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A RELATIONSHIP IN EQUINES BETWEEN AGE OF HOST AND NUMBER OF STRONGYLID PARASITES.

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During 1935, a quantitative study was made of the worm infestations of 48 equines owned by the Panama Canal Department of the U. S. Army (3). One of the most interesting phases of that study, but upon which only a brief comment was made (p. 507), was the indication of an "age resistance" of equines against Strongylid parasites. An additional study has recently been completed in which the number of equines from the same source and studied in the same manner has been increased to 86 (4). It is felt that this significant increase in the data establishes definitely that there is a relationship between age of host and number of Strongylid parasites, and permits of many specific interpretations of considerable interest.

The combined figures for the recovery of 34 species of *Strongylidae* from hosts of different ages are given in table 1 and graph 1. These data have been analyzed without regard to kind of host (horse or mule) since, as indicated in the first report (p. 507), this is not a factor affecting the infestations quantitatively. The smallest number of Strongylid worms recovered from one animal was 28; the largest, 4124. There was also a considerable range in size of infestations for every age, yet the data show that the heavier infestations were harbored by the younger animals and that, in general, the mean infestations for each age from 9 to 30 years (graph 1) declined rather steadily with increasing age. Moreover, it has been calculated that, of the 59 animals, 15 years of age and younger, there were 30 which yielded more worms than the average for the series (994); while of the 27 in the older group, there were only 4 which exceeded this number. Also the average infestation for the younger group (1219) exceeded that for the series by over 20 per cent, while the

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average for the older group (502) fell short of this by about 50 per cent. It is unfortunate that the observations were confined to mature animals, since it is probable that some degree of resistance is already present at 9 years of age, and that younger animals of the same herd would have harbored somewhat heavier infestations.

TABLE 1.

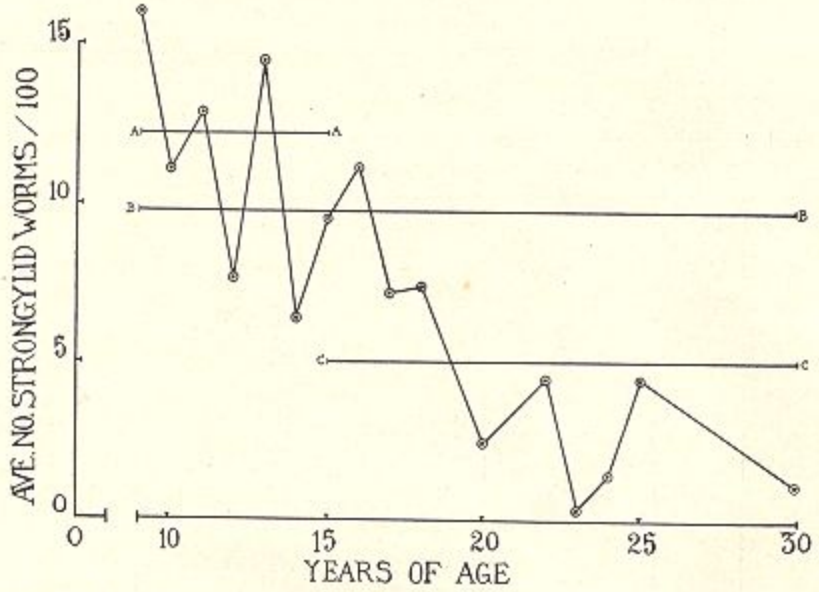
An arrangement of the data from quantitative studies upon the worm burdens of 86 equines (horses and mules) showing the relationship between age of host and number of Strongylid parasites (84 species).

Age	Number of equines	Range	Total worms	Group averages		
9	9	213–4057	14,662	1629		
10	10	163–2825	11,030	1103	1352(19)*	
11	12	39–4012	15,529	1294		
12	8	36–3068	6,103	763		
13	12	179–4124	17,484	1457		
14	2	487–784	1,271	635		
15	6	450–1725	5,868	978	1156(40)	
						1219(59)
16	3	800–1659	3,342	1114		
17	6	420–1682	4,302	717		
18	2	366–1115	1,481	740		
20	4	168–356	1,004	251	675(15)	
22	1	——	459	459		
23	1	——	28	28		
24	4	48–359	564	141		
25	5	47–1072	2,278	455		
30	1	——	106	106	286(12)	
						502(27)
	86	28–4124	85,511	994		

* Numbers in parentheses are the number of animals in the group.

It has seemed natural to question the extent to which this age correlation was evidenced by the fauna of the separate regions of the bowel. An analysis upon this point (table 2) has shown that the older animals harbored fewer parasites and fewer different species in each of the three regions (*viz.*, cecum, ventral colon, and dorsal colon). The differences appear to have been of greater degree in infestations of the colon than in those of the cecum. For example,

from animals 9 to 15 years of age, there was recovered from the ventral colon an average of 676 Strongylid worms per animal; while those animals over 15 years yielded an average of 276. This disparity between the infestations of the two age groups was evident also in the dorsal colon (averages 376 and 112). Although the data upon the fauna of the cecum lend support to these age differences, the findings for this region are not so emphatic (averages 168 and 115,



GRAPH 1. A representation of the average number of Strongylid parasites per animal for the ages 9 to 30 years. The data are given in table 1. *A*———*A* = average level of infestations for 59 animals 15 years of age and under (1219 worms). *B*———*B* = mean level for the entire series of 86 animals (994 worms). *C*———*C* = average level for 27 animals over 15 years of age (502 worms).

respectively). It is probable that this circumstance is correlated with the occurrence in this region of *Strongylus vulgaris*, a species which was not only the commonest parasite of the cecum, but was unusual (as shown by data to be discussed presently) in that it occurred as frequently and as abundantly in the older animals as in the younger.

The occurrence of the individual species in hosts 15 years of age and younger, and in hosts over 15 years, has been summarized in table 3. These age groups are arbitrary, and for this reason it is

TABLE 2.

A summary of comparative data upon the quantitative and qualitative differences in the Strongylid fauna from each of the three regions of the large bowel, in accordance with two arbitrary age divisions of the equine hosts. Data upon animals 9 to 15 years are based upon 59 autopsies, and upon 16 to 30, 27. Note that in each instance the figures are lower for the older age group.

Age group	Range	Total	Average
Number of Strongylid parasites of cecum			
9–15	11–668	9,920	168
16–30	0–301	3,099	115
	0–668	13,019	151
Number of different Strongylid species of cecum			
9–15	1–10	——	5
16–30	0–8	——	4
	0–10	19	5
Parasites of ventral colon			
9–15	8–3765	39,871	676
16–30	0–1240	7,431	276
	0–3765	47,302	550
Species of ventral colon			
9–15	3–16	——	11
16–30	0–15	——	10
	0–16	26	11
Parasites of dorsal colon			
9–15	4–2093	22,156	376
16–30	0–550	3,034	112
	0–2093	25,190	293
Species of dorsal colon			
9–15	2–19	——	5
16–30	0–13	——	4
	0–19	31	5
Total Strongylid parasites			
9–15	36–4124	71,947	1219
16–30	28–1682	13,564	502
	28–4124	85,511	994
Total Strongylid species			
9–15	6–24	——	16
16–30	1–19	——	13
	1–24	34	15

TABLE 3.

A summary of comparative data upon the occurrence of the several Strongylid species in two arbitrary age groups of the hosts, and for the entire series. The data on ages 9 to 15 are based upon 59 animals, and on ages 16 to 30 upon 27. Note that in every case, except that of S. vulgaris, *the incidence, range, and level of infestation are lower in the older age group.*

Species	Age group	Extent infested	Range	Total	Average
		per cent			
Strongylus equinus	9–15	86	0–83	593	10
	16–30	66	0–21	85	3
		80	0–83	678	8
S. edentatus	9–15	79	0–59	499	8
	16–30	66	0–7	59	2
		76	0–59	558	6
S. vulgaris	9–15	100	3–476	5,137	87
	16–30	100	1–236	2,286	85
		100	1–476	7,423	86
Triodontophorus minor	9–15	83	0–73	887	15
	16–30	74	0–39	197	7
		80	0–73	1,084	12
Cyathostomum coronatum	9–15	86	0–337	2,875	48
	16–30	78	0–204	693	25
		84	0–337	3,568	41
C. labiatum	9–15	64	0–278	1,530	25
	16–30	51	0–41	193	7
		60	0–278	1,723	20
C. labratum	9–15	67	0–126	1,011	17
	16–30	62	0–42	262	9
		66	0–126	1,273	14
Cylicocercus catinatus	9–15	91	0–917	4,816	81
	16–30	85	0–234	918	34
		90	0–917	5,734	66

TABLE 3.—*Continued.*

Species	Age group	Extent infested	Range	Total	Average
		per cent			
C. goldi	9–15	89	0–230	2,470	41
	16–30	85	0–94	480	17
		88	0–230	2,950	34
C. pateratus	9–15	67	0–171	1,329	22
	16–30	59	0–28	186	6
		65	0–171	1,515	17
Cylicostephanus calicatus	9–15	86	0–926	9,216	156
	16–30	77	0–512	2,376	88
		84	0–926	11,592	135
C. minutus	9–15	86	0–866	4,684	79
	16–30	77	0–472	1,456	54
		84	0–866	6,140	72
C. longibursatus	9–15	96	0–1370	13,283	225
	16–30	89	0–353	1,946	72
		94	0–1370	15,229	177
Cylicocyclus nassatus	9–15	89	0–1710	16,791	285
	16–30	81	0–345	1,979	73
		87	0–1710	18,770	218
C. insigne	9–15	76	0–1961	5,861	99
	16–30	48	0–61	276	10
		67	0–1961	6,137	71
19 "rarer" species	9–15	—	—	965	16
	16–30	—	—	172	6
				1,137	13
All 34 species	9–15	100	36–4124	71,947	1219
	16–30	100	28–1682	13,564	502
		100	28–4124	85,511	994

regretted that more extensive data cannot be given.[3] Yet these analyses have demonstrated a specific age resistance against each of the commoner species (except, it has seemed, *S. vulgaris*) and have furnished, by reason of their uniformity, an unquestionable significance to the data which have been given above upon the Strongylid species as a group. In the second place, these data have suggested an important factor in the biology of *S. vulgaris*. To evaluate these interpretations, one may consider, for example, the occurrence of the four commonest species. From the 59 animals, 15 years of age and under, there was recovered an average of 285 specimens of *C. nassatus* per animal, while this average for the older group was only 73. Similarly, *C. longibursatus* averaged 225 and 72, respectively, for these age groups. *C. calicatus* averaged 156 specimens for each of the younger animals, and 88 for the older ones. For *C. minutus* the figures were 79 and 54. For each of these species, therefore, the data have demonstrated lighter infestations in the older animals. In contrast, there is no evidence that infestations with *S. vulgaris* varied greatly with the age of the host. This unusual result, particularly in the instance of what we have considered to be the most important parasite of the horse, made it imperative to analyze these findings from every significant angle. There were recovered 7423 specimens of this species from the 86 animals of this series, which, in turn, gives an average of 86 worms per animal. Every animal harbored this species and the range in infestations from 1 to 476 worms per animal, in view of the average figure, is not particularly wide. This latter interpretation is supported by the similar data given on the other species, which in most cases show wider ranges. The average infestation with this species in the 59 younger animals was 87; in the 27 older ones, 85. There were 35, or 41 per cent, of the 86 animals from which were recovered more specimens than the average. In this category were 42 per cent of those 15 years of age and under, and 37 per cent of those over 15 years. Moreover, a study of the occurrence of *S. vulgaris* in the several animals has revealed no abnormally contributing infestations of consequence.

It has seemed, then, that these data are sufficient to warrant the interpretation that, in general, the animals over 15 years of age had a marked degree of protection against severe strongylidosis; and that this protection was separately manifested against each of the com-

[3] The evident impracticability of publishing these data in full has prompted the author to indicate his readiness to co-operate with anyone interested in further or more detailed analyses.

moner Strongylid species, except *S. vulgaris,* a species to which the older animals appeared to be about as susceptible as the younger ones. Because this latter species is, in its adult stage, a blood-sucking parasite and, in its larval stage, the cause of arteritis and aneurysms, it has been felt that this point deserved some emphasis.

The data upon the occurrence of the extra-strongylid species have been summarized in table 4. It may be noted that there was no significant difference between the average infestations of the younger (52 +) and older animals (57 +). This analysis includes data upon 10 species, which makes it necessary to emphasize that certain common forms of native equines of Panama, particularly *Parascaris equorum* and *Oxyuris equi,* were rare among this series. Our observations

TABLE 4.

*An arrangement according to arbitrary age groups of the data on the extra-*Strongylidae *(10 species). In these cases, the stomach worms were by far the most abundant.*

Age	Number of equines	Range	Total worms	Averages
9 and 10.....	19	2+ to 550	1394+	73+
11–15.....	40	1 to 317	1786+	47+ 52+(59)
16–20.....	15	1 to 523	1047+	70+
21–30.....	12	+ to 160+	516+	43+ 57+(27)
	86	+ to 550	4743+	55+

upon these two species have led to the opinion that both are characteristic parasites of younger equines. The heaviest infestations with *P. equorum* have been encountered in hosts under a year old. Of the extra-*Strongylidae* among the present series of animals, those most important quantitatively were the stomach worms, *Habronema muscae* and *H. microstoma.* These species alone contributed nearly 80 per cent of the extra-Strongylid fauna. The data of table 4, therefore, must be interpreted as indicating mainly that no demonstrable relationship was observed between age of host and stomach-worm infestation.

Finally, a question of interest is the nature of the resistance which has been demonstrated. In many respects, the findings suggest the operation of a "self-cure" like that which Stoll (5) described to explain the immunity of sheep to *Haemonchus* infestation. There is against this interpretation the absence of positive proof that this

resistance was elicited by the worms (i.e., acquired). On the other hand, there is no information upon the susceptibility or resistance of old equines where previous infection is not a possible factor. When it is considered, however, that probably every equine becomes parasitized by Strongylid worms at a very early age, that, with few exceptions, some parasites are present throughout the life of the host, and that the conditions are those of constant reinfection, it becomes apparent that the immunity, in this case, develops very slowly and appears to parallel the increasing age of the host. It is clear, of course, that this resistance is not caused by age *per se*, and it is not believed that the responsible factors must be always associated with age. This admission is similarly applicable to the experimental demonstrations by others of the operation of age resistance in other host-parasite combinations. Also, some evidence has already been presented (1, 2) which suggests that this kind of resistance is associated to some extent, in the instance of hookworm infection of dogs, with the well-being of the host, with its diet and hemoglobin level, and with the degree of physiological compensation for the injuries by the parasites.

The above considerations, however, do not preclude the possibility that the resistance demonstrated in this study was the result of long-continued exposure to infection, and certainly this was a complicating factor; yet the absence of evidence that this was the case, has suggested that this phenomenon should, conservatively, be termed an "age resistance."

It may be added that an age resistance has been observed, although not quantitatively demonstrated, among native animals, where the levels of infestation at all ages are much higher than in the animals covered in this report. There is little doubt that these differences are attributable to differences of exposure. It is believed therefore, that the age resistance of equines against Strongylid parasites is probably comparable to the experimental findings in the instances of other host-parasite combinations, wherein the percentages of development of the parasite, rather than the absolute degrees of infestation, fall off with increasing age of the host.

Summary.

Quantitative studies of the worm burdens of 86 equines, varying in age from 9 to 30 years, have demonstrated that the animals from 9 to 15 years old were more than twice as heavily infested, on the

average, with Strongylid parasites than were those over 15 years. From 59 animals, 15 years and under, there was recovered an average of 1219 worms per animal as compared to an average of 502 worms from 27 animals over 15 years. This was interpreted as an age resistance of equines against Strongylid parasites, and was demonstrated quantitatively for the commoner individual species. In the instance of *S. vulgaris,* however, the data afforded no evidence of increased protection in the older animals. This was considered significant in view of the importance of the parasite. In addition, it was concluded that in the data of the present studies there was no evidence of an age resistance of equines against stomach worms.

Bibliography.

1. Foster, A. O.
1935. The immunity of dogs to *A. caninum.* Amer. Jour. Hyg., *22,* 65–105.
2. Foster, A. O.
1936. On a probable relationship between anemia and susceptibility to hookworm infection. Amer. Jour. Hyg., *24,* 109–128.
3. Foster, A. O.
1936. A quantitative study of the nematodes from a selected group of equines in Panama. Jour. Parasit., *22,* 479–510.
4. Foster, A. O., and Pedro Ortiz, O.
1937. A further report on the parasites of a selected group of equines in Panama. Jour. Parasit., *23* (in press).
5. Stoll, N. R.
1929. Studies with the Strongyloid nematode, *Haemonchus contortus.* Amer. Jour. Hyg., *10,* 384–418.