J. Neurophysiol. 8(1):65-69, 1945

THE PSEUDAFFECTIVE STATE AND DECEREBRATE RIGIDITY IN THE SLOTH*

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(Received for publication November 16, 1942.)

THE EXCEEDINGLY low plane of activity on which the sloth lives offers a stimulating challenge to naturalists and experimental workers alike. In studying various functions of this animal recently in its native habitat (2), it seemed desirable to inquire into some phases of cerebral influence on muscular activity. Different ways of speeding up or deslothing the sloth, including excitation of the central nervous system, have already been reported (5). Such stimulation of this ancient mammal, however, does not bring it anywhere near par in a muscular sense with modern, active forms.

The commoner sloths, the two-toed *Cholepus hoffmanni*, and the extremely slow three-toed *Bradypus griseus griseus*, were studied in the present experiments. All observations refer commonly to both didactyl and tridactyl forms, unless otherwise noted.

METHODS

Under light preliminary ether anesthesia, a few square centimeters of the scalp in the mid-region were deflected, a 2-cm. trephine opening made in the cranium, and the rest of the bony vault then removed with rongeur forceps to expose the upper brain surface in its coverings. In earlier work some attempts were made to localize cortical motor areas by electrical stimulation, after cutting and drawing aside the dura mater; these efforts were much handicapped, however, under tropical conditions. More specific inquiry was then made into the possible occurrence of the pseudaffective state in both sloth forms. Cerebral transections were performed with a semi-blunt dissector, in order to reduce bleeding to a minimum. Since the blood pressure in the peripheral tissues of sloths is low (2), ligature of carotid vessels was not necessary. At autopsy the remaining brain tissues were removed and examined after fixation in formalin.

RESULTS

The first sections of the cerebral cortex extended over the frontal and parietal regions, and were carried to the depth of a few millimeters only. Shock was observed to supervene in all cases; the atonic, unresponsive condition was usually profound for about 5 minutes, and gradually gave way in the next 8 or 10 minutes to a nearly normal responsive state. In some cases, however, shock was in evidence for 20–30 minutes.

Such partially decorticate sloths became spontaneously active within an hour after operation, and began climbing about the cage or crawling awk-

* The physiological phases of these studies were carried out at the Gorgas Memorial Laboratory, Rep. Panama, under the terms of a John Simon Guggenheim Memorial Fellowship held by the senior author during 1937–39. The thanks of the authors are gratefully extended to Dr. Herbert C. Clark of this laboratory, for his unfailing courtesies during the investigations.

wardly along the floor. In general, however, voluntary movements of the animal at this time were even slower than normal for the sloth. Further section of the whole cortex was made usually within 2 hours, to the depth of several millimeters lower than the first incision.

The completely decorticate two-toed animal showed itself vigorously aggressive (for the sloth) on merely slight provocation: the flexion striking movement of the fore limbs was fairly quick and powerful, although erratic; teeth were bared, and clawing, biting and grinding actions ensued; snarling and hissing were common features, and continued many minutes after a suspected adversary had retreated. Salivation occurred in a few cases. Sweating was not observed on the foot-pads or any part of the body at any time. It may be mentioned, however, that at least vestigial sweat glands are said to be present in the sloth (2). The quasi-emotional expressions were usually lower in force value than affective reactions found in normal animals, but showed longer, irregular and unbridled continuance.

In the case of the three-toed sloth, pseudaffective responses were somewhat similar but much less vigorous, and striking movements were usually

Table 1. Decorticate and Decerebrate Reactions in Sloths

Animal No.	Species	Days Observed after Operation	Level of Brain Section	Rectal Temp. °C.	Pseudaffectivity	Dominant Rigidity	
						Flexion	Extension
1	2-Toed (Chol. hoff.)	2	Ant. Coll.	30.9	+++	+++	0
2	" "	4	Low	32.8-30.5	+++	+++	0
3	" "	7	Ant. Coll.	34.2-34.8	+++	+++	0
4	" "	6	Low	29.3-32.2	++	+	+++
5	" "	4	Post. Coll.	33.5-33.9	+	+	+++
6	" "	3	Post. Coll.	34.9-35.5	+	+++	+
7	" "	2	Ant. Coll.	34.0	+	+++	+
8	" "	6	Ant.-Post. C.	....	+	+	+
1	3-Toed (Brad. g. g.)	1	Low	....	0	+++	0
2	" " "	2	Low	32.9	+	+	+++
3	" " "	2	High	33.7	+	+	+++
4	" " "	6	Low	....	0	+	0

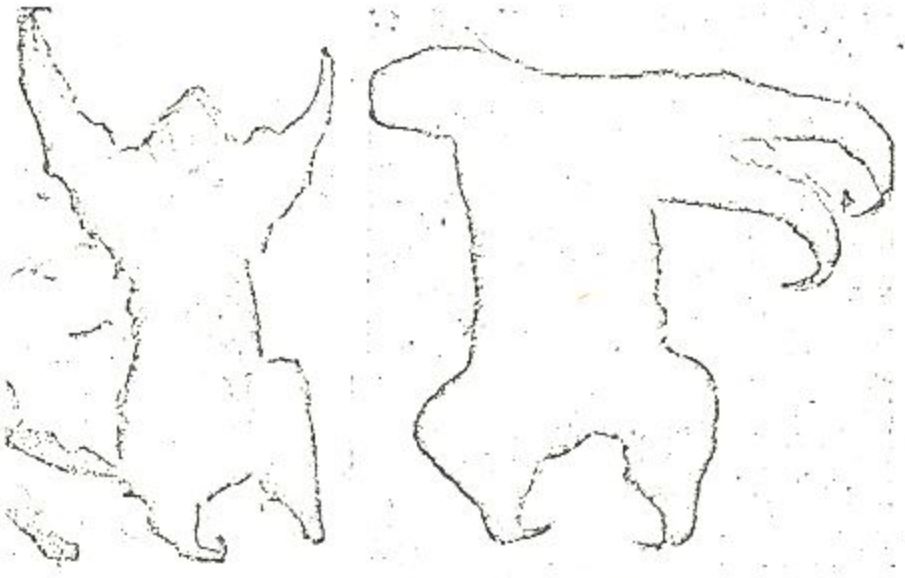
absent. The expressions were really in nearer agreement with the normal behavior of this most torpid of all mammalian types. The results of these experiments are given in summary in Table 1.

There was persistence of pseudaffectivity in nearly all animals even after several brain sections had been carried out, and the immediate consequent shock had disappeared. The condition was apparent to some extent after transections in the vicinity of the anterior colliculi. In the case of low-level or decerebrate preparations, however, such periods of (induced) activity ap-

peared only occasionally, and intermittent outbursts of rigidity were frequent.

In a few of the earlier experiments on decerebrate sloths, the rigidity which was first observed was wholly of the flexor type. The flexion movements were usually extreme, and the animal sometimes remained curled up in a resistant, ball-like mass for 5 15 minutes at a time. In a few instances the forelimbs only were held tightly clasped across the chest and abdominal area. In tridactyl animals, the stumpy tail was usually extended or dorsiflexed.

It was a common finding in many of these experimental animals, however, that decerebrate rigidity of the extensor type also supervened during a part of the post-operative period. In some cases, indeed, this was the dominant condition. The extensor position which was assumed was essentially



A B

Typical extensor rigidity in decerebrate sloths: (A) Two-toed animal, *Cholepus hoffmanni*; (B) Three-toed, *Bradypus griseus griseus*. Note that feet are held in the position of slight flexion. The hind limbs of both species are not straight even in the "fully extended" position.

similar in both didactyl and tridactyl forms, although *Cholepus* usually gave the better display; both fore and hind limbs were involved, and dorsiflexion of the head was seen when the animal was placed on its side and thus allowed freer movement. Slight flexion of the feet occurred almost invariably in correlation with extension of the limbs. In several instances extensor rigidity appeared more prominently in the latter part of the post-operative survival period, when in contrast flexion usually tended to disappear.

Some features of the posture in the decerebrate preparation are shown in the adjoining illustrations (Fig. 1). Decerebrate sloths survived several days – in some cases 6 or 7 – after cerebral section had been carried out. No attempt was made to maintain asepsis, and apparently infections were responsible in a few instances for early exitus.

Rectal temperatures were recorded throughout, and it will be seen from Table 1 that no marked change followed decerebration. Earlier work in this laboratory shows that the rectal temperature of sloths is normally several degrees below that of higher mammals (3, 4, 5), and those now recorded are in agreement. The average readings in our experiments were:

normal two-toed sloth, 34.4°; three-toed, 33.0°.
decerebrate two-toed sloth, 33.0°; three-toed, 33.3°

Pulse and respiratory rates were not significantly different from those of the normal, unoperated sloth.

Discussion

The sum total of the decorticate reactions in the sloth constituted a fairly complete parallel to the pseudaffective or quasi-emotional state first observed by Woodworth and Sherrington (9). Similar in character, pseudaffectivity in this ancient and primitive form was less evident in degree only compared to that described in higher mammals by Cannon and Britton (6).

Decerebrate rigidity of the extensor type occurred frequently in these experiments, but not as often as the flexor type, which was first described by Richter and Bartemeier (8). These earlier investigators did not observe extensor rigidity in the sloth, possibly because of failure to study their preparations over a sufficiently long period after operation. In four of our surviving cases, hypertonus in extension became a notable feature as the condition of flexion regressed. Bazett and Penfield (1) also found differences in the character of tonic decerebrate responses at different periods after operation. Furthermore, our animals were utilized in the fresh state in the tropics, shortly after being brought in from the jungle.

The extensor rigidity appeared to be typical or classical in character, not unlike that in the decerebrate cat. Differences in the response of the decerebrate sloth, *i.e.* flexion or extension under varying conditions, may perhaps be referable to the level of brain section, but on this point our results are not clear.

Langworthy (7) showed that, although the flexors in sloths may represent the anti-gravity muscles, extensor responses of the limbs on stimulation of the cortical motor areas are nevertheless predominant. That the muscle mass of the commoner tardigrades represents only about 25 per cent of the body weight, compared to 40 per cent in most mammals, has already been pointed out (2). The marked hypertonicity which may be developed in the decerebrate sloth is therefore particularly striking, in view of the relative poverty of skeletal muscle in this animal.

SUMMARY

1. Shock which follows transection of the brain in the sloth is profound for about 5 minutes, and usually disappears in 10-15 minutes.

2. Considerable activity, apparently spontaneous, is shown by sloths which have been deprived of large cortical areas, including those dominating motor reactions in higher forms.

3. A pseudaffective state, not significantly different from that observed in higher mammals, appears following removal of the upper parts of the tardigrade cortex. This condition may persist even after brain section has been made to low levels.

4. Decerebrate rigidity in the sloth may be either flexor or extensor in type; the former is somewhat more frequent. Extensor rigidity is usually more evident during the latter part of the post-operative survival period, and is classical in type.

5. Temperature, pulse and respiratory rates were well maintained in the decerebrate sloth.

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