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HELMINTH PARASITES OF TRANSLOCATED RACCOONS (*Procyon lotor*) IN THE SOUTHEASTERN UNITED STATES[□]

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Abstract: Raccoons (*Procyon lotor*) typical of animals released by private hunting clubs in the Appalachian Mountains were examined for helminth parasites to evaluate the influence raccoon translocation might have on parasitic diseases. Results were compared with data from resident raccoons from characteristic release areas. Translocated raccoons harbored 19 helminth species that were exotic to resident animals. Most of these exotic parasites were trematodes (74%). An additional 19 species were found in both translocated and resident raccoons, and another 5 species were present only in residents. Three of the 19 exotic helminth parasites and 10 of the 19 enzootic species found in translocated raccoons are known to have some degree of pathogenicity to raccoons, other wildlife, domestic animals or man. At present, disease risks associated with the helminth parasites of these translocated raccoons were not considered alarmingly high; however, potential problems that could not be discounted were artificial intensification of undesirable enzootic parasites on release sites or expression of pathogenicity by exotic parasites presently considered nonsignificant.

INTRODUCTION

The raccoon (*Procyon lotor*) is widely distributed throughout the United States and is highly prized by both raccoon hunters and trappers. In many areas of the mountain and piedmont physiographic provinces in the Southeast, hunters have been importing and releasing large numbers of raccoons from high density populations, primarily from the coastal plain. This practice has been criticized as biologically hazardous, particularly because of possible disease introduction.^{23,24,26,28}

Helminth parasites represent one group of infectious agents that may be spread by translocation. Although many surveys have been conducted on helminth parasites of raccoons,^{2,6,7,11,12,16,20,29,30} they were not con-

cerned with parasite burdens in translocated raccoons. This study was undertaken to determine the helminth fauna of translocated raccoons in order to evaluate potential influence this practice may have on parasitic diseases in the Southeast. Comparison is made with similar data from resident raccoons from typical release sites.

MATERIALS AND METHODS

One hundred seventy-one raccoons were examined between October, 1976, and May, 1979. Of these, 88 animals were acquired directly or indirectly from commercial sources in Florida, Texas, and Virginia. An additional 30 raccoons were examined from three areas (Glades Co., FL; Liberty Co., GA; and Pender Co., NC)

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that potentially could be exploited for raccoon translocation. For the purpose of this study, the aforementioned animals were designated as translocated raccoons. Fifty-three resident raccoons from typical release areas in Georgia, North Carolina, Tennessee, Virginia and West Virginia were obtained for comparison.

Of the translocated raccoons, 100 were received alive or had died enroute to the laboratory and 18 were received frozen. Sixteen resident raccoons were alive and 37 were frozen when received. Routine parasitologic procedures²⁶ were employed to recover helminths. Each parasite species was identified and complete parasite counts were made. Larval cestodes from three raccoons from Glades County, Florida were fed to two cestode-free domestic cats to obtain adult tapeworms.

Examinations for *Trichinella spiralis* larvae were performed as described by Crum *et al.*⁹ Animals received alive were examined by muscle digestion techniques while frozen animals were examined by muscle compression or standard histologic procedures.

Each helminth species found in translocated raccoons was rated as to its probability of establishment within release areas. Factors thought to favor establishment included: (1) a widespread distribution in North America, particularly in regions with ecologic similarities to typical release destinations; (2) a direct life cycle or widespread distribution of intermediate hosts; (3) a high prevalence and intensity of infection in translocated raccoons; and (4) infectivity for animals other than raccoons present in release areas.²⁷ Helminths known to be enzootic to mountain or piedmont raccoons were considered as having an excellent probability of survival in release areas. Ratings of possible, improbable or unknown were given to helminths of translocated raccoons that presently are considered exotic to the mountains or piedmont.

RESULTS

Forty-three species of helminths were recovered from 118 translocated and 53 resident raccoons. Nineteen species were exotic to resident animals, and an additional 19 were enzootic to both translocated and resident raccoons. Five other helminths were found only in residents. Translocated raccoons (Table 1) had a more diverse helminth fauna than did resident raccoons (Table 2). This difference was due primarily to the presence of 14 species of exotic trematodes in translocated raccoons. Seventeen of 24 (71%) species in other helminth taxa (cestodes, acanthocephalans and nematodes) occurred in both translocated and resident raccoons. Representative specimens were deposited in the U.S. National Museum Helminthologic Collection.

Eurytrema procyonis was the only trematode present in translocated raccoons that also occurred in resident raccoons. The only gross lesion associated with trematode infections was hypertrophy of the pancreatic ducts and was produced by both *E. procyonis* and *Procyotrema marsupiformis*.

Of the three species of cestodes recovered, *Atriotaenia procyonis* and *Mesocestoides variabilis* were present in both translocated and resident raccoons. Spargana were recovered only from translocated raccoons and developed to adult *Spirometra mansonoides* when fed to cats. Gross lesions were not attributed to cestode infections.

The only acanthocephalan recovered, *Macracanthorhynchus ingens*, was present in both translocated and resident raccoons. Gross lesions were not attributed to this helminth.

Fifteen of the 19 (79%) species of nematodes in translocated raccoons also occurred in resident raccoons; the four species which did not occur in resident raccoons were *Dipetalonema llewellyni*,

TABLE 1. Helminth parasites recovered from 118 translocated raccoons.

County/State	Glades/Highlands/ Hillsborough/ Orange, FL (51)	Liberty, GA (10)	Pender, NC (10)	Brown, TX (37)	James City, VA (10)	Establishment Probability Rating
(Sample Size)						
TREMATODA						
*Apophallus venustus (76214)a	—	—	50%, 32, (0-153)	—	30%, 173, (0-513)	Possible
*Carneophallus turgidus (76216)	—	100%, 1466, (405-3293)	—	3%, 200, (0-200)	—	Improbable
*Euparyphium beaveri (76217)	—	—	20%, 26, (0-55)	—	—	Possible
Eurytrema procyonis (76218)	—	—	—	—	50%, 1220, (0-3974)	Excellent
*Fibricola cratera (76219)	14%, 299, b (0-1907)	10%, 32, (0-32)	—	19%, 299, (0-1907)	—	Possible
*Gynaecotyla adunca (76220)	—	100%, 1608, (439-3389)	—	—	—	Improbable
*Heterobilharzia americana (76221)	71%, 8, (0-47)	—	40%, 13, (0-20)	22%, 6, (0-15)	—	Possible
*Parallelorchis diglossus (76223)	6%, 45, (0-87)	—	—	—	—	Improbable
*Parametorchis complexus (76224)	—	—	20%, 57, (0-72)	—	10%, 23, (0-23)	Possible
*Pharyngostomoides adenocephala (76225)	43%, 823, (0-10 414)	—	—	11%, 2214, (0-7964)	—	Possible
*Pharyngostomoides procyonis (76226)	90%, 1079, (0-7039)	—	70%, 520, (0-1307)	43%, 751, (0-4, 791)	80%, 191, (0-514)	Possible
*Plagiorchus muris (76227)	—	—	—	3%, 2, (0-2)	—	Improbable
*Procyotrema marsupiformis (76228)	—	—	40%, 16, (0-47)	—	—	Unknown
*Ribeiroia ondatrae	2%, 2, (0-2)	—	—	—	—	Improbable

TABLE 1. (continued)

County/State	Glades/Highlands/ Hillsborough/ Orange, FL	Liberty, GA	Pender, NC	Brown, TX	James City, VA	Establishment Probability Rating
(Sample Size)	(51)	(10)	(10)	(37)	(10)	
*Stephanoprora spirosa (76229)	—	30%, 3, (0-3)	—	—	—	Improbable
CESTODA						
Atriotaenia procyonis (76230)	16%, 31, (0-127)	10%, 33, (0-33)	70%, 57 (0-179)	92%, 97, (0-818)	60%, 139, (0-226)	Excellent
Mesocostoides variabilis (76231)	8%, 171, (0-313)	—	—	11%, 96, (0-353)	20%, 192, (0-265)	Excellent
*Spirometra mansonioides (0-11)	18%, 4, (0-11)	—	20%, 1, (0-1)	—	—	Possible
ACANTHOCEPHALA						
Macracanthorhynchus ingens (76246)	45%, 4, (0-14)	90%, 15, (0-33)	90%, 7, (0-16)	24%, 5, (0-17)	60%, 3, (0-6)	Excellent
NEMATODA						
Capillaria	—	—	10%, 2, (0-2)	—	—	Excellent
plica	14%, 2, (0-4)	10%, 2, (0-2)	10%, 1, (0-1)	8%, 1, (0-1)	50%, 4, (0-9)	Excellent
procyonis (76234)	4%, 5, (0-9)	—	60%, 36, (0-148)	—	60%, 39, (0-86)	Excellent
Capillaria putorii (76235)	2%, 1, (0-1)	—	—	—	10%, 8, (0-8)	Excellent
spp.	59%, 5, (0-26)	—	60%, 5, (0-12)	14%, 2, (0-7)	30%, 2, (0-4)	Excellent
Crenosoma gobiei (76236)	2%, 1, (0-1)	—	10%, 1, (0-1)	—	—	Improbable
*Dipetalonema llewellyni	22%, 2, (0-8)	—	20%, 1, (0-1)	—	50%, 3, (0-4)	Excellent
Dracunculus insignis (76237)	—	—	—	—	—	—

TABLE 1. (continued)

*Filaria taxideae (76232)	—	—	—	—	78%, 12, (0-38)	—	Possible
*Filaria sp.	—	—	—	—	3%, 1, (0-1)	—	Unknown
Filaroides sp. (76238)	4%, 22, (0-42)	—	—	10%, 9, (0-9)	3%, 1, (0-1)	—	Excellent
Gnathostoma procyonis (76239)	55%, 6, (0-30)	10%, 2, (0-2)	—	10%, 1, (0-1)	—	60%, 2, (0-6)	Excellent
Gongylonema pulchrum (76240)	2%, 1, (0-1)	—	—	—	—	—	Excellent
Molineus barbatulus (76241)	33%, 29, (0-80)	70%, 42, (0-212)	—	100%, 79, (3-296)	27%, 5, (0-15)	90%, 56, (0-222)	Excellent
Physaloptera rara (76242)	18%, 9, (0-28)	30%, 12 (0-13)	—	40%, 2, (0-2)	84%, 14, (0-105)	60%, 7, (0-27)	Excellent
Placoconus lotoris (76243)	71%, 51, (0-207)	40%, 1, (0-1)	—	90%, 90, (0-385)	11%, 7, (0-10)	100%, 69, (3-218)	Excellent
Strongyloides sp. (76244)	49%, 185, (0-1 263)	—	—	—	3%, 1, (0-1)	—	Excellent
Synhimantus sp.	35%, 15, (0-47)	—	—	30%, 2, (0-3)	—	—	Excellent
Trichinella spiralis (76245)	4% ^c	—	—	20%	—	—	Excellent
*Procyonostongylus muelleri (75225)	10%, 2, (0-16)	—	—	—	—	—	Unknown

*Helminths considered exotic to release areas.

^aNumbers in parentheses are U.S.N.M. Helm. Coll. Numbers.^bFigures in columns are: percent prevalence, average number of worms per infected raccoon, and (range).^cPercent prevalence was the only information available.

Filaria taxideae, *Filaria* sp. and *Procyonostrongylus muelleri*. Gross lesions were associated with *Dracunculus insignis*, *Filaroides* sp., *Gnathostoma procyonis* and *Physaloptera rara*. Gravid females of *D. insignis* evoked subcutaneous swelling and inflammation and produced small round ulcers in the skin. Enlarged purulent ulcers as previously described⁴ also were observed. Nodules measuring 2.0 to 3.0 cm in diameter in the stomach wall were attributed to penetration and attachment of *G. procyonis*.^{1,7,15,16,33} *Filaroides* sp. produced palpable nodules up to 2.5 cm in diameter within one or more lobes of the lungs. Histologic examination of lungs infected with *Filaroides* sp. revealed adult nematodes coiled in pulmonary veins. Endothelial proliferation, thrombus formation and perivascular infiltrations of lymphocytes and eosinophils were associated with the nematodes. Erosions of the stomach mucosa similar to those described by Soulsby³² were observed in raccoons with heavy burdens of *P. rara*.

DISCUSSION

The long-term impact of helminths imported via raccoon translocation is contingent upon the pathogenicity of the parasites. Understandably, this capability should not be limited to a disease potential for raccoons but should extend to other wildlife, domestic animals and man. At present, only limited data are available in this regard, and the assessments given herein are based on review of the literature²⁷ and observations made during this study. Evaluations of pathogenicity are arbitrary, and some parasites were categorized as pathogens on the basis of what may be only subclinical tissue damage. Conversely, exotic parasites presently considered harmless may express unforeseen pathogenic capabilities due to biological factors in the release areas.

Pathogenicity was observed during this study or has been described previously from 13 helminth parasites recovered from translocated raccoons, viz., *E. procyonis*,^{13,25,31} *Heterobilharzia americana*,^{5,19} *P. marsupiformis*,^{10,12,18} *S. mansonioides*,^{9,21} *Crenosoma goblei*,¹⁵ *D. insignis*,⁸ *Filaroides* sp., *G. procyonis*,^{1,7,15,16,33} *Molineus barbatus*,¹ *P. rara*,³² *Placoconus lotoris*,^{3,4,33} *Strongyloides* sp.¹⁷ and *T. spiralis*.^{32,34}

Of the 19 exotic helminths found in translocated raccoons, three presently are considered to have pathogenic capabilities, viz., *H. americana*, *P. marsupiformis* and *S. mansonioides*. As rated in Table 1, both *H. americana* and *S. mansonioides* possibly could become established in release areas, and *P. marsupiformis* was rated as unknown. In contrast, 10 of 19 helminth parasites common to translocated and resident raccoons are considered pathogens. In view of these findings, risks associated with artificially intensifying infections of pathogenic enzootic parasites by release of hundreds of translocated raccoons probably are as significant as the danger of exotic helminth introduction.

A major argument against indiscriminant translocation of raccoons has been based on the danger of disease or parasite introduction. Recent reports of rabies,²⁴ parvovirus enteritis²³ and potentially pathogenic protozoan parasites²⁸ in translocated raccoons exemplify some disease hazards associated with this practice. The present study did not reveal helminths that warrant extensive alarm; however, caution is indicated because data on adverse effects of these parasites are far from complete. Furthermore, the origin of raccoons routed through commercial dealers is obscure, and future shipments may be heavily infected with other helminths, such as the neurotropic ascarid, *Baylisascaris procyonis*, that have more obvious ecologic ramifications to resident rodents and lagomorphs.^{14,22}

TABLE 2. Helminth parasites recovered from 53 resident raccoons.

County/State	Banks/Dawson/ Habersham/Stephens, GA (10)	Fannin/Rabun/ Union, GA & Cherokee, NC (13)	Hawkins/Union, TN Wise, VA (20)	Ohio, WV (10)
(Sample Size)				
TREMATODA				
<i>Brachylaima virginianum</i> (76215) ^a	—	—	5%, 37, (0-37)	—
<i>Eurytrema procyonis</i> (76218)	—	—	45%, 425, (0-1929)	—
<i>Metagonomoides oregonensis</i> (76222)	20%, 1402, ^b (0-2383)	8%, 569, (0-569)	10%, 36, (0-71)	—
<i>Metorchis conjunctus</i> (75542)	—	—	5%, 9, (0-9)	—
CESTODA				
<i>Atriotaenia procyonis</i> (76230)	—	—	25%, 95, (0-196)	20%, 36, (0-64)
<i>Mesocostoides variabilis</i> (76231)	10%, 2, (0-2)	15%, 7, (0-8)	5%, 2, (0-2)	50%, 33, (0-76)
ACANTHOCEPHALA				
<i>Macracanthorhynchus ingens</i> (76246)	80%, 13, (0-24)	85%, 29, (0-96)	50%, 5, (0-14)	10%, 1 (0-1)
NEMATODA				
<i>Baylisascaris procyonis</i> (76233)	—	—	—	20%, 3, (0-5)
<i>Capillaria plica</i>	10%, 1, (0-1)	—	—	—
<i>Capillaria procyonis</i> (76234)	50%, 1, (0-1)	54%, 3, (0-7)	35%, 2, (0-4)	20%, 2, (0-2)
<i>Capillaria putorii</i> (76235)	50%, 6, (0-11)	69%, 16, (0-61)	75%, 20, (0-71)	60%, 7, (0-15)
<i>Capillaria</i> spp.	—	—	—	30%, 1, (0-1)

TABLE 2. (continued)

County/State	Banks/Dawson/ Habersham/Stephens, GA	Fannin/Rabun/ Union, GA & Cherokee, NC	Hawkins/Union, TN Wise, VA	Ohio, WV
(Sample Size)	(10)	(13)	(20)	(10)
<i>Crenosoma</i> <i>goblei</i> (76236)	20%, 1, (0-2)	69%, 2, (0-7)	35%, 4, (0-14)	10%, 1, (0-1)
<i>Dracunculus</i> <i>insignis</i> (76237)	20%, 1, (0-1)	—	—	—
<i>Filaroides</i> <i>sp.</i> (76238)	10%, 8, (0-8)	23%, 5, (0-8)	15%, 9, (0-21)	—
<i>Gnathostoma</i> <i>procyonis</i> (76239)	10%, 1, (0-1)	46%, 5, (0-13)	—	—
<i>Gongylonema</i> <i>pulchrum</i> (76240)	10%, 1, (0-1)	8%, 6, (0-6)	5%, 1, (0-1)	—
<i>Heterakis</i> <i>sp.</i>	—	23%, 2, (0-3)	—	—
<i>Molineus</i> <i>barbatus</i> (76241)	70%, 43, (0-86)	78%, 123, (0-951)	95%, 108, (0-889)	80%, 7, (0-14)
<i>Physaloptera</i> <i>rara</i> (76242)	90%, 25, (0-96)	46%, 23, (0-124)	80%, 54, (0-228)	70%, 30, (0-147)
<i>Placoconus</i> <i>litoris</i> (76243)	80%, 11, (0-57)	92%, 20, (0-67)	95%, 49, (0-148)	80%, 55, (0-151)
<i>Strongyloides</i> <i>sp.</i> (76244)	50%, 35, (0-96)	69%, 11, (0-50)	20%, 6, (0-12)	—
<i>Synhimanthus</i> <i>sp.</i>	20%, 2, (0-2)	—	—	—
<i>Trichinella</i> <i>spiralis</i> (76245)	—	20% ^c	5%	10%

^aNumbers in parentheses are U.S.N.M. Helm. Coll. Numbers.^bFigures in columns are: percent prevalence, average number of worms per infected raccoon, and (range).^cPercent prevalence was the only information available.

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