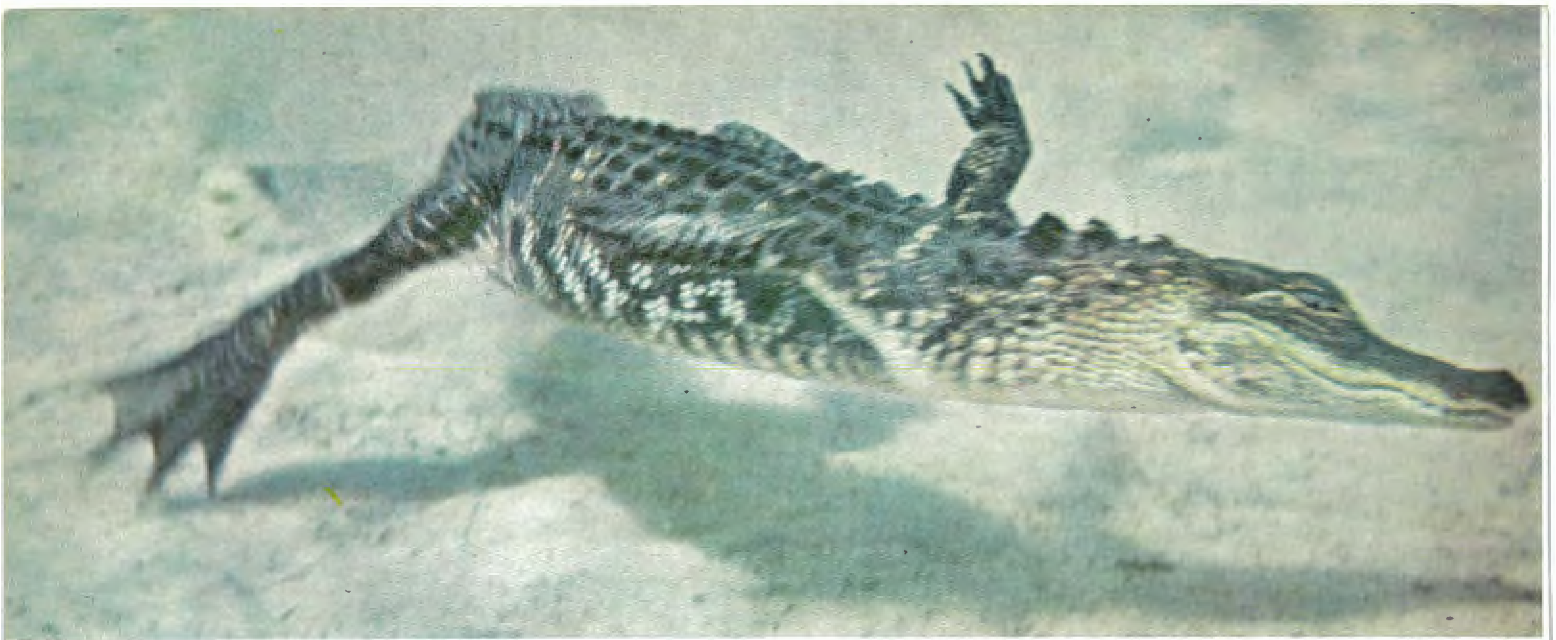
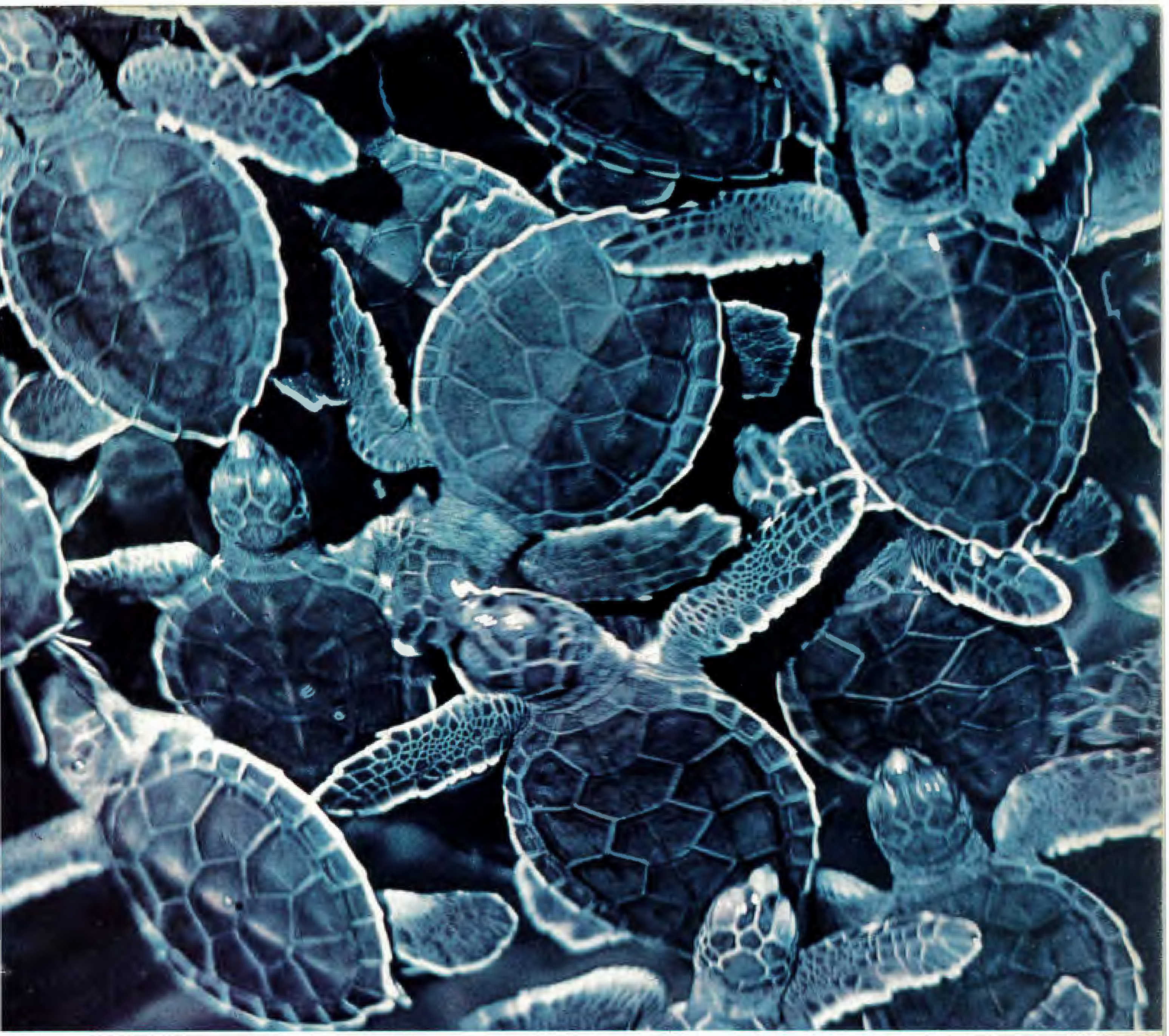


AN AMERICAN ALLIGATOR LEAVES ITS RESTING PLACE ON A RIVER BED. USING A SWIMMING METHOD COMMON TO ALL THE CROCODILIANS, IT

The Many Attractions of Water

Different reptiles utilize the water for different purposes. The amphibious crocodilians use it to swim and hunt in. They also use it to cool off, for though found in warm climates they cannot tolerate great heat since they have little control over their own temperatures. If exposed for a long time to the hottest rays of the sun without water for a dip close by, a crocodile will die. Not unexpectedly the strong crocodilians are proficient swimmers, employing either the high-speed method shown above or a slow paddle. The only modern marine lizard is a species from the eastern Pacific's Galápagos Islands. It lives

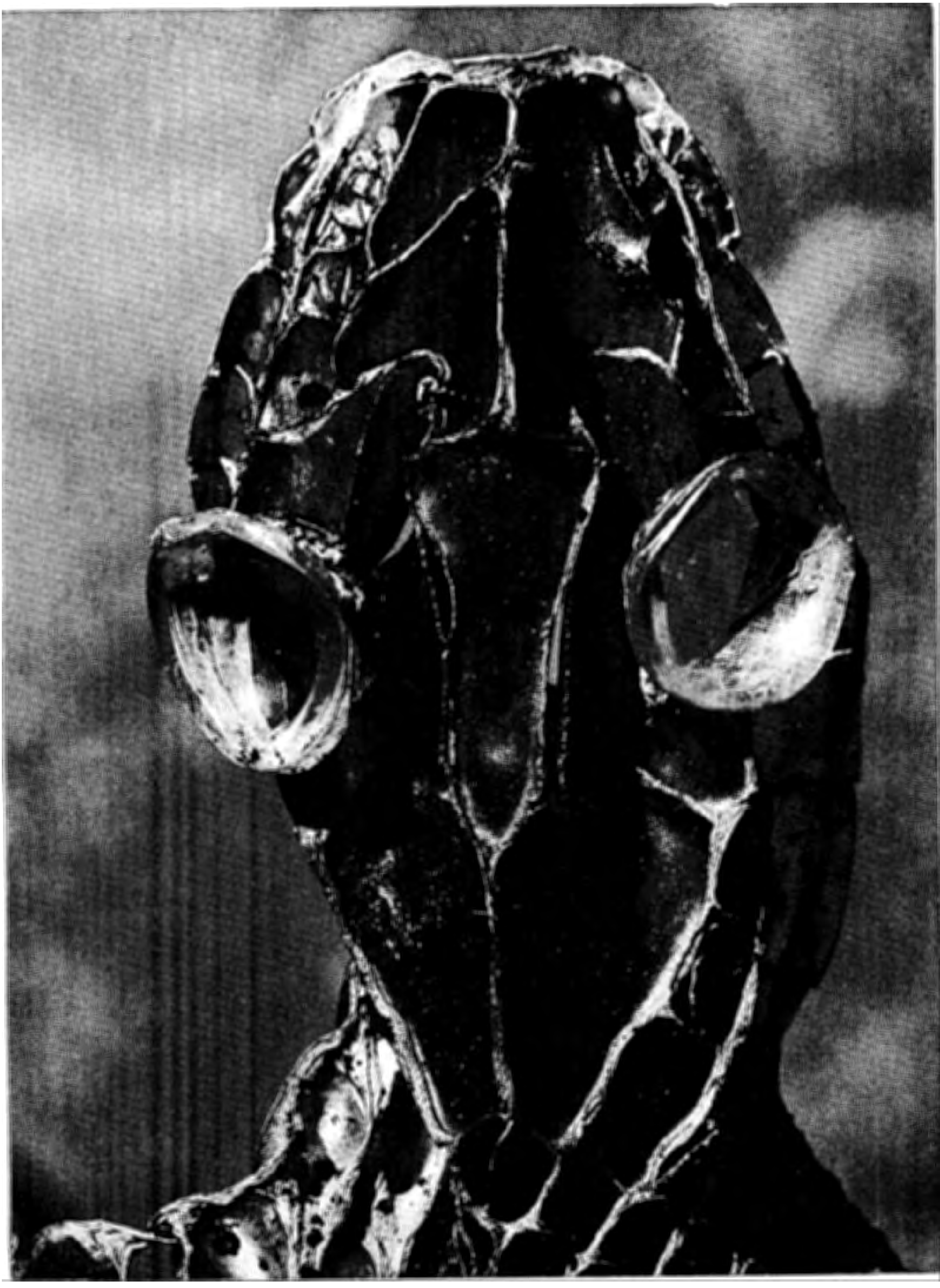
THE SIAMESE SWAMP SNAKE HAS A GREEN CARPET OF ALGAE ALL OVER ITS BODY, MAKING IT INVISIBLE TO THE SMALL FISHES THAT IT EATS

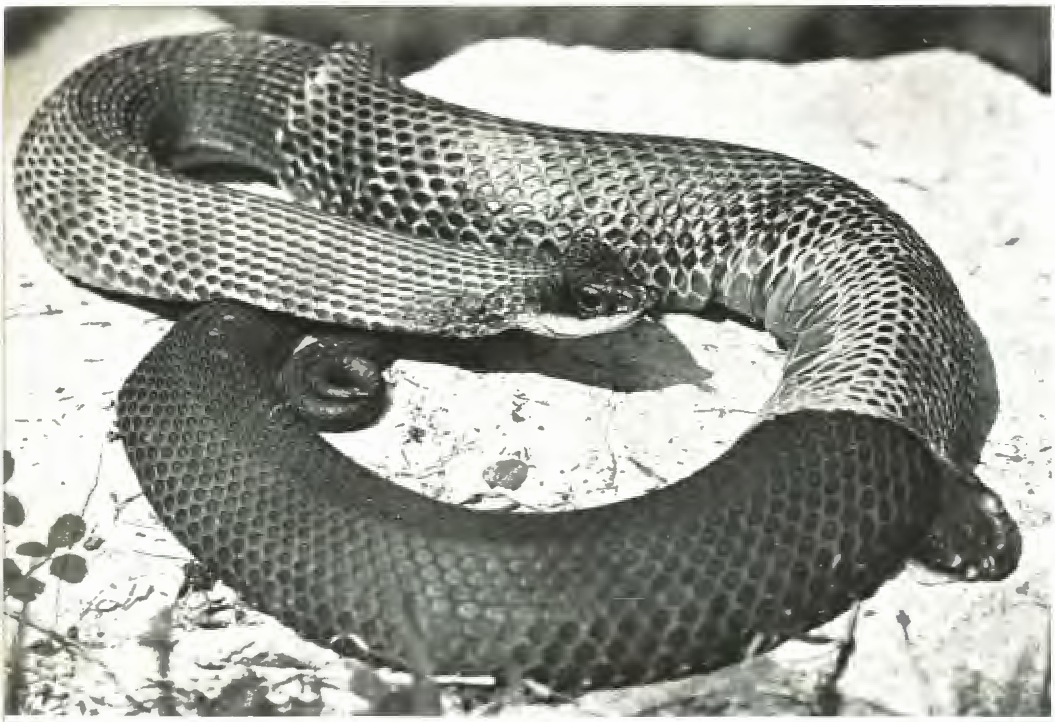


BABY GREEN TURTLES, SHOWN SLEEPING ON THE WATER, THOUGH HATCHED ASHORE WILL SPEND ALMOST THEIR ENTIRE LIFETIME IN THE SEA

The Aquatic Reptiles

After freeing themselves of a dependence on water by evolving a shell egg that could be deposited on land, many primitive reptiles did an about-face and splashed back in. All major groups of modern reptiles, with the exception of the tuatara, now have their amphibious or completely aquatic species. Among these are snakes so specialized for life in the seas that they never venture ashore.

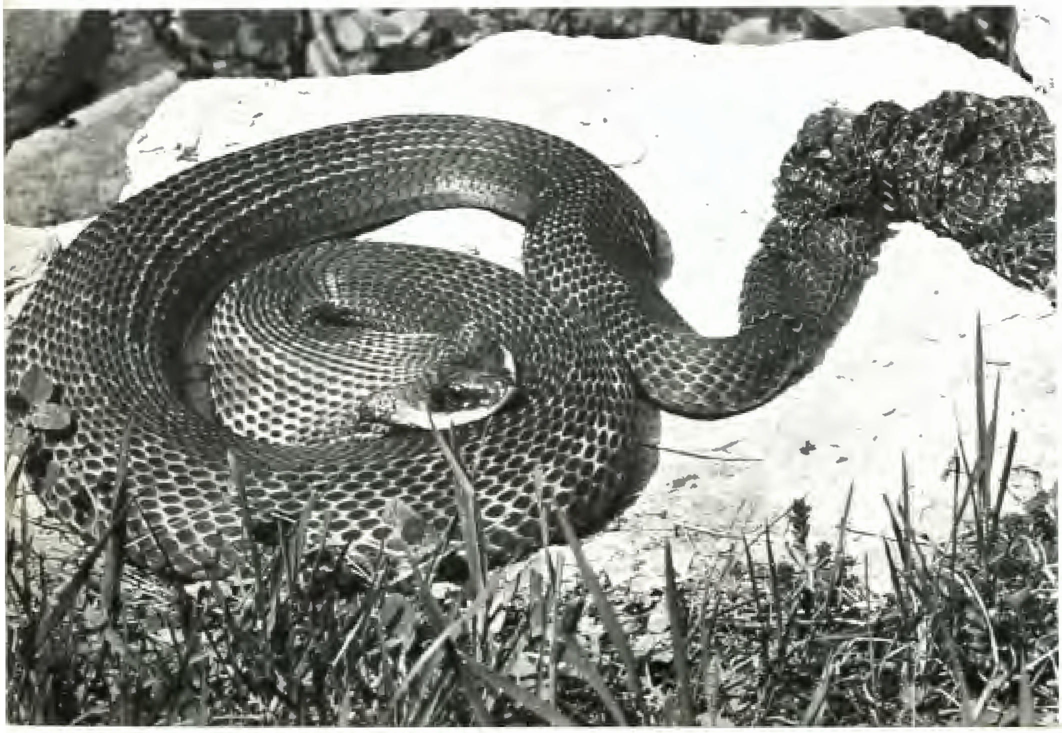




PEELING OFF its old skin, a hognose snake turns the loosened layer inside out by rubbing it against the ground. About a third of the skin has been shed; the head covering is visible at the second bend at the right.

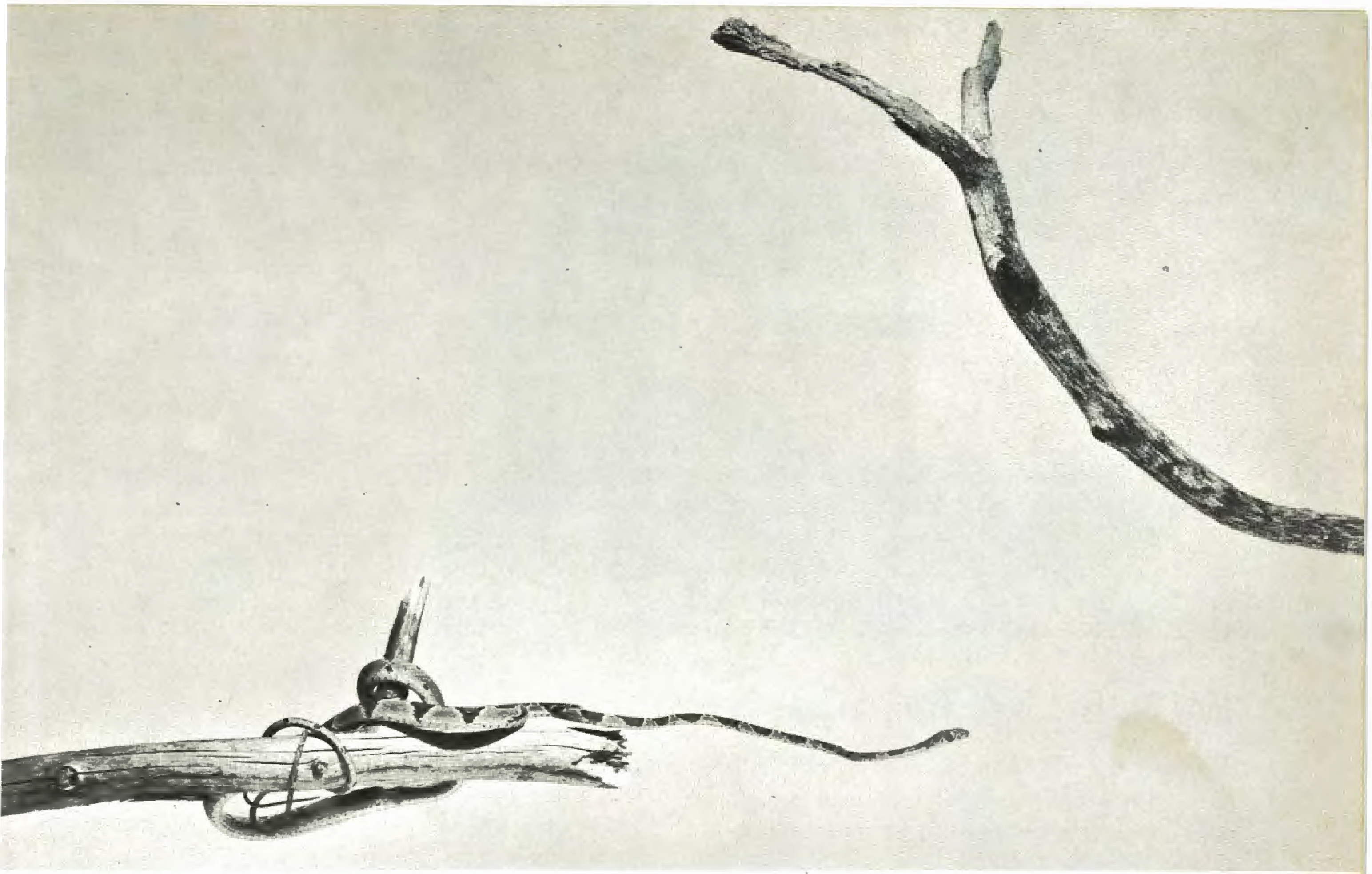
How Snakes Shed Their Skins

Alone among all vertebrates, snakes go through the periodic process of shedding outgrown skin in one elegantly complete operation: when the time comes, they crawl out of the old skin, usually leaving it intact behind. They can do this because they have no limbs or other projections which might inhibit the shedding, and because their outer covering is literally a one-piece suit, from the "spectacles" covering their eyes to the tips of their tapered tails. The process starts a few days before the actual shedding. The snake's skin takes on a dull and lifeless appearance and its eyes cloud over. It also loses its appetite and tends to become irritable. Many species seek water to soak themselves at this time, since they lose a good deal of body liquid along with the old skin. The actual shedding begins when the snake loosens the skin around its lips by rubbing its mouth against a rough surface. This accomplished, it proceeds to work the skin back over its head. Inch by inch, as the snake crawls through scrub and over rocks, the thin outer layer is peeled off inside out like a glove. Finally, often in as little as half an hour, the snake is completely free of its old skin. Resplendent in fresh colours and glistening new scales, it goes on its way, to repeat the process one to six months later when the new skin is worn out.



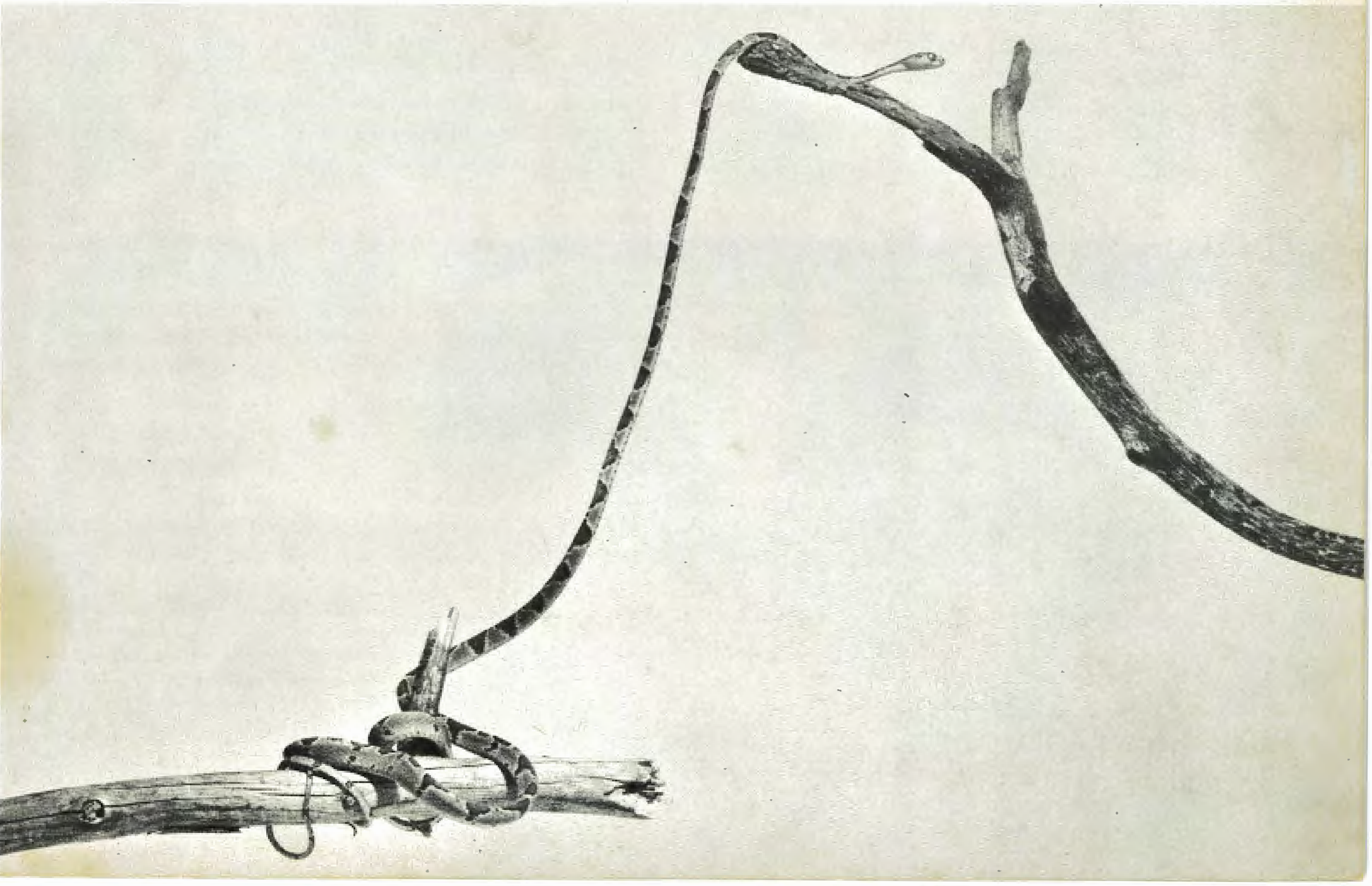
OPERATION COMPLETED, the snake gleams in its new coat, its body swollen with alarm at being disturbed by the photographer. The dead skin behind it is now attached only by a small section at the tail.

A GROTESQUE MASK, the translucent head part of a cast snake skin faithfully reproduces each scale and feature of the living snake's head. The creature even sheds its eye coverings along with the sheath of skin.



1. TIGHTENING ITS MUSCLES TO ACHIEVE RIGIDITY, A FOUR-FOOT TREE SNAKE STRETCHES TOWARDS A DISTANT BRANCH WHILE UNCOILING

3. GLIDING FORWARD, IT TAKES IN SLACK BEFORE UNWINDING THE REST OF ITS BODY AND PULLING IT UP FROM ITS FORMER ANCHORAGE

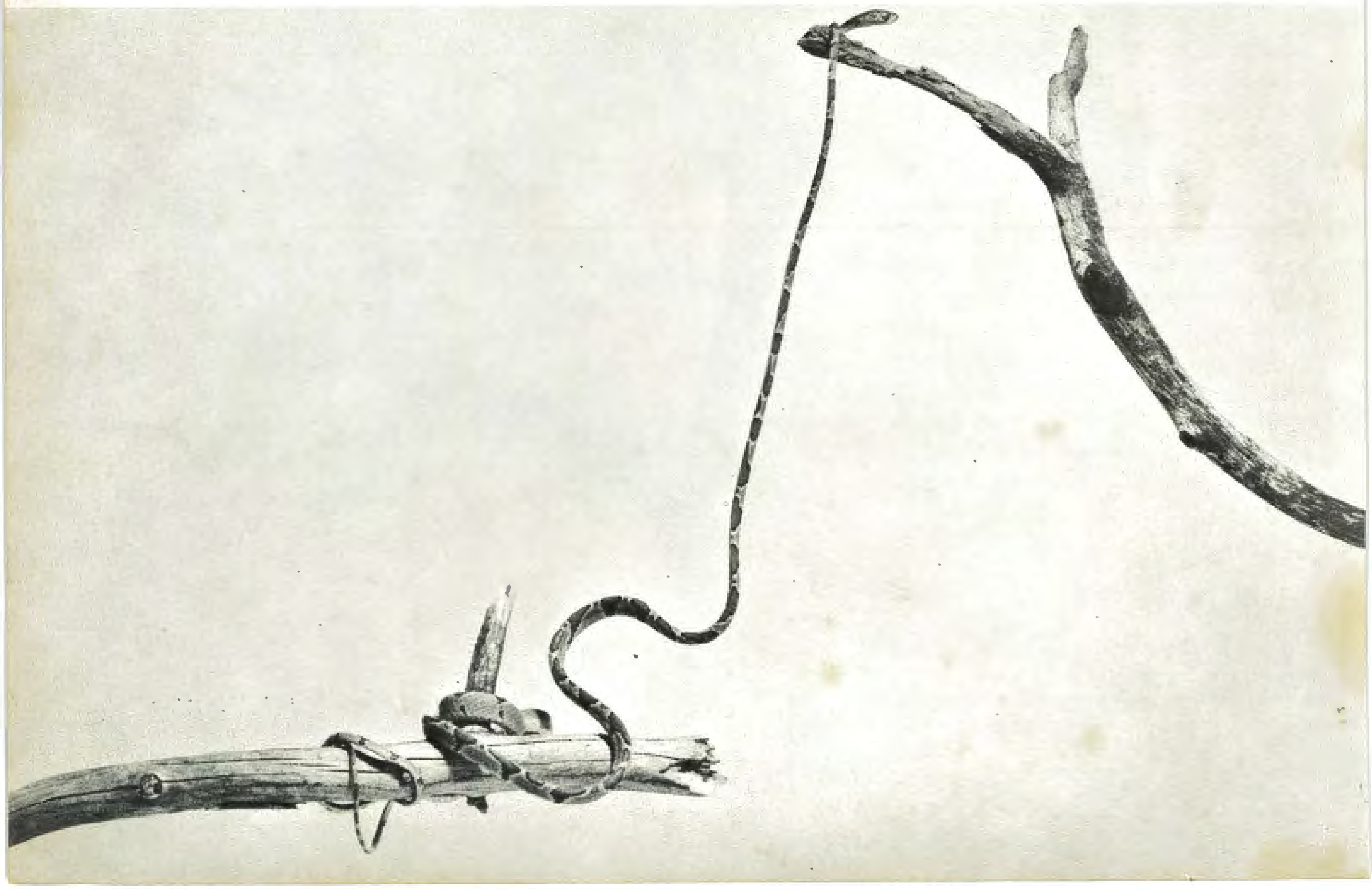


LOOSENING ITS COILS, a blunt-headed tree snake prepares to leave the broken end of one branch and bridge the gap to another. Keeled ventral plates and tightly curled tail anchor it firmly.

Fancy Footwork without Feet

Evolving from lizards, snakes took an extraordinary course in the matter of locomotion: they developed efficient ways of moving about without any legs at all. Generally they are able to accomplish this in the familiar wavy, or "serpentine", fashion of thrusting sideways with the body, much as a fish swims, with the plates or scales on their undersides finding a purchase against irregularities on the ground (if there are no such rough spots, as on a pane of glass, they cannot move at all). Sometimes, however, snakes glide forward in a straight line—in this case arching themselves along like caterpillars. Sidewinders hurl themselves ahead in a complicated but efficient fashion by throwing out successive loops diagonally forward. In tree-dwelling species, like the one shown here, the ventral scales are stiffened by transverse keels which give added traction on rough bark surfaces. Bridging a gap from one branch to another, the snake contracts the muscles along the length of its entire body, thus giving it the rigidity of a beam.

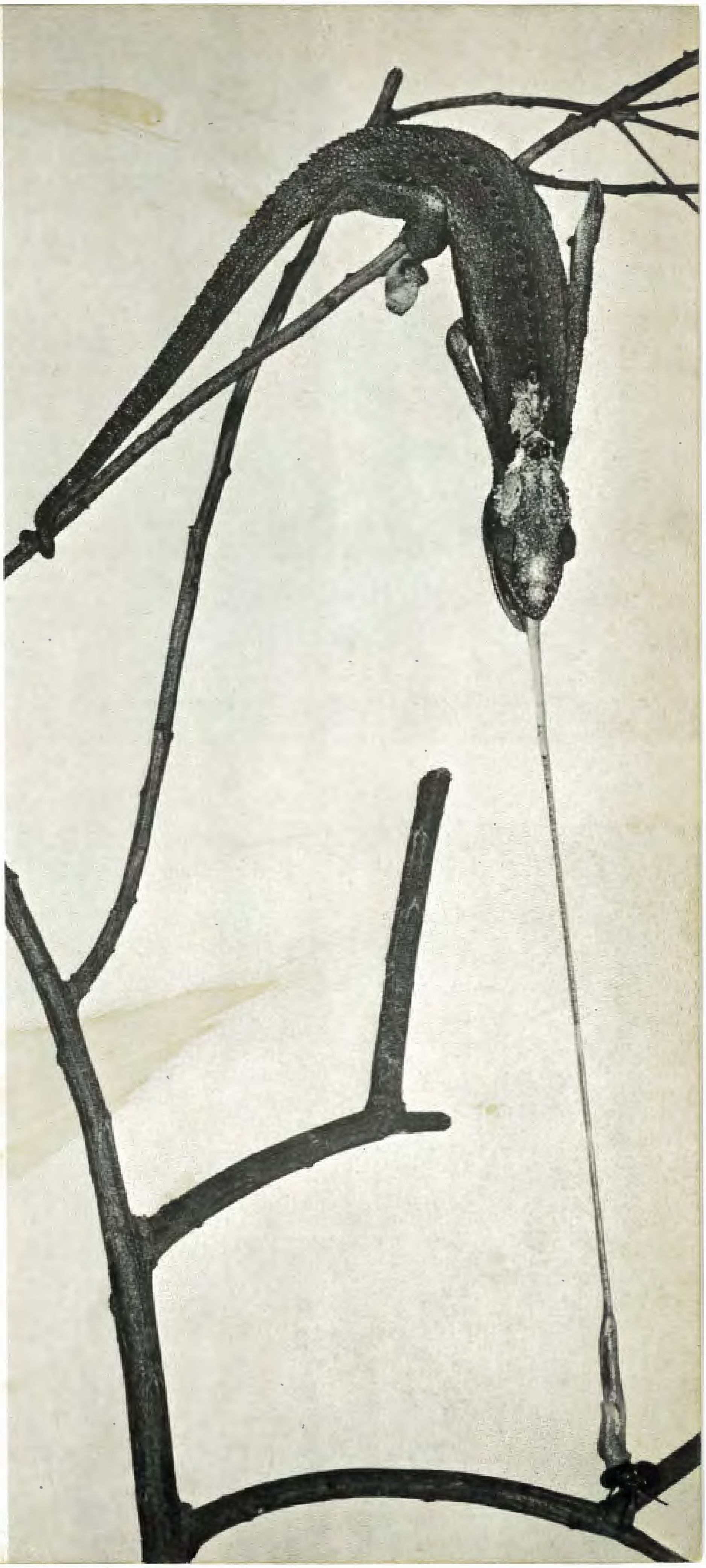
2. LEVERING THE STIFFENED FORWARD PART OF ITS BODY UPWARDS ON ITS COILS, THE SNAKE WINS A PURCHASE ON THE HIGHER LIMB



The Many Uses of Reptiles' Tongues

The flicking tongue of a snake, like that of the sidewinder rattlesnake opposite, is as familiar a part of its popular image as its sinuous leglessness; indeed, the tongue plays an important role in reptiles' lives. Turtles and crocodilians have relatively simple tongues, but in snakes they are highly modified for two particular services. Forked at the end, they flick rapidly in and out, "sipping" or sampling chemical particles in the air or on the ground, which they then transport to Jacobson's organ, a special chemo-receptor which is not quite for smelling, not quite for tasting, perhaps a little of both. Thus the tongue helps a snake to trail its prey, sample food, sometimes to locate mates. Some rattlers also use it as a warning device, brandishing it stiffly at enemies.

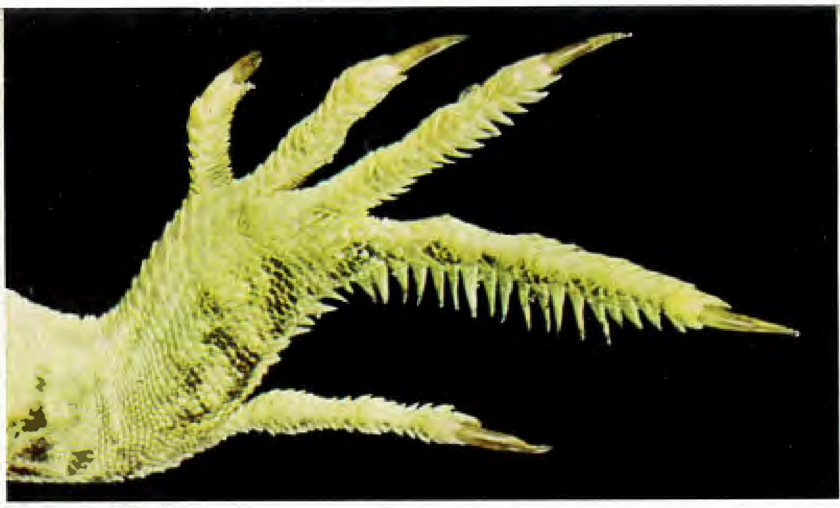
Lizards, by contrast, have unforked tongues which they generally put to the more prosaic uses of picking up, tasting and swallowing food. Some geckos may use their tongues much like windscreen wipers, clearing dirt off the transparent coverings of their eyes like the one opposite (*below*), and chameleons employ them in the most dramatic fashion of all, to catch, immobilize and haul in prey.



TAKING AIM at a fly, a chameleon shoots out its long sticky tongue and scores a bull's-eye. The prehensile tail and tong-like toes keep it firmly anchored. When it is not in use the tongue is bunched up in the throat.

TESTING THE AIR, a sidewinder rattlesnake (*above*) flicks its tongue to pick up microscopic particles for analysis by its Jacobson's organ, a sensory apparatus aiding its sense of smell.

CLEARING ITS VISION, an Australian naked-toed gecko reaches up with its tongue to wipe the "spectacle" over its eye. More normally, its tongue is also used to pick up and swallow food.



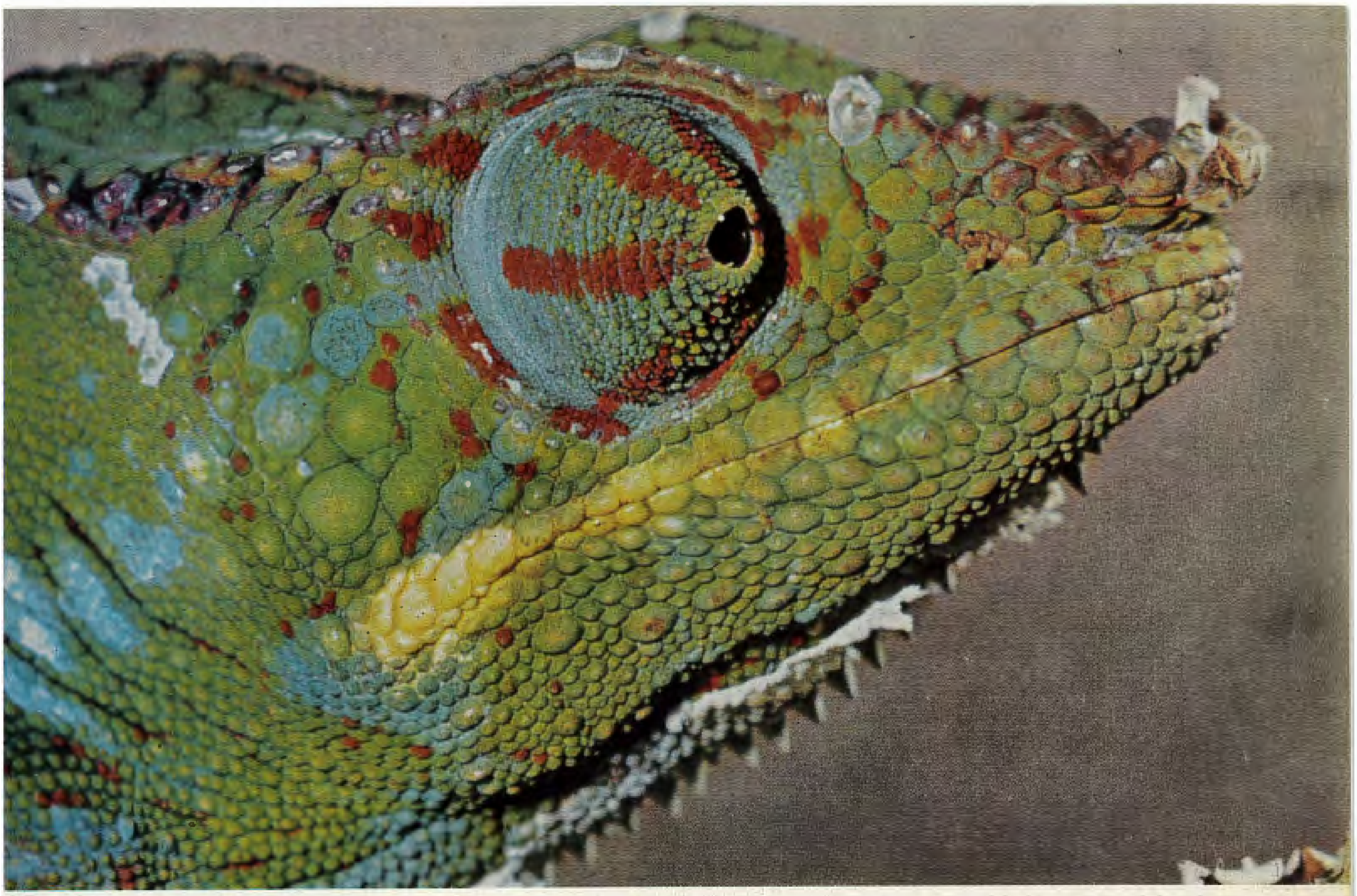
ROWS OF SPINY SCALES on the toes of its hind feet enable the fringe-toed lizard to travel quickly and easily over loose sand. Inhabiting desert areas of the south-western United States, this reptile also uses its specialized feet to dig in and bury itself.

Feet Which Will Go Anywhere

Carrying their heavy shelters around with them, turtles have no need for speed. Their requirement is for powerful legs able to carry the extra weight, and propel them along at a deliberate pace. Most lizards, by comparison, scurry through life at a breakneck speed. Generally, they use all four legs in moving about, but several can run on their hind legs, like man. The majority of them rely on swiftness and agility to capture prey or escape enemies. Thus, depending on where they live, they have feet adapted for running across soft sand or over rocks or for climbing trees. Arboreal species have by far the most specialized feet: the chameleons have opposable toes which grasp branches like pincers, the geckos have marvellous clinging pads. The snakes, on the other hand, have learned how to move about without any legs at all.

PILLAR-LIKE LEGS support the weight of the giant Galápagos tortoise, which sometimes weighs 400 pounds or more. While land turtles have developed short thick legs, sometimes with sharp claws for digging, marine turtles have evolved flippers.

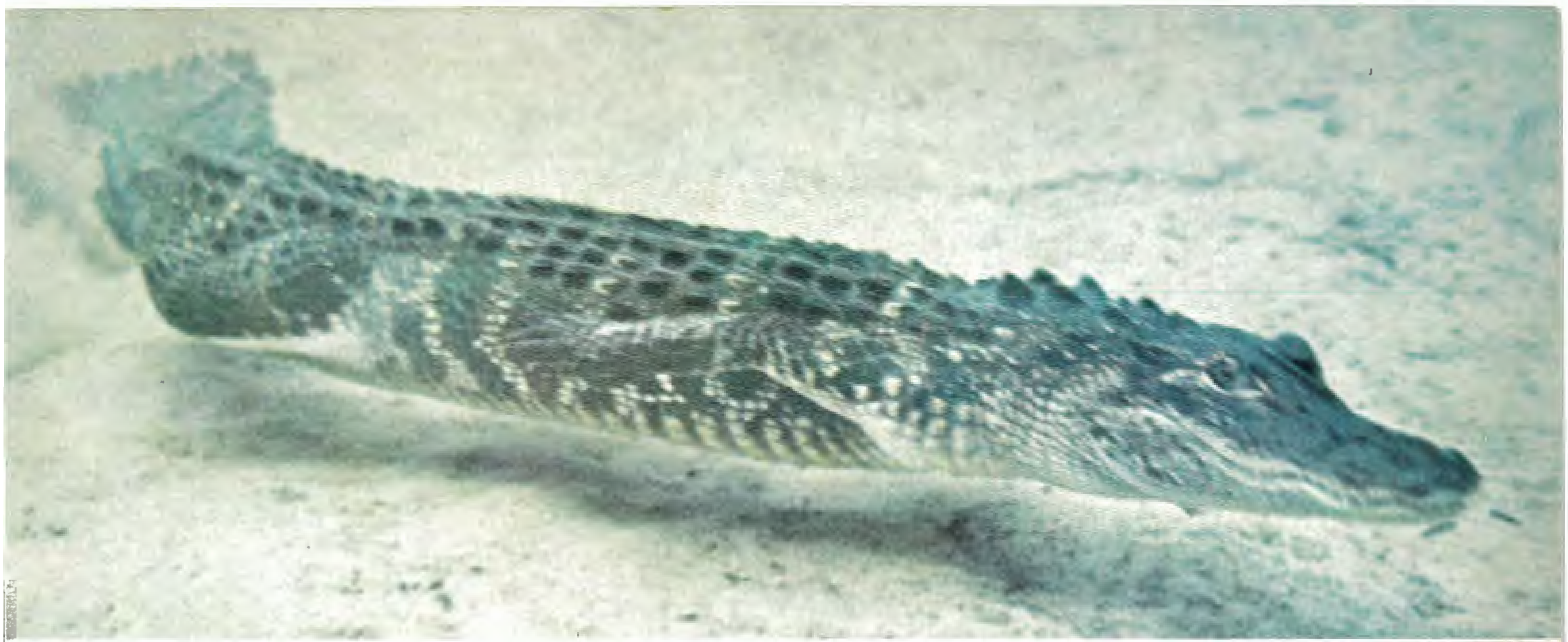
CLINGING PADS on the undersides of a gecko's toes allow it to scurry easily up trees and smooth walls and even dash across ceilings. The pads, present in most gecko species, consist of a series of plates which are equipped with many tiny hook-like cells.



SPOTTING ITS PREY, THE CHAMELEON AIMS BOTH EYES FORWARD, BRINGING BINOCULAR VISION INTO PLAY TO GET ITS VICTIM'S RANGE

ly manoeuvrable, capable of either independent or co-ordinated movement, and matchless in estimating distances for the chameleon's swift shooting tongue. Night-prowling reptiles like the alligator, on the other hand, have eyes which are well adapted for seeing in the dark. Geckos show an elaborate refinement for light control. Their vertical pupils have notched edges, which can be brought together to form a series of tiny pinholes. Their separate images are then superimposed at the back of the eyeball.

IN DARKNESS, the alligator's eye glows rosy-pink, a colour often attributed to blood lust. Actually, this is the colour of a pigment, rhodopsin, which makes night vision possible. Bleached out by daylight, the pigment imparts an eerie glow to light reflected from the retina at night.



TUCKS ITS LEGS AND WEBBED FEET AGAINST ITS SIDES AND SURGES FORWARD WITH UNDULATIONS OF ITS POWERFULLY MUSCLED TAIL

along the shores and enters the water to feed on marine algae, rarely venturing out into swift currents. It has evolved a powerful flattened tail for swimming, and strong clawed legs for climbing back up on the volcanic cliffs that are its base of operations. Among the most aquatic of the reptiles are the big sea turtles; some species are able to swim as fast as a man can run the 100-yard sprint. Most sea snakes live out their entire lives in salt water, feeding on fishes. The Siamese swamp snake (*left, below*) spends a lifetime in fresh water unless dragged out of it, at which point it stiffens up like a board.

THE MARINE IGUANAS OF THE GALAPAGOS ISLANDS ARE SKILFUL SWIMMERS AND DIVE INTO WATER AT LOW TIDE TO FEED ON SEAWEED

GOOSE BARNACLES growing on the head of a sea snake are a potential hazard, sometimes covering an eye, as here. The snake sheds them with its skin.

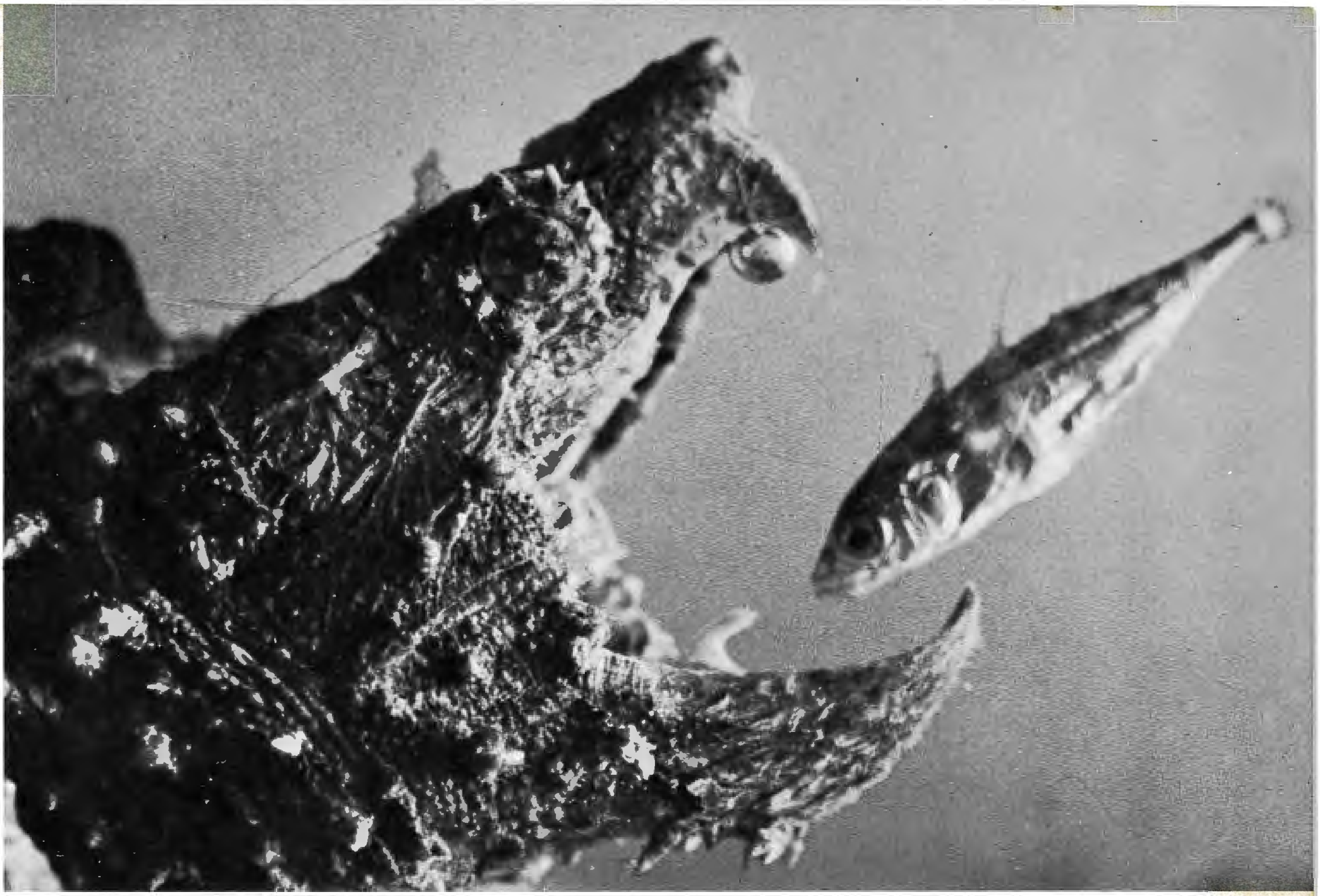
Submersible Snakes

Most snakes can swim, but none are better equipped for it than the poisonous sea snakes with their paddle-like tails and laterally compressed bodies. They inhabit the warm waters of the eastern and western Pacific and the Persian Gulf, and are often seen swimming a thousand miles or more from shore. Some can even swim backwards. A factor enabling many of them to lead a completely aquatic life is their habit of giving birth to living young, thus freeing them of the necessity of ever leaving the water to deposit eggs on shore as the sea turtles must do. Most have dispensed with the enlarged abdominal plates used by land snakes in locomotion. Although all sea snakes must surface to breathe, they can stay submerged for long periods—apparently by extracting the oxygen they need directly from the water.

A SEA SNAKE from south-east Asia shows the typical conformation of many of its kind—a heavy body, with a tiny head and flattened tail. In several species the body is four to six times as broad as the head.

A RIVER SNAKE, the South American anaconda, is an expert swimmer and prefers to stay in water, though it is also adept on land. It feeds on many aquatic animals; one 25 feet long contained a six-foot caiman.

MOUTH AGAPE, an alligator snapper, largest of North American fresh-water turtles, extends its wiggling bait—a worm-like outgrowth of the tongue—and waits for fishes to nibble at it. When thus employed, the whitish or light-grey bait turns pink. The algae covering the shell help to disguise the head in murky water and may also inveigle prey into coming closer to the bait.



DARTING TOWARDS THE BAIT, a fish enters the mouth of the alligator snapping turtle. Instantly (*below*) the jaws snap shut and manipulate the fish into a swallowing position. If the fish were larger, the turtle would first tear it apart with its clawed front feet. The alligator snapper probably forages mainly at night and reserves the bait for occasional use during daylight.

A STRETCHABLE NECK, ALMOST AS LONG AS ITS SPINE, ALLOWS A SUBMERGED MATAMATA TO DRAW IN AIR THROUGH SNORKEL-LIKE NOSTRILS

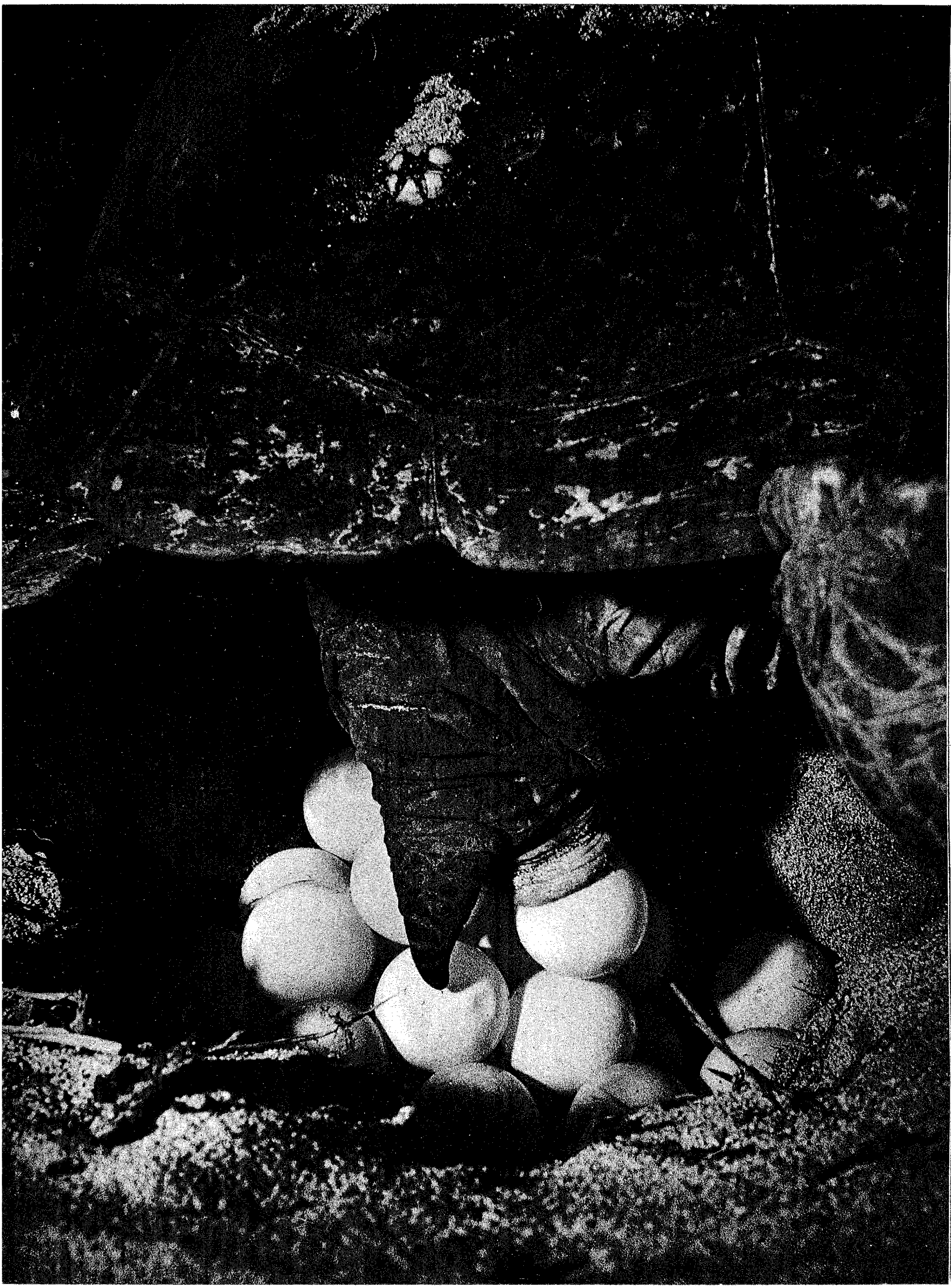
The Matamata, the Weirdest Turtle

The river-dwelling matamata of north-eastern South America looks like one of evolution's mistakes. But its most bizarre features are the ones that serve it best. A cautious, extremely slow-moving predator of small fishes, it lurks on the murky bottom, camouflaged by a mottled greenish-brown skin and a ridged shell festooned with algae. The ear flaps and filaments on the head and neck are movable and act as fish lures. The long neck serves to thrust the tube-like nose out of the water for air, and also as a means of approaching quarry while the body remains almost motionless. When danger threatens, the neck cannot be retracted into the shell in the manner of most other turtles, but is curled under the carapace.

LYING IN AMBUSH, a matamata halts its movements as an unwary gymnotid fish, attracted by waving lappets of flesh fringing its arrow-shaped head, swims closer and closer to its ready mouth.

SUDDENLY OPENING ITS JAWS and expanding its neck, the matamata creates a vacuum that sweeps the fish into its mouth with the inrushing current. Later on, it will expel the water.

THE FACE OF THE MATAMATA suggests an advancing army tank. The nose extends forward over the broad, V-shaped mouth, as do the tiny eyes. The fleshy jaws, which open into a hoop, lack the horny edges of other turtles' mouths since the matamata does not chew its food. Behind the head and swivelling neck is the rest of the body, covered by a lumpy shell.



A FERTILE SEA TURTLE lays round eggs in a hole it has dug in the warm incubating sand of Australia's Great Barrier Reef. When about 100 eggs are laid, it will cover the hole and depart. During one breeding season a mature female will deposit from two to five clutches like this one.

6

The Miraculous Shelled Egg

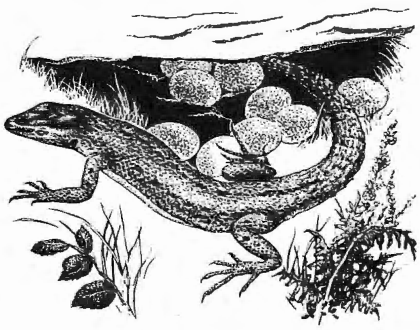
REPTILES are sexual animals and are the group that introduced internal fertilization to the vertebrate line. Thus, in a manner of speaking, they laid the foundation for the family unit in higher vertebrates, and from this came human society itself, with all its excitement and troubles. The ancestral amphibians deposited their eggs virtually naked in the water, and fertilized them by simply releasing sperm in their general vicinity. The hazards of such an informal operation to both sperm and egg are obvious. The reptilian egg, however, enters the world already fertilized, and protected to a certain extent against adverse conditions. One need only compare the dozen or so eggs laid by the average lizard with the thousands laid by toads to see the great economy the new method has brought.

But even an egg with a shell is delicate. It can incubate successfully only within a narrow range of conditions of temperature, humidity and shelter. It is thus not surprising to find that a few reptiles have independently hit upon the recourse that we think of as one of the main attributes of the mammals—that of producing living young.

All the live-bearing reptiles of modern times are lizards and snakes. Turtles and crocodilians produce only eggs, and so does the tuatara. It is significant that of the three reptiles which venture farthest north, even across the Arctic Circle, two—the European adder and the common lizard *Lacerta vivipara*—bear their young alive. So does the slowworm (*Anguis*), another venturer into northern regions. The cold ground of those areas, no doubt, is not well suited to incubating eggs. Neither is water, so far as shelled eggs are concerned, which explains why most reptiles with strongly aquatic habits also bear their young alive.

Many of the live-bearing reptiles, however, belong to groups that have egg-laying members too. The skinks, the lacertas, the boids and the vipers are examples. There are even species that lay eggs in some parts of their ranges but bear live young in other parts. This suggests that their viviparity—as the ability to produce live young is called—is not so formal an undertaking as it is in mammals, and this is true. Some reptiles merely keep the eggs inside the body for varying periods up to and after hatching time. In others there are extensive, placenta-like connections with the tissues of the maternal oviduct. In one type the yolk sac is merely plastered against the wall of the oviduct, and is used primarily for respiration. In a more advanced type the embryonic membranes, the chorion and allantois, interfold with maternal tissues and the embryo not only gets water and nourishment as well as oxygen, but conveniently has its excretory wastes taken away too. None of the live-bearing reptiles has dispensed with a big store of yolk as the main source of nourishment for the growing embryo.

Although lizards do not fare well in cold climates, the Common Lizard of Europe has a wide range, and has become adapted to life in northern latitudes by bearing its litter of young alive (above), keeping the developing eggs as warm as possible by incubating them inside its body. In warmer regions farther south, however, females of the same species (below) produce their young by laying eggs to hatch.



ALL reptiles practise internal fertilization. In all modern forms except the tuatara the male has an organ kept turned outside in, in the base of the tail, and everted through the opening of the cloaca during erection. In the tuatara the transfer of sperm is accomplished by bringing the genital openings into contact, as in birds. This was probably the method used by the ancestral reptiles—it is clear, in any case, that the penis had separate origin in turtles, crocodilians and mammals on the one hand, and in lizards and snakes on the other.

Thus, male lizards and snakes have not just one, but a pair of hollow structures called hemipenes, which make up their copulatory organs. Located as they are in the tail just behind the opening of the cloaca, the hemipenes often give the tail of the male a thicker, more gradually tapering contour than that of the female, and in many species the sexes can be distinguished by this difference. A groove that serves as a channel for the sperm extends from the opening of the sperm ducts along the inner wall (which is the outer wall during erection) of each hemipenis, and the surface may be pleated or set with spines that keep it in place in the oviduct of the female during mating. Either one of the hemipenes may be used, but only one, the one nearest to the female, is everted and protruded from the cloaca during erection, which is brought about by a combination of muscular action and distension of the walls with blood.

Among different reptiles fertilization is scheduled differently with respect to the time of nesting. In most species it seems to occur, as might be expected, just before the eggs are laid; but in some the sperm may live on in the reproductive tract of the female and continue to fertilize eggs months or even years after copulation has taken place. The longest known periods of such deferment of fertilization are four years for the diamondback terrapin of the southern United States, and five years in the case of the tropical American cat-eye snake. The green turtle, which evidently mates only in the sea off the nesting beach, often does so *after* the female has gone ashore and laid her eggs. Since a given female makes her migration to the nesting ground only once in three, or more rarely two, years, it seems probable that sperm must be regularly stored for that length of time between nesting journeys.

In at least two races of lizards there appear to be no males at all, and young are evidently produced from unfertilized eggs. Such reproduction is known as parthenogenesis, or virgin birth. The most familiar case of parthenogenesis is that of the honey bee. The queen lays two kinds of eggs, some fertilized, some unfertilized. The unfertilized eggs produce the males, or drones; the fertilized eggs produce the workers. Ants, wasps and various other invertebrate animals sporadically or periodically reproduce by parthenogenesis. In some cases the parthenogenetic stage occurs at a time when conditions in the environment would make it difficult for the two sexes to meet for mating. How the two lizards evolved the practice, and why, is not clear. In some other species of lizards the females greatly outnumber the males and it is possible that this same phenomenon of parthenogenesis may normally alternate with bisexual reproduction.

Because the genitalia of male reptiles are internal, it is not always easy to tell the sexes apart. It takes an expert, for instance, to determine the sex of a snapping turtle or alligator. However, in most species there are certain external features by which it is possible to distinguish the sexes of fully mature individuals. The two most obvious ones are size and coloration. There is no set rule about which sex may be the larger, but in many species it is the male that is bigger than the female. Where difference in colour patterns exist, it is generally the male which has the more vivid coloration, as is usual in birds; but here again the situation is sometimes reversed. In some species the sexual coloration is a sort of nuptial dress, assumed for breeding and later abandoned.

Internal fertilization is a co-operative process, and to bring it about the sexes must find each other, and must be physiologically prepared for mating. Most if not all reptiles show some sort of courtship behaviour by which the sex of a potential partner is determined, the coyness of the female is overcome, and a readiness to mate is generated in both members of the pair. Courtship often duplicates or blends with the expressions of rivalry and territorial defence between males, and since this whole complex of innate behaviour is a hereditary part of the make-up of a species, it affords an interesting field for study.

THE courtship of a number of different snakes and lizards is a case in point. Although there are clear similarities in behaviour patterns among the two groups, it has been found that most lizards recognize the female visually, while snakes depend on odour, trailing the female with their noses as well as with the tongue and Jacobson's organ. Male lizards put on quite a display among themselves—showing coloured throat fans, erecting crests, arching their necks and affecting various gaits—but how much of this actually carries over into courtship is not surely known. Some of it, however, is brought to bear by the male on a prospective partner. When the female is thoroughly recognized as a female and her reticence overcome, the male lizard (like the males of some snakes) seizes her with his jaws, bends the base of his tail downwards to manoeuvre the cloacal openings into contact, and insertion of one of the hemipenes is effected.

Turtles, both aquatic terrapins and land tortoises, carry out varyingly elaborate courtships which may include butting and nipping of the female by the male, or his swimming backwards in front of her, fluttering his claws beside her face, or stroking her cheeks with his elongated fingernails. Among some species of pond turtles and among sea turtles, courtship is accompanied by competitive behaviour among males. Two males, on rare occasions even three, may attempt to court the same female simultaneously and combine this with a mild struggle among themselves. In the pond in front of my house, during the mating season of the pond cooters, turtle heads are regularly seen in threes or fours. Off and on, for as long as two or three days at a time I have watched groups of these heads with a telescope, and while I could see little of what the bearers of the heads were actually doing, it did not seem to involve any very violent strife. The three heads simply stayed together in a restricted patch of water for a day or more at a time, and there were occasional outbreaks of splashing and finally the back of one of the turtles would come out of the water, indicating that mating was taking place.

A similar thing occurs among the green turtles at their nesting ground on the coast of Costa Rica. Here, too, the observations made have been only in snatches, and whatever subtleties of courtship behaviour are carried out have not been seen. But during the early part of the nesting season the turtles mate out in front of the beach a few hundred yards beyond the surf line. For the first week or so of the mating time there are large numbers of courtship groups involving two males and one female. Among sea turtles, mating is a strenuous process. Attempts of the male to mount the back of the female involve a great deal of thrashing and splashing of water. Once the male attains the position on the upper shell of the female, however, he remains firmly anchored by two huge claws on his front flippers which grip the fore edges of her shell, and by a strong horn at the tip of his tail which curls up under the back edge of her shell. The only time male turtles are seen on shore at the nesting ground is when a copulating pair is caught by a breaker and thrown onto the beach.

The courtship of the alligator is noisy and exciting. The bull bellows and exudes musk from glands on the throat and at the sides of the cloaca. When the female approaches, the two of them race about in wild circles, making a big wake that rocks the reeds and sends the fishes flying. The frogs stop singing and the waterfowl scream.

Closely related to courtship is rivalry and combative behaviour among males. This sort of strife is not generally disorderly and injurious, but actually may serve a variety of useful purposes. It keeps the race physically on its toes, as it were, weeding out the weaker individuals as breeders. It brings about a distribution of territory, and thus lends order to both the reproductive process and the daily life of the individual. It establishes hierarchies of dominance and submission, and these again contribute harmony by forestalling more harmful untrammelled fighting. And just as courtship does, the fighting may help to instigate glandular cycles involved in the mating process.

In some species a by-product of fighting between males is to augment their often dubious capacity to recognize the female at mating time. Experiments show that when breeding males of certain lizards approach another of their kind, their mode of sex recognition is not, as one would expect, to search for signs of femininity. Instead, the criteria seem wholly negative: if the challenged lizard fights back it is a male; if not, the only alternative is to regard it as a female lizard and make appropriate overtures.

In many cases the contests between males are carried out without physical contact. The same ends are accomplished by various kinds of signals, posturings, and flashings of colour patches, such as the throat fans of some lizards. The magnificent bellow of the American alligator, though not thoroughly understood, is partly a sexual call, but is partly used also as a territorial challenge.

A pattern of ritualistic sexual behaviour quite as elaborate as that of some birds is the "combat" dance of some male snakes. The distribution of this extraordinary habit among the various snakes of the world is not accurately known, but it is found in a variety of species and genera—in snakes as unrelated as the rat snakes and the vipers, for instance. The exact aim of the dance is not known either. It may be pre-nuptial rivalry, or it could be a ceremonial way of contesting territory. I first saw this dance performed by a pair of cottonmouth moccasins years ago, and it still ranks as one of the most elaborate and stylized animal ceremonies that I have ever witnessed. It can best be compared to some of the most advanced ballets of birds.

It happened in 1941. My wife and I came upon the snakes in an open pool at the edge of a marshy lake in Florida. We were at once struck with the realization that something untoward was going on, and so sat quietly, watched raptly, and soon began taking notes and making sketches of the figures of the dance.

Throughout we were labouring under the mistaken impression that it was courtship we were witnessing, and because in a number of mated cottonmouth pairs that I had previously come upon the male was the smaller, I quickly decided that the smaller member of the dancing pair was the male in this case too. When the dance was over we took our notes and sketches home and wrote a little description that was later published in a zoological journal. In spite of our somewhat fundamental misapprehension regarding the sexes of the snakes, the description of the dance was faithful, and re-reading it for the first time in ten years brought it vividly back to mind.

WHEN first observed the snakes were gliding slowly about the pool, the forward third of their bodies raised high, crossed and interlocked in an open, symmetrical half-twist. The two heads, side by side, were bent downwards at a slight angle to the necks, which were held almost vertical. The eyes stared out into space in a vacant way suggestive of some sort of cataleptic seizure. Every few seconds the two snakes rapidly and in perfect synchronization smoothly recrossed their necks, reversing the relative positions of their bodies. Although there was little or no contact between the exposed portions of the bodies during this manoeuvre, the rhythmical precision of the reciprocal movements was such that it seemed as though two like parts of a single body were involved. From time to time the two would pause in their journey across the pool and in one place execute and reverse their figure-of-eight several times before moving forward again.

After five minutes of such activity the smaller snake disengaged itself. Swimming slowly around the other two or three times, he scrutinized the raised forepart of his opponent's body minutely, touching it repeatedly with the tips of his tongue or with the end of his snout. Finally, he circled to the rear, looped himself across the partially submerged portion of the body of the other snake and shuffled and slipped himself slowly forward. On reaching the elevated thoracic region of the other, he threw a tight loop of his neck around it and began a spiraling climb upwards. During this procedure the larger snake seemed intent on raising his head as high as possible above the water and, aided in this effort by supporting loops of the body of the other, he succeeded in reaching a height of at least 17 inches for a brief time. When the lesser combatant had enfolded the other in two complete loops, and the heads of the pair were at nearly the same level, the rigid body of the big snake suddenly relaxed and yielded symmetrically to the enveloping coils of his opponent.

Thus intertwined, and with their heads posed almost vertically high above the surface of the water, the pair began what appeared to be a frantic and concerted effort to climb out of the water. At the same time the interlocked bodies swayed slowly back and forth, each backward swing being more extreme than the preceding. After some 60 seconds of this, the combined upward struggling and backward rearing carried the snakes beyond the point of balance and they fell over in a tangle of writhing coils.

This extraordinary operation was repeated three times, and in each instance, after the final collapse, both snakes would suddenly emerge to a third of their lengths, one two inches behind the other, with their snouts pointed upwards. For from one to three minutes they would pose thus, all the while vibrating in harmony back and forth through an arc of about half an inch. At this time the posterior two-thirds of the bodies, which until now had been submerged and presumably intertwined, floated high in the water, side by side, motionless except for deep and rapid breathing.

After 45 minutes the big snake suddenly disengaged himself from the neck-loop of the other, circled the pool once and then struck out at top speed through the cat-tails in a series of zigzag rushes. For perhaps 30 seconds the snake left behind remained motionless in the centre of the pool, watching the antics of his erstwhile partner. When one of the mad dashes of the swimming snake carried him to the edge of the open water, the one left in the pool appeared to realize the danger of losing contact permanently and set out in pursuit.

Then there was a wild chase through the emergent vegetation, far out into the open water and back to shore again, with the smaller snake apparently having no trouble following, at a distance of six to eight inches, the erratic course taken by the larger one. After about five minutes, however, the race terminated abruptly when the big snake plunged through a dense sheaf of dead *Typha* leaves, crossed an open pool and concealed himself in a tussock.

This tactic seemed to baffle the other completely. He dashed about excitedly for a moment and then settled down to a deliberate and methodical search for the trail. Very slowly he cruised a strip of some 50 yards of the lake margin, quartering the zone of vegetation, and thrusting his snout into piles of rubbish and clumps of *Typha*. He vibrated his tongue continuously, flicking its tips against plant stems and floating sticks and into the water itself in a vain attempt to straighten out the intricate course.

We watched the fruitless search for some 30 minutes. Then the sun began to set and a cold rain started falling. When we left, the unpromising search was still going on.

Although the literature of that time had little to say about this most extraordinary of reptile rituals (and what there was mistakenly interpreted it, as we did, as courtship), similar behaviour has now been observed both in the field and in reptile houses, in a number of species including rattlesnakes and colubrids. That a comparable set of complex stereotyped dance figures should have been clung to through all the time since rat snakes and rattlesnakes diverged seems extraordinary. That the same ceremony should have been carried over by the cottonmouth into the water is even more imposing evidence of genetic stability or utility, or both. The comparative study of such behaviour is the material of the burgeoning new field of natural history called ethology.

Practically all the eggs laid by reptiles are spherical or elliptical in shape. Those of snakes and lizards usually have flexible shells; those of crocodilians are hard-shelled, and the shells of turtle eggs may be either parchment-like or like glazed or unglazed porcelain. The eggs laid by a reptile at a given nesting may number from the two or three of the striped mud turtle (there is some indication that the African soft tortoise lays only a single egg) to the 150 or more of the hawksbill turtle. Some reptiles lay more than once during a nesting season. The usual number of nestings for the green turtle is three or four, but there may be as many as seven clutches laid, at intervals of nearly two weeks. The green turtle is one of a few reptiles of various kinds known not to nest every year.

In the big snakes, there appears to be an interesting correlation between the size of the individual and the number of eggs it may lay. On the average, the majority of snake species throughout the world lay between eight and 15 eggs at a time, but big constrictors will considerably exceed this number. Among the African rock pythons, for example, a 14-foot individual will lay about 20 eggs, but a 22-foot snake produces up to 100. An 18-foot reticulate python lays about 33 eggs, whereas a 25-foot female is known to lay as many as 103 at a time.

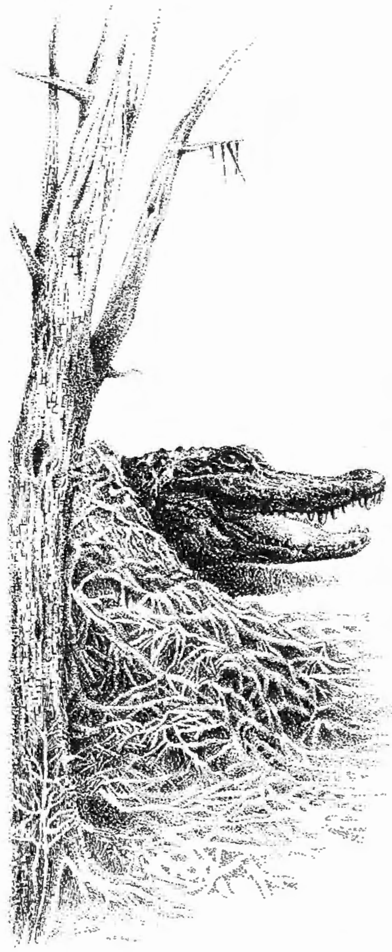
Reptiles usually lay their eggs in sand, soil, humus or rotting logs. The nests range from an angle between tree roots or a scratch in the soil to the deep, cleanly urn-shaped cavity made by some female turtles or the mounded nest of the alligator.

Crocodilians diverge widely in nesting habits. The American crocodile digs holes in the sand as sea turtles do. The American alligator, however, searches out a place at the edge of a pond or marsh where moist debris—leaf mould, twigs and branches, and even growing shrubbery—is available. This she scrapes into a high mound, and then digs a cavity in the top of the heap, deposits her eggs in it and covers it with material from the edges of the mound. This marked difference in a fundamental behavioural process may indicate a basic long-term divergence in crocodilian ecology. Perhaps the crocodiles have, since early in their history, been riparian and marine animals, and thus still tend to nest in the sand of bars and beaches. The alligator, on the other hand, may always have been a dweller in swamps, and as such has kept the tendency to build a raised nest, and to make it of stuff most likely to be available in swamps or marshes but not on the seashore. The mounded nest site raises the eggs above the waterlogged floor of the swamp, and the decomposition of the organic nest material furnishes the heat needed for incubation which is lacking in the shaded nesting place.

On a recent visit to the Caribbean coast between Honduras and Guatemala, I was excited to see on one clean stretch of salt beach the remains of nests and eggshells of three different reptiles all mixed together along the shore. One was the hawksbill sea turtle, which is fairly common in the waters of the region. Another was the American crocodile. The third was the big tree iguana, which has become thoroughly adjusted to a life that takes advantages from both arboreal and aquatic habitats. The mature iguanas spend nearly all their foraging and sleeping hours in trees overhanging the water. But if you seem to an iguana to be invading its haunt in a tree, it will simply let go and fall cleanly into the water. Under water it swims almost as well as a crocodilian, and conceals itself among roots or in cavities in the bank till the alarm is over. Different as the lives of iguanas, sea turtles and crocodiles are, the sand of the ocean beach offers the same attractions to all three animals as a place for incubating eggs.

With the end of the incubation period, the reptilian egg that has afforded such protection to the developing embryo becomes a prison to the young crea-

A MATERNAL ALLIGATOR



The female American alligator builds her nest by biting off huge mouthfuls of damp vegetation and combining them with mud to form a mound which may be six feet wide at its base and a yard high. From 15 to 80 eggs are then laid in a hole scooped out of the top. This is promptly covered by material pulled from the rim and packed down smooth.

Unlike most reptiles, which abandon their eggs after laying, the alligator hovers about to guard the eggs from other animals. When it is time to hatch, the baby alligators make faint squeaking sounds, signalling their mother to amble over and help them to tear open the mound.

ture inside, and clearly some device is needed to enable the hatchling to break out of the tough shell and membrane into the world. This is provided in snakes and lizards in the form of the egg tooth, a true if tiny tooth carried on the premaxillary bone and used by the little reptile to cut its way free. In turtles and crocodilians a similar function is carried out by the caruncle, a horny projection on the tip of the snout. Egg teeth and caruncles are shed soon after hatching—in the lizards and snakes usually within a day or two, in some turtles and crocodilians in two to four weeks.

Breaking out of the egg is a process that may take considerable time, even with the help of an egg tooth and certain secretions which, as hatching approaches, help the reptile young to free themselves by weakening the membranes and shells. In most reptiles, it takes several hours; in some, like the larger snakes, it may take as long as several days. Some of the turtles that spend their first winter after hatching in the nest may remain in the broken shell until the following spring.

CARE for the eggs during incubation, or for the young after hatching, is not characteristic of reptiles, but a very few species do show various, in some cases surprising, degrees of instinctive parental concern. One of the pythons, for instance, appears to brood its eggs, contributing perhaps some degree of metabolic heat to them—in any case, it coils around them in a protective fashion and will even continue to coil around the empty space if the eggs are removed. Certain colubrine snakes also have the brooding habit, as does one of the viper species. Among the lizards, the so-called glass snake and some related species coil around the clutch of eggs in the same way. Some of the American skinks of the genus *Eumeces* actively tend their eggs from the time they are laid in the nest until they hatch. During incubation, these lizards will ward off intruders, turn the eggs regularly and provide brooding warmth from their own sun-warmed bodies. One species even nursemaids its brood after the hatching: it assists the young to break out of the egg, sees to it that they can feed undisturbed, and cleanses their cloacal regions with its tongue.

This sort of post-natal care is certainly the exception among reptiles; turtles, for instance, show no suggestion of brooding or parental care whatever. Nor do most crocodilians, except for the alligator, which may return often to the nest site to fuss about, reshaping and moistening it during incubation and, when the croaking of hatched young is heard inside, to help them to get out of the nest mound. After the young hatch, too, the mother may retain some of her solicitude for them. Old alligators are often found in the company of bands of small ones. This may in part be simply because the hatchlings proceed directly to the nearest open water around, as likely as not a "gator hole"—a deep pool dug out by a big alligator as a lurking place. Nests are frequently made near such holes, or the pools are made near the nesting site where the female keeps watch during the incubation period. In the swamps and marshes in which alligators usually nest, a "gator hole" near the nest would be a logical place for the young to go to when they hatch—irrespective of whether they might get any protective attention from the parent. The point is debated by alligator hunters and other experts, but my own experience leads me to think that a "gator hole" with mother and hatchlings in it is indeed a rude sort of nursery. Certainly a female alligator in such a place, surrounded by offspring of even as much as several weeks old, can be expected to be more irritable and resentful of intrusion than Florida alligators are at other stages of their careers. I have twice blundered into such company while wading after frogs. Both times I nearly drowned myself in fright when the old alligator suddenly rushed half-way across the hole towards me in what seemed clearly a belligerent way. While in both cases the alligators stopped too short for biting, the point is that both mothers made overt defensive moves that quickly took my mind off any plan of putting their offspring in a bag, and would probably have had a comparable effect on any potential natural enemy. A few alligator men with whom I have discussed these incidents have assured me that the alligators that rushed at me were as scared as I was and were really only dashing away in panic. Other men who appear just as versed in "gator" lore say this is not so, that the seeming pugnacity is real.

In any case, there can be no doubt that bands of young alligators hold together for long periods after hatching, and that their croakings draw the mother to them. That alligators can be called out into view by a man croaking like a little one is proof of this, and I saw other evidence of it only recently when my boys found a school of young alligators with an old one in a sinkhole at the edge of a lake, and called me to look at them. These were not new hatchlings but were at least two months old. Nevertheless, they were still banded together in a loose sort of way, and when found were for some reason croaking so loudly in ragged unison that they could be heard from 50 yards off in the woods. They sounded like an uncertain chorus of some unknown frog. When we moved out onto the bank an old alligator cruised away into a patch of maiden cane. Clearly the young were hers, and clearly she still kept some instinctive concern for them—she glided out of the grass and moved a few feet towards us each time the bobbing young resumed their croaking, and also each time we imitated it. There was no sign of fight in her, but her moves were not the usual flight to the far fastnesses of the lake—they were sallies in our direction. Later we caught four of the little alligators. They ranged in length from $14\frac{1}{2}$ to 16 inches. This mother alligator's maternal drive had thus lasted at least two months and perhaps three. Later it may disappear completely, and she will eat as many of her offspring as she can catch.

One of the conspicuous features of reptilian behaviour is the seasonal aggregating of some turtles at nesting sites. The life cycle of an aquatic reptile is in broad outline a reversal of that of the amphibian. Most frogs go back to water to lay their aquatic eggs. Most water reptiles go to the shore to lay theirs. In some cases any kind of shore may be suitable, and the females are thus likely to emerge singly. But some turtles make long journeys to congregate at a specially favoured shore or in a few miles of preferred beach. The most massive known reproductive aggregations of any fresh-water reptile are those of a side-necked turtle, the arrau (*Podocnemis*) of the Orinoco and Amazon Rivers. Since the early naturalists explored the Amazon and Orinoco, the nesting assemblages of *Podocnemis* on certain sandy islands in the rivers has been a theme for excited reporting. The turtles come to the chosen islands from great distances up and down the river, and the gatherings are so vast that actual overcrowding of the nesting bars sometimes occurs. The adaptive function of the migration is not wholly clear. In part it may be dictated by the need for a special set of nesting conditions; but to some extent it may also be simply a hereditary tendency to cling to ancestral travel habits. In any case, the resulting aggregations are spectacular, and the people of the regions have, since pre-Columbian times, depended heavily on the nesting colonies for meat and eggs.

THE WIDE-RANGING GREEN TURTLE

Although green turtles may roam as far as 1,200 miles between their nesting site and foraging grounds in the Caribbean, their travel routes remain in the realm of the unknown. The map above indicates their presumed paths, based on a tagging programme initiated in 1955 at Tortuguero, Costa Rica, in which 3,000 adult female turtles were marked. Of these, 108 were later picked up at the sites indicated by the turtles at the end of each row on the map. Those drawn between Tortuguero and the recovery sites show probable travel paths.

All sea turtles appear to be migratory, and at least part of the periodic travel of all the species is back and forth between foraging places and nesting grounds. From information now available the hawksbill seems the least inclined to gather in groups for nesting, but even in that species some reproduction is weakly colonial and some carried out by widely spaced individuals.

The most clear-cut nesting migrations are those of the green turtle. Since this creature is herbivorous, most of its adult life is spent foraging on submarine pastures of marine plants. These may lie at considerable distances from the nesting beach. A favoured nesting shore thus recruits turtles from different areas, and some of these may lie many hundreds of miles away. The green turtles of the coast of Brazil migrate 1,400 miles to Ascension Island, a dot in the middle of the South Atlantic, battling against adverse currents, and staying on course by signs and senses not yet understood.

In some ways the most dramatic of all marine reptile activities, and among the most impressive assemblages of any aquatic animal, are the *arribadas*, or arrivals, of the Atlantic ridley, a short-shelled, big-headed sea turtle whose breeding habits were until lately almost wholly unknown. Ridleys foregather in immense assemblages on the northern gulf coast of Mexico. Henry Hildebrand of the University of Corpus Christi has described them in a recent paper. One of these incredible aggregations was filmed by Señor Andres Herrera of Tampico, Mexico, in 1948, and his film lay unnoticed by zoologists until discovered by Doctor Hildebrand and shown at the Austin, Texas, meetings of the American Society of Ichthyologists and Herpetologists.

Señor Herrera generously let me have a copy of his film. I have studied it repeatedly, and it seems to me one of the most dramatic revelations of modern zoology. In the first place the film was made in the daytime, whereas most sea turtles nest at night. Señor Herrera and Doctor Hildebrand estimate that 10,000 ridleys are in view in the mile of beach shown, and that at least 40,000 were there during the whole day of the *arribada*. The film gives the impression that one could walk away into the distance for miles, stepping from the back of one nesting ridley to another. The arrivals occur at wholly unpredictable times from April to June. The time signal may vary from year to year, but all the turtles get it and swarm ashore, along many miles of almost uninhabited beach line. There are said to be three *arribadas* a year, and they occur at different points on the beach. This is a good thing because the sand of a section already visited must surely be loaded with eggs, and a later nesting at the same site could only destroy much of the result of the one that preceded it.

Some of the sea snakes periodically band together in the ocean, presumably for reproductive purposes. There is an old report of a migrating train of sea snakes 60 miles long, and several species have been seen in smaller conclaves. Most sea snakes are live-bearing animals, and thus do not come together for nesting. The gatherings therefore are simply a means of mobilizing the sexes at mating time. Much probably remains to be learned of the social customs of sea snakes.

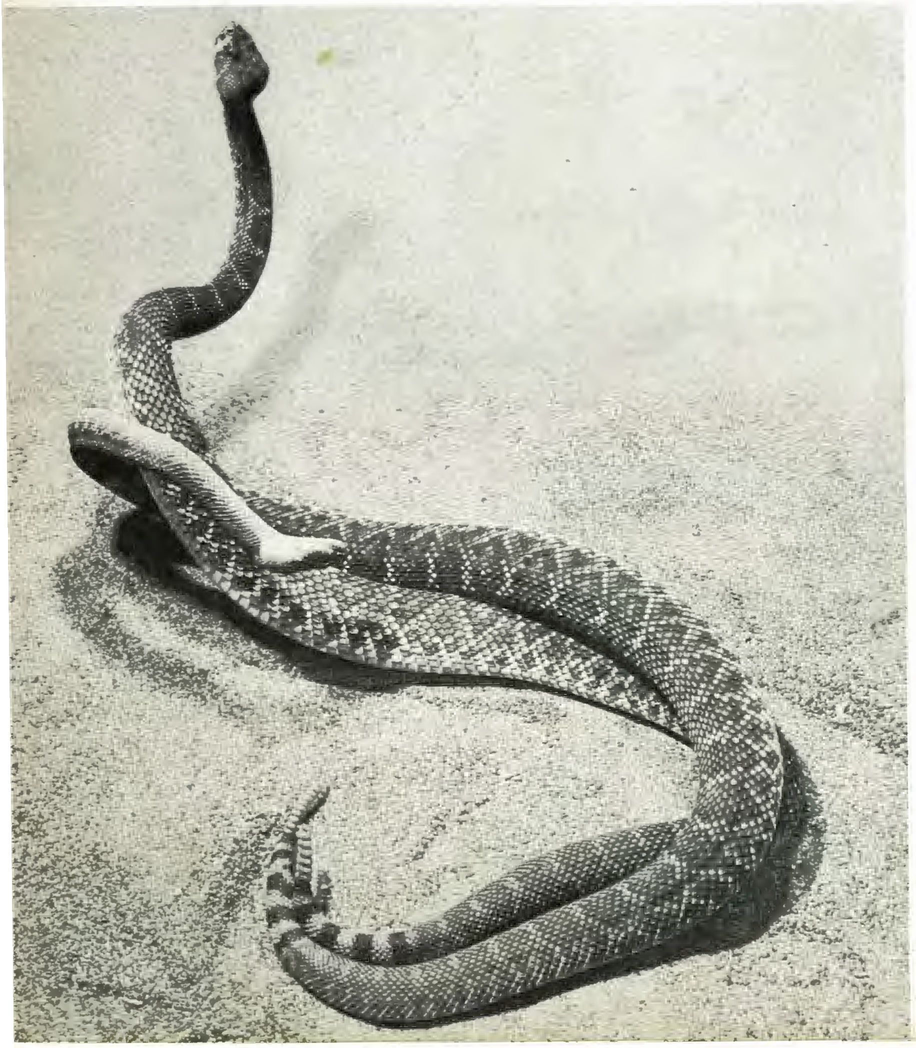
In fact, much remains to be learned about the whole subject of reptile reproduction. The great innovation reptiles made, putting a shell on their egg, seems a forthright, even simple evolutionary move. But the adjustments this single advance brought on have gone spreading and weaving through the lives of all of us for 300 million years. The songs of birds are because of the egg with a shell, and so are the thoughts of men.

BREAKING FROM ITS EGG, A 10-INCH BABY CROCODILE MAKES AN AWKWARD ENTRY AT LONDON'S ZOO. AS AN ADULT IT MAY REACH 16 FEET

Courtship and Egg-Laying

As the first vertebrates to venture far from water into the continental heartlands, reptiles had to evolve hardy eggs and the advanced mating practices that go with life on land. The hardiness of their eggs is confirmed by the one above, which was laid in Africa but hatched in London. Some of the odd ceremonials connected with reptile reproduction are depicted on the following pages.

TEST BY WRESTLING between two red diamondback rattlesnakes *(above)* starts out with one climbing up the other. When they over-reach and collapse inconclusively *(below)*, they writhe and spar in preparation for the next fall.



Combat and Colour among the Males

The generally accepted practice in the animal kingdom, when the time comes to reproduce the species, is for the males to put on a show that will impress and captivate the females—a courting activity which extends right up to man. As in other matters, however, reptiles have their own ways of doing things: their efforts at courtship time, while still confined to the males, seem to be directed more at discouraging male rivals than at winning over females.

The show the males put on is impressive. Some may engage in ritualistic combat, like the two diamondback rattlers shown at the left, wrestling gracefully and sinuously to repeated falls. Others, like the anole lizard opposite, put on gaudy colours and spread frightening fans to intimidate rivals. Some lizards dance, others affect strange, stiff-legged gaits. The net effect is to single out the fittest members of the male population as breeders, leaving the weaker to go elsewhere—a useful practice that may date back to earliest reptile times. As for the females, though they seem generally oblivious to these exaggerated male antics, they succumb in the end and mating takes place.

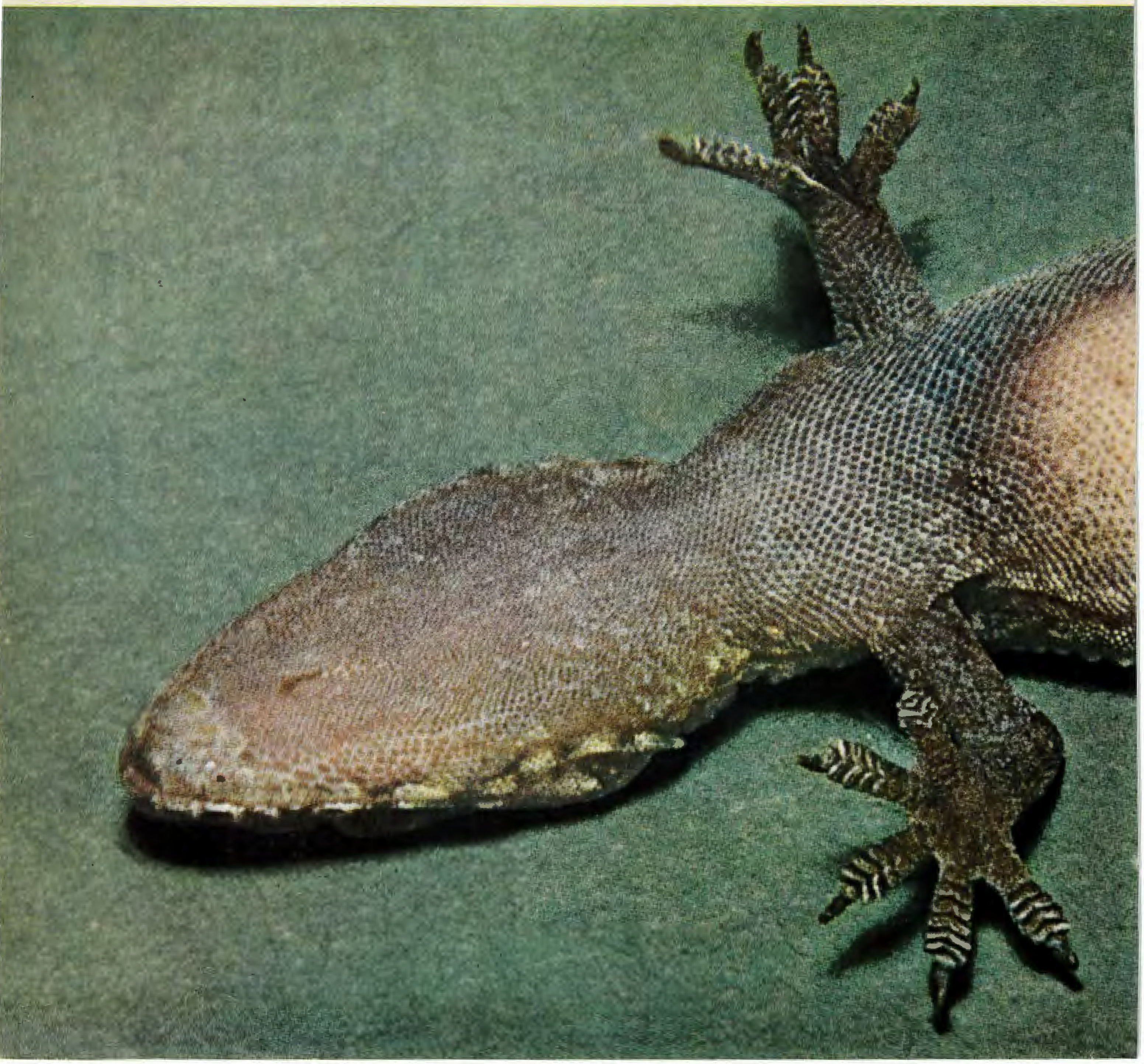
TEST BY INTIMIDATION is practised by the male anole lizard, which can spread these flaccid folds beneath its chin to a fan of bright colour at mating time. A cartilage rod inside serves to flare out the lavender skin.

THE FRUITS OF LABOUR, three large eggs, lie beside an indigo snake as she lays a fourth one. Here photographed in captivity, she would normally lay her clutch in a burrow underground.

The Mother and Her Eggs

The end product of reptilian mating represents one of the great triumphs of evolution: an egg that comes into the world fertilized and fortified, externally by a shell, internally with food and water for the entire development of the embryo inside it. Such an egg has a pretty good chance of surviving on its own, and indeed, there are few reptile eggs that get any maternal attention at all throughout the period of incubation. Turtles, who lay the most eggs—up

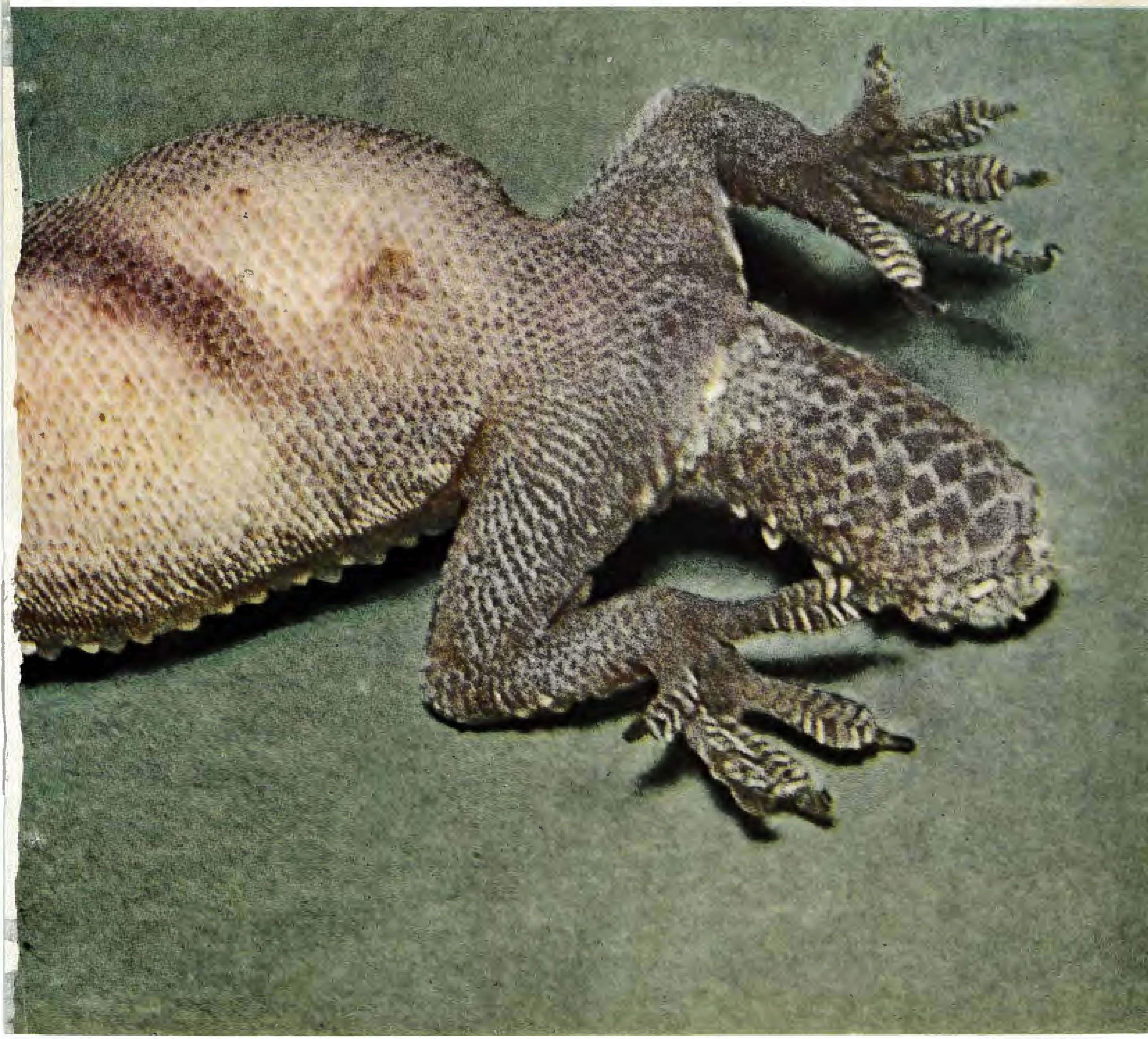
TWO LARGE WHITE EGGS OF A TEMPORARILY TAILLESS TURKISH GECKO SHINE THROUGH THE TRANSLUCENT SKIN OF HER BELLY. SOON SHE WILL

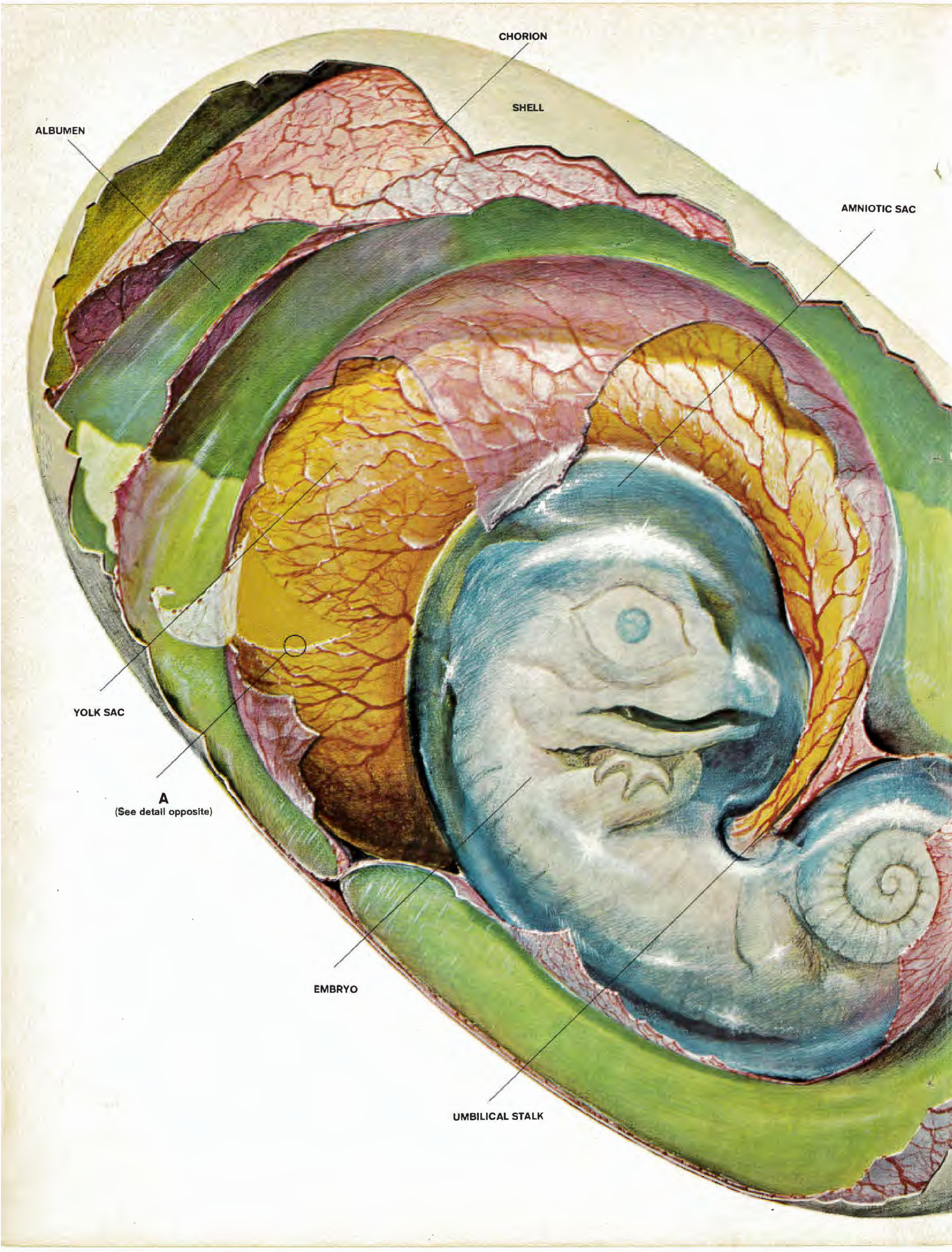


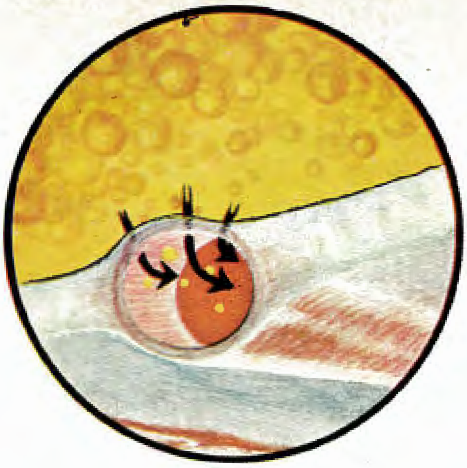
to 400 a year in the case of sea turtles—care for them the least, generally abandoning them to the sand or earth in which they bury them. Crocodiles, lizards and snakes normally lay fewer eggs, but may do more for them—exploiting the sun to keep them warm, or supplementing sunlight with the warmth generated by decay in nests of rotting vegetation. Still others guard their eggs against predators, and one, the Indian python, broods them like a hen.

THE BURIED NEST of a peninsula cooter, a Florida fresh-water turtle, shows a clutch of eggs buried deeply with two left at the sides, possibly as decoys to mislead nest-robbing predators.

LAY THEM, UNDER A STONE OR OTHER SHELTER, TO HATCH IN A FEW MONTHS AND GROW, LIKE THEIR MOTHER, INTO AMIABLE HOUSE PROWLERS




CHORION
SHELL
ALBUMEN
AMNIOTIC SAC
YOLK SAC
A
(See detail opposite)
EMBRYO
UMBILICAL STALK

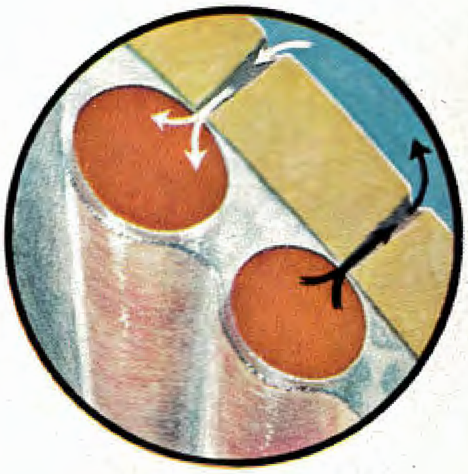


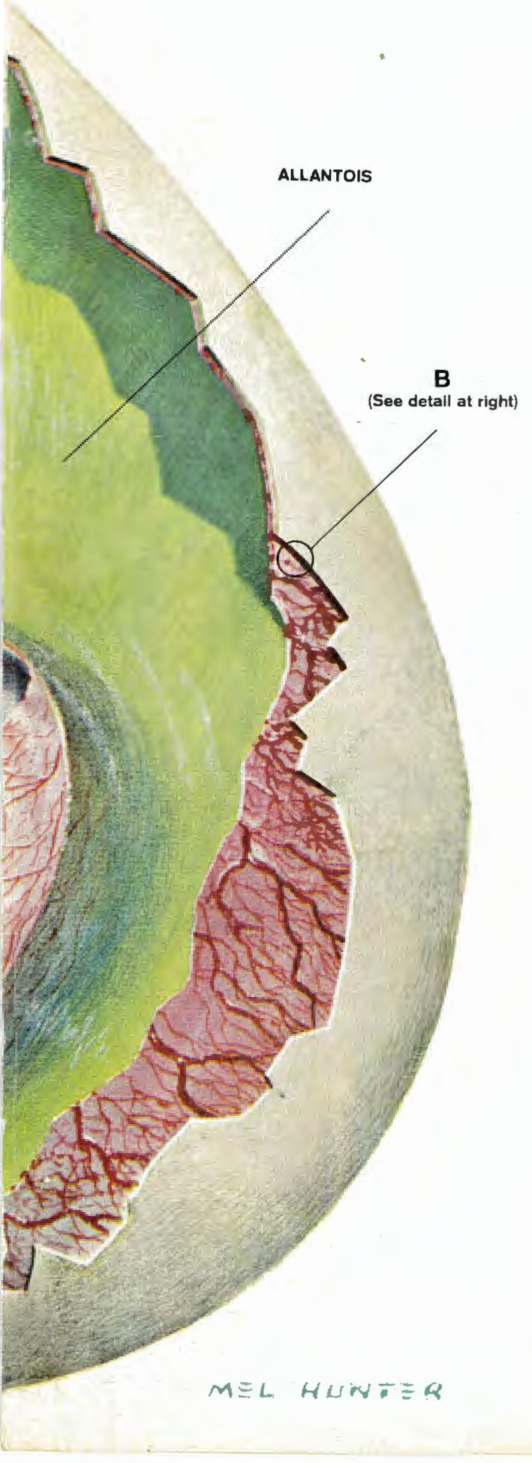
HOW THE EMBRYO FEEDS

Food channels in the form of blood vessels in the lining of the egg's yolk sac (circled area A, opposite) take up nutritious chemicals from the rich golden store of sugars, starches, fats and proteins laid away in the yolk. The blood proceeds to circulate them throughout the whole yolk wall. Thus they reach the abdominal region of the embryo where they are in turn used for growth. Waste chemicals pass out of the embryo into the fluid of the allantois.

HOW THE EMBRYO BREATHES

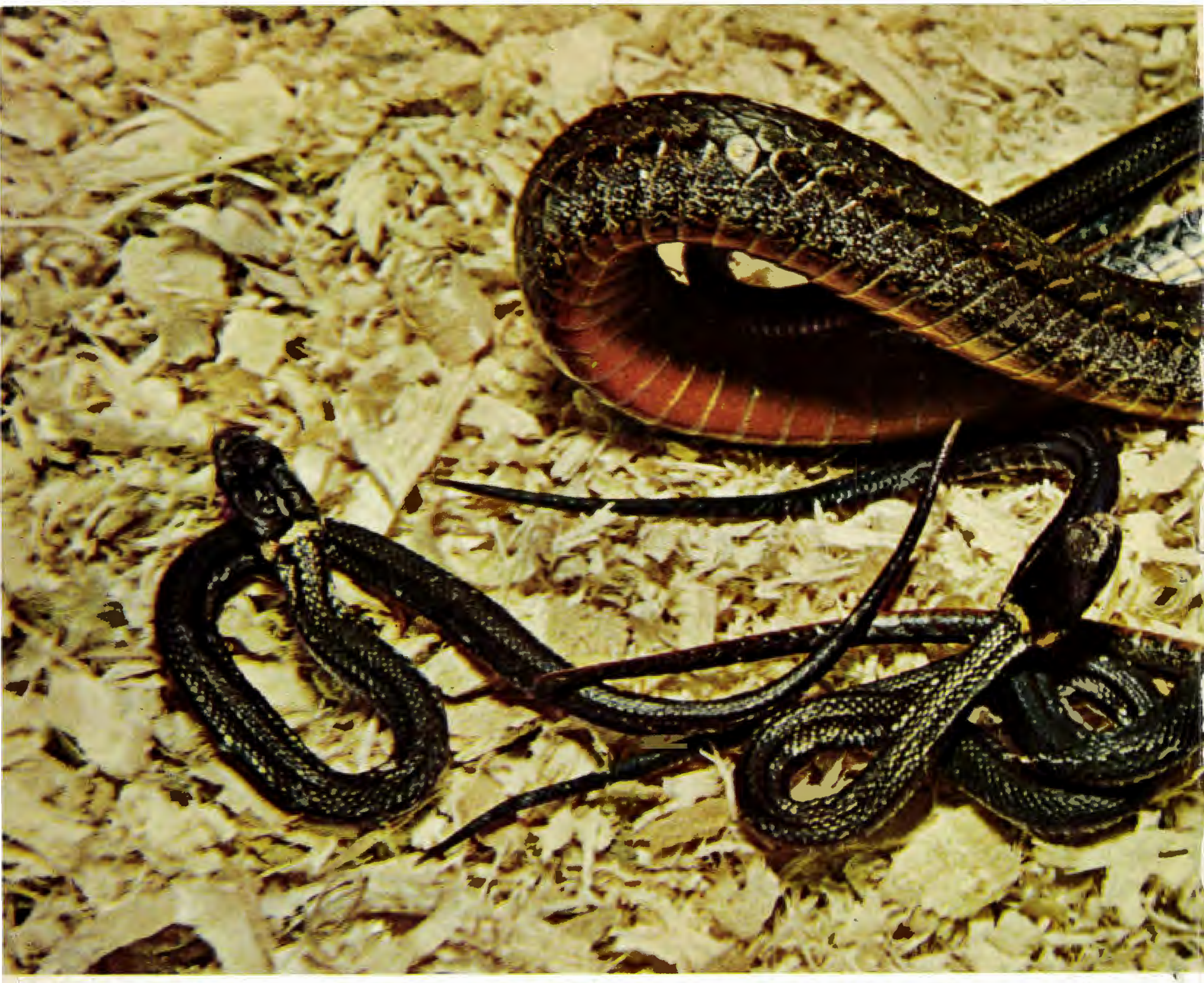
Gas vents in the porous shell wall (circled area B, left) are revealed as small holes in the enlargement at the right. These let life-giving oxygen into the alligator egg and poisonous carbon dioxide out of it. The oxygen is captured by oxygen-hungry haemoglobin molecules in the blood vessels of the chorion, which carry the vital gas by way of the allantois to the embryo. The carbon dioxide escapes from the blood by a process of seepage known as gaseous diffusion.





Inside the Egg

Compared to the simple eggs of fishes and amphibians, which are laid in water and often depend on it to bring fertilizing sperm to them, the reptile egg is a staggering innovation—the product of aeons of development which started when the reptiles' amphibian ancestors first took up internal fertilization. The alligator egg at the left, with its embryo in a half-way stage of development, typifies the complexity of most reptile eggs. The embryo in the centre is connected by an umbilical stalk to the primary food supply, the yellow yolk sac, and is encased in the amniotic sac, an envelope filled with fluid which laves the embryo and cushions it from shock. The amniotic sac and yolk sac, in turn, are surrounded by still another envelope, the allantois, which in the early stages of development grows out from the embryo's hind-gut. The allantois gets larger as the embryo grows and the yolk shrinks. It serves both as a storage bladder for uric acid, ammonia and other wastes, and as a conveyor for incoming oxygen and outgoing carbon dioxide. Another membrane, the chorion, encloses allantois, amniotic sac, yolk sac and embryo in a tough, resilient envelope closely associated with the eggshell itself. In crocodilians and turtles, the chorion contains egg white, or albumen, which serves to supply the embryo with water and probably some food.

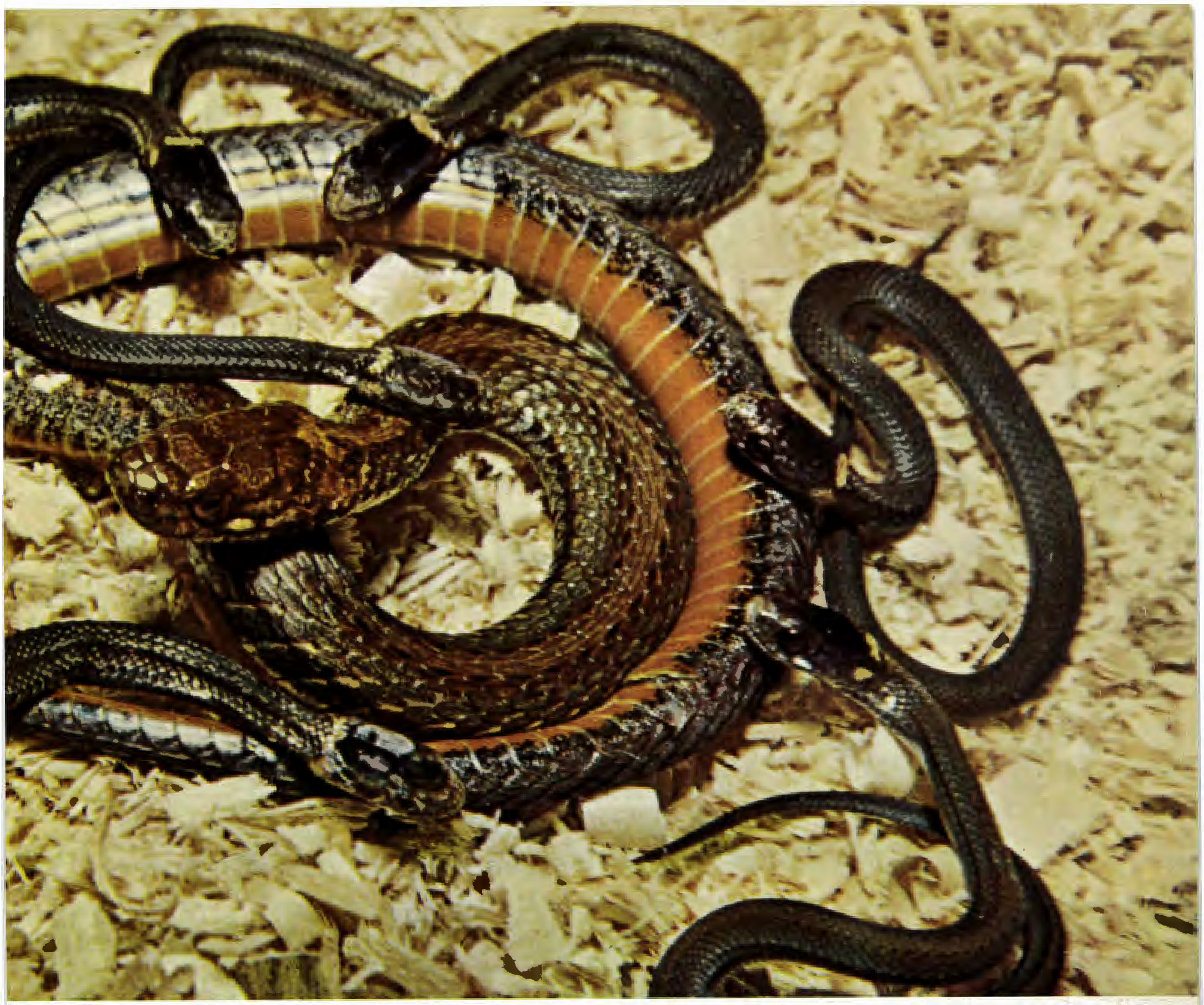


TINY OFFSPRING OF AN AMERICAN RED-BELLIED SNAKE, BORN ALIVE BUT SO SMALL THAT THEY CAN COIL ON A SIXPENCE, WRIGGLE ALL OVER THEIR

HATCHLINGS of the common snapping turtle are barely an inch long. When grown they will weigh 30 pounds each, but they are belligerent from the start, always ready with a quick nip.

The Hazards of Hatching

The protection which the shelled egg gives to the developing embryo is its most obvious contribution to the survival of the species—but scarcely less important is the fact that when it hatches it lets out into the world a tiny miniature of an adult, equipped from the beginning to make its own way in its environment. But to reach this perfected state the embryo needs a long period of development in the egg. Turtles like the snappers at the left need two to three months; the primitive but specialized New Zealand tuatara needs more than a year. During these long incubations the eggs must be protected from predators and other dangers. Turtles achieve this by



10-INCH MOTHER. SMALL AS THEY ARE, THESE YOUNG ALREADY HAVE THE HUNTING INSTINCT AND FEED THEMSELVES ON SLUGS AND EARTHWORMS

laying scores of eggs and burying them for concealment in sand or earth. Tuataras' eggs, which are buried in shallow holes near their burrows, are given still further protection by the very remoteness and desolation of their island hatcheries. But many reptiles have evolved ways of keeping their eggs during part or even all of their incubation period in the safest of all hiding places: the body of the mother. Some hatch the eggs in the oviduct, some have developed placenta-like connections, similar to those in mammals, to feed the embryo as it grows. But however they are born, baby reptiles meet the world fully formed and prepared to fend for themselves.

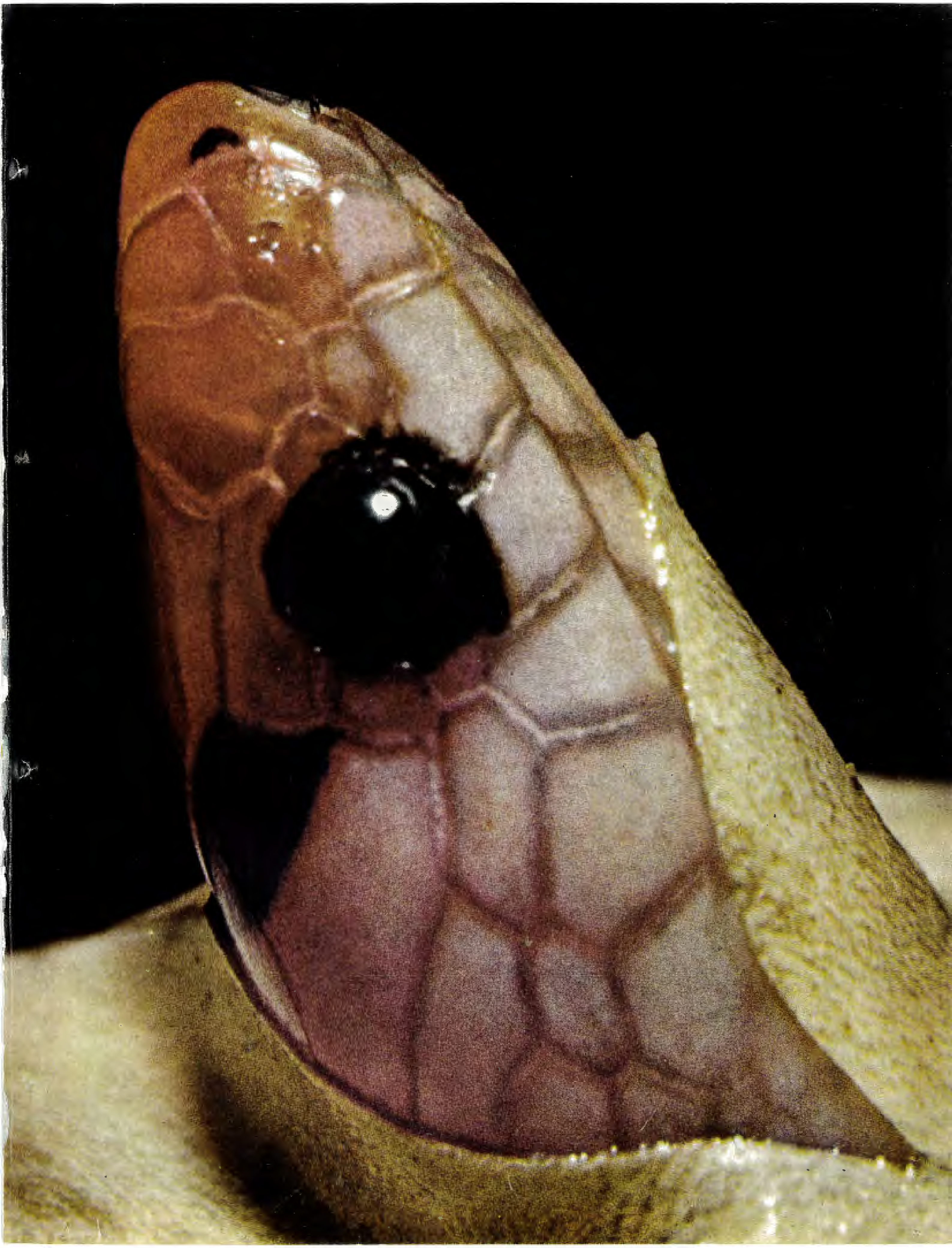
COPPERHEAD YOUNG, roughly nine inches long, are born in sacs, the last relics of an egg. In half an hour, already poisonous enough to kill small prey, they will break from these sheaths.

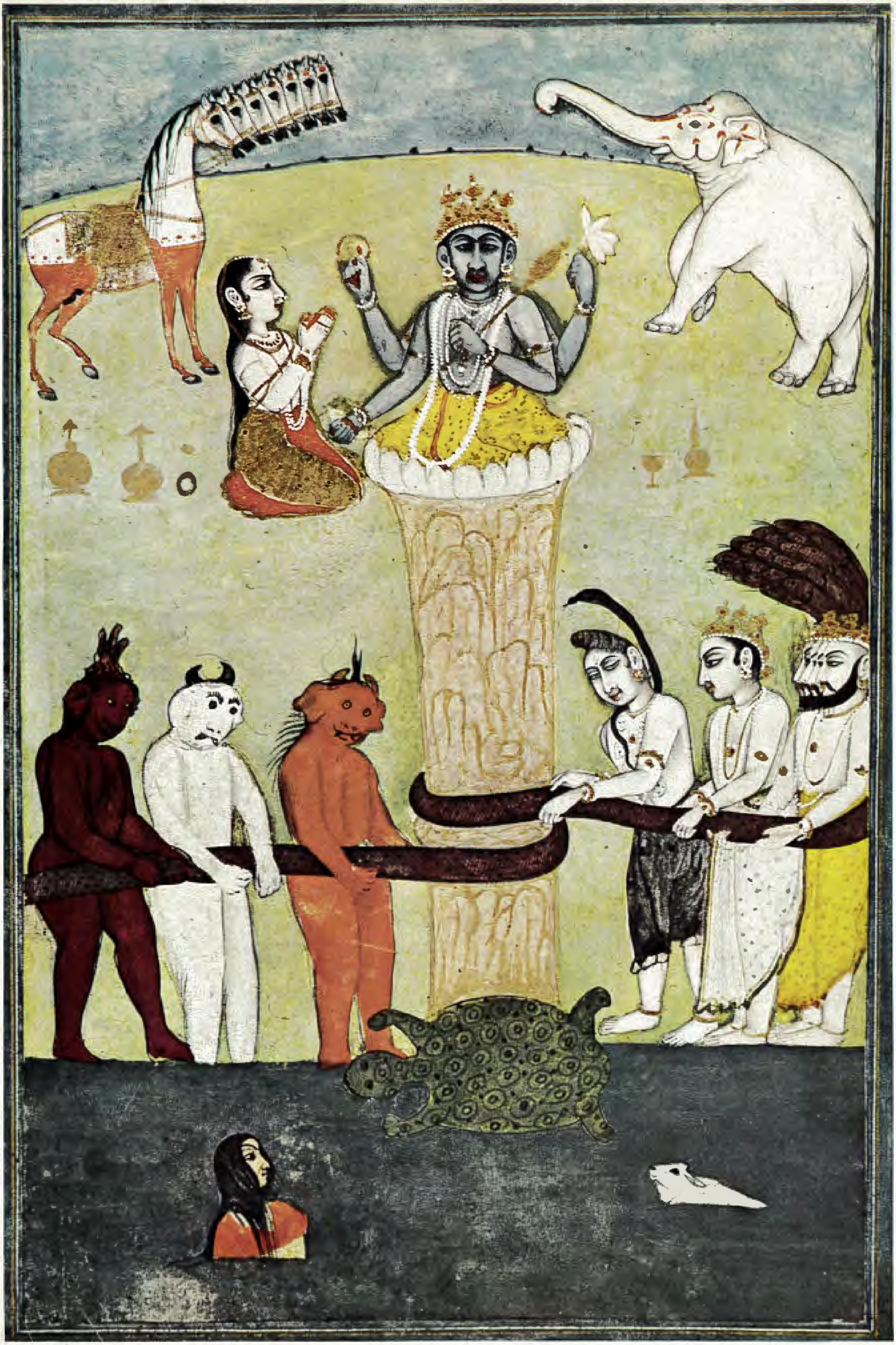
Cutting Out to Meet the World

How tentative and experimental the reptiles still are in their efforts to abandon the egg and bear their young alive is dramatically demonstrated by a special little tool which all of them, even the live-born, still have. This is the egg tooth, a sharp protrusion on the snout with which a baby reptile can cut its way out of its tough, membrane-lined shell. To be sure, in live-bearing species which have no need for it the egg tooth is degenerating (even the egg-layers drop it soon after birth). But it still stands as a reminder of the difficult escape problem the shelled egg has always presented for the beakless reptiles.

CUTTING ITS WAY into the world, a baby scarlet snake makes the first slit in the egg's shell *(top picture)*. Several hours later, it has enlarged the hole sufficiently to crawl out, fully formed.

CLOSE-UP of the baby snake's head *(opposite)* at the moment of emergence from the shell shows the egg tooth as a tiny triangle at the top of the picture just left of where the mouth begins.





AN INDIAN MINIATURE of the 18th Century shows one of many symbolic uses of reptiles in Hindu mythology. Here the god Vishnu is a turtle supporting a serpent-driven churn which brings miracles from the sea.

7

Growing Troubles with Man

Reptiles and people have always been important to each other. In the old days the relation was the natural give-and-take of ecology. Today we have taken the earth in hand, and in the lives of reptiles we loom much larger, while they count for less in ours. But in the time we lived together we were for ever marked by these cool, dry creatures. Their sign is still on the human spirit all over the world, in their pervasion of mythology and religion.

In Judeo-Christian tradition the snake is generally assigned an evil role. The temptation of Adam was instigated by the serpent; and besides getting original man expelled from the Garden of Eden, this turned the mind of the race towards procreation, which will, no doubt, one day make the world unfit for both men and snakes. There is some talk of the leviathan that ate Jonah being a crocodile instead of the whale it is usually thought to be, but this seems unlikely to me. A crocodile generally chops up its prey too thoroughly for it to have much to say if it should ever get out again. A sort of backhanded intrusion of reptiles into Christian history was St. Patrick's taking credit for the palaeogeographic inequity of Ireland's having no snakes. Actually the snakelessness of Ireland is pretty much the same sort of thing as the lack of elephants there, but

I suppose the chance was just too good for St. Patrick's public relations men to miss. I believe it is not generally known that someone once introduced a lot of snakes into Ireland in an effort to establish them there. I cannot say whether this was done idly or scientifically or in a spirit of iconoclasm. The *Edinburgh New Philosophical Journal* for April 1835 had only this to say of the event:

"We have learned from good authority that a recent importation of snakes has been made into Ireland, and that at present they are multiplying rapidly within a few miles of St. Patrick's tomb."

Both turtles and snakes turn up repeatedly in Asiatic mythology. The third incarnation of Vishnu, the supreme god in the Hindu pantheon, was in the form of a turtle. At Vishnu's suggestion the gods and demons set out to churn the ocean of milk to bring up the amrita, the liquor of immortality. They uprooted Mount Meru and set it in the sea as a churn staff. They somehow persuaded the great snake Vasuki to throw a half-hitch of his body around the staff and to let himself be used as a churn rope. Vishnu took the form of a big sea turtle and placed himself under the foot of the staff as a pivot base. There was some squabbling among gods and demons as to which would pull the head end of the churn rope and which the ignoble after-end, but after a while they all fell to and churned for a thousand years. At one point the snake grew indisposed and threw up a terrible poison that came close to killing off all the gods, but Siva seized and swallowed it, and that is how his throat came to be blue. After other awesome vicissitudes the goblet of amrita finally came up, and likewise the comely Lakshmi, the goddess of beauty.

Another set of reptilian beings important in Indian mythology was a fabulous race of snakes, or half-snakes, often shown as put together of a human forepart with the back part normal snake. The males of these were called Nagas and their wives Naginas; and their natures were generally irresponsible and difficult. On the other hand, some Hindu snakes were beneficent. During the epochs of his cosmic rest—the times between his incarnations—Vishnu sleeps on the coils of the noble cobra Shesha, whose seven heads rise over the god as shade for his aeon-long siesta. This is why Indians are kind to cobras.

ALL over the warm parts of the earth, crocodilians have been taken into religion and mythology. In many places the veneration is a sort of bribery, in which crocodiles are fed to gain their good will. Other cults allow only the killing of crocodiles that have attacked people. At Lake Itasy in Madagascar a yearly proclamation is made announcing formally to the crocodiles that the evil ones among them—those which have killed someone during the past year—will be liquidated in their turn, and that all upright crocodiles should thus stay out of the way. In ancient Egypt, crocodiles were worshipped. Herodotus said that in parts of Egypt each household had a tame crocodile, which was fed daily, adorned with jewels and, when it died, embalmed and placed in a sacred repository. Crocodile mummies have been found in tombs. Crocodiles are still kept by fakirs near Karachi in Pakistan, and devout pilgrims buy goats which are cut up and fed to them.

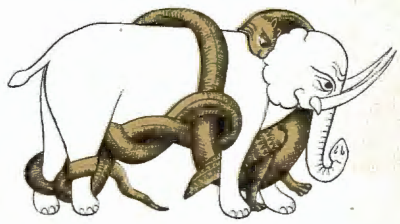
Throughout the Americas reptiles were involved in the religions of the Indians in various ways. The most influential American reptile god—in this case a half-reptile god—was Quetzalcoatl, the feathered serpent and the "fair god" of the ancient Mexicans. This deity was put together from two stirring animals of the Mexican world: the quetzal and the rattlesnake. The quetzal is the resplendent trogon, the most striking of American birds. To this day, seeing a quetzal slash through the green gloom of the cloud forest will make a mystic of the average man. The rattlesnake, especially the big diamondback and irascible tropical rattlesnake that the Toltecs and Aztecs knew, is one of the more imposing reptiles anywhere. The quetzal came to mean the wind, and the rattlesnake the whirlwind; put together they were Quetzalcoatl, who pushed the clouds.

Pushing clouds brought on rain, and so put fertility into the land, and from there all blessings flowed. Like most primitive gods, Quetzalcoatl had such varied manifestations that it takes a specialist to trace them. One of his exploits was sailing across the Gulf of Mexico on a raft of serpents. When the Spaniards landed in Mexico, the emperor Montezuma thought they were Quetzalcoatl and his retinue returning, and this weakened his resistance to the invasion and hastened the fall of the Aztec Empire. The feathered serpent was prevalent in pre-Columbian architecture and decoration through most of southern Mexico, Yucatan and Guatemala. I had lived in the Honduras mountains for three years when archaeologist Doris Stone came by one day excited over a rumour of "painted rocks", and we rode to the far side of my favourite mountain and found Quetzalcoatl there, engraved in the rhyolite face of a shallow scarp.

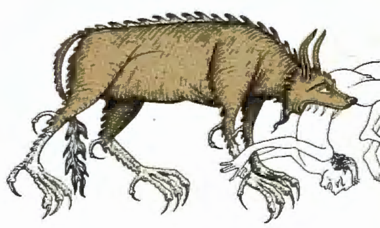
SINCE the dimmest of ancient times Europeans have been religious about vipers. Pliny and Galen prescribed the eating of vipers as a cure for various ills. Both viper broth and the boiled flesh, either prepared at home or bought at the apothecary's, were popular remedies until fairly recent times. Among the ancient Gauls the magic spread from the adder itself to a potent charm called *glein neidr*—serpent's egg, or adder stone. These adder stones were actually old beads found about the countryside, but the Druids claimed that they were produced by a group reproductive effort of a summer congress of adders, and held some of the magic of the parent snakes. Adder stones strengthened their owners in legal disputes and helped them to get access to kings. In Celtic parts of the United Kingdom the beads were until recent decades still valued by country people for driving away an ague or protecting children from such childhood ailments as whooping cough. Perhaps they still are.

In eastern Europe and the Middle East a cult persisted until recently in which snakes were made welcome in farmhouses and allowed to live there rather like beneficent spirits—perhaps a relic from the Greek and Roman custom of keeping snakes to hold down the rat and mouse population. When the cry of the house adder was heard in the evening (needless to say no adder can cry, but that is quibbling) a saucer of milk, covered half over by a clean white cloth, was put out for it, and the adder would come and drink. At least the milk would sometimes be gone the next morning. Whether it ever disappeared in houses in which there was no dog or cat I have never heard. In various parts of Africa house snakes are offered milk too, although there the snakes are thought to be relatives come back in serpent form. I do not suppose there could be any ethnic kinship in the two cults, but all the same it is curious that milk should be the propitiatory offering in both cases, because snakes do not like milk. At least none of mine ever did. And I have tried a lot of snakes on milk, to see whether there could be any sense at all in the various milk-snake stories you hear in the Americas. One of the best-known folk beliefs about snakes in the United States is that a kind of king snake steals milk straight from the udder of the cow. As fastidious as cows are about snakes and strange sensations in their udders, the myth is not worth much thought, except for the coincidence of its dealing with milk again. But this even makes one recall that in the Hindu legend it was a snake that was used as a spindle rope to churn the ocean of milk. Even though all these

MYTHICAL REPTILES



Medieval men entertained some bizarre notions about reptiles. Draco the Dragon was described in a 12th Century bestiary as the biggest of all living things. The strength of this serpent-like beast was supposed to lie not in its teeth, but in a long coiled tail that could suffocate an elephant (above). Beyond these fancies, its genesis remains obscure, but the Crocodylus (below) clearly derives from the African crocodile. It was named for its "crocus" colour. Bred in the Nile, it was correctly assumed to be active at night, to incubate its eggs in the earth, and to eat people. However, its long legs, clawed feet, prominent ears and tail are imaginary.



coincidences are probably fortuitous, they serve to show the close, graded relationship between religion and folklore generally. The folklore of reptiles is immensely rich and would make a book in itself. They have important significance in nearly every cultural pattern except that of the Eskimo. Dragons are really only the medieval version of the older great snakes or "pytons" of Mediterranean theology. The Chinese dragon is also an embellished snake, as anyone who ever saw a Chinese New Year celebration will realize. The widespread "tree of life" symbol stands over a pool guarded by a serpent. The guardian aspect of the serpent is also epitomized in the "uraeus", an important part of the royal insignia of ancient Egypt. It is a cobra with spread hood, symbol of the goddess protector of the Northern Kingdom. The Indian nagas are guardians of jewels and buried treasure. Naas, a Semitic word for serpent, gave rise to Nazar, to protect; and the Gnostic sect of Naasenes worshipped Jesus of Nazareth in the form of a serpent. In Greek mythology Draco was the never-sleeping, many-eyed, serpentine guardian of the apples in the Garden of Hesperides.

A whole system of purification myths in which the initiate figuratively "passes through the body of the serpent" is probably based upon the snake's shedding its skin. The serpent represents wisdom and the transit symbolizes the difficult passing of the spirit through the narrow gates of knowledge. Jonah's adventure with the whale is a greatly garbled version of this conceit.

In Greece and throughout the Mediterranean oracular serpents were considered to be inhabited by the spirits of dead heroes. Even where snakes are not objects of worship or deification, their mystic influence on the human mind shows up in the many-faced phenomenon of snake-charming. The best snake charmers have always lived in the East. Some of the things they do are not yet wholly understood. Although through the centuries Indian snake charmers have been given a great deal of critical attention by visitors determined to be objective and "bring out the true facts", I know of no really adequate appraisal of the art. In some cases the snakes involved were found to have had their fangs drawn or their mouths sewn shut, but obviously such tactics are not the whole answer, because in most cases they are unharmed and perfectly capable of biting—in fact, there was a case a few years ago of a lady snake charmer in the U.S. who was bitten by one of her cobras and died. In any case, the snake charmers of India are said to have to swear a holy oath that they will keep a snake only six months, so that they are constantly having to renew their stock, on pain of being bitten if they violate their promise.

So the question really is whether the snakes are simply tame, or whether the charmer knows tricks of snake psychology unknown to other men. The American herpetologist Clifford Pope thinks the charmed snakes may just be disarmed by being well fed and compares the charmed snake to one basking in the sun, similarly lethargic and not to be frightened away by talking or even shouting. Certainly it is not the music that does whatever charming may be done. Pope records an experiment in which snakes were subjected to terrific noises. Their eyes were taped and then bugles were blown and large tin cans were beaten near their heads. The snakes, being deaf, showed no reaction whatsoever. They did, however, react immediately when anyone walked or moved a chair near by —such movements being transmitted as vibrations through the ground. The belief, however, that music charms snakes dies hard.

Snake-charming is a practice ancient enough to be mentioned in the Bible, and it came to the New World too, bringing rattlesnakes into its lore and legend. There is a story, for instance, mentioned by Laurence M. Klauber in his monumental work on rattlesnakes, of a berry picker who used a mouth organ to render rattlesnakes harmless while he went about his work, and another very tall tale of an Indian who trained a band of rattlesnakes to join him in a mixed chorus: the snakes, which ranged from small to large, carried the soprano, alto, tenor and bass parts with their rattles. Apart from music, however, one thing all snake charmers, whether in India or among the Hopi Indians, have in common is rhythmic and incessant movements of their arms, bodies and, in snakes dances, of their legs. It is possible that snakes may be bewildered by this, possibly even hypnotized in some way. But in any case, with or without a mystic rapport between snake and man, snake-charming recalls an old mindless horror in a small pageant of man, snake, flute and basket; and the pageant panders to primitive desires for about the same reasons that a Spanish bullfight does. A good snake charmer gives a good show. It is a great shame that crude charlatans fake so stupidly, or go overboard with revolting zeal, as in the case reported by a traveller in Egypt, and quoted by the *Pictorial Museum of Animated Nature:*

"I have seen at Cairo a man who came from above the Catacombs, where the pits of the mummy-birds are, who has taken a cerastes [a horned viper] with his naked hand from a number of others at the bottom of a tub, put it upon his bare head, and tied it about his neck like a necklace. After which it has been applied to a hen, and bit it, which has died in a few minutes: and to complete the experiment, the man has taken it by the neck, and beginning at the tail has eaten it as one would do a carrot or stick of celery, without any seeming repugnance."

Being both pictorial and endowed with a background of mysticism, reptiles have served in all kinds of ways as symbols in heraldry. The turtle stands for invulnerability to attack; the reptile-like dragon for aggressive invincibility, showing up as a fierce symbol on shields and banners all around the world and all through history. The Manchu emperors used it, and so did the Mikado, and so do we in Britain, incorporating it in the royal arms of Wales. The basilisk of fable is a sort of snake-lizard whose very glance is fatal—hence the deadly qualities of literature's "basilisk stare". The basilisk probably derives from the royal cobra of ancient Egypt. Its nominal modern representative is a genus of tropical American lizards, *Basiliscus*, which flaunt erectile crests along their heads and backs in a frightening fashion.

IN American heraldry, not surprisingly, it is the rattlesnake that plays the major role. DON'T TREAD ON ME was the warning motto of the coiled rattler pictured on the banner of John Proctor's Independent Battalion of Westmoreland County when these Pennsylvanians went to war against the British, and the first Navy Jack carried a rattler out onto the high seas, stretched diagonally from lower right to upper left across the 13 red and white stripes symbolizing the colonies. One of the original companies of the U.S. Marines also had a rattlesnake painted on its drum when that newly-formed corps first saw action.

Another and usually more peaceful way in which reptiles and people are involved with each other is in the keeping of reptiles as pets. Little boys have always liked any reptile they were not afraid of or, if the liking was affected, the wonderful reaction the reptiles produced in girls certainly was not. But until lately, when a pet was taken into the bosom of a family it was generally furred or feathered, and was hardly ever a scaly reptile. Now however, at first in Europe and a bit more slowly in the United States, reptiles are being taken increasingly into households; and this time it is not as ancestors snooping about in reptile form, but as agreeable and rewarding animal companions. Not long ago little turtles, anole chameleons and baby alligators were almost the only reptiles to be found for sale in American pet stores. Today, in many cities you can choose from a varied line of lizards, snakes and turtles in the pet shops, and this commerce has suddenly become one of the principal ways in which man is exploiting reptiles to his material gain. By far the most popular reptilian pets are baby turtles, which are hatched for the trade by millions in Mississippi Valley hatcheries. The sale of baby alligators is now prohibited, but importation of tropical caimans is filling the gap. Snakes and lizards, because they are partial to live food, are a little less easy to keep than turtles, but for a determined culturist this is no real problem. People are keeping snakes and lizards all over the world, and are no doubt better people for it.

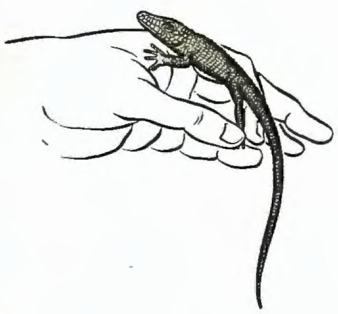
It is perhaps idle but none the less engaging to speculate about the origins of the odd spiritual ties between reptiles and man. The new vogue for reptile pets, like the little boys' old interest in them, is part bravado—a swelling pride in shedding a fear. Therefore, the origin of the conquered fear is the thing that seems worth psychological attention. Some of it is traditional, learned or affected. Part of it, however, may be innate. For a long time it has been the habit of sages to deride the popular belief that the dread of snakes is instinctive. They point out that a baby does not recoil at a proffered snake; he accepts and chews on it joyously. But this means nothing. The same baby will not whistle when a pretty girl passes. The anthropoid animal has had long evolutionary communion with serpents. There is growing evidence that a main centre of human evolution was in a part of Africa where cobras, mambas and pythons are common today and probably have been for a long time. It is unthinkable that with such a background we should have failed to acquire any inherent snake-avoidance adaptations. It is even less likely that we should have wholly lost them.

That is to say, I am pretty sure a little of the fear of snakes *is* instinctive. The greater part of it no doubt comes from the old wives' tales of fearsome snakes in the privy—and children being marked by hearing the tales in the third and fourth generation. But to say without proof that any ape has got over all its hereditary readiness for the snake crisis makes little sense. Your dog goes round and round before lying down in the long-dead grass of your living-room rug—and your mind goes round at the sudden sight of a snake.

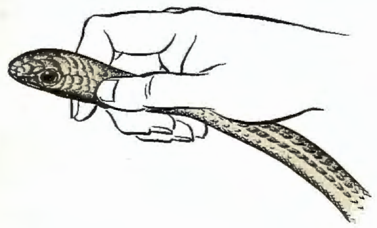
THE lot of reptiles, living on earth with man these latter years, is mainly decimation. By an odd eddy in the current of progress, however, some things we do turn out to further the reptile cause. For instance, land reptiles eat whole small animals, and man does a number of things that favour the increase of these. Predator control is one such thing. The best place I know to hunt for the big pit viper, called in Martinique *fer-de-lance* and in Central America *barba amarilla*, is in newly abandoned banana plantations of Honduras and Nicaragua. Felled woodlands generally make better snake and lizard country than original forest, and the borders between woods and fields are also highly productive of reptiles. The gravitation of some kinds of snakes and lizards into and around human abodes was spoken of in another chapter, as was the inadvertent extension of reptile ranges by transportation in the cargoes of commerce.

Besides these more-or-less accidental aids to reptiles, man has erected a few preserves to save threatened species. The islands set aside for the tuatara in New Zealand are the most notable example. The desert tortoise is protected in California, the diamondback terrapin on part of the Atlantic Coast and the Gila monster and horned lizard in Arizona. For a time there was a python preserve in

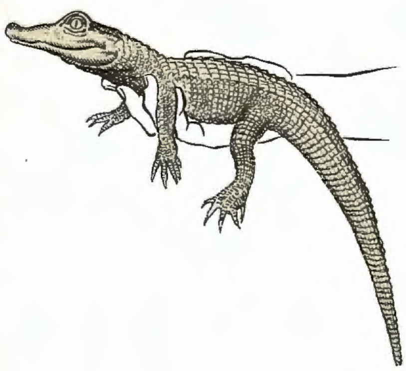
HOW TO HANDLE REPTILIAN PETS



A small lizard can be held by pressing the thumb gently on a hind leg. Grabbing it by the tip of its tail may break it off.



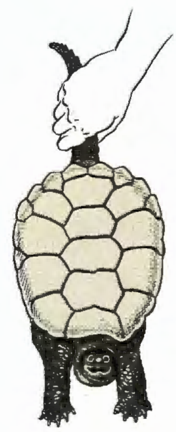
Grasping a snake's neck carefully behind the head will keep it from biting. Squeezing too tightly will increase its struggles.



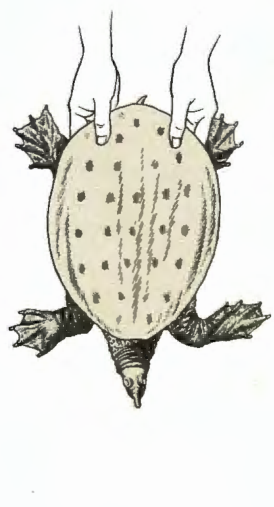
Crocodilians may be held in the manner shown above. Reptiles should not be disturbed for an hour or two after eating.

Lake Chilwa in Nyasaland. In most of the national parks and wild-life sanctuaries of the world reptiles are more or less shielded from persecution. The American alligator gets varyingly effective protection in Florida, Georgia and Alabama, although in Mississippi it gets none at all. In the opinion of people who have carefully appraised the position of crocodilians in the modern world, they are now clearly in danger of disappearing, species by species, before the spread of human culture. There can be no doubt whatever that a brief relaxation of protection for the American alligator would bring its quick and complete extinction, and other species are in a comparably insecure position.

At this stage in history, reptiles are not a major menace to human life. The most important reptilian causes of injury and death are poisonous snakes and crocodiles. In the Indian sub-continent, where people live cosily with cobras and kraits, there are some thousands of deaths by snake bite every year. Although hard figures for the South American continent are not available, snake bite is common in some areas, and despite the pioneering in serum therapy by a Brazilian laboratory, the Butantan Institute, fatalities are frequent in the interior of the American tropics. A number of the bigger crocodilians are perversely unable to see the special nature of the human animal, and absent-mindedly eat him from time to time. One of the caimans behaves like this, and so does the salt-water crocodile of Asia. The worst is no doubt the classic Nile crocodile, chiefly because of an almost ritual indifference on the part of women who wash clothes along East African lakes and rivers. They not only wash there, under the rapt gaze of cruising crocodiles, but actually face the peril rear-end-to, clinging stubbornly to the ancestral custom of standing in the water and scrubbing the wash on a rock on the bank. It is folly to think a crocodile would ignore such an invitation; and they often do not. I am speaking mainly of villages in the southern part of the Great Rift Valley, on Lake Nyasa, or along the Shire River.



Turtles that have long sturdy tails like the snapping turtle (above) can be picked up with a firm grasp of the tail, though prolonged handling in this way may injure them. But species with shorter tails, like the soft-shelled turtle shown below, are best handled by holding on to the back part of the upper shell. Although no turtle is venomous, many can inflict painful bites.



To me it is a mark of curious forbearance on the part of crocodilians that in the rest of their range they eat so few people. In Florida, for instance, where the alligator reaches sizes and appetites big enough to encompass the largest men, there is not a single record of fatal attack. The only attacks of any kind—Ross Allen of Silver Springs, Florida, has collected six authenticated cases—have involved alligators psychopathically over-confident from long association with man. Allen is scared of his own tame bull alligators, but he cheerfully swims after and manhandles the wild ones.

In the mutual feeding relationship between men and reptiles, many more reptiles than men are eaten. As reptile food, man is nowadays not a significant item. If you lie nine days unfound on the bottom of a pond the little stinkjims may finally pick at you in a desultory way. But for a man with his wits about him, being eaten by reptiles is, in much of the world, not a thing to worry about. Similarly, the majority of civilized men do not depend heavily on reptiles as food; although in one place or another in the world natural man has always eaten reptiles of every kind.

Though turtles are generally considered the most edible of the reptiles, all kinds can be eaten and, as I said, all kinds are. The crocodilians appear on tables in various parts of their range. Crocodile meat is coarse, however, and to me confusingly intermediate in quality between fish and beef. I have never heard an enthusiastic appraisal of alligator steak by anyone not either very hungry or trying hard to be open-minded. Most of the bigger lizards are hunted for food by indigenous folk, and at least one—the big tree iguana—is very toothsome game. On the Central American coast the Creoles cook a female iguana with her unlaid eggs in a most delicious manner.

Westerners generally avoid eating snakes, but from early time they have been eaten by simple people. And the Japanese, whose culture is ancient and cuisine respectable, consume sea snakes in volumes that support major fisheries. Snakeries? To delicate-natured western people snakes are simply outside the pale, and the reasons for this are not clear. There is nothing offensive about snake meat—it has no alarming taste or texture. It is as good as veal cutlets. Like them, it is pallid and without force, but harmless as mother's milk and nourishing withal. Snakes look like worms in a way, and this is cited by many as grounds for their revulsion. But what is so bad about worms? And anyway, snakes are not much like them, really. There is more than worms behind the prejudice, just as the world-wide cringing of people before a harmless small snake, whether on a jungle trail or at Piccadilly Circus, is a sign of something more than worms.

IGUANA STEW

Catch a fat female iguana, preferably in March or April, kill it and skin it and remove the insides. Save the eggs, including the yellow ones, also the liver and heart. Dismember the body by cutting it down the backbone and dividing the sections in three parts and the legs in two. Place the pieces in a pot containing a little heated coconut oil and brown lightly over a low fire. Pour in enough water to cover the meat, and drop in a chile piquante and garlic to taste.

Meanwhile, in another pot of very salty water, boil the eggs in shells with a chile pod for half an hour. Drain them and add, shells and all, to the meat, along with the diced liver and heart and the yellow eggs. Now cook everything until the liquid has almost disappeared. Pour the remaining broth over red beans and rice, and heap the stewed meat on top.

Of all the reptiles it is the turtles that have counted most notably in human diets, both civilized and savage. Most primitive people living where turtles live eat them, and excavations show that this has always been so. Although in much of the western world turtle is today unknown as food, or has become a luxury or novelty item, there are in some places folk to whom it remains a staple diet. Sea turtles or their eggs are eaten almost wherever they can be found. In the rivers of north-eastern South America turtles are a more important source of meat than any domesticated animal. In the lower Amazon the array of turtle dishes prepared involves a variety of species and almost constitutes a special endemic turtle cuisine. In China and Japan soft-shelled turtles are held in great, and I might say, wholly deserved, esteem; and the same genus has a few centres of popularity in the generally reptile-shy United States and Europe.

The big herbivorous giant tortoises have in the past been an important item for the crews of ships on long voyages in the eastern Pacific and Indian Oceans. The statistics of the depredations of whaling vessels stopping at the Galápagos Islands during the 19th Century to take on giant tortoises are almost beyond belief. In the south-eastern United States the gopher tortoise was a blessing to Indians and pioneers, and has remained so even to a few modern folk of advanced gastronomic criteria. In another chapter I mentioned the importance of the South American arrau (*Podocnemis expansa*) to people of the Amazon and Orinoco where these turtles congregate by thousands to nest on a few islands in the rivers. The naturalist H. W. Bates wrote that during the time of his South American explorations 48 million eggs of the arrau were being harvested each year at the islands.

A curious bit of ethnozoology was the culinary prestige of the salt-marsh terrapin (*Malaclemys terrapin*) in the United States during the three decades before the first World War. The terrapin somehow became a sort of gastronomic status symbol, and before Prohibition and the war prevented high living for a time, female terrapins seven and eight inches long were bringing as much as £30 a dozen. This reverence was in part justified; terrapin Maryland is a gorgeous dish. But the glamour was mainly ritual, and most of the *élite* society demanding terrapin would have done as well on gopher. Today there is more trade in freshwater snapping turtles and in the soft-shelled variety, both keenly sought by an oddly localized clientele. Philadelphia is of course the original home of snapping-turtle soup, but both snappers and soft-shelled turtles reach their economic and gastronomic peak today in the middle western cities of the United States.

The most important source of human food among reptiles is the green sea turtle. In every part of its range, which extends completely around the tropical regions of the world, people eat green turtles or their eggs. In many places—the Cayman Islands, for example, parts of South-East Asia and some of the islands of the south-west Pacific—the green turtle has been a major source of food or revenue. Before Columbus's day, Europeans were making the long voyage to the Cape Verde Islands to eat the turtles that congregated there, in this case because of the belief in the value of turtle meat and oil in the treatment of disease. The history of the colonization of the Caribbean was in part moulded by the then teeming green turtles that victualled the ships of foreign fleets and buccaneers and served as a staple for the colonies.

Two recent trends are dimming prospects for conservation of marine turtles. One of these is a sudden increase in the demand for calipee by the soup industry. The other is a wholly unexpected resurgence of the market for tortoise shell, or carey.

Calipee is the essential ingredient of clear turtle soup. It is the cartilage of the lower shell. In the marine turtles the armour is lightened for aquatic life by a suppression of the growth of bones which, during the early development of other species of turtles, fuse together into two solid shields, the carapace and the plastron. Even in the sea turtles the spaces at each side of the upper shell tend to be closed by bone as the animal ages, but the openings among the plastral bones remain, and throughout life are covered only by broad scales over an inner layer of cartilage. This cartilage is the calipee.

It is easy to cut out calipee by slicing with a sharp knife around the edges of the space it fills. The pieces thus taken are scraped, washed and dried in the sun. A 300-pound green turtle yields about six pounds of well-dried calipee, but today this may bring prices several times higher than those paid to the turtler for the whole animal a few years ago.

THE danger in this new negotiability of calipee is obvious. In former days the mere bulk of the green turtle and the remoteness of its sources were an important protection. Now, chefs in Europe and the U.S.A. are making turtle soup of no more of the green turtle than calipee, which is a storable product that a man can pack to market on his back or paddle in by canoe, or can hold for the boats that come in sporadically to buy coconuts. Thus, the temptation to the poor fishermen to poach for calipee is strong. And because turtles are most abundant in thinly-settled places in which the local need for the meat is quickly satisfied, they are being killed and left to rot for their yield of calipee alone.

The fundamental trouble is that clear green turtle soup is delectable, and that much of its excellence can be achieved using no more of the turtle than the calipee. On a recent short trip to Germany I found "*echte Schildkrötensuppe*" (genuine turtle soup) in six of the eight restaurants in which I had meals. In all it was good, and in one as good as I had ever tasted. In all cases the soup was made with calipee adroitly combined with stock of beef or calves' heads, sherry or madeira wine, and the proper spices.

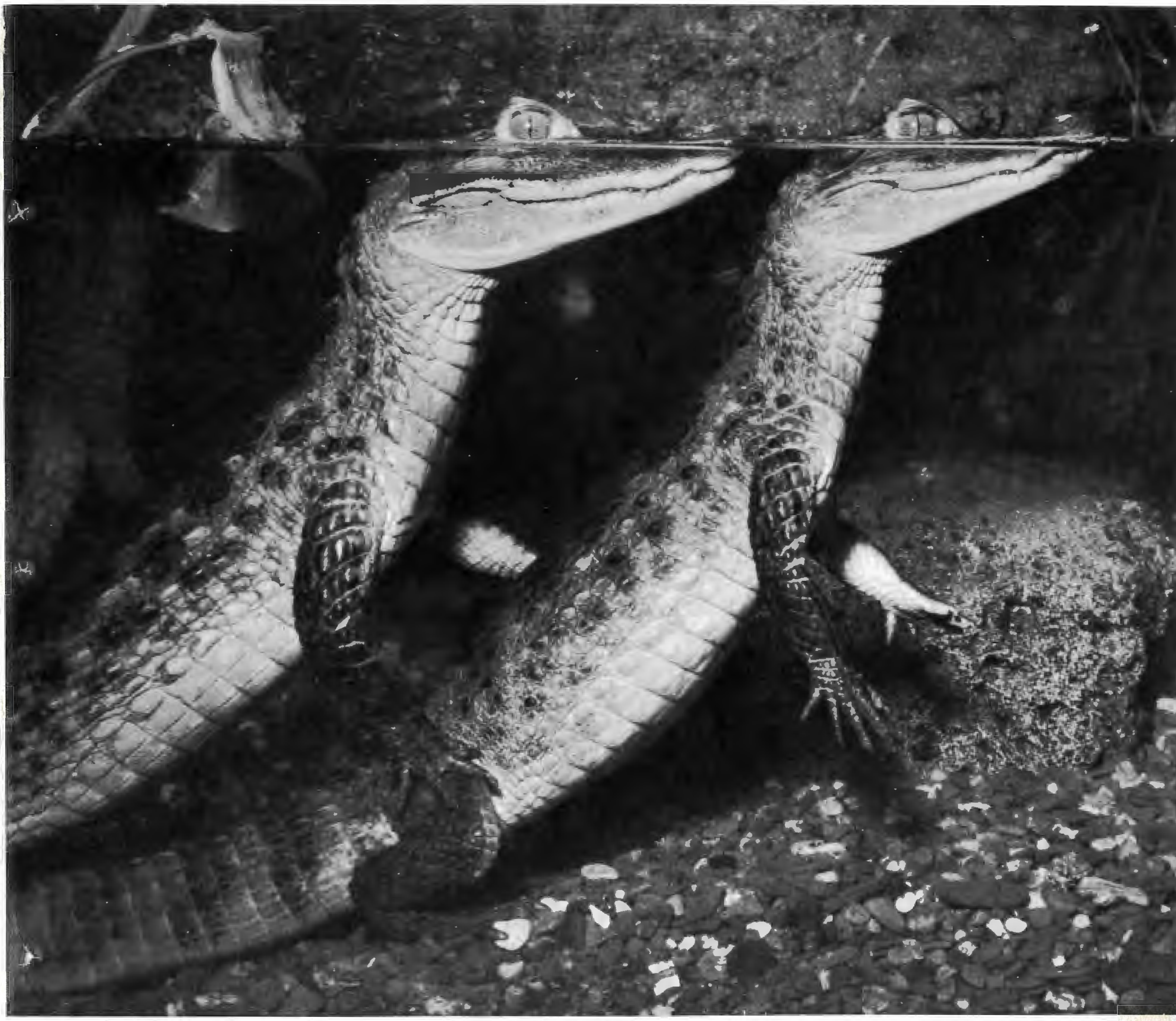
JAPANESE TURTLE SOUP

In Japan, turtle is such a popular marine dish that several restaurants specialize in its cuisine. [The *suppon*, a kind of snapping turtle, is cultivated in nurseries throughout Japan.] To prepare *suppon-jiru*, or clear turtle soup, first brew the stock by boiling 7 parts water, three parts sake, and a 6 inch square piece of dried kelp, or *kombu*. Just before the stock boils, remove the *kombu* and add the turtle meat after separating it from the shell. Cook until tender. Season with salt and garnish with ginger juice.

This growing market for calipee is insidious. Turtles live mostly in unpoliced regions. It is not possible that the poor people there will voluntarily forbear trafficking in them with the rewards so great, and it is not possible to provide the inspection to ensure that only turtles that can be consumed locally are killed for calipee.

A surprising aspect of the problem is that calipee from all the four shelled sea turtles—green turtle, hawksbill, ridley and loggerhead—is acceptable on the market. A soup chef who would sneer at the thought of making his product of any but the finest green turtle meat will cheerfully make the veal-calipee compromise without even asking what kind of calipee it is. In the case of the loggerhead, the new commercial value is not a serious threat. The loggerhead nests mostly along the inhabited shores of the southern United States where it is given fairly effective protection against overt poaching, and where being killed for calipee is a lesser hazard than the solicitous crowds that gather about each female that comes ashore to lay, or than the lights over coastal roads that draw the hatchlings away from the sea, to be mashed by the thousands under the wheels of traffic. As for the Atlantic ridley, its nesting place is so remote and its nesting schedule so erratic that it will no doubt remain immune to the new exploitation for a time—although if commercial interests ever do make connection with the ridley *arribadas* on the Mexican coast the slaughter will be unprecedented. In fact, if it should be done with determination an entire species could be wiped out there in two or three seasons. But of all the sea turtles it is the hawksbill that suddenly stands out as a species in critical need of protective attention. The hawksbill nests singly and in scattered small groups in wild places all through the Caribbean and southern Gulf of Mexico. There is therefore no way to concentrate protective surveillance of breeding grounds, as can be done at the green-turtle rookeries. The Caribbean hawksbill is thus hunted both ashore on its widespread nesting beaches and at sea on the reefs and banks where it forages throughout most of the year. During the decades when human populations were spreading so rapidly around the Caribbean, the price of tortoise shell was declining, and the hawksbill has not noticeably diminished in numbers. Now, however, with the market for both carey and calipee expanding, the hawksbill has a double price on its head.

I DO not know what is behind the new demand for carey. There are rumours that it is the Japanese who boosted the price, as their leather industry has raised the pressure on the world's crocodilians as a source of hides. For centuries the Japanese have been the best of all tortoise-shell craftsmen. They are the only ones, I believe, who successfully weld it into blocks of any thickness with no sign of joint planes, even in the honey-clear carey that they esteem so highly. During the 1940's, with the growth of the plastics industry, tortoise shell seemed sure to be superseded. The price of carey fell to almost nothing, and all over the Caribbean *careyeros* turned to other work. When I went to Costa Rica in the summer of 1962, a neighbour at our green-turtle camp who for 20 years had given up his old calling of hawksbill-hunting was back at it again, and his little house had become headquarters for eight other *careyeros* who on every calm day were harpooning hawksbills on a rock bank in front of the camp. The same thing is happening all through the Caribbean; and in the port towns there are new signs in the windows of export houses, offering to buy calipee and tortoise shell. I seriously doubt that the small world populations of *Eretmochelys* will long survive the unchecked spread of this new commerce.



YOUNG CAIMANS SHOW ONE OF THE DEFENSIVE MEASURES OF THE CROCODILIANS—HIDING AS MUCH OF THEMSELVES IN WATER AS POSSIBLE

Techniques for Survival

Not all the reptiles are so formidably armoured as the turtles, nor so fearsomely toothed as the crocodilians, nor so venomously fanged as many snakes. How, then, do the others take care of themselves? Their methods range from nimble retreats to Houdini escape acts and such ruses as pretending to be big or dead, the last so convincingly played by one snake that it goes through convulsions.


AN ANGRY TOAD-HEADED AGAMID LIZARD FROM ARABIA REARS UP ON ITS HAUNCHES, ITS MOUTH OPEN MENACINGLY AND ITS TAIL CURLED STIFFLY

Here One Moment, Gone the Next

To escape danger, many reptiles simply run away. Others hide in holes, under rocks and in similar inaccessible spots. A few, however, do not have retreats regularly available to them and must rely on such protective measures as threats and burrowing. The Arabian toad-headed lizard and the South African puff adder, both desert dwellers, bury themselves in sand to elude their enemies. But before wriggling underground, the courageous little lizard assumes a defensive stance and tries to bluff its attacker. If hard put, it will even bite, usually holding on so tightly that its jaws must be pried loose. Another desert lizard of the same family grimaces ferociously, expanding and reddening large folds of skin at the corners of its mouth.

Should the bluff fail, the lizard quickly buries itself by tilting its body from side to side and edging into the sand. At first it ploughs in with its sloping head, but once under the surface, it arches the neck upwards and is in a position to crawl out again after

A SOUTH AFRICAN DWARF PUFF ADDER, RETREATING INTO THE SAND TAIL FIRST, WRIGGLES ITS BODY TO SINK BELOW THE SURFACE. AS IT DESCENDS

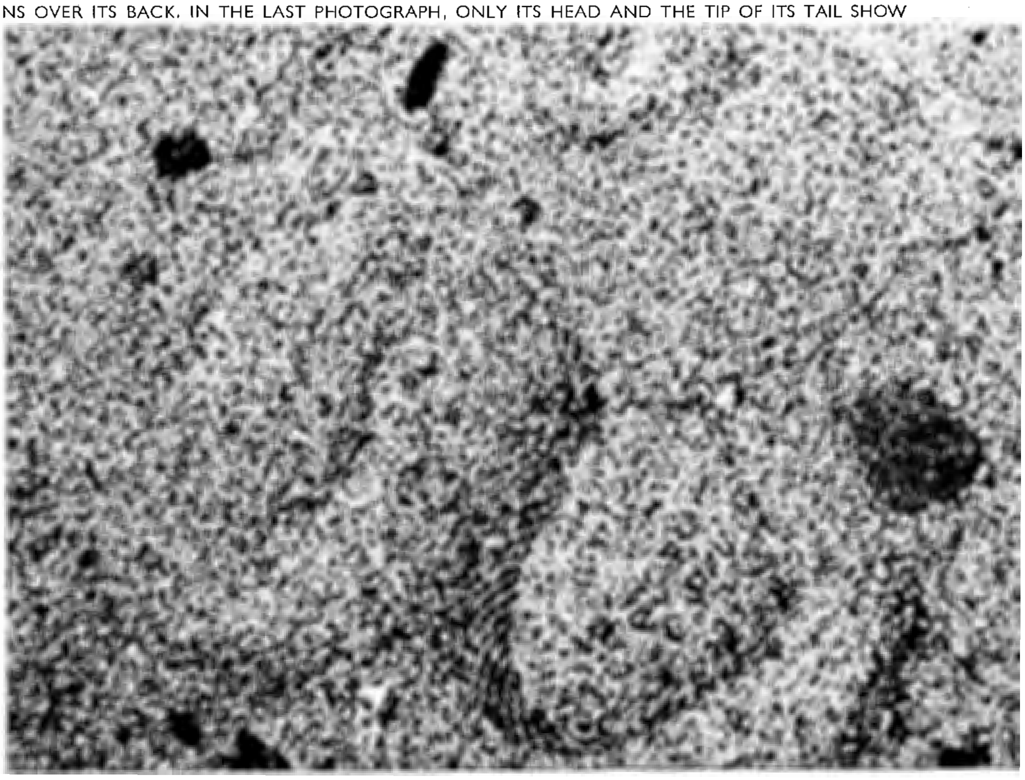

BUT WHEN ITS BLUFF FAILS, IT ROCKS ITS BODY FROM SIDE TO SIDE AND DISAPPEARS HEAD FIRST INTO THE SAND, WHISKING ITS TAIL UNDER LAST

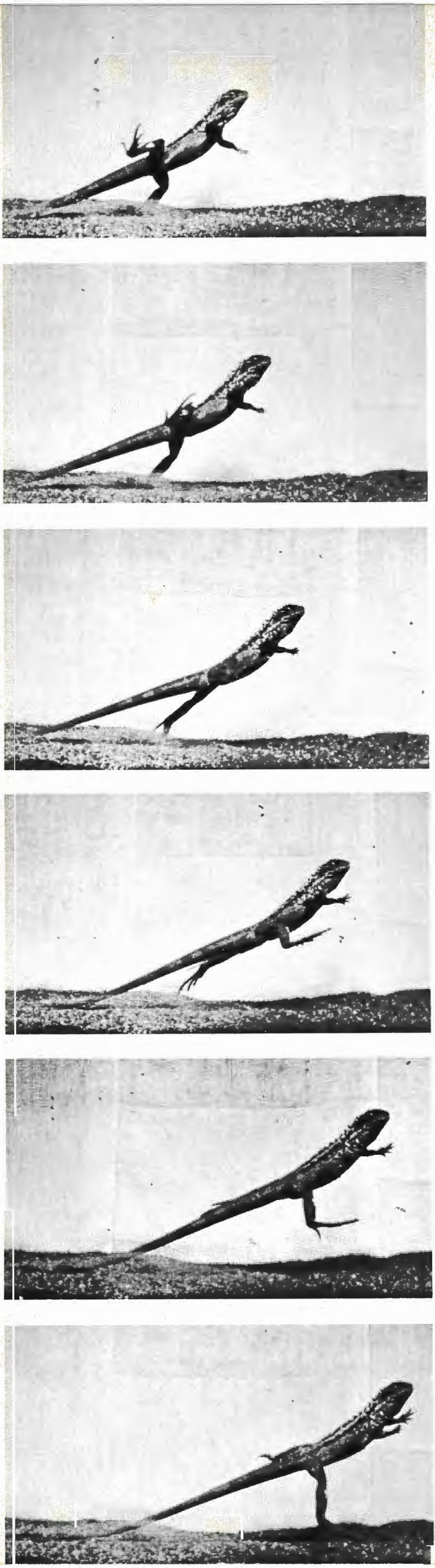
the enemy leaves. Besides burrowing to hide from enemies, this and other desert reptiles go under the sand simply to escape the intense heat of the sun.

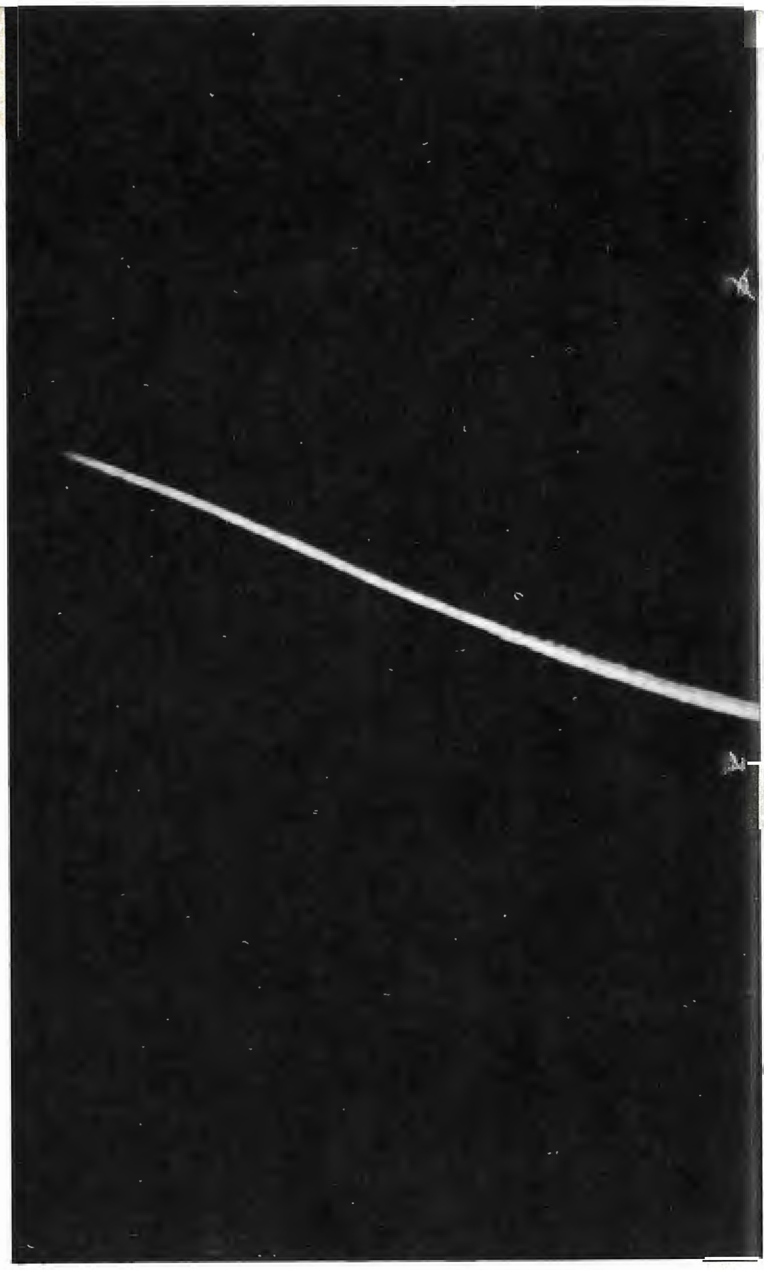
The dwarf puff adder, although equipped with fangs and venom glands that give the back of the head a swollen look, does not stand up to an enemy as the toad-headed lizard does, but wriggles into the sand immediately, leaving a ghostly impression behind in the surface. It is aided in its downward retreat by scales which work the grains away from the bottom and sides of its thick body.

The dwarf puff adder's eyes are well protected from irritating grains of sand by the clear shields, or spectacles, covering them, found in all snakes. The toad-headed lizard does not have these shields, but does have scaly "eyebrows" which project out over its eyes, and long scales that fringe the eyelids and serve as lashes. Above ground, these "lashes" help to keep wind-blown particles and dust out of the eyes.

VERTICALLY, ITS RASP-LIKE SCALES PUSH THE GRAINS OVER ITS BACK. IN THE LAST PHOTOGRAPH, ONLY ITS HEAD AND THE TIP OF ITS TAIL SHOW





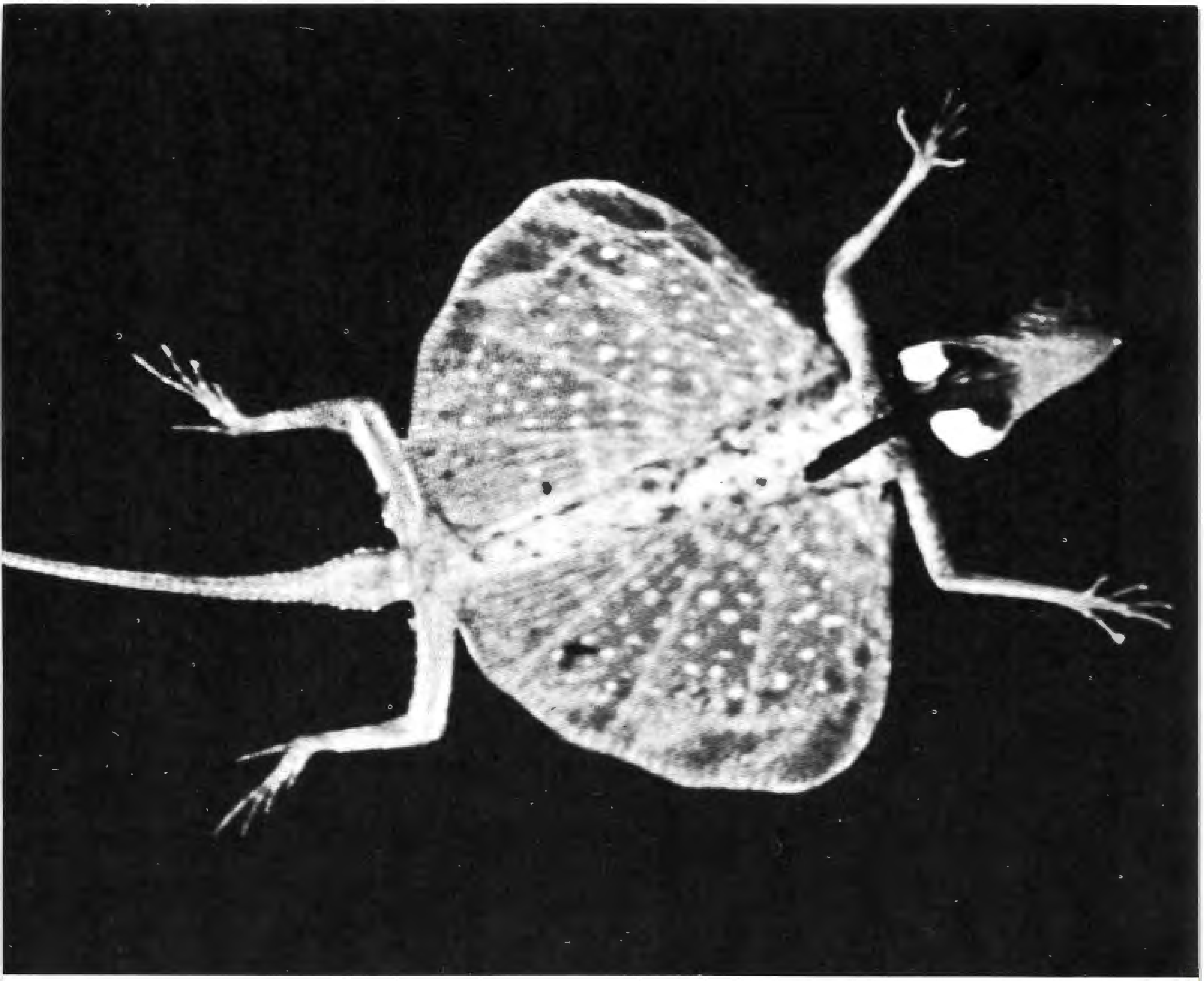


DRACO VOLANS, A FLYING LIZARD OF SOUTH-EAST ASIA, EXECUTES A

Fast Runners and Artful Gliders

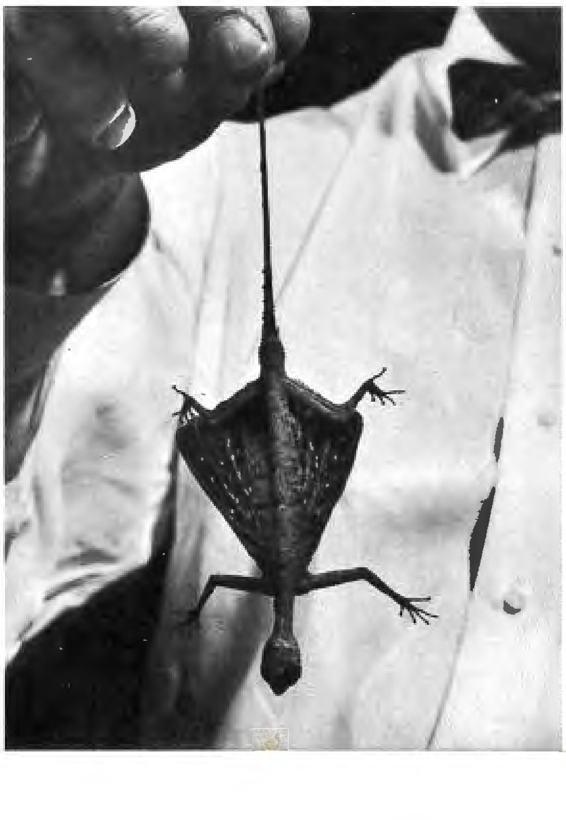
Survival for many reptiles depends upon the speed of their get-away. The American zebra-tailed and collared lizards, timed at 16 to 17 miles an hour, are the fastest runners of their group. Along with the crested dragon shown in the motion sequence at the left, they are among the few lizards to start off in an upright position. Many other bipedal lizards begin at a trot and as they gain speed rise on their long hind legs and bound off. Some bipedal lizards, such as the Central American basilisk, can even take

THE CRESTED DRAGON, Australia's "bicycle lizard", resorts to a bipedal gait when in a hurry; each stride is two-and-a-half times the body length. The long tail acts as a counterbalance.



GLIDE. THE "WINGS" MAY BE YELLOW BELOW AND ORANGE AND BLACK ON TOP, OR BURNT UMBER WITH BLACK STRIPES AND MAROON EDGES

several steps on the surface of water before they fall in and swim. No modern reptiles can fly as could the extinct pterosaurs. The nearest they come to true flight is gliding, an art which one lizard genus, *Draco*, the flying dragons, has developed to a considerable state of refinement. Their "wings" are actually folds of scaly membrane supported by five or six pairs of ribs growing from their stick-thin bodies. With these skin flaps outspread, a *Draco* can glide more than 50 feet between tree trunks.



DANGLING from a human hand, a *Draco* reveals its small size. When crawling on a tree, it folds its colourful "wings"—and thus the narrow body looks green all over and blends with the bark.

THE FRILLED LIZARD of Australia is shown in the photograph at the upper left resting on a log as a tree snake glides up. In the next photograph, the lizard bobs up hissing and begins to unfurl its umbrella-like frill in an attempt to frighten the intruder. Fully extended (*below*), the frill is yellow, scarlet and steel blue, and in an eight-inch-long specimen may be seven inches wide.

The Intimidators

Several small, inadequately armed reptiles resort to bluffing as a defence. Horned lizards squirt blood, swell up and sometimes bite feebly or inflict wounds with their horns. The lizard on the left meets danger head on, erecting its frill, showing its teeth and occasionally even rearing on its hind legs in an attempt to bite. Other lizards swell brightly coloured throat fans. Some bob up and down or rock back and forth.

SPATTERED WITH BLOOD, which it has just squirted from its own eye, a California horned lizard waits for the cornea to clear. The blood may possibly irritate other animals' eyes.

WAVING A FALSE HEAD, the rubber boa hides its real head among coils of its body. The decoy is actually the blunt tail. When threatened, this small, gentle snake, northernmost relative of the giant boas, rolls up into a protective ball with only the tail sticking out. An enemy will almost invariably bite the wrong end, as evidenced by the scars on this specimen's tail.

FULL OF BRAVADO when first confronted by an aggressor, the harmless eastern hog-nosed snake flattens its neck like a cobra, swells up, waves its tail and hisses loudly.

WHEN ITS BLUFF FAILS a hognose plays dead. It turns on its back, its mouth wide open. To give such "deaths" a realistic touch, hognoses will often fake convulsions.

RAISING ITS HEAD, a hognose peeks to see whether the enemy has left. If sighted, it will promptly flop on its back in a limp pose, as though to prove it is still dead.

AT EASE on a leaf, the South African armadillo lizard bears some resemblance to a crocodile. But whereas the crocodile's scales are flat, the lizard's are spiked, especially along the tail.

A Coiled Lizard

There is a mythical snake that can put its tail in its mouth and roll along like a hoop. But few people know that there is a real reptile—the armadillo lizard of South Africa—that has perfected such a position as a means of self-defence. And though this lizard cannot roll away over the veld, its projecting spiny scales form an effective stockade around its most vulnerable part—its soft-skinned belly.

When pursued, this slow-moving little lizard, often coloured to blend with the sand, heads for a crevice in a rock. Once hidden, it sweeps its tail, which accounts for more than half its length, like a shield around the belly, usually stuffing the tip into its mouth, and lies there. Even a fairly strong pull is not likely to dislodge it. Unlike most lizards, it does not have the "break-away" tail that they depend on for escape in emergencies. Its tail is firmly attached and will withstand a stiff wrench before coming off.

ON THE DEFENCE, the armadillo lizard looks like a wreath. It holds its tail in its mouth with its forefeet, thus protecting the belly from any animals foolish enough to disregard the spines.

A GREEN TURTLE, leaving a tractor-like trail in the sand, lumbers towards the sea after laying her eggs on shore. Because of the effort needed to move her great weight, she often stops and emits a great sigh.

8

A Dubious Future

If the world goes on the way it is going it will one day be a world without reptiles. Some people will accept this calmly, but I mistrust the prospect. Reptiles are a part of the old wilderness of earth, the environment in which man got the nerves and hormones that make him human. If we let the reptile go it is a sign we are ready to let all wilderness go. When that happens we shall no longer be exactly human.

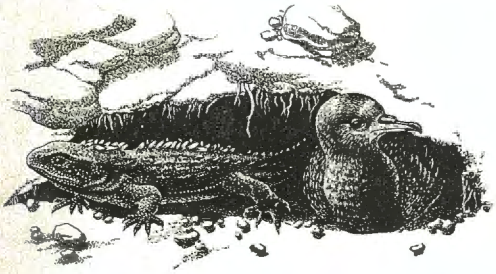
One of the awesome enigmas of today is how to slow the ruin of the natural earth while our mindless breeding continues. The ironic fact is that population control is probably not far off. There is no more need to multiply with the old fever. There is no more need for barn-dances and massed infantry. Breeding is good business, but it is herding our race towards a tragic impasse. When this is clearly seen and the reproduction is slowed down it will be because thoughtful people have taken charge; and these people will look about for what has been left of old values. One of the values is what the human spirit gets from wilderness, from all kinds of wild original landscapes and beings. The way we are going, what we keep of the old earth will not be enough to save our honour with our descendants.

Writing this, I felt one of the qualms you cannot keep down when in your mind you weigh new industries against rough country empty of all but unused beasts and vegetables. I have no real doubts myself, mind you, but to many others in the world, especially the Florida world, to question the complete goodness of population growth is a perverse and sinister sort of iconoclasm that should probably be investigated by a committee. Thinking that way, I scared myself a little, and to get over it I called off the writing for a spell and went over to Jonah's Pond. Jonah's Pond is one of the solid assets of the University of Florida. It is a sinkhole lake with tree-swamp at one end and open water at the other, and all through it a grand confusion of marsh creatures and of floating and emergent plants. The place is a little relic of a vanishing past, and, incredibly, it lies on the campus of a university with 13,000 students, less than half a mile from where I am writing now. It is there to go to when euphoria spreads through the press over some new gain the state has made in people.

I went this time to where an alligator called Crooked-jaw has her nest beside a wire fence, at one edge of the swampy end of the lake. I stopped the car and walked over to the nest and looked at it closely. I had taken a picture of it the day before, and I could see that Crooked-jaw had made some changes during the night. They were not drastic—only small, fastidious adjustments to show she knew the heap was warming a new generation of her kind. A root-mass of buttonbush had been added, and a few live switches of *Decodon*, and some scooped-up slush of coontail from the bottom. On the top of the pile was a single screwed-up paper ball; and though it seems unlikely, I am sure I had seen this lying six feet to one side of the nest the day before. I can say that because I was aroused at the sight of it, at the idea of anybody defiling with pink the premises of an alligator nest. Crooked-jaw clearly failed to share by resentment. There is no accounting for tastes. The nest did not look as good to me with the paper ball on it, but the matter was not in my hands.

The alligator was not in her usual station, her lying-in pool, as it were—the little dredged-out hole of water a mother 'gator waits in for eggs to hatch. She was off somewhere among the floating islands, and I started croaking, *eer-rump, eer-rump*, like a little 'gator croaking. A long way out through the flooded willows a floating island began to quake; and then all at once water surged out from the frogbit raft beside the waiting pool, and Crooked-jaw came up looking at me. A moorhen whined from the rushes, and in the high haze to the west the sand-hill cranes were bugling. I croaked again, but the alligator had lost interest. She sank into the water till her chin rested on the mud, and only the bumps of her eyes and nose and the big scales of her back stuck out.

TWO IN A BURROW



A sooty shearwater and a tuatara peer from a nesting burrow dug by the bird. These two animals often live together in harmony. Their cohabitation is made easy through much of the year by their routines: usually the bird is off fishing during the day and the tuatara out foraging at night. When the bird migrates, the tuatara hibernates in the burrow.

LOOKING at her there in her fragment of a doomed landscape, I was sure again that the saving of parts of the primitive earth has got to be done, and that it has got to be done without trying to justify it on practical grounds. Species and landscapes must be kept because it pleases people to contemplate them, and because freer men of future times will be appalled if we irresponsibly let them go. Not facing that fact seems to me the great weakness in the outlook for wilderness preservation today.

It will take resolute people to put abstract values in place of material progress. In testing the mettle and conscience of recruits for the work, the reptile—particularly the unloved, legless snake—may serve as a sort of shibboleth. A man who feels in his bones that snakes must be kept in the woods will be proper stuff for the struggle coming.

Snakes are probably disappearing at a more rapidly rising rate than any other group of vertebrates. Besides the widespread antipathy they get from man, marshes are drained, country is reforested in pure stands of unsuitable cover, poisons spread abroad kill off the food supplies of the creatures snakes eat, and even kill the snakes themselves. But the most spectacular thing happening to snakes is the onslaught of cars on the roads. Twenty years ago, in his book *That Vanishing Eden*, Thomas Barbour spoke of the passing of snakes before cars on the roads of Florida, but he never saw the big change. It came with the many-laned highways of the 1950's and 1960's.

THE worst snake traps are the causeways across marshes and the streams of cars that cross them. Snakes are lured to them to enjoy the warm paving, or to escape flooded habitat, or merely in the course of their foraging. I remember a vast dying of snakes on the road across Paynes Prairie two decades ago, when man and weather chanced to move together against the creatures of the marsh. On October 18, 1941, a hurricane moved in from the gulf and spun in the vicinity for 36 hours, bringing 14 inches of rain during five days. The prairie changed from a marsh to a lake and the water rose so high that only the tips of the tallest grasses showed. On the 25th some students brought in 200 snakes they had caught along the roadside and told of a great hegira of snakes, and of congregations of buzzards squabbling over the dead ones squashed by passing cars. There was clearly something extraordinary going on, and four of us from the biology department went out to investigate. We started at the northern edge of the prairie and walked abreast down the road with flashlights, one of us at each guardrail and two along the middle of the roadway. The road over the marsh was two miles long. We counted every snake dead or alive between the guardrails, which in those single-lane days were 20 feet apart. We picked up 723 snakes in the two miles, about two-thirds of them dead or injured.

As an accumulation of several days, this number of casualties would not have been unprecedented. But these were the accumulation of no more than the four hours or so since sunset. During the daylight hours buzzards—black vultures and turkey vultures—had been attracted to the killing by the hundreds and had carried the dead snakes away almost as fast as they were run over. So the snakes we counted had been killed after dark. The tally was: 64 banded water snakes; 85 green water snakes; 55 garter snakes; 200 ribbon snakes; 6 brown snakes; 3 king snakes; 284 red-bellied snakes; 19 Allen's mud snakes; 3 horn snakes; 4 cottonmouth moccasins.

The slaughter had no noticeable effect on the levels of snake populations in the prairie. For a decade afterwards the road remained a mecca for snake collectors, and they kept coming from distant places to walk along it with bag and stick. But in recent years the prairie snakes have declined. Although the roadside was made a wildlife sanctuary not long ago, and the snakes in it are now immune to people who used to take them away in sacks, the cars keep going by, and snakes have no immunity to them.

At the end of Chapter 2, I held up the New Zealand tuatara as a sort of sign of the palaeontologic waning of reptiles—a symbol of their decline since the roaring Mesozoic when their forefathers browbeat a cowering world. This same lonesome wisp of a reptilian remnant also tells a story of reptiles against men. The tuatara, even more than snakes, gives the precarious feel of the hold that useless wild things have on the world. I want to dwell a little upon what is known about a creature that is unique and one so wholly at the mercy of a few people of good will, the New Zealanders, who have made a preserve of the tuatara islands.

This loneliest reptile in the world, known technically as *Sphenodon punctatus*, looks like a stocky, big-headed lizard. The males average about two feet long and weigh about two pounds. Females are a good deal shorter and only half as heavy. The common name, tuatara, is a Maori word that means spiny, and refers to a low, toothed crest down the neck and back. A few hundred years ago there were tuataras on mainland New Zealand, and the Maoris ate them. Today they live only on 20 cliff-bound islets off the New Zealand coast—the only representative of an order with one of the smallest geographic ranges of any vertebrate animal.

ALTHOUGH *Sphenodon* looks like a lizard, it clearly is not. It differs from lizards in many ways. One of the most arresting is in the lack of any copulatory organ. Even more engrossing, to the palaeontologist at least, is the presence of two complete bony arcades in the temporal region of the skull, as in the ancient diapsid reptiles. Recent evidence suggests that the open-sided skull of lizards is probably a modification of this old two-arcade style. So the tuatara appears to fade back into the ancestral line of the lizards and snakes. The wonder is how little it has changed in the millions of years that lizards and snakes were evolving so variously.

One of the features of *Sphenodon* that used to be considered distinctive is a third, or median, eye, located on top of the head but roofed over by the skin. Although this organ has the lens, retina and nerve connections that go with light-reception, there are no eye muscles or other apparatus for accommodation or focusing, and experiments indicate that no seeing is done with the eye. Its function, if it still has any, is thus unknown. In any case, the median eye is not peculiar to *Sphenodon*. It occurs in various modern lizards too, and may be used by them in their behavioural temperature control. In some fossil reptiles it was much more strongly developed and perhaps used for vision.

The female tuatara lays from eight to 15 soft-shelled eggs, each a little over an inch long. The nest is a pit in well-drained soil, dug and covered by the female. The period of incubation is 15 months, which is far longer than that of most other reptiles. The tuatara is one of the rare reptiles with a true voice, and has been heard to croak dolefully on misty nights or on becoming annoyed with a captor. It seems to take 20 years to reach sexual maturity. This, and the slow growth rates that have been recorded, lead to the belief that it may attain ages of a century or more.

The tuatara today is mainly insectivorous and nocturnal. It has been observed foraging in temperatures as low as 45° Fahrenheit. It lives in intimate association with the sea birds that swarm on the islands. The birds keep the underbrush broken down and manure the soil heavily, and an abundant insect fauna lives in it. One of the bird associates, a petrel, digs burrows. The tuatara regularly occupies these, sometimes moving in before the petrel is through incubating eggs or raising chicks. The association is not obligatory, however, and some tuataras dig their own burrows.

The sparse tuatara community reveals ecological relationships with singular clarity. Although the long-term survival of the tuatara may never be explained, it is easy to see why the creature is able to hold on now. Its inaccessible islands, with their bird colony and salt-forest habitat, are a remote asylum where an ancient type, elsewhere replaced by more nimble lizards and mammals, can live on in ancestral ways. The sun goes on spilling into the cold sea. The plankton catch up the energy of sunshine and multiply, and feed the teeming fishes. The petrels, terns, cormorants and penguins swarm out from the islets and harvest the fields of fish, and then go back and leave their droppings on the ground under the scrub where they roost and nest and where the tuatara lives. The guano grows thick and odorous and the insects thrive. There is food and peace on the islets, and *Sphenodon* lives on, anachronistic but safe for a while.

In some ways the tuatara is an ideal model for preservation practice. Like any animal, it is part of a community. Unlike most animals, however, its community is a simple one that can easily be understood and kept free of disorganizing influences. The economic value of both the animal and its environment is quite small, and above all, the tuatara is a fantastically appropriate example of the last of a kind—the very last of an order older than the dinosaurs that vanished an aeon ago. The one grave defect in its case as a triumph of wilderness preservation is that the effort involved in saving it should have been so slight. Saving the tuatara required only laws protecting the animal itself, and the removal of a few sheep that hurt the habitat. That way, it is a bad lesson. No significant preserving of nature can be done with slight sacrifice. The true test will come when great sacrifices are needed, when it becomes necessary to fight the indifference of most of the world and the active opposition of much of it, to surmount man's ingrained determination to put the far future out of his mind in matters of current profit.

THE HELPFUL BIRDS

The tuatara's existence on its remote islands is made possible by sea birds like the cormorants shown above. They cover the ground and rocks with their droppings, creating an ideal environment for the development of a large population of ground insects such as beetles and crickets. These are the tuatara's main source of food, and it forages for them at night (below).

BESIDES the inherent technical difficulties of wilderness conservation, the effort to save original nature faces a whole constellation of other kinds of problems. The easiest obstacle to recognize is the opposition by people who oppose the keeping of wilderness for material reasons. These people would shape the world into an ant-hill; they are clearly mad. It is unthinkable that they will much longer control the destiny of the race. There is another block of humanity that simply does not care; and an unsorted lot who think of themselves as conservationists, and who in one way or another are, but who are not facing the really tough obligation at all. I refer to all people who think of saving nature for meat, water, timber or picnic grounds for the future; and to the hunters who hope their grandsons will get red blood by shooting things, and to the reverence-for-life cultists who are foredoomed to inconsistency, and to the biologists who resist the loss of material for study, and to keepers of zoological gardens who preserve nature in cages. Putting this mixture of motives and aspirations together under the label conservation has made, in some cases, a temporarily stronger front. But it has obscured the real issue, hidden the dimensions of the long job and kept everybody from stating the awful certainty that the hard saving has got to be done for the sake of abstract values.

For several years I have been involved in a preservation programme which, like the tuatara project, has been atypically feasible—although for different reasons. This is a campaign to rehabilitate the green turtle in the Caribbean Sea, where its once extensive nesting range has been reduced to only two rookery beaches.

The green sea turtle, *Chelonia mydas*, is the most important source of human food among the reptiles and the most valuable reptile in the world. Historically, its economic role is conspicuous, and in the planning to raise the food production of the oceans it offers strong promise. Its potential is based on the fact that it eats plants, and tends to aggregate wherever submerged marine vegetation —several spermatophytes and a few kinds of algae—grow in more or less continuous stands. Today most such underwater pastures are unused by any but the tiniest of marine animals, but there is evidence that they were once extensively grazed by green turtles. The decline was evidently due mainly to human depredations on the nesting grounds.

Probably the greatest concentration of nesting green turtles in the world, and certainly the most intensively exploited and soundly regulated nesting colony, is in the Sarawak Islands of Borneo. Here Tom Harrisson, curator of the Sarawak Museum, has studied the colony for years, and his researches and the recent intensive investigations of John R. Hendrickson of the University of Malaya have laid the groundwork for a sound programme of management of the rookery. The Sarawak turtles are not killed; only a carefully set proportion of the eggs is taken. The yield of the rookery has generally been between one and two million eggs for the dozen years or so that good records have been kept.

IN the Caribbean, the way things were going a short while ago, the green turtle was facing complete extirpation. Now I believe there is no such danger. Instead there is even the prospect that this once threatened species will become a resource of major importance. The change in outlook was made possible by a combination of circumstances such as cannot be counted on in most preservation projects. In the first place, the suspected migratory feats of green turtles focused scientific interest on them and brought support from American research foundations—the U.S. National Science Foundation and the Office of Naval Research—for studies of their basic natural history. Another factor favouring the intervention was the historic and potential importance of the animal as human food. Still another was its evident amenability to management as a harvester of great areas of marine vegetation that otherwise would go to waste. A final factor that has greatly eased the way is the lucky circumstance that the single nesting beach remaining in the western Caribbean is situated at Tortuguero, on the coast of that gem of a small nation, the Republic of Costa Rica. In former times exploitation of the Tortuguero colony brought Costa Rica a steady small revenue in the form of a fee paid by the concessionaire, who parcelled out the beach to the turtlers and sold their catch to the caiman schooners or sent it away as deckloads on freight boats going back to Florida. But in 1957 the government closed the beach to exploitation. The move saved the green turtle for the western Caribbean, but at the same time it deprived Costa Rica of all profit from its green turtles, because there is no good turtle pasture along the Costa Rican shore and no turtles go there except during the breeding season. The refuge will re-populate the pastures from Colombia to Mexico, and will increase the yield of the turtle grounds of the Nicaraguan Miskitia to schooners turtling for the markets of New York and Europe. For Costa Rica itself there is only the satisfaction of having faced the choice between quick gain and a better future—and having chosen with characteristic wisdom.

In 1955, when the first of a series of grants from the National Science Foundation was made, a tagging camp was established at Tortuguero. The information accumulated helped to stimulate the founding of the Caribbean Conservation Corporation, a non-profit undertaking dedicated to restoring the Atlantic green turtle in American waters. This is the strongest effort, I suppose, ever made on behalf of any reptile. The effort began to grow when Joshua B. Powers, an international publishers' representative with a long-standing interest in Latin America and its people, read my book, *The Windward Road*, in which I told of the history and plight of the Caribbean green turtle and of its potential as a renewed source of food. As a result, Joshua Powers founded The Brotherhood of the Green

Turtle, a fraternity of influential people who had in common the idea of finding a way to save the Caribbean green turtle. The movement attracted the attention of John H. Phipps, a Florida philanthropist and conservationist, and with his support the Caribbean Conservation Corporation took shape and went to work. It is now in its eighth year of operation.

The current aim of the organization is to re-establish breeding colonies of *Chelonia* in the places where they once were. To this end, eggs from a two-mile section of the Tortuguero beach are placed in artificial nests in a wire enclosure where they are free from the usual hazards that attend incubation and hatching. After about two months the young turtles begin erupting from the sand and are placed in tanks of sea water and fed on chopped fish until distribution time. The United States Navy has assisted in the distribution. The Caribbean Sea Frontier sent down an amphibious aeroplane from Roosevelt Roads, Puerto Rico, to carry batches of hatchlings—more than 100,000 so far—to introduction sites all around the Caribbean and in Florida and the Bahamas.

The restoration project is a gamble. There is no way to be sure the planted hatchlings will go back to the introduction site when they reach maturity. They may fall back into the ancestral cycle of reproductive travel, and return to Tortuguero instead. This chance must be taken. Results with salmon suggest that young fish are imprinted by some sensory experience at the site of introduction, and that this impression overrides any tendency to return to the ancestral spawning ground, but instead draws them to the new locality to nest. It is the hope that young green turtles will do the same. Meanwhile, the protection being given to the Costa Rican nesting ground is the one factor preventing the loss of the green turtle from the western Caribbean.

Another field in which the information provided by the green turtle investigations will be useful is turtle farming. The submarine plants which the green turtle feeds on grow in pure stands in shallow water behind reefs, or on shelves among islands. Some of these places lend themselves to being easily fenced. In such enclosed natural pastures, green turtles could be kept like aquatic cattle. The Caribbean Conservation Corporation is planning pilot projects of this kind. If they are successful, the green turtle may become one of the first marine vertebrates to be successfully cultured for food.

When I hear of a new idea for raising the food yield of the sea—or of the land for that matter—I have mixed feelings. I hate to see any comfort come to those who encourage the useless multiplication of man. But there are very hungry people in places where green turtles were once abundant and are now unknown. It is the sea that will be called on to feed these people, as well as the hordes of our descendants. And anyway, when you save a species for meat you are bound to save useless bits of wilderness to go along with it. So whenever a bit of the waning world can be saved for meat, then go ahead and do it that way. But inadvertent saving of scraps will never stave off the ruin of the earth. The only way is to name the real obligation clearly, to say without hedging that no price can be set for the things that have to be preserved.

When New Zealand set up the *Sphenodon* preserve I wish they had said it was not to placate zoologists, but so that plain men could go on singing the tuatara out of its hole. Casting about for old accounts of the tuatara in New Zealand, I found these five sentences from a 1903 issue of the *Lyttelton Times*, quoted by James Hutton and Frederick Wallaston Drummond in their book, *The Animals of New Zealand:*

"The tuatara lizards at the Opaiva fisheries seem to be susceptible to music. They will come out of their holes to hear a song, when nothing else will induce them to appear. They prefer a good rousing chorus rather than a solo. Some time ago a number of visitors to the hatcheries wanted to see the tuataras, which, however, refused to come forth until a little girl sang 'Soldiers of the Queen', and others joined in the chorus. The sound seemed to have appealed to the reptiles, and they responded by showing themselves to the singers."

Ask a New Zealander why he saved the tuatara and he will no doubt think the question silly, and say because it's one of a kind, and because zoologists are partial to the beast and because once gone it would be lost for ever. And all that is so. But the same can be said of all reptiles, with only the time shifted about a bit. The New Zealanders are responsible for the tuatara, and the world is responsible for reptiles. The only difference is that the New Zealanders came to grips with their problem sooner. The problem itself was far, far simpler. It was so simple and clear-cut, and the material sacrifice so negligible, that no really searching appraisal of values had to be made.

Basically, what you have to do is go ahead and admit that tuataras must be saved so that people can sing them out of holes. Only then are you ready for the harder jobs, like justifying a future for snakes, which have no legs, hear no music and trouble the taxonomist. Bore through to the core of what is required and you see that it is an aggressive stewardship of relics, of samples of original order, of objects and organizations of nebulous craft. This work will take staunch people, and the reptile can be the shibboleth by which they pass.

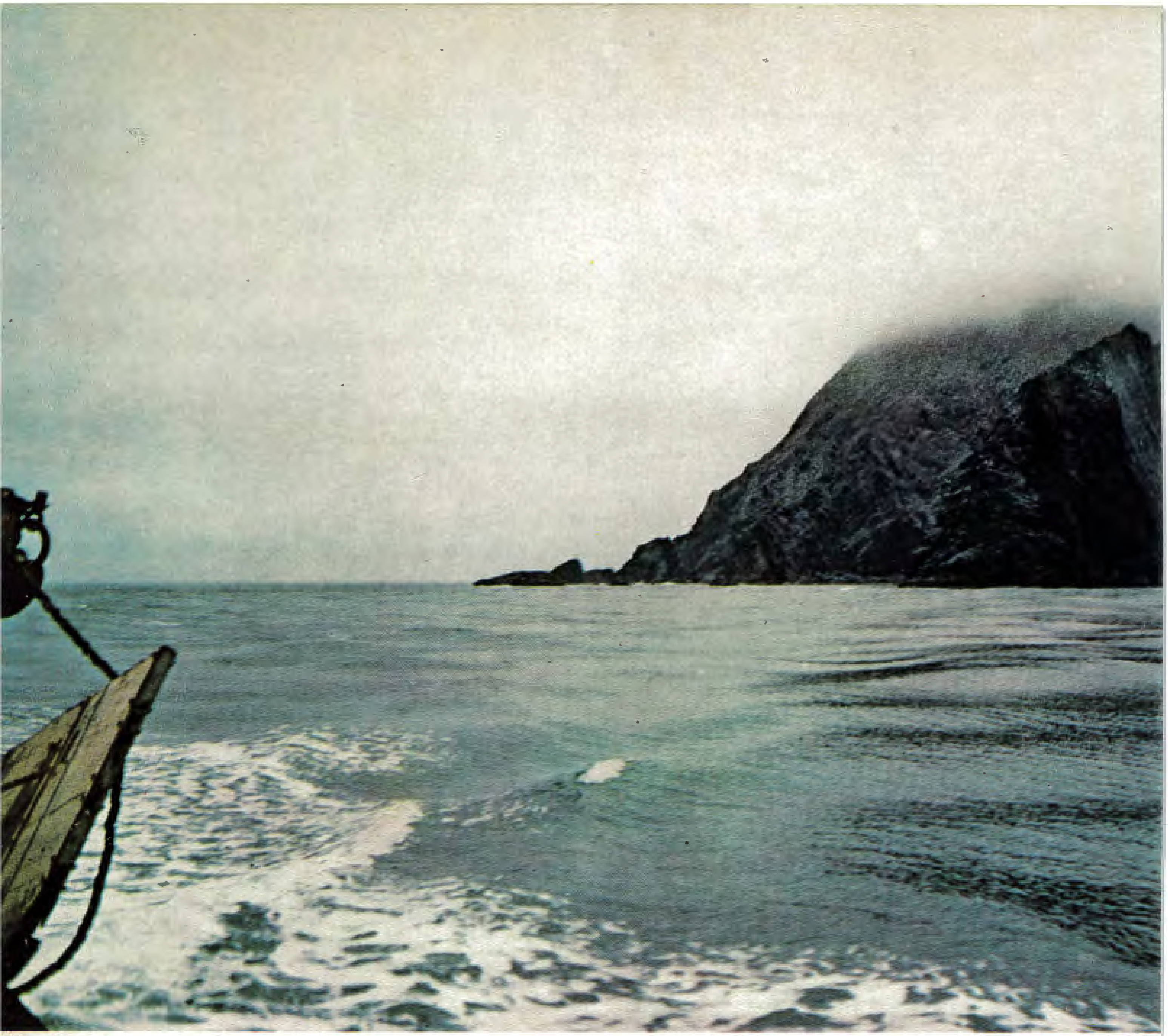
To get the real feel of the problem, I think of a man of some far future time, walking in some last woods lying unruined among launching pads of a planetary missile terminal, and coming astounded upon the last of all living individuals of *Crotalus adamanteus*, the great unruly diamondback rattlesnake. It is a full-grown female snake that I see, two yards long, stern of face, and marked off in geometric velvet. It is the sort of being that always, inadvertently and without malice, has been a thorn in the flesh of Americans, one of the novel terrors the land held for men whether they came in caravels or wandered down into the New World out of the snake-free Siberian cold. Seeing the man, this last diamondback begins preparing the steel of its coils, and they ebb and flow behind the thin neck holding the broad head steady and still, except for the long tongue waving. By the girth of her I judge that this is a pregnant snake, heavy with some dozens of pre-hatched perfect little snakes the same as herself, all venomous and indignant from the start, all intractable and, like their mother, unable to live except as free snakes.

The snake that confronts the imagined man is a moving thing to see. It is not easy to understand all the feelings aroused by such a sight, and the snake I think forward to is the last in all the pablum agar culture of the purified world. The coils of her body rise and fall in slow spirals, the keen singing of her rattle sounds, and she waits there, testing with the forks of her tongue the whole future of her kind. In my thought the man then stoops with an old urge and picks up a stick. It is almost the only stick left lying in the eastern half of North America, and the man takes it up and moves in closer to the wondering snake. He raises the stick, then somehow lowers it as if in thought, then halfway brings it up again. And then thought fails for me, and the snake song falls away, like the song of cicadas losing heart, one by one. The woods grow dark and fade off into distant times.

A LONE, FULLY GROWN TUATARA, PERHAPS A CENTURY OLD, CROAKS ITS PLAINTIVE SONG FROM THE SAFETY OF ITS BLEAK ISLAND REFUGE

Twilight of the Reptiles

It has taken some 150 million years of palaeontological disasters to reduce the immense diversity of reptilian life to a meagre four orders. But it has taken man only a few hundred years of indiscriminate slaughter to bring many survivors to the brink of complete extinction. Belatedly, in some areas of the world, conservationists are now studying ways to save these relics of the distant past.



A MATURE MALE weighs about two pounds and reaches a length of two feet; adult females are shorter and weigh only half as much. Handlers need not fear, tuataras are harmless to man.

Chosen for Survival

Because they are no longer eaten and their hides have no commercial value, and because they inhabit clusters of remote islands which neither men nor other large predators want, the less than 10,000 remaining tuataras enjoy the protection of conservationists. But the species also has its own formidable survival equipment. This includes the ability to keep active at extremely low body temperatures, an adaptation well suited to its cool climate, and a relatively low metabolism, which means it can get along on a reduced diet—usually insects, worms and snails.

CLOAKED IN GLOOM, Stephens Island is the most thoroughly studied habitat of tuataras. A square mile of cloud-capped land, it rises in sheer cliffs, 1,000 feet above the waters of Cook Strait, New Zealand.

TAIL REGENERATION, which tuataras share with many lizards, takes several years. A broken tail (*top*) will replace itself with a tail of a different texture (*centre*) or, occasionally, with a forked tail (*bottom*).

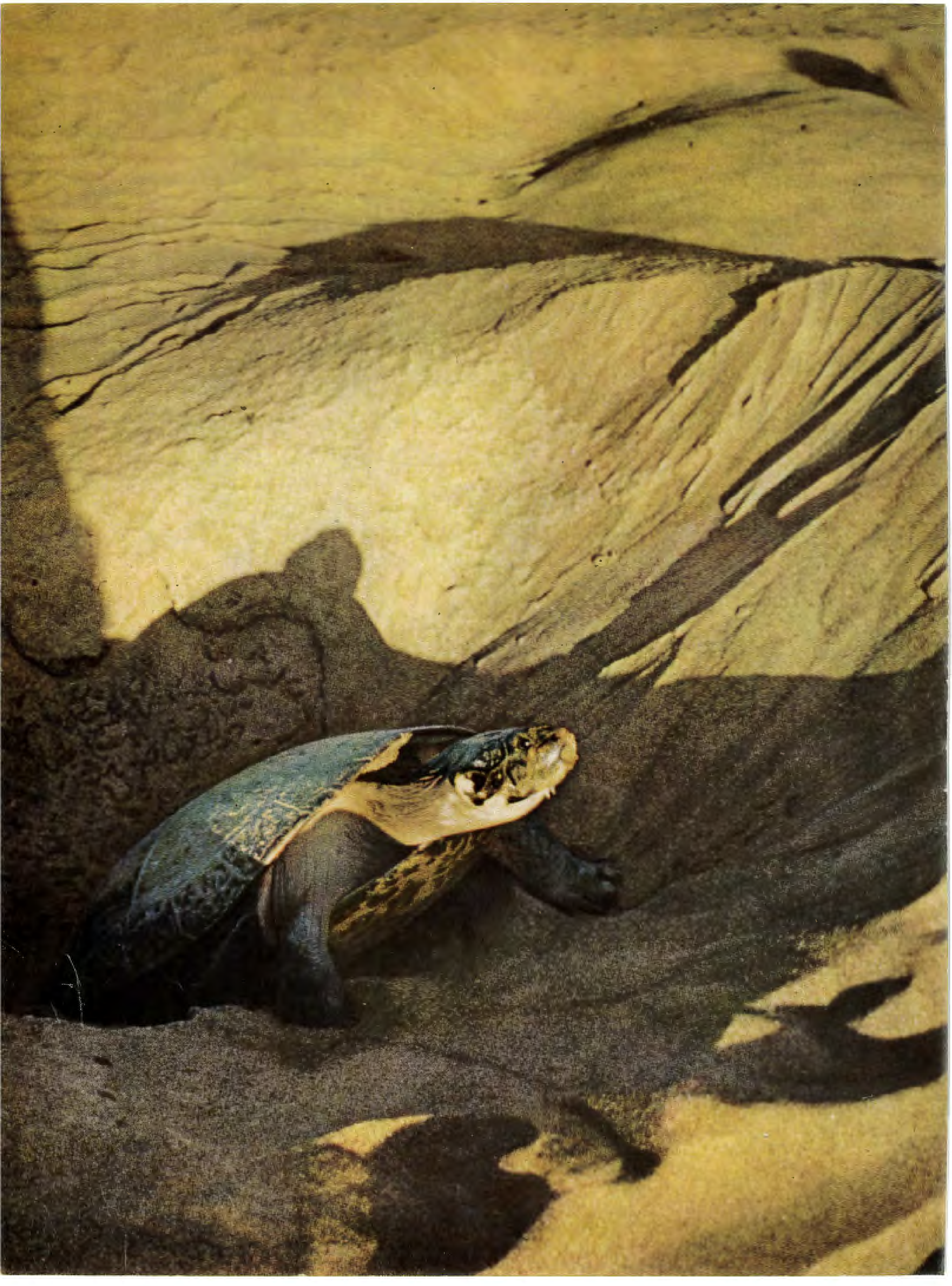
A CLOUD OF SAND rises behind a female green turtle excavating her nest on an Australian Great Barrier Reef beach. She excavates with all four flippers until her shell is level with the surface of the beach. She then uses her rear flippers to dig a deeper hole for her eggs. Since her eggs are prized by the local population, many will not be incubated long enough to hatch.

A COUPLE OF HATCHLINGS scramble out of the nest. They must now run a perilous gauntlet to the sea while hungry birds swoop down upon them and predaceous fishes wait below.

Candidates for Extinction

Unlike the tuatara, some of the more common aquatic turtles have been fair game for primitive hunters and patrician gourmets alike for centuries. From the Great Barrier Reef islands of Australia to Venezuela's Orinoco River, turtle eggs are harvested in the tens of millions. In the Caribbean thousands of turtles are killed for their flesh, while others are shipped abroad for processing. Just a few years ago, 5,000 Caribbean marine turtles were transformed into 600,000 quarts of soup annually by one New York City firm. And there is still a market for "tortoise-shell" (actually turtle-shell) ornaments. With so much slaughter and so little conservation, the sea turtles' long history may soon be concluded.

A BUTCHERED FEMALE has her egg clusters removed and placed inside a tin can by a native of the island of Mer, near New Guinea. Both the meat and eggs are highly prized by the people of the south-west Pacific. On the little island of Talang Talang off Borneo, for example, it has been estimated that close to two million turtle eggs have been collected in a single year.



A SWARM OF FEMALE RIVER TURTLES AWAITS A COVER OF DARKNESS BEFORE BEACHING

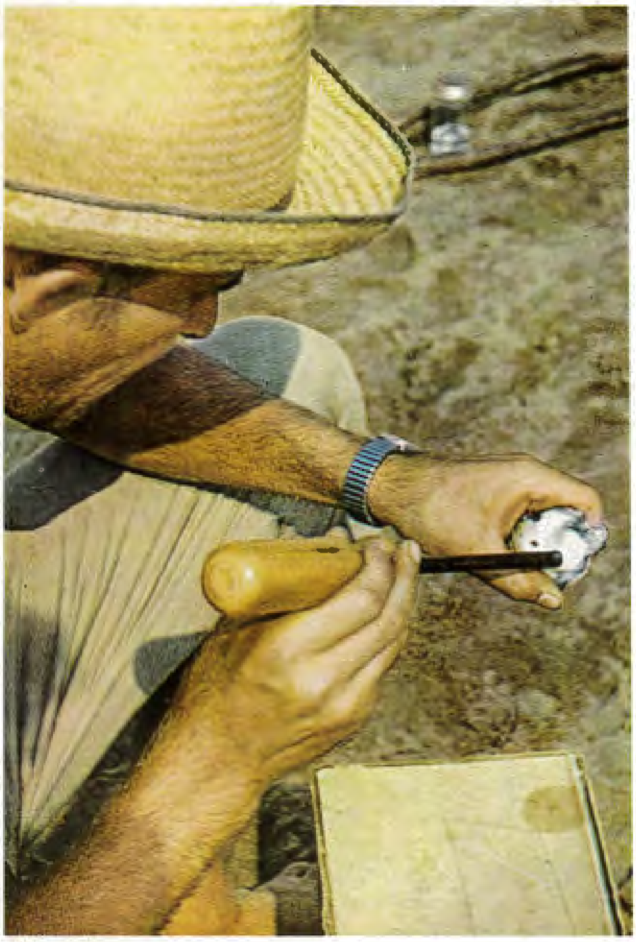
Hope for the River Turtles

The South American river turtles may yet escape the fate of total annihilation, despite the 48 million eggs and countless adults and hatchlings pillaged each year by local Indian raids on their island nesting places. A long-range study programme is now under way in which eggs and hatchlings are counted, young turtles are branded and breeding schedules recorded. Conservationists hope to discover the most beneficial population level for the turtles and to control the take at a level below the minimum number necessary to the species' survival.

DEEP IN THEIR CATCH, Venezuelan natives load their small boats with live turtles. Those not eaten will be sold. The high toll taken of river turtles is made possible because they congregate at the same places year after year for breeding and nesting.

DEEP IN HER NEST, a tardy female hurries to complete her excavation as the sun rises over a beach on the Orinoco River. Digging the nest, laying and covering the eggs and returning to the river are usually completed between sunset and dawn.

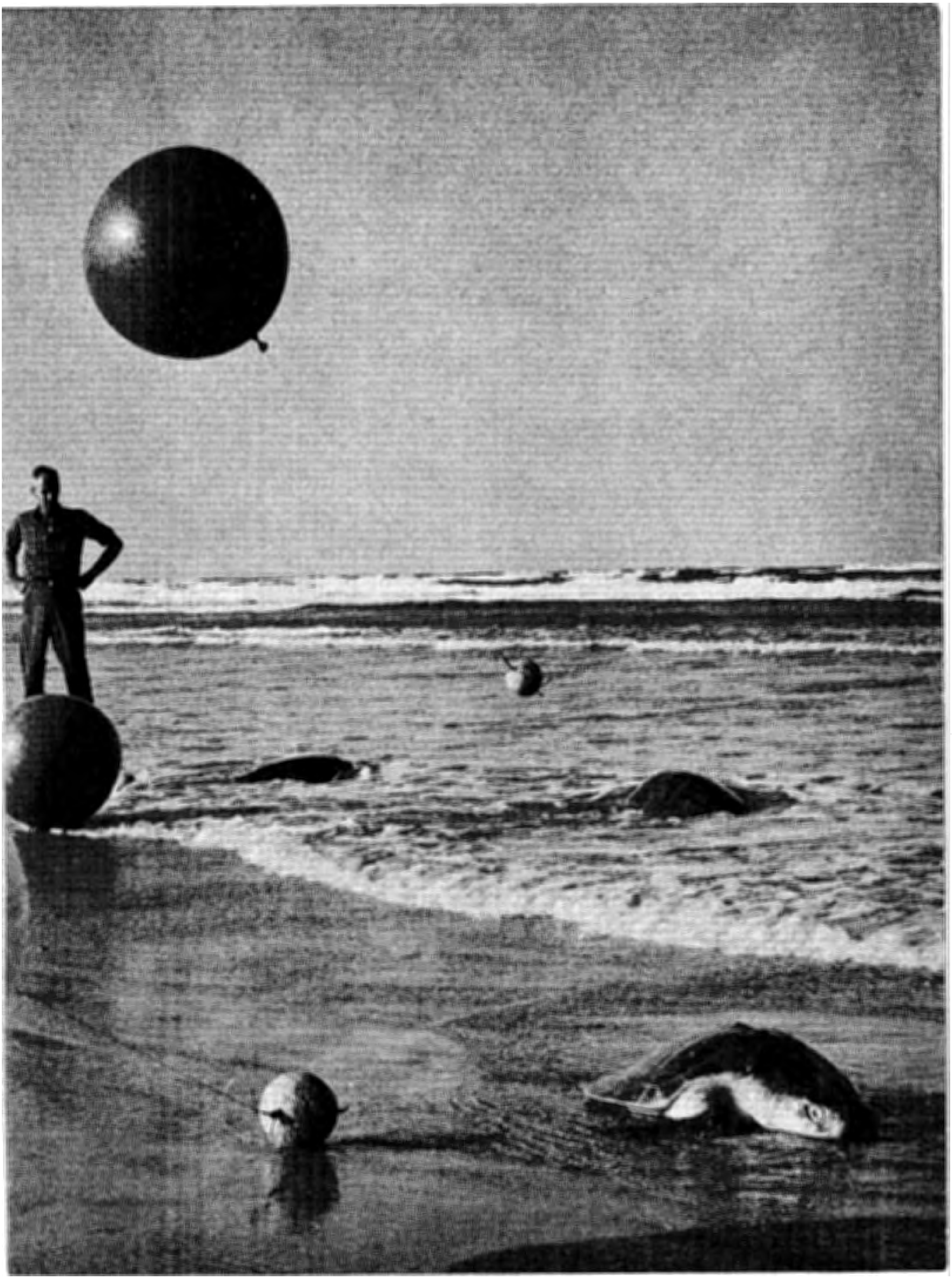
CONSERVATIONISTS MARK AN ORINOCO RIVER NESTING SITE WITH STAKES. THE EGGS WILL BE REMOVED TO A SAFE PLACE FOR INCUBATION



HATCHLING TURTLES that have just been branded are released by Dr. Janis Roze, a biologist with the University of Venezuela. Instinctively, these creatures scramble towards the Orinoco.

BRANDING THE YOUNG provides a record of growth for turtles captured later on Branding also reveals distribution patterns and the frequency of visits to nesting places.

VISUAL TRACKING experiment, designed to supply information about female sea-turtle navigation during nesting, is attempted with balloons attached to their shells.



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