

Selective Susceptibility of Ateles Monkeys to Infection with Type I Poliomyelitis and Col SK Virus.* (21177)

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It is well known that various species of monkeys differ in their susceptibility to infection with poliomyelitis virus; generally speaking, Old World monkeys are considered more susceptible than those of the Western Hemisphere. Among the New World monkeys the genera *Cebus*, *Alouatta*, and *Ateles* have been investigated to some extent. Thus, ringtail monkeys (*Cebus capucina*) from Central or South America have been variously reported as being refractory (1-3), or susceptible (4,5) while Panamanian howler monkeys (*Alouatta palliata*) proved susceptible in the experience of one investigator (5). Negative results were obtained by 2 workers (5,6) with spider monkeys (*Ateles fusciceps robustus* or *Ateles ater*). In many of these experiments comparatively small numbers of animals were studied. The significance of the results may, therefore, be influenced by host factors connected with the geographic origin or race of the animal as well as by the choice of virus strain used. In view of these uncertainties, the efforts of 2 laboratories were combined to reinvestigate the status of susceptibility of Ateles monkeys to infection with the 3 serological types of poliomyelitis virus. Because Col SK virus shares many of the properties of poliomyelitis virus, the former virus was also included in this study.

Materials and methods. A total of 57 red (*Ateles geoffroyi*) or black (*Ateles fusciceps robustus*) young spider monkeys, either captured in Panama or imported from Colombia, and weighing about 3-5 lb were used. To control the virulence of the test virus, a total of 29 rhesus monkeys were employed. Infection was carried out, as a rule, by intracerebral injection of 0.5 cc of a 1:10 virus suspension, made up from infected rhesus cords. The following strains of poliomyelitis virus were rep-

resented: Brunhilde, J.V.(7), Mahoney (Type I); Aycok, MEF₁ (Type II); Leon, Farabaugh (Type III).¹ Col SK virus was harvested from infected mouse brains. Following infection, the animals were observed for a period of 3-4 weeks. Monkeys developing paralysis were sacrificed and histological cord sections were examined for the presence of lesions. In some instances, infected spider cords were further passed to new spider or rhesus monkeys. Monkeys which survived without paralytic symptoms were reinfected with another type-strain of poliomyelitis virus.

Normal spider monkey serum, collected before infection, was tested for the presence of neutralizing antibodies against Brunhilde (Type I), Aycok (Type II), and Leon (Type III) virus. In these tests, one cc of pooled undiluted serum was mixed with one cc of a 1:10 viral cord suspension of each of the 3 strains and one cc of the mixtures, following incubation for one hour at 37°C, was injected intracerebrally into pairs of rhesus monkeys. Controls with normal rhesus monkey serum accompanied this test. A group of 40 individual specimens of normal spider monkey serum was also tested for neutralizing antibodies against Col SK virus. The test was carried out by mixing 0.5 cc of undiluted serum with 0.5 cc of decimal virus dilutions, ranging from 10⁻⁴ to 10⁻⁶, and injecting the incubated serum-virus mixtures intraperitoneally in doses of 0.2 cc into groups of 4 mice for each level tested. A virulence control of the virus from 10⁻⁴ to 10⁻⁸ dilution, mixed with normal rhesus monkey serum, was added to each test.

Results. Table I shows that 3 Type I strains of poliomyelitis virus were equally

¹ We are indebted to Dr. Jonas E. Salk, of University of Pittsburgh, for supplying us with the Mahoney, MEF₁ (monkey line) and Farabaugh strains.

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ATELES MONKEYS AND INFECTION TYPE I POLIOMYELITIS

TABLE I. Susceptibility of Ateles Monkeys and Rhesus Monkeys to Infection with Poliomyelitis and Col SK Virus.

Virus strain	Ateles monkeys						Rhesus monkeys					
	No.		Paralysis		No paralysis		No.		Paralysis		No paralysis	
Type I:												
Brunhilde	6	<i>4</i>	6	<i>3</i>	0	<i>1</i>	4	<i>2</i>	4	<i>2</i>	0	<i>0</i>
J.V.	4		4		0		2		2		0	
Mahoney	2		1		1		2		1		1	
Total	12	<i>4</i>	11	<i>3</i>	1	<i>1</i>	8	<i>2</i>	7	<i>2</i>	1	<i>0</i>
Type II:												
Aycock	8	<i>2</i>	0	<i>0</i>	8	<i>2</i>	3	<i>1</i>	3	<i>1</i>	0	<i>0</i>
MEF ₁	3	<i>4</i>	0	<i>0</i>	3	<i>4</i>	2	<i>2</i>	2	<i>2</i>	0	<i>0</i>
Total	11	<i>6</i>	0	<i>0</i>	11	<i>6</i>	5	<i>3</i>	5	<i>3</i>	0	<i>0</i>
Type III:												
Leon	7	<i>4</i>	0	<i>0</i>	7	<i>4</i>	3	<i>2</i>	3	<i>2</i>	0	<i>0</i>
Farabaugh	3	<i>4</i>	0	<i>0</i>	3	<i>4</i>	2	<i>2</i>	2	<i>2</i>	0	<i>0</i>
Total	10	<i>8</i>	0	<i>0</i>	10	<i>8</i>	5	<i>4</i>	5	<i>4</i>	0	<i>0</i>
Col SK (para-polio)	4	<i>2</i>	4	<i>2</i>	0	<i>0</i>	2		0		2	
Total	6		6		0		2		0		2	

Figures in standard print refer to work in New York; figures in italics refer to work in Panama. Dose: 0.5 cc 10⁻¹ i.c.

pathogenic for Ateles and rhesus monkeys, 14 of 16 of the former and 9 of 10 of the latter developing flaccid paralysis, with involvement of one or several limbs, within an incubation period of from one to 3 weeks. The spinal cords of the paralyzed spider monkeys showed typical poliomyelitic lesions which could not be distinguished from those found in rhesus monkeys. By contrast, none of 17 spider monkeys injected with 2 Type II strains and none of 18 spider monkeys injected with 2 Type III strains showed any signs of illness; all rhesus monkeys injected simultaneously with these strains, *i.e.*, 8 of 8 with Type II and 9 of 9 with Type III, developed paralysis. Six spider monkeys injected with Col SK virus all developed more or less extensive paralysis within 5-10 days following infection; 2 similarly injected rhesus monkeys remained free from symptoms. The cord lesions in the paralyzed spider monkeys were indistinguishable from those previously described in cynomolgus monkeys(8) and agreed in all histological details with the lesions induced in spider monkeys by infection with Type I poliomyelitis virus. The results obtained with the different strains of virus in

the 2 laboratories closely paralleled each other.

The results of the reinfection experiments are brought together in Table II. In all, 20 spider monkeys which had resisted infection with either Type II or Type III poliomyelitis virus were reinfected, about one month later, with spider-pathogenic Type I poliomyelitis virus, the challenge strain being either Brunhilde or J.V. virus. The control animals for these tests are included in Table I. Previous infection with Type III virus (Leon, Farabaugh) afforded almost complete protection, and previous infection with Type II virus (Aycock, MEF₁) afforded partial protection against reinfection with the Type I Brunhilde strain (Table II). On the other hand, no protection was observed in either group against reinfection with the type I J.V. strain.

Neutralization tests showed that the normal spider monkey serum contained no antibodies against Types I, II or III poliomyelitis virus or Col SK virus which were demonstrable with the technics used in this work.

Discussion. The reported observations demonstrate a state of selective susceptibility in Ateles monkeys to infection with Type I poliomyelitis virus and with Col SK virus. To

TABLE II. Reinfection Experiments in Ateles Monkeys.

Previous asymptomatic infection		Reinfection with Type I poliomyelitis virus							
Strain	No.	Brunnhilde				J.V.			
		No.	Paralysis	No paralysis	No.	Paralysis	No paralysis		
Type II:									
Aycock	3 ♀	2	1	1	1 ♀	1 ♀	0	0	
MEF ₁	2 ♀	2	1	1	2	2	0	0	
Type III:									
Leon	4 ♀	2 ♀	1	1	2	2	0	0	
Parabaugh	1 ♀	1 ♀	0	0	1	0	1	1	
	10	4	2	2	6	5	1	1	
Total	20	12	3	9	8	7	1	1	

Figures in standard print refer to work in New York; figures in italics refer to work in Panama. Dose: 0.5 cc 10^{-1} i.e.

our knowledge, this is a unique phenomenon since all 3 serological type strains of poliomyelitis virus are highly virulent for other species of monkeys, including *M. rhesus* and *M. cynomolgus*. That more subtle differences may exist, however, between the 3 antigenic types (CNS material) with respect to their ability to infect cells is indicated by the observations of Youngner(9) who found that Type I strains, as a group, produce cytopathogenic changes more readily in monkey testis tissue culture roller tubes than do Type II or Type III strains. Inasmuch as a preliminary search for the presence of type-specific antibodies in the normal spider monkey serum gave negative results, the possibility of a previous immunizing exposure during the jungle life of these monkeys to Type II and Type III virus seems remote. The reasons for the refractory state are, therefore, entirely obscure. Equally unexplained is the fact that previous asymptomatic infection with Type II and Type III virus conveys a measure of non-specific cross protection against reinfection with Type I virus. A possibility exists that this phenomenon is caused by interference which has already been demonstrated in tissue culture medium between the 3 antigenic types of poliomyelitis virus(10). It is hoped that further investigation will throw more light on these problems.

Summary and conclusions. A group of 57 spider monkeys (*Ateles geoffreyi* or *Ateles fusciceps robustus*) from Central and South America were studied for their susceptibility to infection with poliomyelitis virus and Col SK virus. The animals were found to be

highly susceptible to infection with 3 strains of Type I poliomyelitis and Col SK virus but were completely refractory to infection with 2 strains each of Type II and Type III poliomyelitis virus. Asymptomatic infection with Type II or Type III poliomyelitis virus conferred various degrees of protection against reinfection with one strain of Type I poliomyelitis virus.

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