



## FORM AND FUNCTION IN THE SLOTH ✓

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### INTRODUCTION

**S**PEED, speed and still more speed" began a newspaper editorial recently, considering the impulses of civilized man. Regarding simple rate of physical movement, however, the distance-in-time curve for man and most of his interests has now become rather flattened at the higher levels. It may be interesting to observe in contrast a lowlier form, but one still in our own mammalian class, the proverbially tardy sloth. Its curve of activity, after many aeons of concentrated specialization, has become almost asymptotic at a very low level. But withal its biological restrictions the sloth has achieved in some ways much freedom.

The opening of an inter-American highway through Panama will allow the 60-miles-an-hour motorist to meet the 6-hours-a-mile sloth. It will be one of the most unique creatures to be found in the tropics. Loafing lazily in nearby trees, or crawling occasionally with many pains and much difficulty across the road, this blissfully inhibited tardigrade may prompt a refreshing and rewarding pause. It will furnish an amazing object lesson in leisurely living.

Almost wholly the three-toed species will thus be observed by the roadway, for the two-toed animal gives the deadly *Homo* a wide berth. The deep curiosity and normal absence of fear which are shown by

the three-toed *Bradypus* lead it into strange highways and byways in life. Somewhat like the inquisitive and voracious opossum, it may now and then be found almost within the precincts of one's culinary quarters. Yet relatively few people to date, even in the tropics, have met the humble sloth. On a well-travelled tropical highway, however, there will soon occur a great loss by slaughter of these animals—totalling many more than were ever consumed by the hungry native or utilized by the zealous scientist. Happily their great number and relative inaccessibility in the forest will prevent extinction of a highly interesting and edifying mammalian form.

### HISTORICAL

Early accounts of the sloth are given by a number of writers, although they interest one more often by their quaint description than by factual exactness. One of the most interesting and apparently the earliest reference is that of Oviedo y Valdés (1526). Following several visits to many parts of the Americas, and gold-smelting operations in San Domingo, this Spanish knight and historiographer contributed classical and fairly trustworthy accounts of his travels. His book issued in summary form in Toledo over 400 years ago represents his first published natural history of the Indies, and from it the following delightful account of the sloth is derived.

[The author is greatly indebted to Professor Julio S. Galban of the University of Virginia for the translation here given from Oviedo's rare "Historia," in the University's Tracy McGregor Library. It may be observed that an effort has been made to retain the spirit as well as the letter of the author, in making the translation.]

Little Quick Pedro is the stupidest animal that can be seen in the world. So slow and heavy is he that it takes him all day to go fifty paces. The first Christians who saw this animal (remembering that in Spain the negro is usually called John White, so that it may be understood conversely) as soon as they set eyes on him gave him the name opposite to his nature: because he was extremely slow, they called him quick. This is one of the strange animals, very much seen in the mainland, and very different from all other animals. He must be as long as two spans when fully grown; very little more than this measure if somewhat over-grown: any smaller ones that are found are young. They are almost as broad as long; and they have four thin feet, and on each hand and foot four long nails, like those of birds, and joined: but neither the nails nor the hands are such as he can support himself on them, and because of this, and because of the slightness of his arms and legs and the weight of the body, he carries his belly almost dragging on the ground. His neck is high and straight just like a pestle of equal width to the end, without making any difference in width between the head and neck; and at the end of that neck he has a face almost round, very similar to that of an owl, and the hair itself makes a ring around his face, a little longer than wide; and his eyes are small and round, and his nose like a monkey's, and his mouth very small, and he moves his neck from one side to the other as if astonished; and his intention, or what he seems to try and desire the most is to hold on to a tree, or anything that he can climb, and so most of the times that these animals are found they are taken in trees, on which climbing very slowly they go clinging with their long nails. Their hair is between light and dark, almost the very color of the hair of a weasel, and they have no tail. His voice is very different from that of all the rest of the animals of the world: because it sounds only at night, and as a whole, in continued chant, from time to time, singing six notes one higher than the other, always descending: so the highest note is the first, and from that one he descends, lowering his voice, as one might say, *la sol fa mi re do*, thus this animal says *ha ha ha ha ha ha*. Without doubt it seems to me that, as I said in the chapter of the Armadillos, these animals might have been the origin or hint to make the armour of horses; so, hearing this animal, the first

inventor of music could have had a good base to give it beginning, better than any in the world, because the said Little Quick Pedro teaches us by his six notes the same as can be understood by *la sol fa mi re do*: returning to my story, I say that after this animal has sung at short intervals, he sings the same thing again. This he does at night and never in the daytime, and because of this and because he is near-sighted it seems to me that he must be a nocturnal animal and a friend of darkness. Whenever Christians take this animal, and bring him home, he goes around at his own gait; and neither by threat, blow, nor prodding does he move any faster than he is accustomed to do without tiring; and if he encounters a tree he goes to it and climbs to the highest of the branches, and remains in the tree, eight and ten and twenty days, and it cannot be known or understood what he eats. I have had him at home and what I was able to understand of this animal is that he must sustain himself on air; and of my opinion I found many in the land, because he has never been seen to eat a thing but continuously to turn his head, or mouth, towards the wind, more frequently than to any other part, by which it is known that the air is very agreeable to them. He bites not nor can he do so, since his mouth is extremely small, nor is he poisonous; nor have I ever until now seen an uglier animal, or appearing as useless as this one.

The illustration of the three-toed sloth from Oviedo's history (Fig. 1) represents the animal as if placed on the ground in a sitting posture like that assumed by a young child. This unique attitude is one which the animal may to be sure maintain momentarily: in any case it is true that the sloth presents an extremely quaint picture whether viewed sedant or scandent.

One of the early buccaneers, Exquemelin (1678), recounts that a Captain Sharp and his crew caught a sloth on a small island (the Isle of Gorgona or "Captain Sharp's Isle"), and commented that it was a beast "well-deserving that name."

Captain William Dampier's travels around the Bay of Campeachy and other parts brought him into contact with the humble sloth. Some of the animal's habits are described interestingly, with



not unusual over-emphasis. In his "Voyages" (1697) he remarks that

"They are very mischievous to the Trees where they come. . . . They never descend till they have stript every Limb and Bough, and made them as bare as Winter. It takes them up eight or nine Minutes to move one of their Feet three Inches forward; and they move all their four Feet one after another, at the same slow rate; neither will stripes make them mend their pace, which I have tried to do, by whip-

It resembles a middling monkey, but of a wretched appearance, its skin being of a greyish brown, all over corrugated, and the legs and feet without hair. He is so lumpish, as not to stand in need of either chain or hutch, for he never stirs till compelled by hunger. . . . The food of this creature is generally wild fruits; when he can find none on the ground, he looks out for a tree well loaded, which, with a great deal of pain, he climbs; and, to save himself such another toilsome ascent, plucks off all the fruit, throwing them on the ground; and to avoid the pain



FIG. 1. PROBABLY THE OLDEST PICTURIZATION OF THE THREE-TOED SLOTH (OVIEDO Y VALDÉS, 1526)

The unsupported sedant position is really an impossible one for the sloth, and the not unusual anthropomorphic representation is evident.

ping them; but they seem insensible, and can neither be frighted, or provoked to move faster" (Masefield edition, 1906).

The comments of Don Juan and de Ulloa on the sloth are more fanciful. These Spanish sea-captains, it may be recalled, visited the New World in 1735. A short excerpt is taken from the translation of their work (1748) by Adams (1807):

of descending, forms himself into a ball, and drops from the branches. At the foot of this tree he continues till all the fruits are consumed, never stirring till hunger forces him to seek again for food.

Bulfinch (1766) has described the broader features of the anatomy of sloths, including the stomach and intestines, sex apparatus, teeth and bones, as well as many external characteristics. He also remarks

that the Marquis de Montmirail kept a two-toed sloth for three years in a menagerie, and that it fed on bread, apples, milk,

Interesting observations have also been made by Oliver Goldsmith (1825). An animal that is slow from necessity, he



FIG. 2. A RATHER LULL-LIKE ILLUSTRATION OF THE TARDIGRADE SLOTH FROM PENNANT (1771)

and "poisonous leaves." The illustrations by Pennant (1771) and by Buffon (1776) are rather imaginative (Figs. 1 and 3).

remarks, the sloth may move three feet an hour when impelled by the severest stings of hunger. He considered it represented an unfinished production of nature, the

"meanest and most ill-formed of creatures that chew the cud."

remarking on the sluggardy of the sloth, Cuvier (1837) explains it "because of a construction truly heteroclitic." Nature, he says, seems to have amused herself by producing something imperfect and grotesque.

Some recent engaging articles on sloths have been written by Beebe (1925, 1926). Observing that it lives at a low ebb, or in low gear, the personification of deliberation, he adds that the sloth would be a fitting inhabitant of Mars, where the year is six hundred days long; self-centered and sub-reptilian in mentality, in a "perpetual stivation of sorts," it had no right to be living on earth. Probably about the lowest in its scale, as to touch, taste, sight and hearing, it was nevertheless better off, offactorily speaking, than man. Many interesting habits and activities of sloths are described by Beebe, and several anatomical facts are given. Jaguars and wild cats, coatis, the anaconda and the harpy eagle are listed as enemies which at least occasionally eat sloths.

In a number of recent contributions, Wislocki has dealt with the important anatomical aspects of sloths; these are referred to in detail later. Extended bibliographies are given by this writer, and also by Beebe (1926). Other articles in the literature on the sloth are appropriately referred to herein, but no attempt has been made to give a complete bibliography. Most of the data contained in this review are, it may be said, derived from the writer's own records of experimental work carried out during several expeditions to the tropics. In nearly all cases observations were made on the commoner Panamanian sloths, the two-toed *Cholepus Hoffmanni* Peters and the three-toed *Bradypus griseus griseus* Gray.

Three expeditions to Panama were made by members of the Department of Physiology of the University of Virginia Medical School in 1937, 1938 and 1939. Members of these expeditions besides the author were Mrs. S. W. Britton, Dr. Murray Brown, Mr. W. E. Atkinson and Mr. Raymond F. Kline. To these workers credit is due for much of the information contained herein, as indicated in separate scientific reports under their authorship. The author worked under the terms of a John Simon Guggenheim Memorial Fellowship during the years



FIG. 3. AN IMAGINATIVE, PLAYFUL SCENE OF YOUNG SLOTHS PICTURED BY BULLON (1776)

1937 and 1938. Work was carried out in the first two years chiefly at the Institute for Research in Tropical America at Barro Colorado Island and surrounding territory, with the splendid help of Mr. James Zetek, Curator. Here it was possible to live with large colonies (50 to 100) of sloths, imported from the mainland, and observe very intimately their living habits. In 1939 investigations were undertaken at the Gorgas Memorial Laboratory, and from there field trips were made, with the invaluable co-operation of Dr. Herbert C. Clark, Director of the Labora-



tory. The author is much indebted to Mrs. Britton for the drawings contained herein.

#### CLASSIFICATION AND ANTIQUITY

Sloths may be designated briefly, zoologically, as of the mammalian subclass Eutheria, order Edentata, sub-order Xenarthra, and family Bradypodidae. In the two genera, *Bradypus* and *Cholepus*, several species have been described—*Bradypus infuscatus*, *B. griseus griseus*, *B. tridactylus*, *B. castaneiceps*, *B. ignavus*, *B. torquatus*, etc.; *Cholepus hoffmanni*, *C. didactylus*, etc. Differences in species appear to be highly variable and in considerable dispute, however, especially in the case of *Bradypus*. Four other distinct families also occur in the Edentates besides the Bradypodidae, namely the Manidae, Dasypodidae, Myrmecophagidae and Orycteropodidae. It should be said that the Edentates have been divided by some workers into the sub-orders Pilosa (including the sloths) and Loricata (armored Edentates).

Flower (1882) states that probably all the New-World Edentates, which represent by far the majority of the known species, sprang from one common stock in the Pliocene and Pleistocene periods, relatively late in geological history. In contrast, in his work on placentation in the sloth, Wislocki (1927) remarks on the possibility of the great antiquity of the Xenarthra, including the sloths. The work of the present author also indicates that the sloth is a relic of a dim and ancient past. Some interesting connections of surviving sloths with the gigantic extinct Tardigrada (Glyptodontidae, Megatheriidae) have been suggested by some workers. According to Miller (1939), however, there is little or no conclusive evidence regarding the extinct forerunners of present-day sloths.

The term "sloth" was used to denote the animals described herein more than

300 years ago. Purchas (1613) writes that "The Spaniards call it . . . the light dog. The Portugals Sloth, The Indians, Hay." A further early reference is that of Crew (1681), who mentions "The Sloath. . . . An animal of so slow a motion, that he will be three or four days, at least, in climbing up and coming down a Tree." The two-toed sloth, *Cholepus*, possessing two toes on the fore-limb and three on the hind, also is given the common but still little-known name "unau," of South American (probably Tupian Indian) origin. *Bradypus*, or the three-toed sloth, having three toes on both fore and hind feet, is known commonly by the name "ai," an onomatopoeic term having reference to the shrill, bleating cry occasionally emitted by the animal, especially at night or when molested.

The delightful early Spanish term of ironical concept for a sloth is *perico ligero*, or nimble little Peter! By far the slowest and most typical of sloth-like animals, the antithesis of speed, are the three-toed Bradypodidae. The Cholepine two-toed sloths are in contrast much better grade or higher type animals; this is apparent from many physiological aspects, although they are still distinctly and properly classified as sloths. Some of the slowly-moving lemurs would almost certainly show functional correlations with the sloths, but zoologically they are widely separated from *Bradypus* and *Cholepus*. The sloth bear, sloth monkey, ground sloth and sloth animalcule are interesting extinct or present-day animals which are not included in the subject of this study.

#### Distribution

Sloths are found in the forest regions of tropical America from Honduras and Nicaragua in the north down through Panama and as far south as upper Brazil and Bolivia. They occur on both sides of the

Andes, a fact which earlier observers did not recognize. They are strictly limited to the New World, it may be emphasized, although several of the older historians indicate otherwise. It is nevertheless true that other animals inhabiting the Old World, such as African potto-lemurs and Asiatic lorises, have in the literature been popularly called sloths.

*Bradypus* occurs only in the lower neotropical altitudes, and is particularly prevalent in regions where the temperature is not widely fluctuating (in the heavily-wooded jungle depths). *Cholepus* also lives chiefly in the warm, tree-shaded lowlands, but is able to withstand the cold (possibly occasional freezing) of altitudes up to 7000 or 8000 feet. The latter form apparently does not extend farther north, however, than Costa Rica. Most species of *Bradypus* are distributed generally throughout the neotropics, although *B. costaricensis* and *B. ignavus* have a more northerly distribution, and are particularly common in Panama and Costa Rica. *C. hoffmanni* is also commonly found in the latter places, as well as in Ecuador. *C. didactylus* inhabits chiefly Brazil and the Guianas. The largest sloths observed by the author have been those taken in Colombia. It appears likely from many considerations that these animals thrive best in the highly humid and wooded equatorial regions.

#### CHARACTERISTICS

##### General

In both genera of sloths and especially in *Bradypus* the head appears small for the body size. The broader snout and head in *Cholepus* are due in large measure to the extensive sinuses which are present. The external ears are very small and hidden in the hair; in *Bradypus* only a tiny pinna about 1 cm. across is present. The eyes are also small and round, and of a dirty

brown color. Passage through trees is obviously facilitated by the head arrangements.

Contrasted with the short neck of *Cholepus*, that of *Bradypus* is long and mobile, and along with the small head is suggestively reptilian. It is remarkable that the Bradypodine head may be rotated through 360°; starting from the dorsal facing position a complete turn may be made. The fore-limbs in sloths are longer than the hind, which appears important in meeting the demands of arboreal life. In *Bradypus* the fore-limbs are longer, the hind-limbs shorter than the respective limbs in *Cholepus*; there is also greater mobility of the fore-limbs, which may indeed be drawn around to the back of the body, crossed, and returned forward to meet again over the abdomen. The hind-limbs of sloths (greatly shortened in *Bradypus*) serve a great deal of the time for maintaining hold or stance. A stumpy tail 8 or 10 cms. in length is present in *Bradypus*, while *Cholepus* is tailless.

*Cholepus* is much the larger, stockier-built animal, and is considerably less sluggish—under ordinary conditions it travels about twice as fast as *Bradypus*. Adult didactyl animals reach weights between 6.5 and 7.5 kgs., while the tridactyl form weighs between 3.5 and 4.5 kgs. The females are smaller by about 0.5 kg.

About as large as a small or medium-sized dog, therefore, sloths are markedly different in general form and appearance. The shaggy coat, long limbs and long curved claws, small head with bead-like eyes, and remarkably slow movement in the upside down position, set the animal apart from all other types. A very furry or hairy "teddy bear" indicates somewhat its general appearance (Figs. 4, 5, 9, 10), the young sloth especially resembling a ball of rather fluffy fur. For several months after birth the young possesses a

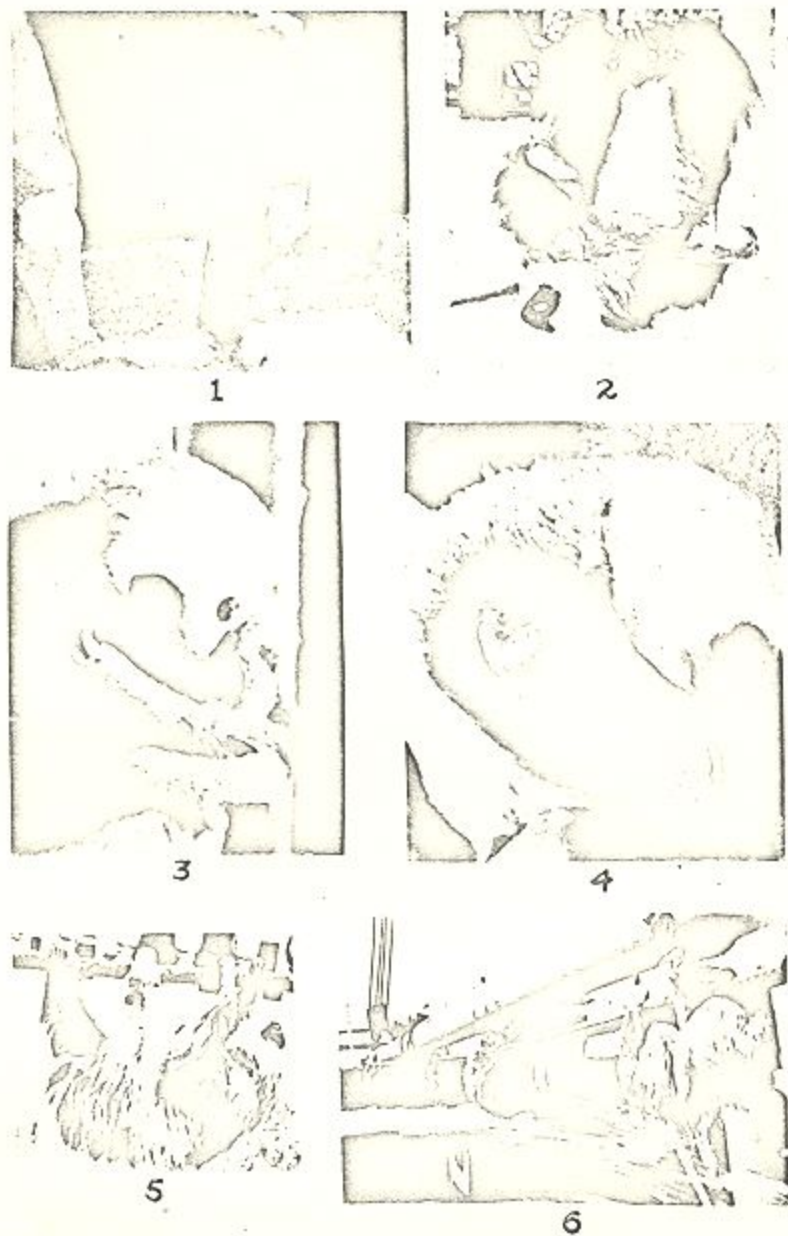


FIG. 4. THE TWO-TOED SLOTH (*CHOLEPES HOFFMANNI*) IN VARIOUS POSITIONS

1 and 2, fighting; 3 and 4, nursing its young; 5, normal walking; 6, a bath before immigration check-up, on going north from Panama.



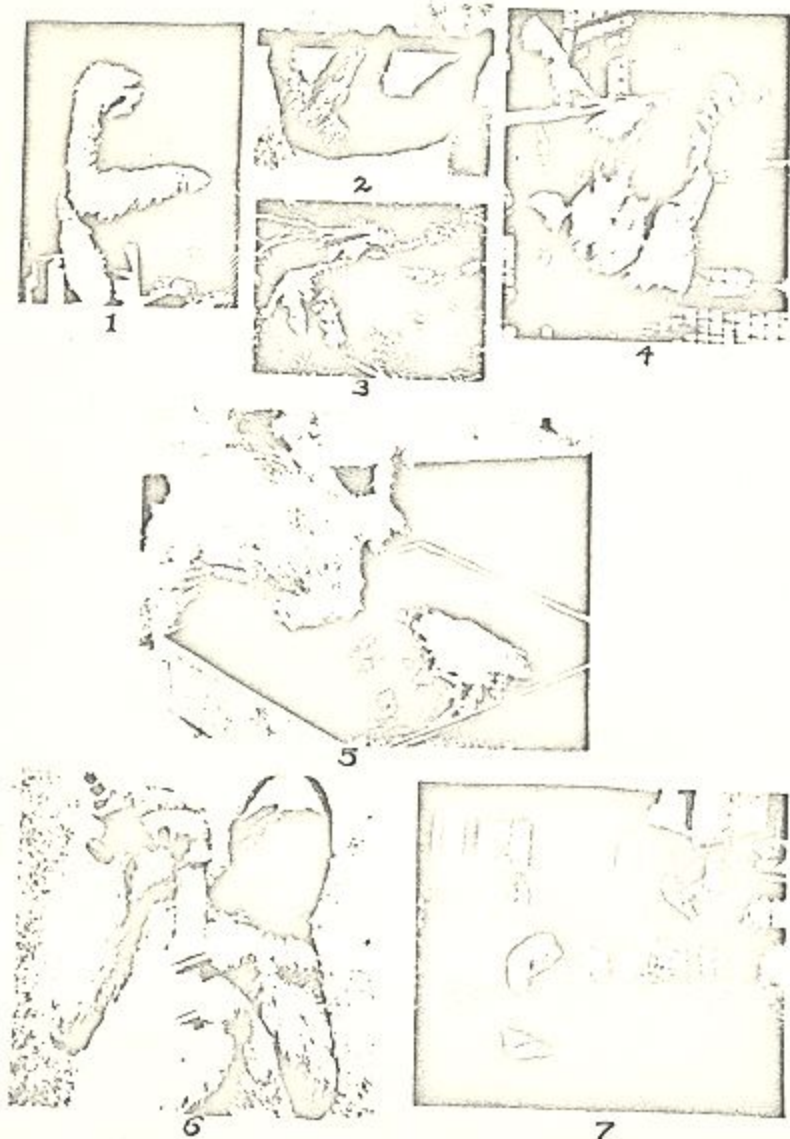


FIG. 5. 1, 2, 3 AND 4. THE THREE-TOED SLOTH IN TYPICAL POSITIONS, THE LAST-NAMED (4) A MALE WITH DORSAL SADDLE MARK, 5 AND 6. TWO WAYS OF DRINKING IN THE LABORATORY; 7. NATIVE BRINGING SLOTH IN FROM THE JUNGLE

soft, fine coat, and the three-toed form displays fur as an undercoat intermingled with coarse hair throughout life.

*Bradypus* is found, when shorn of its outer hair, to be beautifully marked with a black and white coat, somewhat leopard-like in character but with coarse linear mottlings of glossy black from 1 to 3 cms. wide. Both male and female three-toed sloths are thus observed to be marked when clipped. The male tridactyl animal gives a clue to this condition by its dorsal exposed white and black mottled area (in the older adult, yellow and black), some 10 by 15 cms. in extent, in the saddle position (Figs. 5, 4). This very distinctive dorsal marking has received no explanation, except to say that it represents a male sex characteristic. It begins to appear in males only a few weeks of age, and evidently the outer hair is then lost by slow degrees until the animal reaches about one year old, at which time it seems as if the area had been neatly plucked or clipped. Wislocki (1928) states that the beginning of a saddle mark is apparent in fetal male and female *Bradypods*, but that the male only develops the definitive mark at about the time of puberty. The condition may be reproduced in the female by shearing (Fig. 6, 1). In the two-toed sloth both under and outer hairy coats are similar in color and texture, and in this form there is no sex marking (Fig. 6, 3a).

Male and female sloths are difficult to distinguish, except for the dorsal marking in *Bradypus*. After long practice, slight differences in the urogenital area, indicative of the sex, may be detected.

In both genera, the long, coarse hair affords splendid protective coloring in the tropical foliage (Fig. 7). Patches or areas of different shades are very common. Various tints of gray are observed in *Bradypus*, while gray-brown (sometimes greenish-gray) usually predominates in

*Cholepus*. In the latter the coat is much less shaggy, and in its best condition it is indeed of a rather sleek, smooth appearance. The hair in *Cholepus* inclines back from the head and limbs and abdominal areas towards the mid-dorsal line and tail. In *Bradypus* also the hair exhibits this tendency, but is much more irregularly disposed and shows a frontal ruff, a central dorsal division and small shoulder and pelvic whorls (Fig. 8). In the case of both genera the hair arrangement undoubtedly allows optimal shedding of water, which is highly desirable in the (usually) very rainy sloth country.

In the didactyl sloth the hair under the microscope is found to be fluted longitudinally—the only known case of such mammalian hair markings (Fig. 11, A, A1). Exceptions are the vibrissae and fine hairs about the eyes, which are normally round and plain. From 8 to 10 grooves and columns, well rounded and the former with a tendency toward lateral hollowing-out, are found in cross-section in each hair; they run from base to tip, where all disappear uniformly. The three-toed sloth shows no such hair flutings, but transverse markings occur (Fig. 11, B, B1). In both forms the hair is scaly. Individual hairs appear under the microscope as white, yellowish, brown, gray, or black.

Different coat shades and ruff markings, and also skull contours and number of vertebrae, have influenced observers in designating "new" species. These characteristics are, however, highly variable in any small group of sloths collected in one locality, and the author sees no good basis for many of the species described.

#### *Activities and habits*

In the same order—the Edentates—with the aard-vark, pangolin and other divertingly interesting forms, the sloth presents an equally engaging cross-word puzzle to

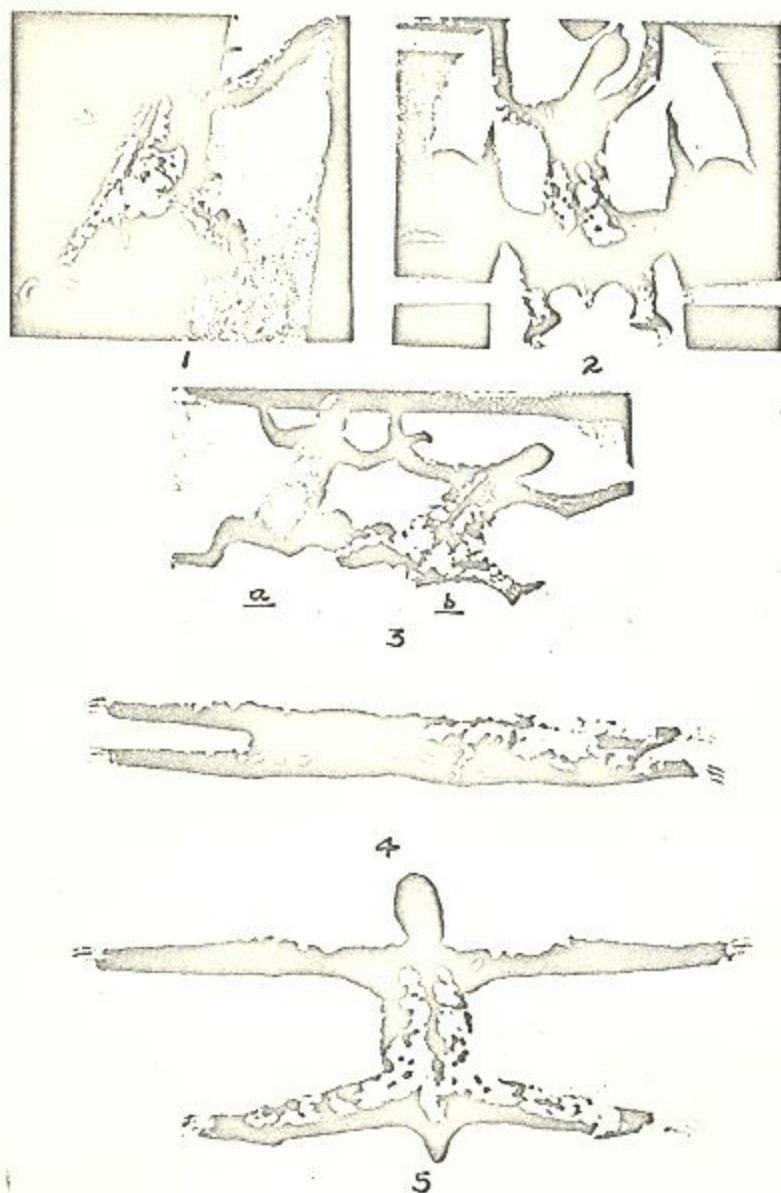


FIG. 6. MALE AND FEMALE SLOTHS SHORN OF OUTER HAIKY COAT, EXHIBING UNDER-FUR

All are three-toed animals, except *3a*, which is two-toed and of a uniform gray color. The black and white leopard-like mottlings in three-toed sloths are well seen in *1* and *2*, in *4*, the extraordinary streamlined form is observed, and in *5*, the very long, slender limbs and extremely long claws are evident.



both naturalist and experimental scientist. "One more defect," wrote Buffon, "and it would cease to survive." But, while it is a defective creature, comments Beebe (1926), and a sloth in Paris would surely not long survive the pace, Buffon clinging upside-down to the branch of a tree in the jungle would expire even sooner! Spending most of its life in the mid-jungle trees, looking much like a hanging mass of gray-beard mosses, the sloth is wonderfully built for clinging and climbing. Nor-

slower than, those made head-foremost. Again, there is frequently no definite order of limb-movement maintained by tridactyl sloths, and one gets the impression that a "touch-and-go" style of progression is followed. In such an empirical way of travel, one movement is probably not dependent on or conditioned by that immediately preceding it so much as by the specific position of the body in space, which is modified from moment to moment by the swaying branches along



FIG. 7. THE SLOTH (THREE-TOED) IN A TYPICAL CRAWLING POSITION ON THE GROUND, AMONGST SOME CULTIVATED PANAMANIAN GRASSES

In the jungle trees and grasses the shaggy, patchy-colored hair is an even more effectual protective covering against detection.

melly, it travels on the under side of limbs in the inverted or back-down position, and shows very poor ability to progress in the upright position. While it usually advances head-forward, to be sure, the three-toed sloth may frequently pivot and go tail-first, while maintaining the same direction of movement, say along a branch or pole; and it may thus change about several times while traveling, in the course of a minute or two. Tail-forward movements are as fast as, or no

which the animal moves. Another influential factor is, of course, the proximity of food.

Sloths thus appear to possess an extremely limited sense of equilibrium. The upright position on all fours is seldom assumed under normal, active conditions, when the animal perches in tree crotches or comes to the ground. In the latter case progression is very slow (even for the sloth) and difficult; the spread-out or sprawling position of the body and limbs

indicates an undeveloped musculature (for this situation), and also demands no effort in balance. Although its home for the greater part has been made in the trees, the sloth has resisted to only a slight extent

appears to do most of the time, if one may credit the observations of hunters and laboratory workers.

In justice to the sloth, however, its normal mode of progression gives it easier



FIG. 8. YOUNG THREE-TOED MALE SLOTH, CLINGING TO VERTICAL WALL

The hair lines of limbs and back are typical, and the dorsal saddle mark is about one-half developed in this case

the influence of gravity, and covets the delights of dangling and swinging in space. With its remarkably long, curved claws, it is also well adapted for maintaining a fixed position with ease. This it

and surer access to pendant fruits and leaves on which it feeds. Only a slight development of attitudinal and equilibrational reflexes would appear to have been demanded. In the case of monkeys, the

usual upright or head-up position involves, in contrast, a much more compli-

slip or even fall from the trees on which they are feeding, the sloth is in contrast



FIG. 9. SKETCH OF THE TWO-TOED SLOTH (*CHOLEPUS HOFFMANNI*) TAKING UP TYPICAL FIGHTING POSTURE WITH ARM RAISED TO STRIKE

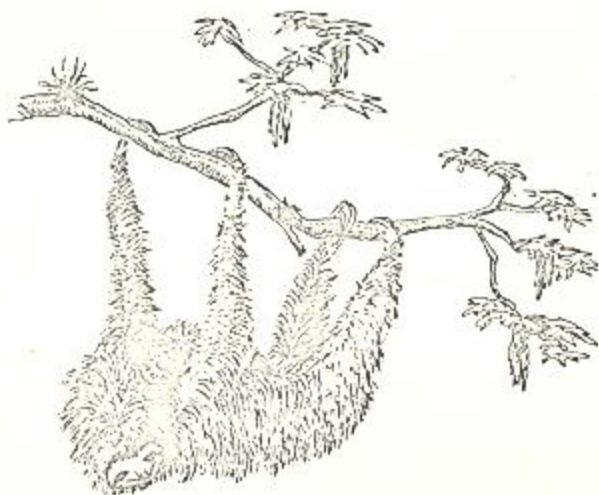


FIG. 10. LIFE-SKETCH OF THREE-TOED SLOTH (*BRADYPUS GRISEUS*) CARRYING YOUNG ON BREAST, AMONGST *CECROPIA* FOLIAGE, ITS COMMON FOOD

cated set of reactions; and while these primates may occasionally be observed to the surer-footed and more specifically adapted animal for arboreal life.



*Bradypus* is a great sitter; the greater part of its life, perhaps four-fifths, appears to be spent thus, sleeping or dozing in the branches or smaller forks of trees, with

The higher trees are sought for rest when the foliage is thin, and the lower ones when the vegetation is dense enough for hiding. The stumpy tail helps consider-

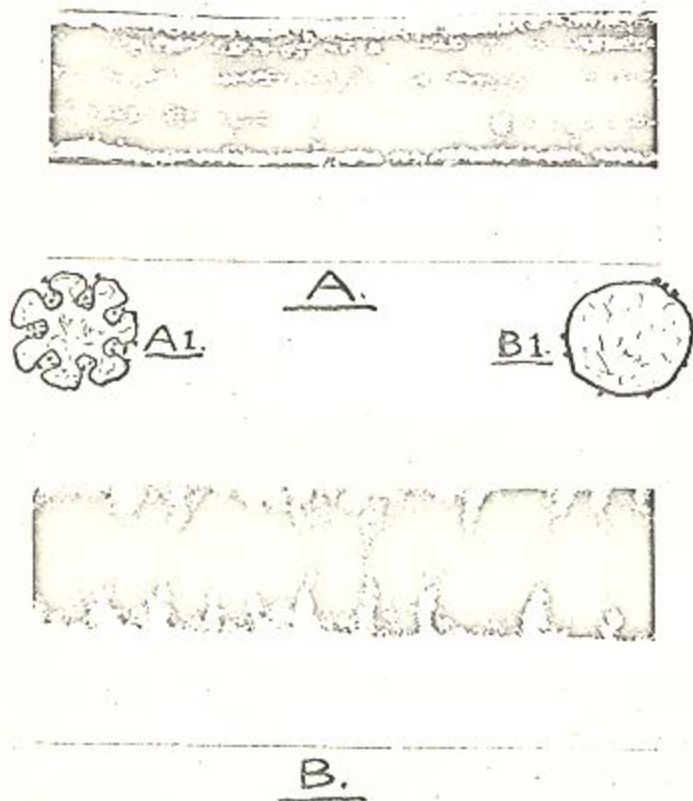


FIG. 11. MICROPHOTOGRAPHS OF TWO-TOED (A) AND THREE-TOED (B) SLOTH HAIR

A1 and B1 indicate the respective hair shapes in cross-section. The flurings in the *Cholepinae* hair are unique amongst mammals. The great numbers of algae infesting the hair are evident.

fore-limbs often crossed over the breast and head tucked upon them. Notwithstanding this, and the fact that the sloth's stomach is always chock-full, it never accumulates any fat or "puts on weight"!

ably as a prop in providing the personal sitting quarters, and this is possibly correlated with the stunted and worn-down appearance of the caudal member.

*Cholepus* also spends a great deal of time

in the squatting posture, but rests occasionally in the upside-down position, suspended by all four limbs. Wislocki (1928) has stated his belief that *Cholepus* spends much of its time in the latter position, but the present writer could not confirm the point. In observations made in Panama on a large colony of sloths over a period of two weeks, at different times during the day, the two-toed variety was found when resting to maintain the upright clinging or squatting position in 85 per cent of the counts, and the three-toed animal in 90 per cent (Britton, unpublished observations). At other times the inverted, clinging posture was assumed. The rather unnatural conditions present in even a jungle laboratory would modify to some extent, however, the deportment of the sloth.

#### *Habitat and travel*

Commonly a particular neighborhood is favored by individual sloths for long periods at a time. In some cases an animal has been observed to remain even in the same tree for days or weeks. Favorite roosts in trees and thick foliage have often been observed. The alcabu or prickly yellow tree, possessing large spines on its trunk which defy climbers, appears to be a common resting place of *Cholepus*. Excursions for food are made particularly at night, when both species are most active. The Indians have a saying, however, that when the wind blows the sloth begins to travel—and in much of the sloth country the trade winds start at about 10 a.m.!

Movement is made from tree to tree via the ends of branches when possible (as it usually is in the thick jungle), but descent to the ground for passage may occasionally be made. While the more agile two-toed form is rarely seen on terra firma, *Bradypus* may be met fairly often on the highway or trail, and it sometimes approaches the out-

skirts of towns. Mating and parturition apparently occur on the ground in both species (see later).

Sometimes, distances of several miles may be covered in the course of a few days. The sloth is moreover a good swimmer, and may cross rivers or a mile or so of open water. The latter fact has been observed in the Gatun Lake area of the Panama Canal, where sloths fled from the islands about twenty-five years ago when the lake was formed. Today, these animals baffle all attempts to insulate them in this area by swimming to the mainland whenever they are released on even the larger islands, such as Barro Colorado.

There are indications that considerable numbers of sloths may move or migrate from one locality to another, several miles distant, in the course of a few years. Such changes do not appear to be related to food or climatic conditions, or to the larger animal enemies. Observations which have been made on this point have been limited, however, to the central parts of Panama, particularly to the Canal Zone where man has extended his activities rather rapidly, and they may possibly not hold for other areas.

In the jungle, sloths are usually found resting or travelling as solitary individuals. Many natives assert that if one sloth is discovered, however, another may be found not far away. In one very unusual instance, native workers near Cristobal sighted five three-toed sloths in different parts of one large tree. Both didactyl and tridactyl sloths may range over the same neighborhood together, while in other cases one genus may occupy an extensive area alone. In the case of long-confined animals under laboratory conditions, each genus may be observed congregating separately, in the heat of the day, in shady corners of the pen.

Males and females associate together in this way indiscriminately.

When first taken and placed in open-air cages near the laboratory, the sloth appears ill at ease and continually seeks a way of escape. Clawing of the cage and frequent sniffing of everything animate and inanimate within range are observed over a period of three or four days, after which time the animal settles down to an apparently normal, sedentary life.

#### *Fighting propensity*

When sloth meets sloth there is usually a fight, at least in the rather restricted quarters of the laboratory. Two-toed sloths are aggressive, and when approached will readily tackle almost any animal including man. *Bradypus*, however, is a poor fighter and never appears to pick a quarrel, but will strike back weakly when molested.

The fighting *Cholepus* usually holds on grimly by its hind-limbs to a branch or the cage wall, and lashes out fairly quickly with one or both long and dangerous fore-limbs, while teeth are bared and the powerful jaws stand open ready to come together on any object with resounding clack (Fig. 4, 1, 2). An attempt is made to draw an adversary, when caught, towards the open jaws. The claws and teeth are formidable weapons, and even sloths themselves with their supertough hide may be badly scarred and torn in combat with each other. An inch pine board may be bitten through and splintered readily. The fore-limb flexion or striking movement of *Cholepus* is fairly quick, and has been called a "pugilistic short-arm hook" (Beebe, 1926); the preparatory extension component is, however, a slow, "wind-up" affair.

#### *Tenacity to life*

Wounds in both forms usually show clean, rapid healing, but deep injuries may

become badly infected. An amazing tenacity to life is shown by sloths in their ability to survive for long periods after extensive trauma, apparent drowning, or anesthetization far beyond respiratory failure. Beebe (1926) has mentioned for example that a sloth may survive immersion for 40 minutes in water—almost as long a period as the whale may spend submerged! In the writer's experience, recovery of an animal may also occur after suppression of respiration for 30 minutes by ether.

In some tropical areas the sloth has been used by natives for food, but the flesh is very tough and most difficult to strip of its hide. In other parts there are definite taboos, or "trafers" against killing the animal. Kahn (1931) remarks that individual natives may have particular traferes: thus, one may not shoot a sloth in Dutch Guiana, but if he should do so, his gun would be spoiled. Amongst native hunters it is rather generally considered to be unlucky to shoot or otherwise injure the sloth.

If one may make a rough approximation regarding age from observations on about 300 sloths in their native country, it would seem likely that these animals have a normal life-span of from 8 to 12 years, and may perhaps even live up to 15 years of age under optimal conditions.

#### *Ability to learn*

Although it puts up a weak resistance to capture in the jungle, *Bradypus* soon becomes docile and shrinking in the surroundings of the laboratory or garden, and may quickly become a pet. Colombian and other natives may now and then be seen travelling with such animals as pets clinging to their backs. *Cholepus* is tractable when young, but rather difficult to tame in adulthood. When kept in the laboratory for some weeks, however, it



tends to become fairly sociable. The earlier American workers on the Panama Canal collected sloths, among many other interesting forms, and hunters and others there today occasionally take the animals home to their gardens as attractions.

Some ability to learn or develop certain habits is shown, especially by *Cholepus*, after a week or two under laboratory conditions. Regular eating and drinking habits become established readily (Fig. 5, 5, 6), and food such as a banana may be eagerly sought after, and even delicately taken from one's hand. The appearance of the water boy signalizes drinking time, and turning on a faucet in the pen quickly attracts the thirsty individual. *Cholepus* has been observed to drink from a running water tap.

Fairly good responses are noted in training the sloth to travel on a horizontal bar or along a special track; also, when one makes frequent blood samplings from a vein, a certain adaptation of the sloth to such treatment is observed. Individual haunts in the pen are recognized and honored after animals have been in captivity for a few days. In the tropics both genera may be kept indefinitely under good conditions in the laboratory. In cooler latitudes also *Cholepus* lives well, but *Bradypus* is kept alive only by very careful diet and attention to environmental temperature.

#### *Sloth parasites*

Sloths afford harbor for an assortment of animal and even some plant life. The hair of both *Cholepus* and *Bradypus* is thickly covered with small green algae similar to the common parasite *Chlorococcum* (Fig. 11): *Bradypus* usually shows the greater infestation. Young sloths acquire the parasitic covering after they are a few weeks old. The algae are very densely packed, and occur irregularly or in

columns or chains, one to four in number wide, around the hair, in the case of the three-toed sloth with ordinary round hairs. Similar chains are found along the hair length, but in the grooves, in the two-toed animal with fluted hair. The dorsal parts are particularly well covered with algae. A rather bright green coloration is thus developed over the more exposed areas of the sloth, because of the algae infestation, in the wet season of the year. In the drier periods the algaous covering tends toward a brownish-green hue, although a little water sprayed over the animal restores the brighter green tint.

Supporting this protective coloration afforded the sloth in its changing jungle environment may be noted the coarse, moss-like hair itself, strikingly similar to the surrounding masses of epiphytic vegetation. When these facts are coupled with the animal's very slow movements and tendency to secrete itself, sleeping hours on end, in the thicker foliage or angular, more inaccessible branches, the preservation coefficient of the sloth would appear to have been set at a high level. With such relatively passive or easily acquired and effective survival factors, the limited defensive ability of this tardigrade (especially *Bradypus*) and also its uniparous habit are in good biological harmony.

The sloth pelage, besides being covered with small algae, gives gracious refuge to several higher forms. Moths are at home in the hairy coat, small beetles have been observed, and ticks burrow through and into the skin to find their living. In the tropical laboratory, large cockroaches sometimes find a hiding-place and possibly food in the sloth hair. With rather generalized internal vermic infestations added to the list, the sloth takes first rank as a "buggy" animal. Several species of moths, ticks, and roundworms which infest the sloth have been described. A few

generally interesting facts on some of these parasites are given here.

Sloth moths are the only Lepidoptera known to be ectoparasitic in the adult stage. Three which have been described are of the family Pyralidae, and belong to distinct genera. The moths show great activity, scurrying about in the deep hair, as soon as the sloth is caught; if much disturbed they will fly off to a nearby perch, or settle on the intruder's hair, and then return to their host later. They do not appear to spend all their life in sloth

preen themselves, very little attention appears to be paid to the ticks, which are found on different parts of the body and sometimes attain a large size, some 2 cms. or so in diameter.

A small black insect, apparently a beetle and about 3 mms. in length, has been observed occasionally by Beebe (1938) and by the author in the commodious sloth hair. It does not appear to have been described in the literature.

Three or four different helminth parasites (Filariidae, Spiruridae, etc.) have

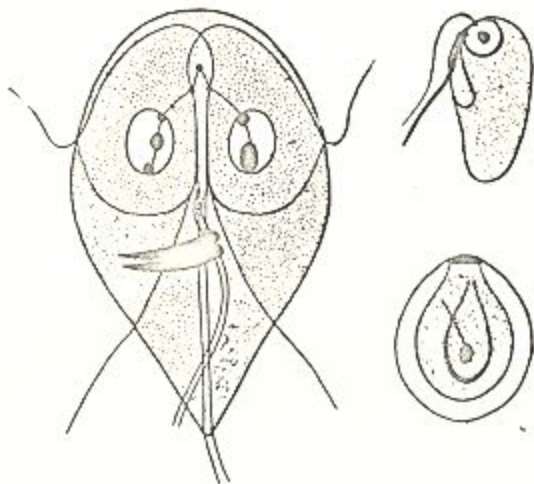


FIG. 12. SOME INTERESTING PARASITES FROM THE SLOTH INTESTINE (FROM HEGNER AND SCHUMAKER, 1928)

hair, however, since they have been taken in night-traps. Further, they do not seem to feed while on the sloth, since the mouth parts of all specimens examined have appeared coiled and atrophic. The larvae have apparently not yet been recognized but are possibly present, and may feed on fats on the sloth hair or on the abundant algae.

Four species of ticks have been described as infesting *Bradypus*, and apparently one or two species are found on *Choloepus*. Although sloths occasionally scratch and

been observed in sloths (Fig. 12). They occur in the stomach, mesentery, and other parts, sometimes in great numbers, and many appear to be peculiar only to the sloth. Again, the three-toed form would appear to be the greater sufferer; at least, most vermes have been observed in this animal.

#### Food

Voracious eaters under natural conditions, sloths apparently utilize many varieties of leaves and fruits for food. When



an animal is taken in the field, the stomach contents may be found to comprise more than a quarter of the body weight. The gastric sac is really amazingly large. Even under laboratory conditions, didactyl sloths consume large amounts of foodstuffs—bananas, oranges, figs, lettuce, hibiscus, and especially cecropia leaves. Tridactyl animals in captivity may usually be coaxed to take cecropia and hibiscus leaves, but sometimes refuse all food and succumb within a week or so. Raw beef was taken from the hand and eaten fairly readily by *Cholepus*, while *Bradypus* showed little interest in it. Both forms devour the placenta following birth of their young. Water is taken in fairly large amounts by lapping with the tongue, similar to a dog.

#### *Mating, placentation, birth*

Only one report of the apparent mating of sloths has come to the attention of the author. This was given by three bush workers in the Panama Canal Zone, who stated that they came across two animals of the two-toed species together in the tall jungle grass. They were locked in close embrace, ventre-à-ventre, the long claws of each embedded in the thick fur of the other, and almost certainly engaged in sexual intercourse, according to the witnesses. No signs of fighting were evident. Several general muscular spasms were said to have taken place over the period of about half-an-hour while the animals were observed. It may be said that although the sloth usually will scuttle away as fast as it can travel on the approach of man, not the least attention was paid in this case to the onlookers. It was found impossible to separate the animals by force, and they were left to their own devices by the usually kind natives. The ventre-à-ventre position in mating would appear to be demanded by

the anterior position of the genitalia and the forward-tilting pelvis.

Some cryptic comments have been made by Beebe (1926) on the mating of sloths, which he notes occurs in spring. The courtship, he relates further, is "unemotional, direct and brief."

Following the older work of Turner (1873), a number of observations have been made in recent years on placentation and the early development of sloths. Those of Wislocki (1927) and Heuser and Wislocki (1935) are very interesting and comprehensive. It is indicated by these workers that breeding may occur at any time of the year, but more often early in the dry season. Intrauterine development showed in numerous respects, particularly in the relations of body stalk, amnion and yolk sac, a striking degree of similarity to the corresponding developmental stages in man.

The hair lines in fetal sloths are said to be the same as in the adult, and the posture *in utero* is similar to that of the grown animal in sleep (Fig. 13). Fetus and adult alike retain masses of fecal pellets in the rectal pouch for long periods. The gestation period probably lasts between 4 and 6 months, Wislocki states, or considerably longer than that of cats and dogs.

Several sloths have been born in the laboratories set up by the author and his associates, both in Panama and in the more natural surroundings at Barro Colorado Island. Only in two cases, however, have the birth processes been observed from the beginning. These are recorded below.

Gorgas Memorial Laboratory, March 17, 1939.

At 1.30 p.m., the attention of Tom, the laboratory boy, was drawn to one corner of the pen, where a two-toed sloth was crouching and being teased by a group of chattering monkeys picking at it from the adjoining cage. The sloth made low groaning sounds occasionally, as it apparently experienced labor pains. It frequently stretched itself, and then drew



up into a ball-like mass. Presently a small amount of blood was noted about the urogenital opening. No other fluid appeared.

At 1.30, the top of the head of the baby sloth was observed at the opening, and ten minutes or so later the shoulders appeared.

At 1.45, the baby sloth was expelled fully enclosed in a rather thick, loose-fitting periderm or epitrichial membrane. The membrane invested all parts of the

the mother's fur, and in the near vicinity. Occasionally, tension on the cord held with the placenta by the mother caused the young one to cry out with a long, high-pitched squeal. Every little while the mother licked and fondled the baby, and also ate remaining fragments of the periderm. The mouth parts of the mother were covered with blood at this time.

At 2.05, the baby was very active. It was with-

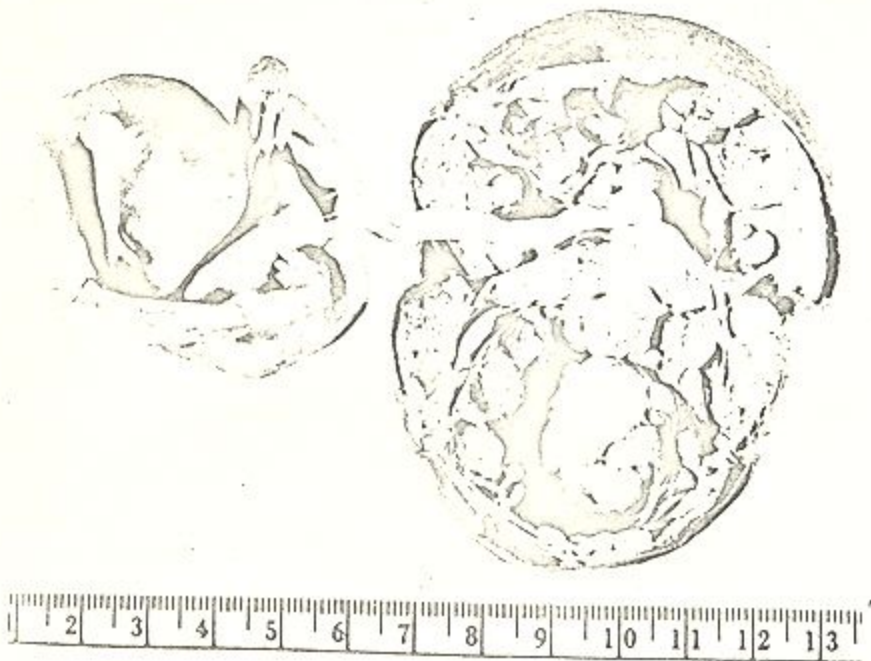


FIG. 13. FETUS OF THREE-TOED SLOTH AT ABOUT TWO-THIRDS TERM, WITH CORD AND DIFFUSE PLACENTA ATTACHED

The hair has not erupted, and the epitrichial covering of the fetus has therefore not lifted. Note the small paws and the extremely long fore-limb (6 cms.) compared to a total body length of 10 cms. The tail is relatively prominent at this age.

body like a garment and was not of the usual mammalian, amniotic sac-like formation. The umbilical cord was attached. Within a few moments the placenta appeared. After parturition, the mother quickly began to claw and chew the membrane, and the new-born sloth struggling vigorously at the same time caused its coverings to rupture further. A little later the mother chewed up the placenta, and began to swallow it in small fragments. The new-born sloth meanwhile began to crawl about on

drawn from the mother, upon which the latter displayed resistance and anxious concern. Several photographs were taken.

At 2.40, when the young one was returned, the mother again became very excited, and then showed considerable affection for the offspring. In a few minutes she again began eating the placenta, and soon had devoured it completely; later the cord was bitten off close to the baby's abdomen. The mother ate part of a banana, but was evidently

fatigued and soon fell asleep with its baby on its breast.

At 3.30, the weight of the young sloth was found to be 340 grams, and of the mother 3.97 kilograms.

The mother sloth became much disturbed every time its newborn was temporarily removed, running (sloth-like!) around the cage, clawing and biting at all objects and growling viciously. When given its young one again it immediately became quiet, and began licking and nursing it with great care. It also cleaned all its accessible parts by licking, giving special attention to the urogenital area.

Next day the mother sloth still retained the same corner of the large cage, carefully nursing its baby.

On another occasion (May 10, 1937) a two-toed sloth was born dead in the laboratory. It was enclosed in a thick epitrichial sheath, but no placenta was observed at the time. The young sloth weighed 398 grams.

The birth of one three-toed sloth has been observed. When the attendant noticed the mother, it

was in one part of the large cage alone, stretching and moving occasionally as if in weak labor. The top of the oncoming head had appeared at the urogenital opening, there was no evidence of blood or other fluid in the neighbourhood. Within three minutes the young sloth was fully delivered, covered completely with the epitrichium. It struggled and cried, and the attendant slit the membrane and peeled it away, and also severed the umbilical cord and tied it. The remaining end of the cord was left extending from the urogenital canal. At no time during these procedures did the adult tridactyl animal show any maternal concern for its offspring. The newborn sloth, when placed near its mother, crawled quickly on to the latter's breast and began nursing. Later the mother was found to weigh 3.62 kilograms, and the young sloth 250 grams.

No placenta or cord was found in the pen some time afterwards.

The young one was kept with its mother for some time under laboratory conditions, and both did well.

*(To be concluded)*

