EXPERIMENTAL POLIOMYELITIS IN CERCOPITHECUS AETHIOPS SABAEUS (THE GREEN AFRICAN MONKEY) BY ORAL AND OTHER ROUTES*

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In 1910 Flexner and Lewis (1) described experimental poliomyelitis in *Cercopithecus callitrichus* and other monkeys. No extended comparative study was made but a lower degree of susceptibility was observed in 2 species of monkeys from the New World than in 6 from the Old World.

The present report is to describe three experiments on the comparative susceptibility of *Cercopithecus aethiops sabaeus*, which the dealers call the green African monkey. This variety may be the same as the one mentioned in previous reports, but there are uncertainties in the classification of monkeys, and so for orientation a photograph of one of our animals is reproduced (Fig. 1). They have cost no more than *Macaca mulatta* and they have remained comparatively healthy when kept in stock.

Monkeys which we have used frequently for experimental work in poliomyelitis include the *Macaca mulatta*, *Macaca cynomolgus*, *Macaca mordax*, and *Cercopithecus aethiops sabaeus*. Other varieties which we have used infrequently, include *Erythrocebus patas*, *Cercocebus torquatus lunulatus*, and one New World monkey, a single *Cebus fatuellus*.

M. mordax and *M. cynomolgus* resemble each other in appearance, but with our specimens (of uncertain age) the former is smaller (weight usually 1.5 to 2 kg.) as compared to the latter which weighs 3 to 4 kg. Our attempts to classify these two exactly have not been entirely successful but these varieties are closely related. The words *cynomolgus* and *mordax* do not appear in Zuckerman and Fulton's manual (2) which we follow here when possible, but by reference to Miller (3) it appears that both species would belong in the manual (2) under the name *Macaca irus*. This term is uncommon in the literature on poliomyelitis, but recently Burnet, Jackson, and Robertson (4) used it in saying that: "[there] are three statements that *Macacus cynomolgus* (*Macaca irus*) is more susceptible to the virus than *M. rhesus* (*Macaca mulatto*)," and it may be mentioned parenthetically that the results of their experiments corroborated these statements (4). Thomsen (5) seems to have been the first to make this important observation regarding *Cynomolgus*. Kling and his collaborators often mention *Cynomolgus*, and they (6–8) made the additional contribution that in this species infection with

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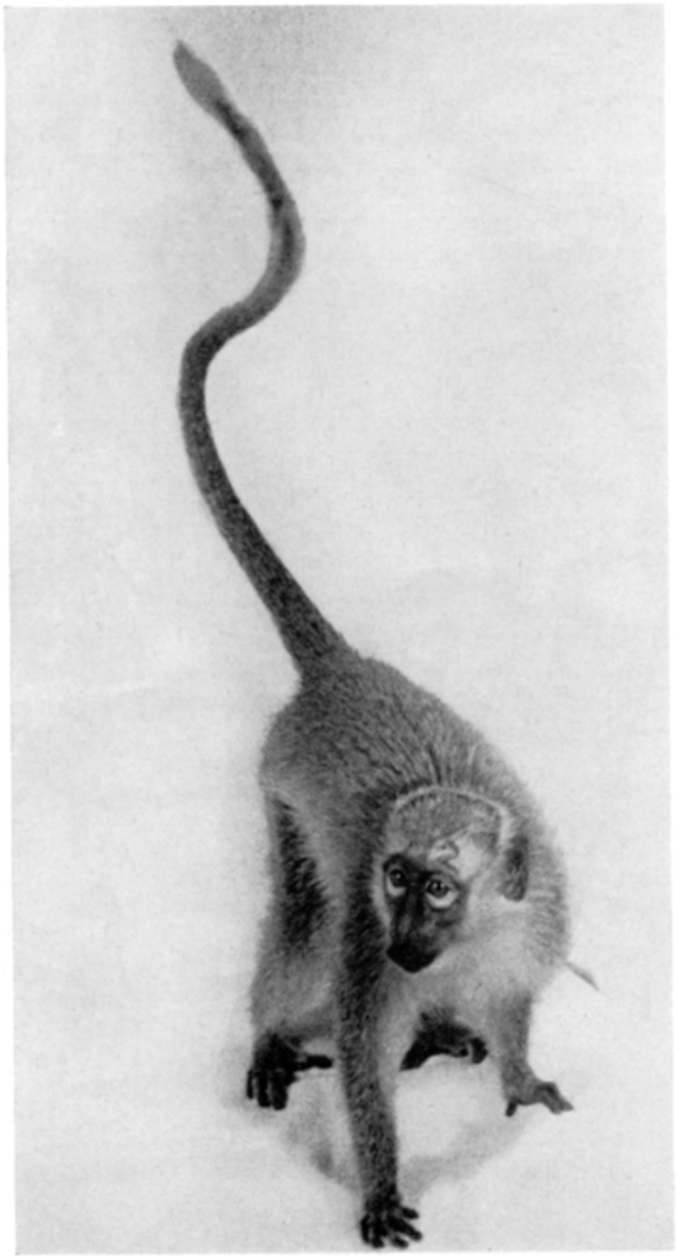

FIG. 1. The green African monkey, *Cercopithecus aethiops sabaeus*; which may be translated: the tailed monkey with a black face from Sheba.

experimental poliomyelitis can be produced by feeding (7, 8). This has been confirmed by Saddington (9), Vignec *et al.* (10), and Burnet *et al.* (4). Infection by feeding has not been described in *M. rhesus*. It has been effected in the chimpanzee by Howe and Bodian (11).

It is obvious therefore that differences exist in regard to the ease of infection of monkeys by poliomyelitis virus. The literature on this phase of the subject has been summarized up to 1932 by Harrington (12). Since then MacKay and Schroeder (13) have made a comparative experiment with a New World monkey and *rhesus*, and Ruch (14) has listed the monkeys which have proved susceptible to poliomyelitis, but the field has not been systematically explored.

In the series of three experiments presented here, 12 green African monkeys were used along with various other monkeys to make a total of 30. The criteria for successful infection were (*a*) the characteristic phenomena of experimental poliomyelitis which are: incubation period, elevation of temperature, excitement, and paralysis of one or more extremities which usually was maximal with a critical fall in rectal temperature; and (*b*) the demonstration of characteristic histological findings: perivascular cuffing and neuronophagia in the medulla and in the grey matter of the cord, including that of the lumbar swelling.

A comparative experiment, which involved 3 species of monkeys subjected to intracerebral inoculation is shown in Table I. The animals consisted of 2 *C. aethiops sabaeus*, 4 *M. mordax*, and 4 *M. mulatta*, and they were inoculated with suspensions of glycerolated cord, which represented generation 11 of the SK strain. All the monkeys developed experimental poliomyelitis including *M. mulatta* inoculated with 0.1 per cent and 0.01 per cent suspensions of the cord. The disease in *Cercopithecus* (the green African monkeys) had a relatively short incubation period and was more acute and more severe than is usual in *M. mulatta* infected with the SK strain. On histological examination the lesions throughout the brain stem and cord were particularly extensive and acute in *Cercopithecus*.

The experiments with feeding are presented in parts A and B of Table II.

In part A, which was begun May 10, 1939, glycerolated and fresh monkey cord virus was fed to 2 *C. aethiops sabaeus*, 2 *M. mordax*, 1 *M. cynomolgus*, and 1 New World monkey, *Cebus fatuellus*. The details of the feeding appear in the table. The results were that one *Cercopithecus* (11-93) contracted experimental poliomyelitis; *viz.*, this animal remained well until May 25, when the experimental disease developed; on June 1 there was a critical fall in temperature and weakness of both arms was noted; on June 3 arms and legs were weak and the gait was flaccid, and the monkey was killed with ether. Histological examination revealed typical lesions in the medulla and in the grey matter of the cord at all levels. In the olfactory bulbs no lesions were found. Passage from No. 11-93 was not attempted.

M. cynomolgus 11-71 (*M. irus*) had fever and tremor May 29 and 30 but no other signs appeared, and no lesions were observed on histological examination of medulla or cord at the termination of the experiment, the monkey having been killed June 20. The olfactory bulbs were not examined. In an earlier generation, the SK strain of virus had led to infection after feeding in *M. cynomolgus* and *M. mordax*, but not in *M. mulatta* (10).

Part B of Table II records another experiment, done 10 months after part A on the feeding of *Cercopithecus*, which were the only monkeys included this time. 6 animals

TABLE I

Experimental Poliomyelitis Following Intracerebral Inoculation in Three Varieties of Monkeys, December 19, 1939

Monkey		Virus*	Experimental poliomyelitis†						
				Paralysis			Pathology		
No.	Variety	Dose 0.5 cc. of suspension	1st day of fever	1st day	Extent	Outcome	Olfactory bulbs	Medulla	Cord
		per cent							
13-67	*C. aethiops sabaeus*	1	3	8	++++	K 10	−	+	+
13-68	" " "	1	?	9	++++	D 13	−	+	+
13-66	*M. mordax*	1	5	12	±±	C 19			
12-81	" "	1	5	9	+++±	K 11	0	+	+
13-65	" "	1	6	12	++++	D 20	0	+	+
12-82	" "	1	7	9	±±±±	C 18			
13-99	*M. mulatta*	1	6	9	+++±	K 38	0	+	+
14-00	" "	1	29	29	±±±±	K 72	0	+	+
14-01	" "	0.1	8	9	±±±±	K 10	0	+	+
14-02	" "	0.01	10	11	+++±	K 33	0	+	+

* Virus = glycerolated cord No. 13-89 killed Dec. 3, 1939, representing generation 11 of the SK strain.

† Extent: ++++ = paralysis of 4 extremities.
±± = weakness of 2 extremities.

Outcome: K 10 = killed 10th day; D 13 = died 13th day; C 19 = convalescence beginning 19th day.

Pathology: + = typical microscopic lesions.
− = no lesion.
0 = not done.

were used; 5 of these remained well and were susceptible to experimental poliomyelitis on intracerebral inoculation, May 16. The sixth monkey, No. 14-56, had a normal rectal temperature which ranged between 103° and 104°F. during March and most of April. It remained well until Apr. 30 when the temperature was 104.8°. May 1 it was 105.6°. May 2 and 3 there was a critical fall in temperature and the back and legs seemed weak thereafter. The animal was killed May 11 and in the thoracic cord one small vessel with perivascular cuffing was observed. There was a mononuclear reaction of the spinal meninges but the medulla and rest of the cord revealed no lesions. No further passage was attempted. It is uncertain whether or not No. 14-56 was infected with experimental poliomyelitis, and the response is recorded as equivocal.

In a third comparative experiment the source of virus was a human stool, and 6 *Macaca* and 2 *Cercopithecus* were inoculated as shown in Table III.

TABLE II

Experimental Poliomyelitis after Feeding

Monkeys			Experimental poliomyelitis						Reinoculation
					Pathology				
No.	Species	Other names	1st day of fever	Paralysis	Olfactory bulbs	Medulla	Cord	Result	
A. Comparative Feeding Study of May, 1939*									Dec. 19, 1939
11-72	*Cebus fatuellus*	Capuchin		−				−	R
11-76	*M. mordax*	*M. irus*		−				−	R
11-80	" "	" "		−				−	S
11-71	*M. cynomolgus*	" "	20	−	0	−	−	−	
11-92	*C. aethiops sabaeus*	Green African		−				−	S
11-93	" " "	" "	16	+	−	+	+	+	
B. Feeding of 6 *Cercopithecus*, March and April, 1940†									May 16, 1940
14-52	*C. aethiops sabaeus*	Green African		−				−	S
14-53	" " "	" "	8	−				−	S
14-55	" " "	" "		−				−	S
14-56	" " "	" "	54	±	0	−	±	?	
14-57	" " "	" "		−				−	S
14-58	" " "	" "		−				−	S

R = resistant to; S = susceptible to intracerebral inoculation of SK strain.

Lesions in cord and medulla of all *Cercopithecus* were particularly acute and extensive.

* Feedings were with SK strain: on May 10, 11, and 12 with glycerolated cord of *M. mulatta* 11-83 dead of poliomyelitis May 3, representing generation 9. Feedings with fresh cord virus were on May 15 with cord of *M. mordax* 11-75 killed May 15 while paralyzed, representing generation 10; and on May 18 with cord of *M. mulatta* 12-02 killed May 18 while paralyzed also representing generation 10.

† Feedings were with SK strain: on Mar. 8, 9, and 10 with glycerolated cord of *M. mulatta* 14-15 killed Feb. 3 when prostrate representing generation 12; on Mar. 18 with glycerolated cord of *M. mulatta* 14-65 killed Mar. 17 when prostrate representing generation 13; and on Apr. 11, 12, and 13 with glycerolated cord of *M. mulatta* 14-38 killed Mar. 1 when prostrate representing generation 13.

The stool had been collected from a child in the 5th day of paralytic poliomyelitis. Intraabdominal and intranasal routes of inoculation were compared. The 2 *Cercopithecus* monkeys developed typical experimental poliomyelitis while at the most *M. mulatta* 15-80 had an equivocal reaction. This difference in the response of the monkeys

is the more striking because *Macaca* 15-80 and 15-83 had 10 times the dose given to *Cercopithecus* 15-70 and 15-71. Moreover, the histological lesions were, again, particularly widespread and acute throughout cord and brain stem of *Cercopithecus*. It is to be noted that the incubation period in monkey 15-70, inoculated intranasally, was 28 days to the onset of fever and 32 days to paralysis. Also, No. 15-70 had olfactory lesions while in No. 15-71 none were found.

TABLE III

Comparative Susceptibility of Macaca mulatta and Cercopithecus aethiops sabaeus to Human Stool Suspensions by Intranasal and Intraabdominal Routes

Inoculum*		Monkey	Experimental poliomyelitis					
Stool suspension	Dose	Variety and number	Incubation	Paralysis	Pathology			Result
					Olfactory bulbs	Medulla	Cord	
per cent								
		M. mulatta						
10		15-80	30	−	−	+	−	?
1	Intranasal 5 cc.	15-81		−				−
0.1		15-82		−				−
		C. aethiops sabaeus						
1		15-70	28	+	+	+	+	+
		M. mulatta						
10		15-83		−	−	−	−	−
1		15-84		−				−
0.1	Intraabdominal 15 cc.	15-85		−	−	−	−	−
		C. aethiops sabaeus						
1		15-71	8	+	−	+	+	+

* Stool was from R. W., age 13, paralytic poliomyelitis in 5th day of disease, Aug. 4, 1940. Intranasal dose was divided among 3 instillations, Aug. 19, 20, and 21; stool was treated with 15 per cent ether overnight for intraabdominal injection on Aug. 20.

Up to Dec. 31, 1940, besides the 12 animals included in the tables, we have used 75 other specimens of the green African monkey for work in poliomyelitis; of these 13 have acquired the experimental disease. We have observed that the symptomatology may be somewhat indefinite in comparison to that seen in *M. mulatta* because some animals have run a short course and some have failed to develop appreciable fever. Thus in several monkeys the diagnosis remained uncertain until the histological examination of the spinal cord was made. None has contracted tuberculosis, relatively few died in stock, 3 have developed low calcium tetany

while on the usual stock diet, but altogether they have continued to prove useful laboratory animals.[1]

SUMMARY

The green African monkey, *Cercopithecus aethiops sabaeus*, has been infected with experimental poliomyelitis after feeding artificially contaminated food. This species is also highly susceptible to intracerebral, intranasal, and intraabdominal inoculations. In one experiment with a human stool from a case of poliomyelitis, *Cercopithecus* was more susceptible to intranasal and to intraabdominal inoculation than *Macaca mulatta*.

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[1] Since writing this report, susceptibility to experimental poliomyelitis following intracutaneous inoculation has been compared in *M. mulatta* and in *C. aethiops sabaeus* in three separate experiments, using two strains of the virus (SK and O-H). In each trial the experimental disease was produced in *Cercopithecus* while *Macaca* were infected in one only and in this instance the disease was milder and the incubation period longer for *Macaca* than for *Cercopithecus*.