovery.

Between 1958 and 1961 no eggs were laid. Beginning in 1961, all females that laid eggs were numbered in order to keep records of their reproduction. Of the twenty-three adult tortoises in our collection, seven are females and five are known to lay eggs, but only two have laid fertile eggs in the period from 1961 to 1965. Since early 1961, and the beginning of more accurate record-keeping on the egg clutches, we have attempted the incubation of a total of 258 Galapagos tortoise eggs. From these, seventeen young tortoises have hatched and there have been ten dead embryos in varying stages of development. This gives a fertility percentage of 10.42 with 6.97 per cent of the eggs actually hatching.

"Put to Bed" in the Winter

During the winter months, even in San Diego, it is necessary to "put the tortoises to bed" every evening to protect them from the cold and rain, since these animals are prone to respiratory ailments. It is usually during the winter months that the greatest laying activity occurs along with the greatest activity in courtship and attempted copulation. Courtship and copulation occur throughout the year in our latitude, with, however, a peak in the fall and winter months. We have egg-laying records for every month of the year, with the exception of June, September and October. The greatest frequency of egg deposition occurs from November through April.

It is generally when the tortoises are being put into their barn for the night that a female will be observed at her nesting activities. As a preliminary, this consists of a good deal of wandering over the sandy area of the enclosure and frequent stops to "smell" the sand. When

the female is satisfied with a particular spot, she then begins to excavate the nest with her hind feet. Selection of the site and actual laying may occur in a single day, or if the female is apparently not pleased with the condition she finds, she may take several days to select the nesting site. For example, female No. 1, on February 22, 1966, was observed doing a great deal of earth-"sniffing" and was left out for the night. In the night of February 23, she dug three holes, but laid no eggs. On February 24, she dug two holes, laying no eggs. On February 25, three holes were dug again, but no eggs. On March 5, all of us gave up and she went into the barn for the night.

Behaviour of the Nesting Females

It appears that during particularly dry winters in the San Diego area, the females may have difficulty in finding a nest site to their liking. In such cases, we have employed a lawn sprinkler covering a wide area to wet down the sand thoroughly. This generally induces the female to lay. Usually the nesting and laying process is completed in a single evening. Generally, the females are observed digging about 3.30 p.m. although this has been observed as early as 1.30 p.m. Sometimes the process is completed before sunset, but at other times not until after dark.

To cite a typical case, female No. 1, on April 8, 1963, was first observed excavating her nesting site at 2.30 p.m. The removal of sand from the nest by alternate use of the hind feet continued, with short rests, until just after 4.00 p.m. During this time there was copious voiding of the bladder to facilitate digging, even though the sand is quite soft, as well as occasional defecation into the nest. The nest was about sixteen inches in depth and had the usual jug shape, that is, the opening at the surface was noticeably narrower than the bottom chamber where the eggs would be deposited. The female laid her first egg at 4.39 p.m., another at 4.51 p.m., and a third at 4.52 p.m. The remainder followed at very nearly one-minute intervals, the next to the last coming 15 seconds after its predecessor, and the last thirty seconds later. The clutch total was eighteen eggs, and represented this female's second laying for the year, the first clutch of sixteen eggs having been laid 37 days earlier on March 2.

Following the deposition of her eggs, the female went through the usual motions of "arranging" them in the nest. Using alternate hind feet, she inserted a foot and rolled the eggs around the bottom of the nest. This is generally a wasteful practice, for some of the eggs inevitably are cracked or broken. Also wasteful is the laying process itself, for the female usually raises herself on her legs, slightly above the position she holds while digging the nest site. As a consequence, the hard-shelled eggs are dropped one upon the other, from varying heights, so that many might subsequently be cracked. For example, of 17 eggs incubated, fourteen were cracked; of 11 eggs incubated, 4

were cracked; of a clutch of 16, three eggs were broken open in laying and eight were cracked. As soon as the female finishes sorting the eggs in the nest, she starts filling the nest site. using her back feet alternately. The whole covering process undoubtedly contributes to more egg breakage or more severe breakage of those already cracked, since the female stamps down the covering earth with fairly forceful blows of her hind feet. Generally she packs the sand down so tightly that it takes some effort to get at the eggs. On one atypical occasion, however, the female did not dig a deep enough nest and left the upper part of one egg protruding through the surface of the sand.

Typically, the eggs are an immaculate white and nearly spherical. Average measurements and weight of 12 eggs from female No. 1 were: 59.72 mm by 55.18 mm and 106.86 gms. Average measurements and weight of a clutch of 7 eggs laid by female No. 3 were: 59.54 mm by 56.48 mm and 113.1 gms.

Clutch complements in our specimens range from 2 to 22 eggs with a mean of 12.3 eggs in 23 clutches comprising 283 eggs. Females numbered one and three, those that so far have laid the only fertile eggs, are the best producers, however. Since 1961, female number 1 has produced a total of 153 eggs with clutches ranging from 10 to 21 eggs in number and averaging 15.3. Female number 3 has laid at least 110 eggs since 1961 (egg fragments found in one nest make an accurate total uncertain) with clutches ranging in size from 5 to 22 and averaging 15.7

We are unable to furnish any actual incubation periods for the reason that the eggs are placed in large crocks and buried in the sand in which they are laid. They are then taken into the heated corridors of the reptile house for incubation where, depending on outside temperatures, air temperatures may vary slightly from year to year. In 1961, maximum and minimum air temperatures were recorded daily during the period a clutch of tortoise eggs were successfully incubating. The minimum air temperature during this time was 81°F., and the maximum 90°F. The average minimum temperature was 82.5°F, and the average maximum was 84.9°F.

Rather than incubation periods, what we actually have are emergence dates for the young from the sand in which their eggs were incubated. For the first clutch of five young, the period between the time of egg laying and the discovery of the young, all of which were on the sand surface together, was 246 days. For the second clutch of eggs successfully incubated (laid March 2nd, 1961), emergence times for the four young were 173, 174, 175 and 191 days. The third clutch of eggs that hatched had emergence dates of 198, 200, 204 and 232 days from the date of laying. The first young of the fourth clutch hatched was discovered early on August 9, 1963, 161 days from the date of laying on March 2, 1963. Another young in this clutch appeared by 9.30 a.m. and was followed by the discovery of the third young tortoise at 3.00 p.m. Search was made through the sand and all

Plate 17. GALAPAGOS TORTOISES AT SAN DIEGO ZOO. The large lawn in the background provides extra forage in addition to their daily ration of romaine and whole carrots. *San Diego Zoo Photos by Ron Garrison*

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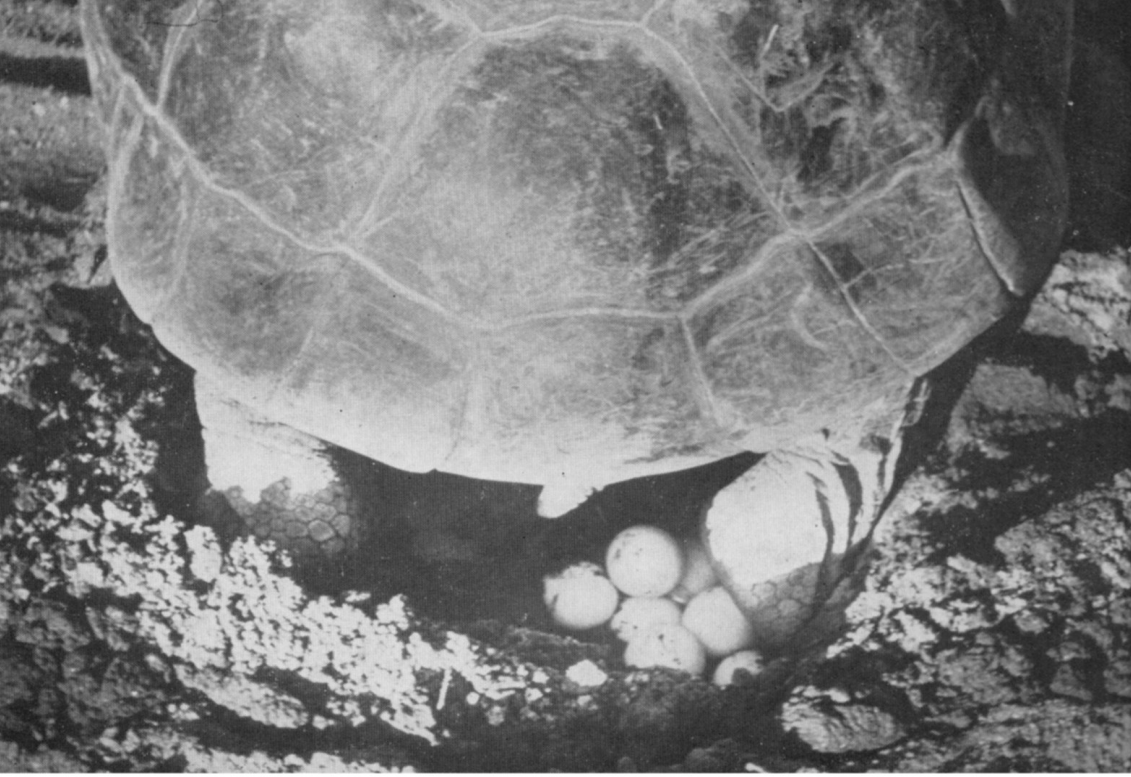

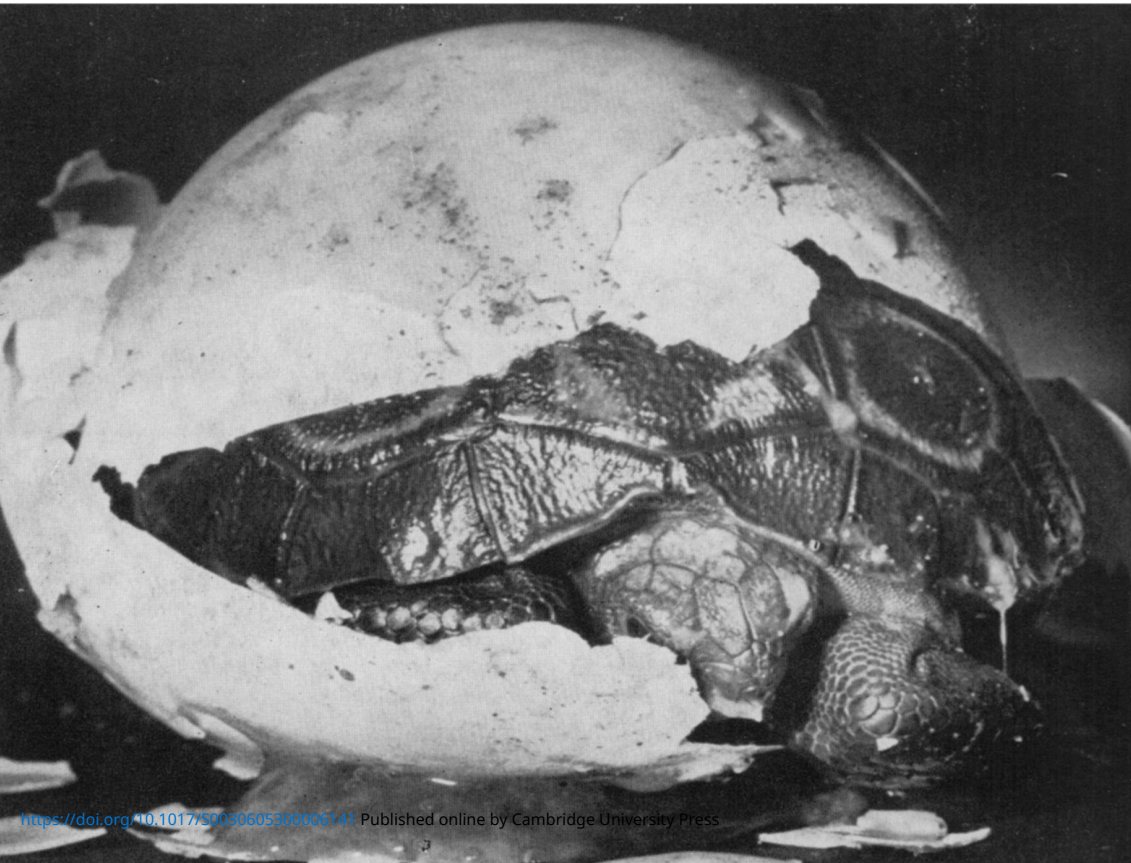

Plate 20. NEWLY HATCHED GALAPAGOS TORTOISE. One of four young of the second clutch successfully incubated at San Diego. The first of these emerged onto the sand surface on August 22, 1961. Usually the central and lateral laminae of newly hatched Testudo elephantopus have light borders with a central dark spot. The only exception seen at San Diego was a single young hatched in 1966. When newly hatched the young have on the first four central laminae a low, but obvious, keel; the fifth lamina bears a weaker keel anteriorly. This young tortoise had a straight-line carapace length of 65.66mm. and weighed 69.9 gms at hatching

Plates 18 and 19 opposite.
EGG-LAYING. Female No. 1 just after completing her clutch of 16 eggs on March 2, 1963. Nine eggs hatched and seven were infertile.
HATCHING. The last of the young emerging on September 7, 1961, from the second clutch of eggs successfully incubated at the San Diego Zoo. Note the prominent caruncle on the rostrum of the young tortoise.

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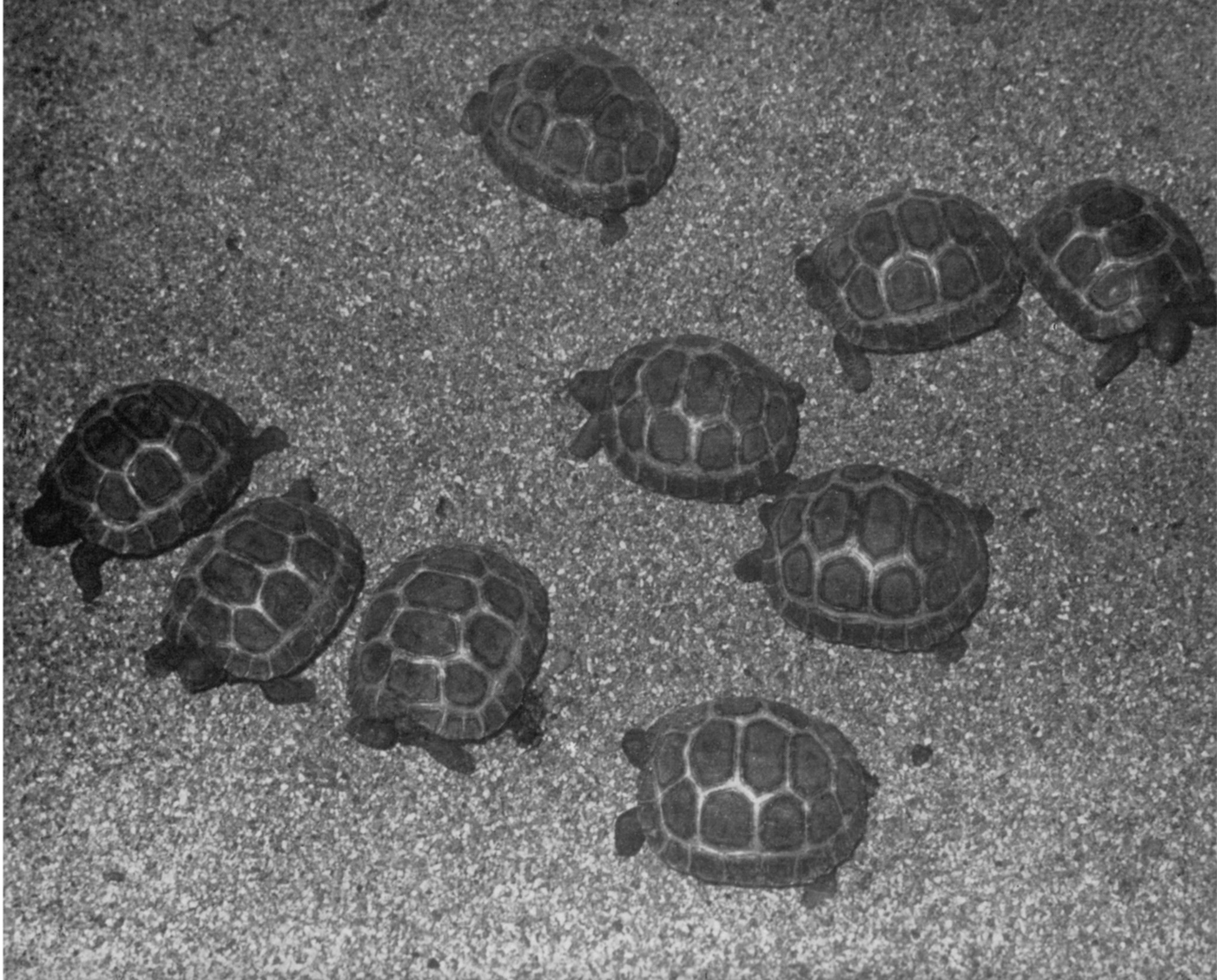
Plate 21.

SUCCESSFUL HATCH

Nine young Galapagos tortoises found hatched on August 9, 1963, the 161st day after the eggs were laid by female No. 1 on March 2. The photograph was taken on October 1. Note that the light border of the central and lateral laminae has disappeared at this age. The keel of the central lamina, though still apparent, has almost disappeared. Rapid growth is indicated by the light areas between the laminae.



but one of the remaining young were found working their way to the surface. The ninth, and last, individual to hatch was still in its shell with its back feet protruding from the shell. This young tortoise had completely freed itself by 5.40 p.m.

The shell, incidentally, becomes quite friable just before hatching, and the struggles of the young within it cause it to break apart, leaving only the tough membrane inside to encase the tortoise. As noted in the above instance, the sharp claws of the young tortoise seem equally, if not more adept at tearing the membrane than the prominent caruncle at the tip of the snout, presumably provided for this purpose.

As a result of numbering the females so that records could be kept of their egg laying, we have found that, like many turtles, the Galapagos tortoise may lay more than a single clutch of eggs per year. The following table indicates the years, numbers of clutches laid and results for females number 1 and 3 since 1961:

Female No. 1

1961	March 2	4 hatched
	April 18	infertile
1962	March 21	4 hatched
1963	March 2	9 hatched
	April 8	infertile
1964	January 6	infertile
	February 15	1 egg (of 17) contained a dead embryo about 5 mm in length
	March 30	infertile
1965	March 2	infertile
1966	April 17 (may have laid at least 1 if not 2 more clutches)	20 eggs still incubating (1)

Female No. 3

1961	November 14	3 dead embryos in 18 eggs
1962	Did not lay	
1963	Did not lay	
1964	February 12	infertile
	March 30	infertile
1965	March 10	infertile
1966	January 17	infertile
	March 15	infertile
	May 2	16 eggs still incubating (2)

(1) From this clutch of eggs, four young hatched commencing on November 5, 1966. Of the remaining 16 eggs, 14 had been cracked in laying. Of these 14 cracked eggs, 9 were fertile with embryos in varying stages of development; all remaining eggs were infertile.

(2) From this clutch of eggs 2 young hatched, the first being found at the surface of the sand on November 25, 1966. Of the remaining 14 eggs only 3 were uncracked. Of the 11 cracked eggs 6 proved to be fertile with embryos in varying stages of development; 8 eggs were infertile.

As a result of the demonstrated low fertility in the eggs of the Galapagos tortoises in our own collection—6.97 per cent of 258 eggs producing viable young within a five-year period (1961-1965) — coupled with the fact that there has been a seemingly equally low fertility in specimens in other collections, perhaps more favourably situated climatically or latitudinally than our own, e.g. Honolulu, Bermuda and Miami, Florida, it is my own conviction that these tortoises probably, within at least recent times, have never reproduced in substantial numbers. They may now be inherently incapable of doing so. The almost total absence of natural predators, other than the Galapagos hawk mentioned by Darwin, as well as an abundant food supply before the advent of man and his introduction of goats and cattle as food competitors, together with a longevity that remains unknown, may have made reproduction not only a comparative rarity, but perhaps dangerous, in terms of food competition, to the existing, stable population. This view is also held by Hendrickson (*op. cit.*) who speculates: " . . . only the merest fraction of the eggs laid had to survive to adulthood in order to replace the old animals which died annually. If, once a decade, things worked out to allow the year's nests to produce new recruits to the population, there would probably be more than enough young to replace the oldsters who disappeared. The population would remain stable and at the capacity of the land."

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