MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 159 · Nr. 7

THE DISTRIBUTION OF *TRICHINELLA SPIRALIS* IN SLEDGE DOGS AND WILD MAMMALS IN GREENLAND

UNDER A GLOBAL ASPECT.

BY
HOLGER MADSEN

WITH 13 FIGURES IN THE TEXT

С РУССКИМ РЕЗЮМЕ

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1961

Dr. HANS ROTH in the laboratory.

DEDICATED TO THE MEMORY OF

Hans & Ursula Roth

CONTENTS

PREFACE

The writer has had the privilege of being acquainted with the well-known German-born parasitologist Dr. HANS ROTH (1905—1951) since 1933, in which year Dr. ROTH arrived in Denmark with his family. In this country and in Sweden, where he stayed as a refugee during the years 1943—45, he published all his parasitological works. He especially acquired a name as a thorough specialist in problems connected with the nematode *Trichinella spiralis*. He had, however, a broad knowledge of, and was actively engaged in, other fields of parasitology as well. (For a bibliography, see Vidensk. Medd., Dansk Naturh. Foren. 113, pp. VII—IX, 1951). In 1949 he became a Danish citizen.

As in the year 1947 severe epidemics resembling typhoid fever which had broken out in Greenland, turned out to be trichinosis, it was a matter of course that Dr. ROTH was entrusted with the investigation of the distribution of the worm in various mammals in Greenland. On his initiative an extensive collection of meat samples from a variety of animals was organised by the Greenland Department, and the samples were examined by Dr. ROTH personally or under his supervision. Because of his deplorable premature death due to a heart failure, he was only able to treat a minor portion of the immense material, while the greater part was examined by his widow, Mrs. URSULA ROTH, who, however, was all too soon to follow her husband in death, leaving behind a young daughter and a son.

Mrs. ROTH asked me, as a parasitologist of her acquaintance, to give a review of the whole material before the 14th International Congress of Zoology in Copenhagen in 1953. Owing to the familiarity with the subject which I had thus acquired, the Greenland Department asked me to write the final paper on the results of the investigations of the many meat samples. The work on this unique material has been very interesting. I have endeavoured to treat it as painstakingly and exhaustively as, I am certain, Dr. ROTH would have done it himself.

Jagtfondens Vildtbiologiske Undersøgelser.
Universitetsparken 15, Copenhagen, Ø. Denmark.

HOLGER MADSEN.

ACKNOWLEDGEMENTS

My thanks are especially due to the Greenland Department, for handing over to me the valuable material which forms the basis of the present paper. Further, through Mr. S. M. Saxtorph, M. D. and Mr. Ph. Rosendahl, chief of office, I was helped and supported in every possible way during the completion of the work. I am also grateful for the readiness with which Professor Aage Jepsen (Hygienic-Bacteriological Institute, Royal Veterinary and Agricultural College) had a number of additional samples examined. I likewise received valuable help from the State Veterinary Service (Veterinærdirektoratet). Finally my thanks are due to the Academy of Science, USSR, which sent me many valuable reprints.

INTRODUCTION

Some large outbreaks of a typhoid-paratyphoid fever–like disease among the population of West Greenland in 1947 were diagnosed as *trichinosis* (371, 372). These, as well as former and later outbreaks together with simultaneous outbreaks among human beings in the Canadian Arctic and Alaska have been described together with the results of several serological surveys on the prevalence of trichinae (73—76; 93—94; 157—158; 302—303; 342, 399). Further outbreaks in West Greenland have occurred in 1949, 1953 and 1959.

At the time these outbreaks came as a great surprise. The following story (303) is typical of the situation: "La conception assez étroite que l'ours blanc, dans son pays arctique, devait être tout à fait exempt de ce parasite redoutable *(Trichinella spiralis)*, fut, en 1932 mise en lumière par un événement caractéristique. Une expédition cinématographique qui se trouvait au nord du Groenland avait amené un ours blanc du jardin zoologique de Hambourg. Alors que l'expédition, son travail terminé, devait rentrer, on voulut mettre en liberté l'animal, mais les autorités du Groenland l'interdirent, craignant qu'un tel ours, venant de captivité, puisse disséminer la trichinose au Groenland. C'est pourquoi on a dû tuer l'animal et jeter le cadavre à la mer".

However our knowledge of the occurrence in the Arctic of *Trichinella spiralis* was actually of an earlier date, for already in 1934 (276), this nematode was found in the polar bear and the arctic fox in the Eastern Canadian Arctic. The hypothesis was even advanced that walruses and seals might be infected, and thus occasion outbreaks, which might previously have been taken to be cases of meat poisoning[1]).

The occurrence in the Arctic of *Trichinella* was corroborated by the finding (211) of the worm in the same animals, in the zoological garden

[1]) It may be appropriate here to quote (348, p. 449): "the death of several persons apparently from eating beluga (white whale) meat. Cases of this kind are, in an offhand way, explained by whalers, etc., as cases of ptomaine poisoning. This can hardly be so, for the cases known to me have all involved the eating of fresh-killed beluga, with one exception——. It seems likely to me that the disease is rather in the nature of *Trichinosis* than of the type of ptomaines". This report is from the Arctic coast of Alaska.

of London, under such circumstances that an infection outside of the Arctic would be out of the question. The present author (227) suggested, with reference to the above-mentioned paper, an investigation of carnivorous mammals in Greenland. That these papers have been forgotten, appears from the fact that they were not cited in GOULD's (1945) recent monograph on trichinosis. A paper (196), reporting trichinae in a polar bear which had only stayed for a few days in Moscow's zoological garden, was not noticed either. This recent knowledge throws new light on the common finds of *Trichinella* in polar bears in zoological gardens.

As soon as the cause of the outbreaks became clear, a collection of meat samples from animals in Greenland was organized by the Greenland Administration. (For details see p. 11). The collecting was concluded in 1953. The examination of the samples was undertaken by professional trichina inspectors and was supervised at first by Dr. HANS ROTH, later owing to his premature death in 1951, by his widow, Mrs. URSULA ROTH, who was herself a professional inspector. He published a preliminary report in "Nature", 1949 (301), and gave more details in 1950 (303), when before the 18th session of the "Office International des Épizooties", in Paris, he reported upon some 1,500 out of the final total of about 10,200 samples. A brief preliminary report on the total material was given by the present author to the 14th International Congress of Zoology, in Copenhagen, 1953 (304) (see Preface). In this presentation the main conclusions of Dr. ROTH were corroborated, even though some of his views had to be modified in the light of fresh evidence. The most striking result of Dr. ROTH's work was the first proof that *Trichinella spiralis* may occur in marine mammals.

MATERIAL AND METHODS

It was endeavoured to obtain samples from all mammals which might be imagined to be potential hosts. Therefore, a number of herbivorous mammals were also investigated, because of the well-known fact that under arctic conditions these animals may also devour meat.

It took some time and experience before the sending in of specimens became satisfactory. Representing the Greenland Administration (Ministeriet for Grønland), Mr. PH. ROSENDAHL finally issued very detailed instructions, in Greenlandic and Danish, to the various administrative bodies and to the health officers in Greenland. The Greenland version was to be posted in the shops (which were, at the time, all governmental).

The instructions gave details as to the species wanted, how and from which parts of the animal the samples should be taken, etc. At the same time consecutively numbered aluminium tags were distributed. The approximate number of samples wanted from the various places were indicated, and partly regulated by the number of tags issued.

The municipal councils were instructed to inform the population of the problems of trichinosis, to give instructions regarding disposal of carcasses (careful burying), to encourage the hunters to collect samples and to make known where to deliver them. It was recommended that hunters living far from the shops should dry the samples before delivery. The managers of the shops were ordered to receive, tag, salt, and further handle the samples and to keep lists on printed forms, following the numbers of the samples.

The information wanted, printed on the forms, was the following: species of animal; name of the collecting hunter; locality, and, if possible, date of sampling. For dogs furthermore: approximate age; whether it had died by accident or from disease or it had been killed because of disease (especially, suspected distemper or rabies) or weakness.

The samples were to be treated by the managers of the shop in the following way. After being wiped off, the tagged samples, irrespective of the species, should be put into boxes (empty sugar or condensed milk boxes) and covered with salt. When the box was full, it had to be marked with the name and number of the settlement, the name of the district,

and the designation "meat samples" and be sent, together with the lists to the district head, who had to take care of the safe shipment to Copenhagen.

Certain fees per sample were paid, to the hunters and the officials at the shop, sufficiently high to maintain their interest in the sampling. When tags were running short new ones would be sent on request.

The samples were taken from various parts of the musculature, in the case of the terrestric carnivores generally from some limb, in the case of the seals from the diaphragm. The comparatively few samples from rodents and ermines were taken from the masseter. Many additional samples were collected from hides and skulls including several samples from museum-specimens.

Upon their arrival in the laboratory (Hygienic-Bacteriological Institute (Chief: Professor AAGE JEPSEN), Royal Veterinary and Agricultural College, Copenhagen), the samples were soaked in hot water. Subsequently, small pieces were cut off and soaked in a 5 % KOH solution.

The samples were examined according to the compression method, compressors of the German type being used (see e. g. 136, p. 171, fig. 110—111). As a rule 2 compressors full were prepared from each sample, comprising 28 cuts each, thus a total of 56 cuts, corresponding to about 1 g of meat examined. If many parasites were present, only one compressor was counted. Each compressor was examined twice with painstaking care under the microscope, and then inspected once more in the trichinoscope.

Owing to Dr. ROTH's comprehensive knowledge of *Trichinella*, it was possible, within certain limits, to estimate the age of the infection in terms like "2—4 months, $1^1/_2$ months, 3—4 months, 6—12 months; about a year, several years", etc. These age determinations were arranged by me in two groups. One comprising those of 3 months or less, termed "young infestations", and those of one year or more, termed "old infestations", e. g. "6—12 months" being referred to this latter and, say, "3—6 months" to the former group. Furthermore, the observable occurrence of more than one infestation was indicated. A considerable number of capsules were measured. This material will be treated in Appendix 2, p. 90.

Some Major Results of the Investigation in Greenland.

It will appear from table 1 that in all essentials the total material corroborates the results arrived at by Dr. ROTH. The dogs are heavily infected, viz. more than 60 per cent of all the samples. As will appear from the more detailed discussion under the heading of the individual host species, this estimate of the infection of the dogs is actually too

Table 1.

Species of host	Material treated by Hans Roth			Total Material		
	Number investigated	Number positive	Percentage positive	Number investigated	Number positive	Percentage positive
Dog *(Canis familiaris)*	227	151	66.5	956	591	61.9
Polar bear *(Thalarctos maritimus)*..	112	31	27.7	231	56	24.2
Arctic fox *(Alopex lagopus)*.....	264	3	1.1	1743	25	1.4
Walrus *(Odobaenus rosmarus)*	207	2	0.9	489	5	1.0
Bearded seal *(Erignathus barbatus)*.	56	1	1.8	245	2	0.8
Ringed seal *(Phoca hispida)*	52	1	1.9	1775	1	0.06
Seals, undetermined.....	99	0	0	1657	1	0.06
Bladdernose *(Cystophora cristata)*..	59	0	0	203	0	0
Harp seal (*Pagophilus groenlandicus)*	40	0	0	2405	0	0
Spotted seal *(Phoca vitulina)*.....	–	–	–	25	0	0
Narwhal *(Monodon monoceros)*	4	0	0	53	0	0
White whale *(Delphinapterus leucas)*	91	0	0	235	0	0

low. This tremendous level of infection is not by far reached by any other animal (this statement, also, will have to be modified somewhat later on). Still, the polar bear shows a high percent of infection, every fourth bear being infected. The arctic wolf is rare in Greenland to-day and no fresh material has been available. Dr. ROTH collected samples of muscle tissue from four hides in the collections of the Zoological Museum in Copenhagen. Two of these samples proved positive, indicating a high level of infestation in this animal too. Compared with the last-mentioned animals, the infection in the arctic fox was astonishingly low, constituting only about one per cent.

Also in the case of walrus and bearded seal the level of infection, about one per cent, as stated by ROTH was corroborated. This testifies to the exceptional position of these two animals among the seals. In bladdernose seal, harp seal, narwhal and white whale no trichinae have as yet been found in Greenland, and incidentally, with the exception of the white whale, nowhere else. As will be seen from the table, some of this material has been greatly augmented.

Comparatively early during ROTH's studies, *Trichinella* was found in one specimen of ringed seal, originating from North-East Greenland. This find must at that time seem very significant, especially as a potential source of infection for the polar bear. However, the total material considerably decreases the significance of this unique occurrence. An additional number of almost 2000 ringed seals have been examined without result. The material presented under the heading of "undetermined seals" undoubtedly also comprised ringed seals. The single positive find among

Table 2. Number of samples from various Greenland mammals all proving negative.

Mustela erminea, ermine, shorttail weasel, stoat	(3)	26
Hyperoödon ampullatus, bottlenose whale		1
Phocaena phocaena, harbour or common porpoise	(5)	21
Globicephalus melaena, common blackfish		11
Physeter macrocephalus, sperm whale	(1)	4
Sibbaldus musculus, blue whale	(2)	2
Balaenoptera physalus, finback whale	(4)	6
Dicrostonyx torquatus, collared lemming	(4)	9
Lepus arcticus, arctic hare	(20)	191
Rattus norvegicus, brown or Norway rat	(18)	18
Sus scrofa domestica, domestic pig		28
Ovis aries domesticus, sheep	(210)	784
Ovibos moschatus, musk ox		1

Figures in parenthesis indicate number of samples available to Dr. ROTH.

more than 1,500 undetermined seals, represented in all probability a bearded seal, judging by the size and structure of the sample, according to personal communication by the late Mrs. URSULA ROTH.

In table 2, a number of negative samples are presented. Most interesting are the ermines, lemmings, hares and rats, for these animals, or their near relatives, are known to be hosts of *Trichinella spiralis* in Alaska (295). The rat is only rarely able to establish itself for longer periods of time in Greenland. Because of the high incidence in the dogs and the way in which they acquire infection, they may, no doubt, actually be infected in some places. But as is well known, this is generally of no practical consequence, since rats cannot maintain an infection among themselves (see p. 52 ff.). Their infections are only symptomatic of an infection in their surroundings.

The same is the case with the lemming and the hare. If an infection in these animals is present in Greenland, it must be extremely rare. The ermine follows the lemming exactly in its distribution in Northern and Northeastern Greenland, being almost completely dependent upon it for food. If the lemmings were infested to any appreciable extent, *Trichinella* would occur in the ermines. All over Greenland the foxes take many hares. The generally low incidence of trichinae in foxes tells against any material infection in the hares. The considerable collection of samples from hares is rather well distributed all over Greenland. The numerous samples from sheep have been examined because of the above-mentioned tendency of herbivores under Arctic conditions to occasionally consume meat. Experimentally it is possible to establish the infection in ruminants. The material of whales presented in table 2 is too scanty to furnish any conclusive evidence. An extensive study of the killer whale might yield interesting results.

SURVEY OF THE INDIVIDUAL HOST SPECIES IN THE ARCTIC

Dog (Canis familiaris)

In table 3 the collections of samples are arranged according to localities. On the West Coast the localities are arranged geographically from south to north, on the East Coast from north to south. It will be seen that the percentage of infection is generally very high, the all-over percentage being 71. But it is evident that the individual localities differ greatly. In order to be able to perform a Chi-square test, some of the localities were pooled in order to bring the single group of numbers up to at least five, to a total of 25 degrees of freedom. A Chi-square of 69 ensued. This is highly significant on the one per mille level.

The question now arises what may be the cause of this great variation? It is evident that the material is not ideal for comparisons of this kind, since it has been collected over a long period of time and from animals of different age and therefore of varying times of exposure. The information of the single animal was often limited, even regarding the time of collection. One source of variation was eleminated to a certain degree; all reported puppies being disregarded, also the few positive ones. In spite of all these handicaps certain striking features are apparent.

In West Greenland, sledge dogs are only kept from Holsteinsborg District northward (see table 5). The few dogs in East Greenland are also sledge dogs. The few dogs kept south of Holsteinsborg, notably in the Julianehåb District, are either shepherd's dogs, used in the sheep rearing industry, or they are kept because of their hides and meat. This special breed of dogs has recently been eradicated. Of the former category, only three are represented in the collections, all negative, giving no information. The dogs from Sukkertoppen, being of the second category, are especially interesting in presenting an infestation on the same level of incidence as in most other parts of West Greenland. This point will be discussed in more detail below (p. 21).

A comparison of the individual districts along the coast shows that up to Upernavik the percentage of infestation is fairly uniform, around 70. The most outstanding exception is Qutdligssat, with a percentage

Table 3. The distribution of *Trichinella spiralis* in dogs in Greenland.

Locality	+	—	Total	% inf.
I. Julianehåb	0	3	3	–
II. Sukkertoppen	–	–	–	–
III. Holsteinsborg	3	0	3	–
IV. Agto	3	1	4	–
V. Igíniarfik	12	11	23	*52*
VI. Niaqornârssuk ...	1	0	1	–
VII. Kangâtsiaq	18	5	23	*78*
VIII. Manermiut	6	0	6	–
IX. *Egedesminde*	19	7	26	*73*
X. Hunde Ejlande ..	3	0	3	–
IX. Akúnâq	10	1	11	*91*
Egedesminde District.....	72	25	97	*74*
XII. Íkamiut	25	20	45	*56*
XIII. Akugdlît	7	5	12	*58*
XIV. *Christianshåb*	1	1	2	–
XV. Claushavn	14	4	18	*78*
Christianshåb District	47	30	77	*61*
XVI. *Jakobshavn*	7	8	15	*47*
XVII. Rodebay	45	11	56	*80*
XVIII. Atâ	5	3	8	*63*
XIX. Ritenbenk	2	0	2	–
XX. Qeqertaq	12	3	15	*80*
XXI. Sarqaq	28	15	43	*65*
Jakobshavn District.....	99	40	139	*71*
XXII. Nakorsaq.....	1	0	1	–
XXIII. Ujarasugssuk	17	4	21	*81*
XXIV. *Qutdligssat*	11	2	13	*85*
Qutligssat District	29	6	35	*83*
XXV. Skansen	3	0	3	–
XXVI. *Godhavn*.....	9	5	14	*64*
XXVII. Diskofjord.....	5	1	6	–
Godhavn District	17	6	23	*74*
XXVIII. Niaqornat	27	10	37	*73*
XXIX. Qaersut	16	3	19	*84*
XXX. *Umanak*.....	13	6	19	*68*
XXXI. Ikerasak	5	4	9	*56*
XXXII. Sãtut	28	6	34	*82*
XXXIII. Uvkusigssat	1	0	1	–
XXXIV. Igdlorssuit.....	18	12	30	*60*
XXXV. Nûgâtsiaq	14	15	19	*74*
Umanak District.....	122	46	168	*73*

(*continued*)

Table 3 (continued).

Locality	+	—	Total	% inf.
XXXVI. Sdr. Upernavik...	5	5	10	*50*
XXXVII. Prøven.....	33	12	45	*73*
XXXVIII. *Upernavik*.....	25	15	40	*63*
XXXIX. Augpilagtoq	27	7	34	*79*
XL. Tuvssâq.....	2	8	10	*20*
XLI. Tasiussaq.....	12	7	19	*63*
XLII. Kraulshavn.....	9	2	11	*82*
Upernavik District.....	113	56	169	*67*
XLIII. Savigsivik	11	2	13	*85*
XLIV. *Thule*	15	1	16	*94*
XLV. Siorapaluk.....	12	1	13	*92*
Thule District	38	4	42	*91*
XLVI. Daneborg.....	1	0	1	–
XLVII. Scoresby Sund...	3	0	3	–
XLVIII. Sermiligaq.....	1	0	1	–
IL. *Angmagssalik*	5	9	14	*36*
L. Skjoldungen	3	3	6	–
Total...	571	236	807	*71*

of over 80. As pointed out below, this locality presents special features in other respects also. On the other hand, the Christianshåb district has as low a percentage as 61. Within the individual districts some of the small settlements have especially low percentages of infestation (E. g. Igíniarfik, Íkamiut, Akugdlît, Jakobshavn, and quite especially Tuvssâq (only 20 per cent!) or especially high percentages (e. g. Akunâq, Rodebay, Ujarasugssuk, Qaersut, Sãtut, Kraulshavn) (see also Fig. 1—2).

At Thule the infestation is evidently very high. A Chi-square test comparing Upernavik and Thule is significant on the one per cent level. This special feature of Thule can be accounted for when it is born in mind that the dogs there are generally tied and fed directly. The diet in this case consists especially of meat of polar bear and walrus (see table 5). In the rest of Greenland (with the exception of East Greenland) the dogs stray about most of the time and feed upon all kinds of waste. On this background, the low percentage of infestation in Angmagssalik, East Greenland is astonishing. The cause may be an especially extensive feeding with fish and less opportunity of picking up rubbish. For the time being it does not seem possible to account for the other above-mentioned differences in the incidence of infestation. The main cause may be differences in the age composition of the dog material.

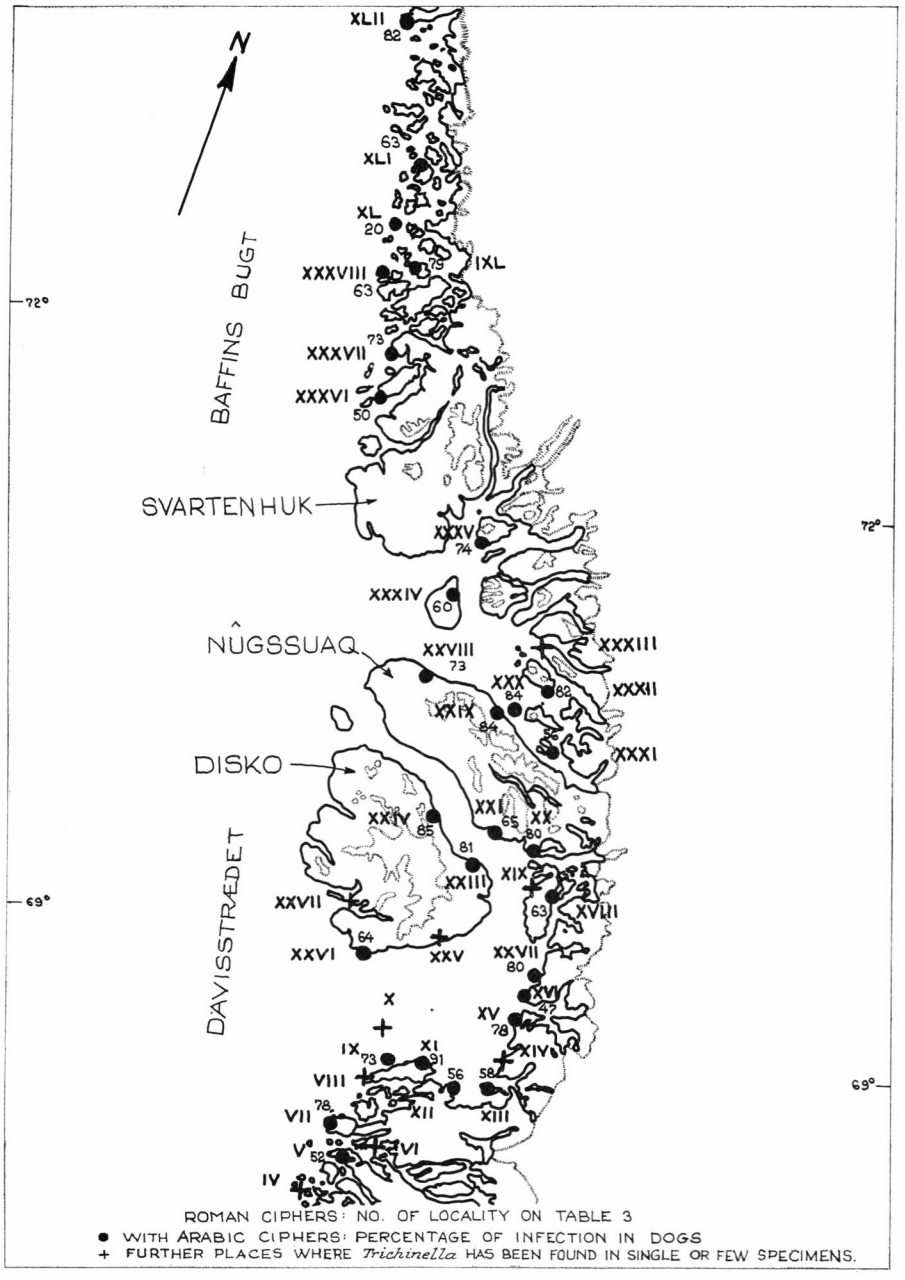


Fig. 1. Distribution of *Trichinella spiralis* in dogs in Central West Greenland.

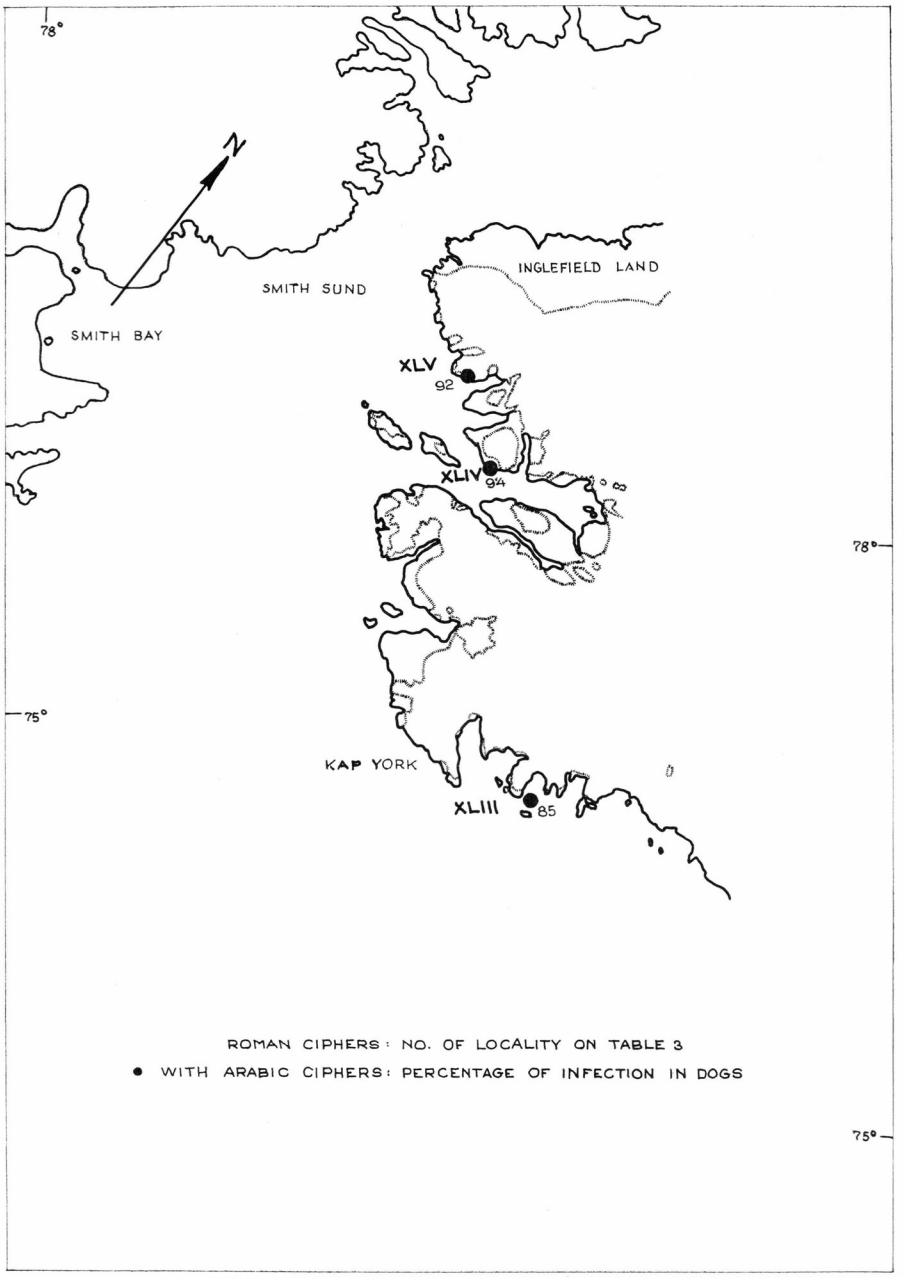


Fig. 2. Distribution of *Trichinella spiralis* in dogs in the Thule District, North West Greenland.

Table 4.

District & host	Number examined	Number infected	Percentage infected	Percentage "young" capsules (about three months or less)*)	Percentage "old" capsules (about one year or more)*)	Percentage double infections*)	Percentage "low" infection (< eleven capsules per compressor)*)	Mean number of larvae per compressor*)	Maximum number per compressor
Dog									
Egedesminde.....	97	72	74	47	24	18	25	89	770
Christianshåb	77	47	61	74	15	17	45	94	663
Jakobshavn.....	139	99	71	71	19	14	28	81	1923
Qutdligssat	35	29	83	76	41	31	34	69	553
Umanak.....	168	122	73	40	11	11	34	56	700
Upernavik.....	169	113	67	41	32	16	21	91	1481
Thule	42	38	91	45	13	26	11	117	758
Total...	727	520	72	53	21	16	28	81	1923
Polar bear	231	56	24	40	51	6	48	32	165
Arctic fox	1743	25	1	42	42	8	20	71	783
Bearded seal	–	3	–	–	–	–	–	72	244
Walrus.....	–	5	–	–	–	–	–	293	821

*) Calculated on the basis of number infected. (See p. 12).

In the chapter "Material and Methods" various data are mentioned relating to the age determination of the capsules, etc. These are arranged in table 4 according to districts. The deficiences in the collection mentioned for table 3 apply to this material also. However, certain characteristic features are to be found. It will be seen that considerable differences occur. With the exception of Egedesminde, the percentages of young infestations are high up along the West Coast (including Qutdligssat) above 60 (average 64.3 %), whereas farther northward they drop to about 40, (average 40.3 %). A Chi-square test of these two percentages is significant on the one per mille level. A high percentage of young infections points to a predominantly recent exposure to infection. This may be due to differences in age of the dogs examined. The date of sampling may play a role too. The material does not permit a decision of this question.

The percentage of old infestations varies more irregularly than that of young ones. It is high in Qutdligssat, suggesting a previous exposure besides the recent one. It might be suggestive for the validity of the above-mentioned high incidence of infection in Qutdligssat that in this place we find a high percentage of double infections, as at Thule, the other place with an exceptionally high incidence of infestation. While

at Thule the infestations are generally heavier than in other places, corresponding to the heavier exposure as explained above, no clear relation to the percentages of infestation in other places can be observed.

In other studies, seven dogs were found infected out of nine examined, from West Greenland (255) In East Greenland, *Trichinella* was found in one of four dogs (375). This agrees well with the picture outlined above.

In the Canadian Arctic also, high percentages of infestation in sledge dogs have been found, in small materials, it is true (203, 205). Also in Spitsbergen (Svalbard) a single dog has been found to be infested (94). The largest material of dogs examined in other arctic regions is from Alaska (295). A total of 225 dogs were examined. Sixty dogs in and around Anchorage, a small town of U. S.-standards, proved negative. But in localities comparable to those of Greenland high percentages were found, since 40 of 47 dogs (85 %) from St. Lawrence Island and 38 of 41 dogs (93 %) from Point Barrow on the Arctic coast proved to be positive. The grand total of 165 dogs presented an infestation of 62 per cent. This altogether comes close to the conditions in Greenland.

As to the source of infestation of the dogs, it is evident that in the Arctic they very often have access to infected meat of polar bear, arctic fox and marine mammals. It has been pointed out above that locally in Greenland, especially at Thule, the feeding with flesh of polar bear and walrus plays an important role, and may raise the level of infestation above the average. But there can be no doubt that the dogs have also access to carrion of dogs, (295, 303).

This source of infection becomes especially evident if we consider the conditions in Central West Greenland, where there is a consistent high percentage of infestation in the dogs. Here they very rarely have access to polar bear meat, there are practically no trichinae in the foxes and only occasionally have they access to walrus meat. This latter source of infection is not even available at Sukkertoppen (see table 5), which makes the above mentioned high percentage in the dogs from this place especially interesting and supports, to a very high degree, the following statements.

Dogs are regularly eaten in West Greenland. In most cases they are well cooked and they present, therefore, no great hazard to man. Without doubt kitchen refuse, and raw at that, from these meals will inevitably be eaten by the dogs strolling about all over the place. In this way they have a steady source of infestation, to say nothing of dog carrion, which will often lie about.

The access of the dogs to dog carrion (in the widest sense of the word) seems to give the most reasonable explanation of the prevailing high infection with *Trichinella* in dog. This assumption is also corroborated

Table 5. Indicating population 1947, average yearly catch of important mammals 1943–1947 per 100 inhabitants, sledge dog population per 100 inhabitants.

(Main part of table extraced from tables in Beretninger vedrørende Grønlands Styrelse, No. 1, 1948).

District	Population 1947	Walrus	Bearded seal	White whale	Narhval	Polar bear	Blue fox	White fox	Sledge dogs 1946, average per 100 inhabitants (1947)	Index blue foxes/ white foxes caught
Julianehåb	4280	.006	?	.006	–	.19	6.0	4.78	–	1.26
Frederikshåb	1372	–	?	.07	–	.05	10.2	4.92	–	2.07
Godthåb	1994	–	?	.01	–	.02	16.7	5.72	–	2.92
Sukkertoppen.....	1750	–	?	.14	–	.03	7.24	2.84	–	2.55
Holsteinsborg.....	1617	8.2	?	1.8	–	.08	5.8	5.55	26.3	1.04
Egedesminde	2477	5.5	4.5	4.3	.12	.01	10.2	5.84	64.8	1.74
Christianshåb	670	–	.30	2.1	.04	–	5.04	9.58	125.3	.53
Jakobshavn	1354	.07	1.5	4.5	.1	.02	2.81	3.86	106.0	.73
Qutdligssat.....	1039	1.2	1.4	3.1	2.3	–	.38	.19	72.3	–
Godhavn.....	566	12.9	6.8	2.6	3.5	–	7.63	8.92	149.8	.86
Umanak	1490	.23	1.7	2.8	.07	.02	1.13	2.13	85.8	.53
Upernavik.....	1459	1.2	11.5	7.8	4.2	.24	1.08	2.71	69.0	.40
Thule*)	335	36.4	14.3	3.3	10.4	3.3	176.0	45.1	282	3.91
Angmagssalik*)	1178	–	14.9	–	.42	2.2	0.76	1.7	54.4	.45

*) Only in recent years are hunting statistics available from this district. Hence, the average numbers for 1954—57 are used here (kindly placed at my disposal by Mr. PH. ROSENDAHL).

by the fact that no difference in incidence could be found between the bigger places, the so called "towns", (which give name to the districts), and the smaller settlements, called "villages" in spite of the fact that much more game is brought in to the small settlements than to the larger ones (29, p. 231—232). Consequently, if wild animals constitute the source of infection of the dogs, the exposure would be larger at the small settlements (Chi-square (d. f. 1) < 2).

The assumption of the dog-to-dog infection is supported by another fact, also. In 41 positive cases we have the date of sampling. If the date of exposure is calculated on the basis of the age of the capsules, it will be found that 12 dogs acquired their infection during the winter, 9 in summer, 12 in spring, and 8 in the autumn. If we apply the null hypothesis, viz. that all these figures represent the same figure (which would then be expected to be 10.25), we get a Chi-square of only 1.246. From this it would seem probable that the source of infection is comparatively fresh meat. If that were not the case, a drop during the winter might

be expected, since a loss of larvae in carcasses must occur in winter because of the frost.

In spite of the widespread, often heavy, infections of dogs in Greenland, no observations on clinical symptoms are known. There can be only little doubt that if looked for, they would be found. Only little is known of clinical symptoms in animals with spontaneous infections. Most observations are available from bears in zoological gardens (see p. 76), but some few obseravtions on cats and dogs have been reported (193). In many respects the symptoms resemble those found in man: in the initial stages diarrhoea, later on stiffness to paralysis of the limbs and myalgia, sometimes changes of the voice. Even edema of the head has been reported, occasionally also keratitis. Naturally, the skin reactions look different in animals, becoming more eczema-like, sometimes combined with the loss of hair.

Polar bear (Thalarctos maritimus).

The polar bear occurs in Greenland chiefly in the eastern and northern parts, from which our materials is derived. Apart from the southernmost part, the Julianehåb District, and the northernmost part, the Upernavik District, only few bears are captured along the West Coast (Table 5). This extremely vagrant species presents the highest rate of infestation found in any wild animal in Greenland. In the material taken as a whole, every fourth bear harbours trichinae (Table 1). The districts from where it was sent in are seen in Fig. 3.

Table 4 (p. 20) shows that there is a very high proportion of old infestations, probably a reflection of the comparatively high age attained by these animals. Whether the low percentage of double infections, as compared with the dogs, reflects a reality is not easy to decide, for in the old infections double ones, if any, will naturally be obscured, but it seems probable, since the polar bear is presumably not so regularly exposed to infections as are the dogs. It is obvious that there is a predominance of light infestations (48 $^0/_0$ as against 28 $^0/_0$ in the dogs), as was the case in the samples from polar bear from Alaska, (295).

Based upon the papers published by Roth, and those published simultaneously from the Canadian Arctic (74, 75), supplemented with unpublished information circulating among some people interested in arctic exploration, under the leadership of Dr. Stefánsson, it was possible as early as 1949 to state (94) that trichinelliasis is circumpolar, at any rate in the polar bear.

Already in 1910 the finding of trichinae was reported in polar bears in Hagenbeck's zoological garden in Hamburg (62). Later on, they have been reported again and again. *Trichinella* from polar bears was re-

corded in the zoo's of Munich, and Prague (63, 120). At that time it was naturally assumed that the animals in the zoo's had become infected during captivity, presumably from rats, which were often found to be positive in the zoo's in many places in Central and Northern Europe at that time. It is, however, significant that it was expressly stated that the capsules were highly calcified, suggesting a high age of the infestation (63).

Calcified capsules were also found in the flesh of polar bears in Hannover (Germany) (107), but also some which were not calcified. Since the period of confinement of the bear is not stated, it cannot be decided whether the probable second infection was acquired in captivity. Such an infection has actually been reported in some instances (180). The great majority of the capsules found in a polar bear in the zoo of Helsinki (Finland) were completely calcified (155). A similar case was observed by the same author already in 1924. This case was sensational for that reason also, that trichinae had not for years been met with in Finnish pigs.

Notorious is a heavy outbreak in 1930 with many deaths caused by meat of polar bear, in Stuttgart (Germany) (271, 360). From a zoo in Germany a secondary infection in brown bears, which could be traced back to polar bear meat, is reported (154). A quite similar case occurred in Denmark a few years ago. This will be discussed at greater length below (p. 75). Several other occurrences are described (25, 82, 180, 190). More recent finds in polar bears in captivity are also recorded (31, 44, 287, 379, 398, 401), frequently under circumstances which make the acquisition of the infestation in the Arctic quite probable.

Together with the above-mentioned papers (196, 211, 276), all these reports offer additional evidence of the widespread occurrence of *Trichinella spiralis* in the polar bear. In the official statistics of the Norwegian Veterinary Service (32) an interesting story is related: In 1946 a Norwegian went to Spitsbergen (Svalbard) to hunt polar bears. He took his dog with him, and fed it on raw meat of polar bear. Two years later the dog was killed and presented a heavy infection with trichinae. It was concluded that the infection was acquired by eating meat of polar bear. In the same report the finding of *Trichinella* in pieces of muscle taken from 7 out of 9 hides of polar bear from Spitsbergen is mentioned (106). Additional finds from Spitsbergen during the war were reported (98). Two out of 9 polar bears examined trichinoscopically proved to be infected. Here mention might also be made of the demonstration of trichinae in a hide of a polar bear originating from Andrée's North Pole Expedition in 1897 (303).

The circumpolar distribution of trichinosis has also been substantiated by later research, which has brought to light further outbreaks

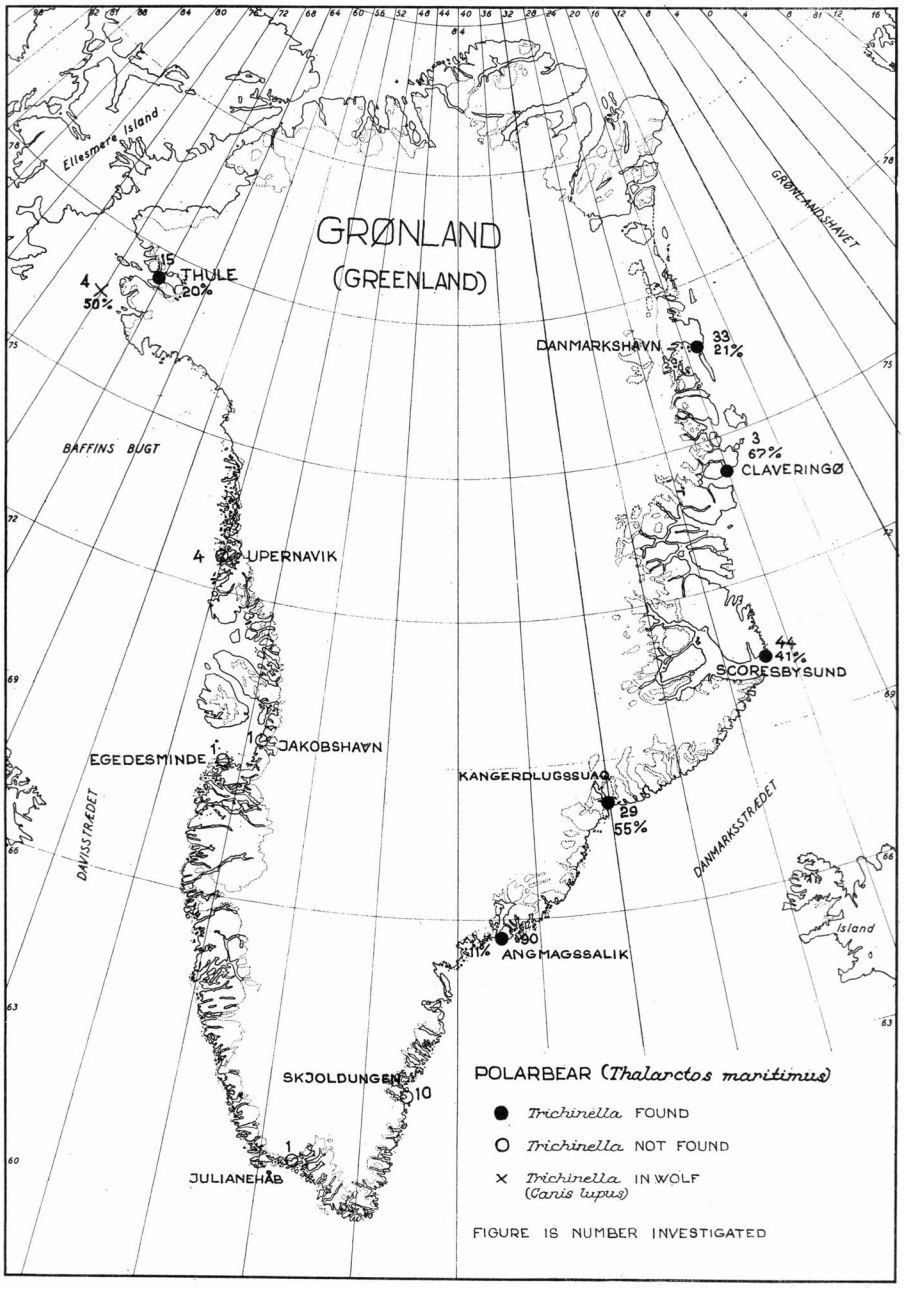


Fig. 3. Localities of samples, according to Districts, from polar bear and wolf.

among human beings, the source being meat of polar bear. Part of this later evidence has already been summarised (303). Of special interest is a paper (273) which reports an outbreak among members of an arctic expedition on Bennet's Island (= de Long's Island), after consumption of meat of polar bear. As to the quotation by ROTH (303) of a verbal communication from Mr. ALWIN PETERSEN regarding outbreaks among Sibirian Eskimos shortly before the Second World War, reported in an Arctic Russian periodical, it is surprising that the above-mentioned Russian authors describe the outbreak as the first one known from the Sovjetic Arctic.

In Alaska, nine out of seventeen polar bears were found to be infested (50 %) (295). This high percentage in a small collection is not surprising in the light of our material. Quite similar percentages were found in 29 polar bears from Kangerdlugssuaq (55 %) and among 44 bears from Scoresby Sund (41 %); while the percentage in 33 bears from Danmarkshavn was 21, and in 90 bears from Angmassalik it was even only 11 (see Fig. 3). The percentage in our material as a whole was 24. In good accordance with this, three out of eight bears in North-East Greenland were found to be positive (2).

On this background the finding of 163 trichinous polar bears among 278 bears examined (59 %), might seem surprising. They originated from the northern and eastern icefields in the Polar Sea (375). A clue to the explanation of all these differences may be found in the indications given by the last-mentioned authors. In a small part of the material the age of the bears was determined: of 12 bears of the age of one to two years, two were positive (17 %); as for older animals, 23 of 29 (80 %) were positive! (Chi-square significant on the one per mille level). They state that the Norwegian ships generally capture more old than young bears. It is probable, therefore, that the total number of young bears was greater in our material than in that of the Norwegian authors.

The probable source of this tremendous infection has been somewhat disputed. It is generally agreed that a favourite prey of the polar bear is constituted by seals, especially the ringed seal. The early finding of trichinae in this latter species, in the material available to Dr. ROTH, prompted him to consider it very significant, as *Trichinella* might be anticipated to be of widespread occurrence in seals. Its exceptional occurrence in ringed seal and its total absence in other seals (apart from bearded seal and walrus) were only apparent from our additional big material. At the same time, however, ROTH highly stressed the opportunity for the polar bear to find carcasses, also of polar bear.

The extent of the hunting activity, if not to say slaughter, carried on by man in the Arctic through several centuries is not always clearly conceived, especially not that by Europeans. Vivid descriptions are

given of the tremendous heaps of carcasses of walrus, for instance, left on the ice in the Polar Sea, heaps which attract flocks of polar bears (375). Everyone familiar with the Arctic knows how the polar bears stroll about picking up anything eatable, often of a quality and stench which, certainly, do not bear witness of their being very particular about their food. It must be borne in mind that *Trichinella* can survive for long periods, at any rate up to 138 days, in decaying meat, especially so, of course, in the cool arctic summers (167, 283, 419). They are also able to survive e. g. in blowfly larvae for some period (245). Finally, it is not always taken into consideration that the polar bear, surviving for several years, has a longer time available for contracting the infestation than, say, foxes.

The high infestation in polar bears, therefore, seems sufficiently accounted for, considering the innumerable chances of infestation through cannibalism (carcasses), refuse in the widest sense of the word, and the eating of bearded seal. The statement (4,5): "Trotzdem muss die Frage der Richtigkeit der Theorie von der Hauptinfektionsquelle durch trichinöses Aas offen bleiben" accordingly seems unwarranted. The author's far-fetched hypothesis of an all round explanation of the spreading of *Trichinella* in the Arctic will be considered later (p. 56).

Arctic Fox. (Alopex lagopus).

The all over percentage of infestation in our material is only 1.4 (see table 1). But this does not give a true picture of the conditions. It will be seen from the map (fig. 4) that fairly high percentages of *Trichinella* have only been found in East Greenland. On the West Coast a low percentage has been found in the southernmost part of the country, viz. the Julianehåb District, also in farm foxes (one in 86 = 1.2 %) (113). To the north, it appears again on the island of Disko (while is absent in large materials collected along the West Greenland coast proper, but is met with regularly in the northern districts of West Greenland (Umanak, Upernavik, Thule) where percentages of 2—4 have been ascertained. Thus the percentages are astonishingly low, considering the omnivorous habits of the arctic fox. One important reason for the small percentages would appear from parts of the preceding discussion: the short life of the fox as compared with both dogs and polar bears, with the consequential smaller chance for the population of building up an infestation on a similar scale as these latter animals.

According to the most recent survey (384), two races of the Arctic fox exist in Greenland, viz. the White Fox and the Blue Fox, which fall into two and three groups, respectively. 1) The big white foxes,

which may also be called the lemming foxes, and have got this name from their favorite diet. They have their main distribution in common with the collared lemming, *Dicrostonyx torquatus*, in high arctic regions: Thule, North and East Greenland, southward to Scoresby Sund. On the West Coast they stray southward as far as the Upernavik and Umanak Districts. Only exceptionally do they go further south. Along the East Coast they go southward with the sea ice, and may in this way reach the Julianehåb District, the southernmost part of the West Coast. The straying mentioned occurs especially in years in which lemmings are scarce. The other forms of the arctic fox are more stationary. 2) The small white foxes, which according to VIBE constitute surviving descendants of the big white foxes, occur in regions where lemmings are absent. 3) The West Greenland blue foxes, which are the true coastal foxes of some authors, being in the main distributed together with the small white foxes. The last two groups of blue foxes have a more restricted occurrence, and are almost entirely dependent upon bird cliffs, viz. 4) The Thule blue foxes and 5) The Scoresby Sund blue foxes.

It is a special habit of the lemming foxes to follow in the track of the polar bear, and in that case feed upon remnants of its meals. It may be mentioned that the main occurrence of the polar bear in Greenland coincides with the distribution outlined for lemming foxes. In the greater part of West Greenland about 90 per cent of the foxes caught are less than one year old, whereas in the northern parts of both West and East Greenland there is a larger proportion of older animals, a characteristic feature mainly of the lemming foxes (384).

It appears significant that the demonstrated occurrence of *Trichinella* in the arctic fox in Greenland coincides with the distribution of the lemming fox. The only exception seems to be formed by the trichinous foxes on the island of Disko. But this exception may be explained by the view that parts of the population in Central West Greenland are in periods made up of lemming foxes which have crossed Baffin Bay with the western sea ice (65). Disko lies in the centre of this migration. Some authors (4,5) expected differences in the infection rate according to differences in habits. This has turned out to be right. They expected a higher percentage in the coastal foxes. However, just the opposite appears to be the case.

There remains the most astounding fact that we have no evidence showing that *Trichinella* does occur in the foxes on the mainland of West Greenland, south of the Nugssuaq peninsula. As demonstrated above, there is a very high percentage of infestation in dogs precisely in these regions. Foxes are scavengers, as is well known. How is the complete absence, or, at the most, the extreme rarity, of infestation to be

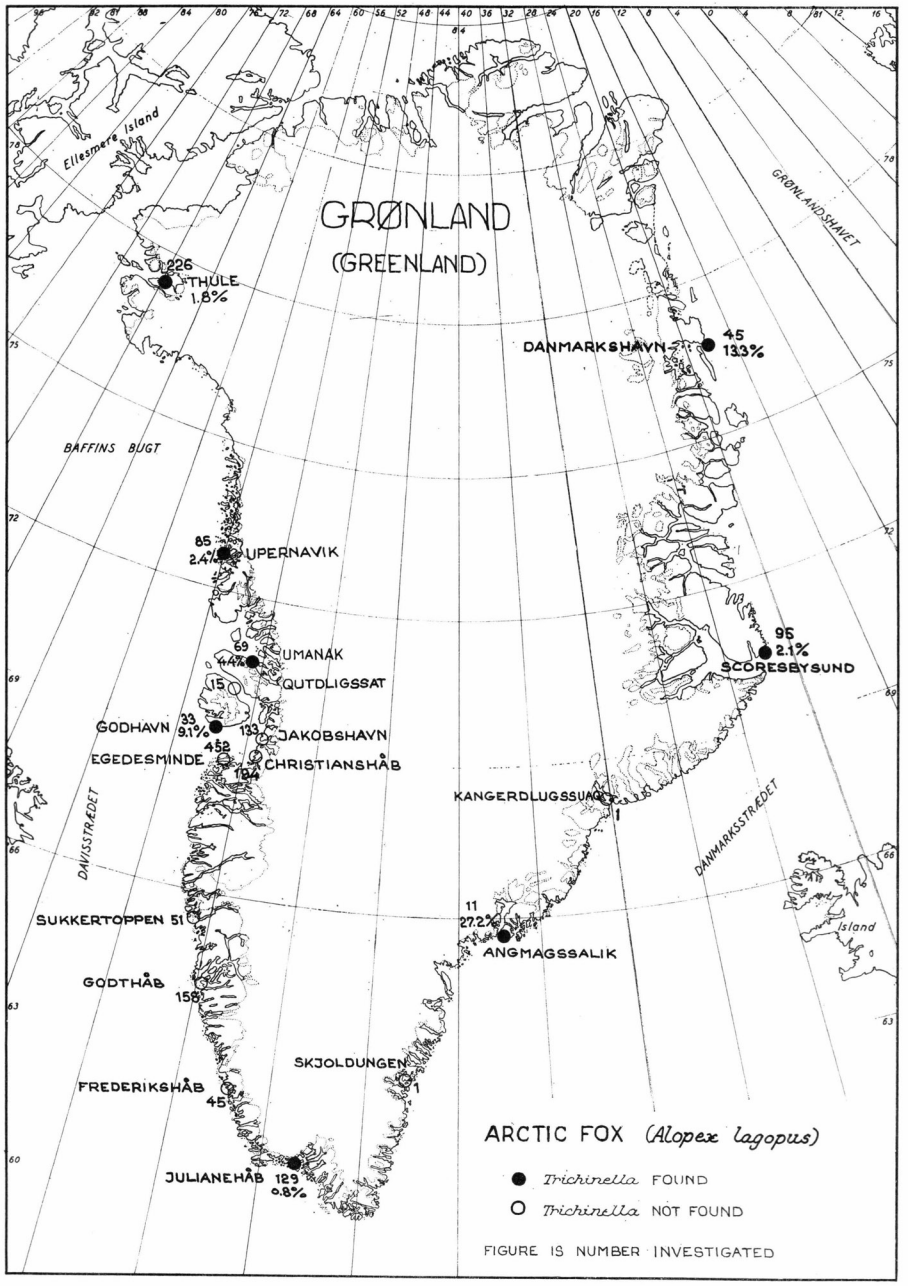


Fig. 4. Localities of samples, according to Districts, from Arctic fox.

explained? The only suggestion which it seems possible to give is that since the human population in West Greenland has risen considerably in recent years, the foxes have been driven more and more away from inhabited places. Therefore, they have practically no occasion of being infested any longer, since the main bearer, apart from dogs, of the arctic trichinelliasis, viz. the polar bear, does practically not occur in the domain of these trichina-free foxes (see table 5). Furthermore, the coastal foxes appear to have very specialised feeding habits.

Apart from the Danish material, 78 foxes from East Greenland have been examined (2). Only two were found to be positive (2.6 %). This percentage, low for these regions, suggests that many of the foxes were young. Seven foxes from North East Greenland proved to be negative (235).

Trichinae occur in the arctic fox in Arctic Canada (276), and the same is the case in Alaska (295). In a total collection of 222 foxes, 16 (7.2 %) were found to be infested. The authors expressly stress that the foxes from the two main localities, the Arctic coast and St. Lawrence Island (the least arctic of these), are chiefly dependent for food upon mouse like rodents, that is to say, there will be a considerable proportion of foxes corresponding to the lemming foxes in Greenland. In the first-mentioned locality 12 out of 117 proved to be infested (10.3 per cent), in the last-mentioned locality 3 of 94 (3.1 per cent), two examples corresponding well to the conditions in East and North West Greenland, respectively.

From the evidence presented it might be concluded with considerable probability that the trichinelliasis in the arctic fox is also circumpolar. The demonstration in the zoological gardens of Petrograd and Aschchabat of trichinae in *Alopex lagopus* (which may be assumed to have been of Russian or Sibirian origin) gives additional support to this view (140, 263). They have also been found in wild arctic foxes in the U.S.S.R. (54).

Regarding the source of infection in the case of the arctic fox, it may be summarised from the above considerations that the scavenging habits of the fox in regions where trichinous carrion is available to them, may account sufficiently for the infections found. Its low rate is probably explained by the short life of this host.

Walrus (Odobaenus rosmarus) and Bearded (or Square Flipper) Seal (Erignathus barbatus).

The manifestation of trichinelliasis in these strictly arctic animals is so similar in several respects that some common feature in their habits might be expected when compared with other seals. ROTH was the first to point out one common feature in connection with the problem

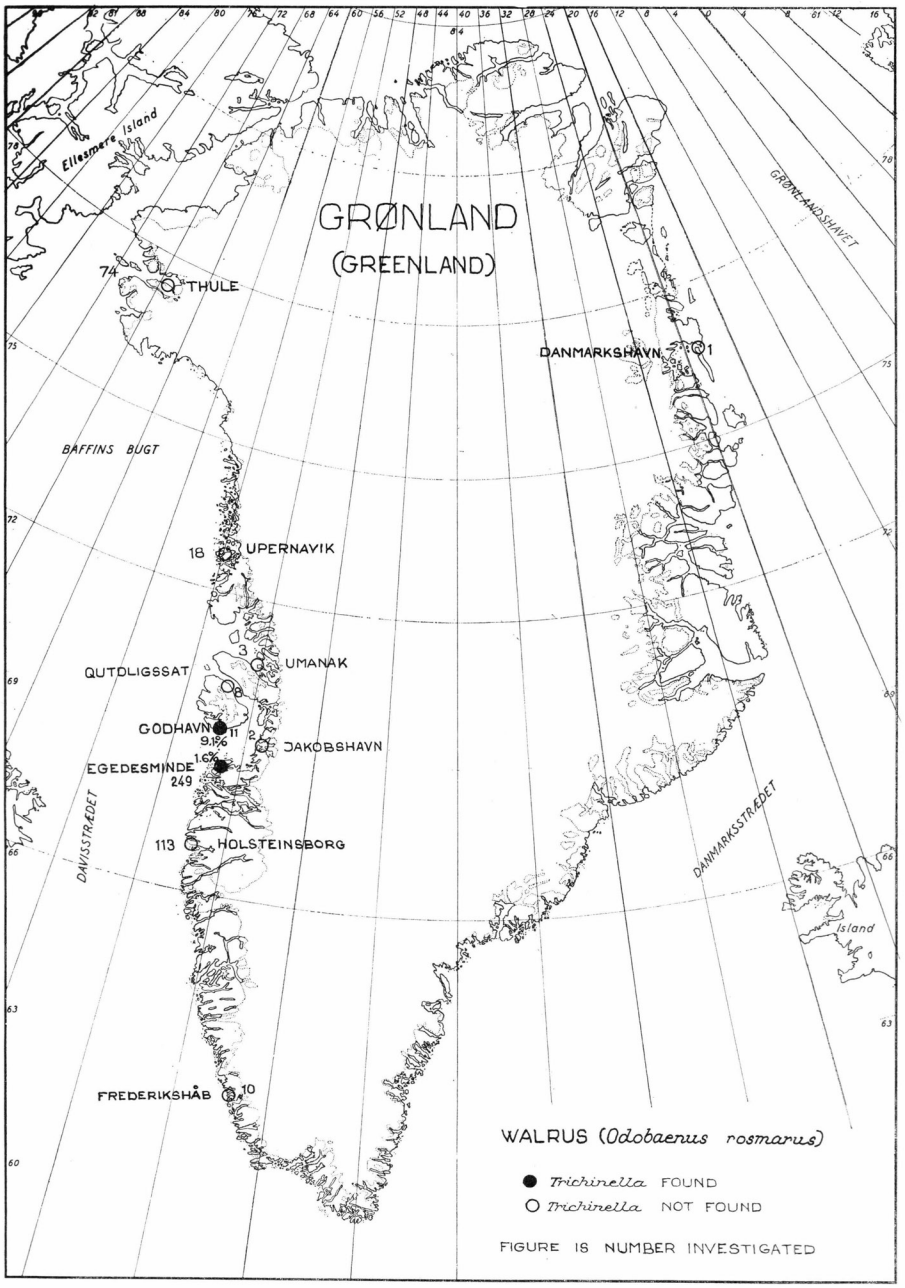


Fig. 5. Localities of samples, according to Districts, from walrus. In 1959 an infected specimen was found in Upernavik.

of *Trichinella:* the main feeding upon bottom animals (372). The problem was further elaborated (383) and it was stressed by me at the Zoological Congress in 1953 (304).

Other authors, without knowing VIBE's paper, were aware of this phenomenon (5), which probably holds one of the keys to the question of the source of the infection. Nevertheless, certain differences between walrus and bearded seal are apparent in this respect, and will be discussed in more detail below.

Walrus. The total collection of samples from Greenland comprised 489 specimens, of which 5 were positive, that is to say, a one percent infestation. (Only one specimen (negative) originated from East Greenland) (see fig. 5, p. 31). Although this is a low infection, epidemiologically the walrus plays an important rôle for man in the Arctic. From the Holsteinsborg District 113 samples were examined; none of them harboured *Trichinella.* Of 249 walrusses from the Egedesminde District four were positive (1.6 per cent). A number of 74 from the Thule District were examined without result. One more positive walrus was found among 11 walrusses from the Godhavn District. In 1959, a trichinous walrus was found in Upernavik. Thus the positive samples originated from regions in which outbreaks in man had occurred.

It appears from several papers that the infestation in walruses is widespread, as in the other animals treated here as yet. Seven out of 74 walruses which had been taken on the sea ice in the northern and eastern parts of the Polar Sea were found to be infected (9.5 per cent) (375). No trichinae were found in samples from seven and 47 walruses caught in the Canadian Northwest Territorries (74, 203), while in the Eastern Canadian Arctic off Baffin Island, Cornwallis Island, Chesterfield Island and Southampton Island, 17 out of 394 collected specimens were found to harbour *Trichinella*, or 4.3 per cent (204). As many as fifteen of the positive animals were taken off Southampton Island. This might indicate that the distribution among walruses is not uniform as suggested also by the findings in Greenland. This was pointed out by Dr. ROTH at an early stage of the investigation, in a report to the Greenland Administration: "It seems that only relatively few animals or flocks are infected, which only at years' interval will cause outbreaks". That 51 walruses from the arctic coast of Alaska and from St. Lawrence Island were found to be negative, agrees with this assumption (295).

There can be no doubt that the walrus generally feeds upon marine invertebrates, with a preference for bottom animals (105, 159, 183). This well-known fact was the cause of the perplexity aroused by the proven occurrence of *Trichinella spiralis* in a marine mammal. However, there is now ample evidence that the walrus may attack and kill seals, even men in kajaks (105, 383), and in many places it has access to fresh

carcasses of walrus and polar bear, which are left on the ice or thrown over board in vast amounts (375). Furthermore, dead dogs are often left on the ice during sledge travels, or may drift out to sea with the ice and disappear. Flensing of walrus and other big mammals is often performed in the tidal zone, with the result that débris of meat may flow about.

Finally, in inhabited places, dead dogs are generally thrown into the tidal cracks during the winter, and directly into the sea in summer, where they will often sink to the bottom. It will be seen therefore, that there is ample opportunity for the walrus to be infected, even if it only occasionally eats meat. It must be borne in mind too, that the walrus attains a great age. Not till it is four years of age will it be mature, and it is known to become at least 16 years old.

Bearded Seal. In the collections from Greenland, comprising 245 samples (31 of these from East Greenland), two were found to be trichinous, or 0.8 per cent. Of 36 specimens from Thule one proved to be positive (7.4 %). Of 74 from the Holsteinsborg and Egedesminde Districts, one was positive (1.4 %). One additional positive specimen occurred in the group of "undetermined seals" off Upernavik (see fig. 6). As pointed out above (p. 14), this specimen originated in all probability from a bearded seal.

Among 300 bearded seals captured on the ice in the northern and eastern parts of the Polar Sea, and 29 in the Canadian Arctic, none were found to be infected (203, 375). That the infestation (as might be expected) is nevertheless widespread, is suggested by the fact that one of 126 bearded seals (0.8 per cent) which were killed on the arctic coast of Alaska was positive (295). The apparent lower incidence, as compared with that of the walrus may be partially accounted for by the fact that these seals do not attain as great an age as the walrus. The above-stated difference between Thule (7 %) and Holsteinsborg-Egedesminde (1 %) may be correlated with the fact that the bearded seals caught tend to be older in more northern regions.

Even though the infection of walrusses with *Trichinella* may be a matter of some surprise, the infection of the bearded seal is still more puzzling. The circumstance that the walrus decidedly prefers mussels to other marine invertebrates, while the bearded seal prefers certain snails, and devours a great many crustaceans and occasionally even eats fish, means that walrus and bearded seal as regards food in no way compete with each other (383). Therefore, the common habit emphasised above: feeding on bottom animals, does not after all play a very great rôle. As pointed out above the infection in walrus might probably be attributed mainly to its occasional scavenging habits, while little is known of such habits in the bearded seal. That it may occur, very

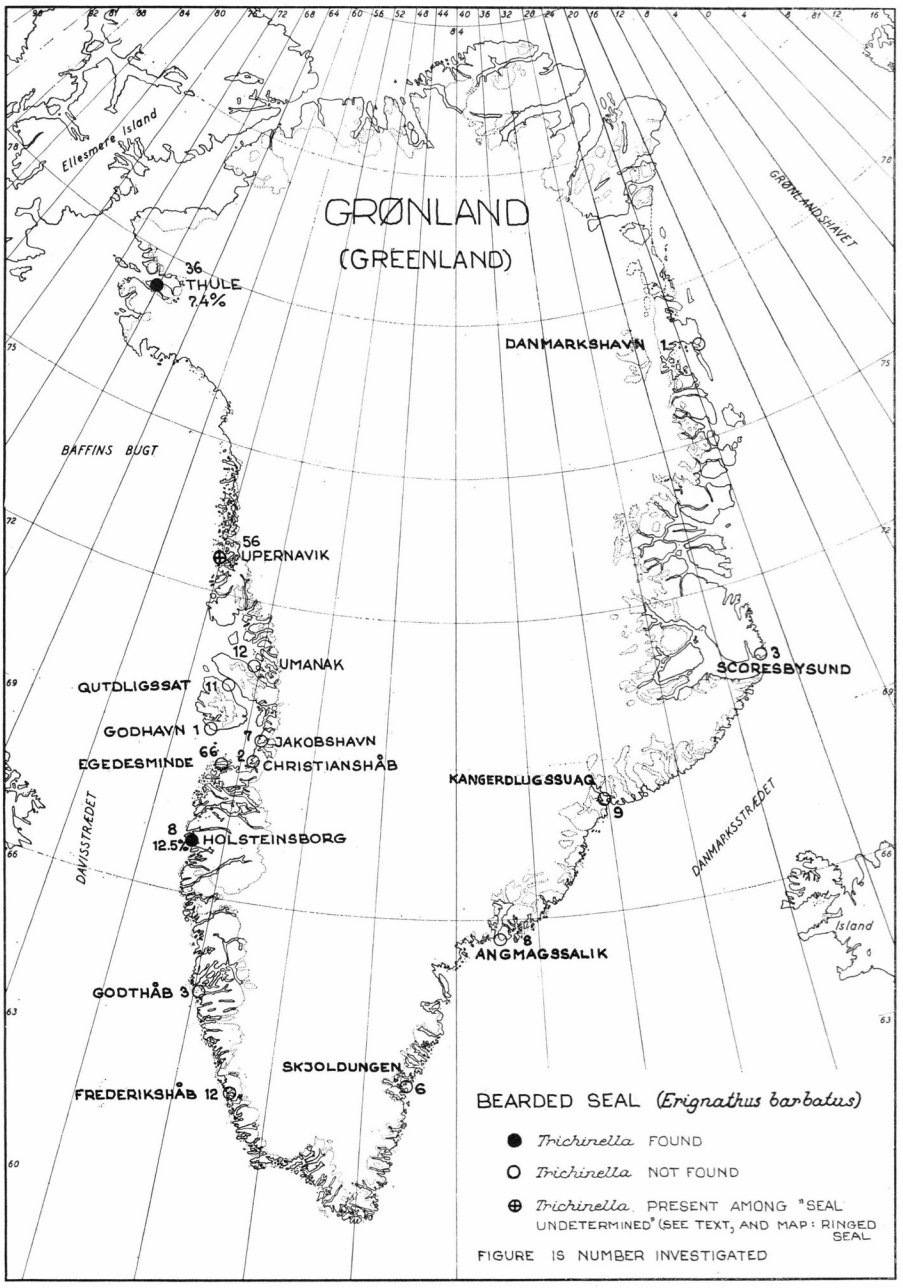


Fig. 6. Localities of samples, according to Districts, from bearded seal.

occasionally, is suggested by the observation that seals have been seen to feed upon carcasses left on the ice (375).

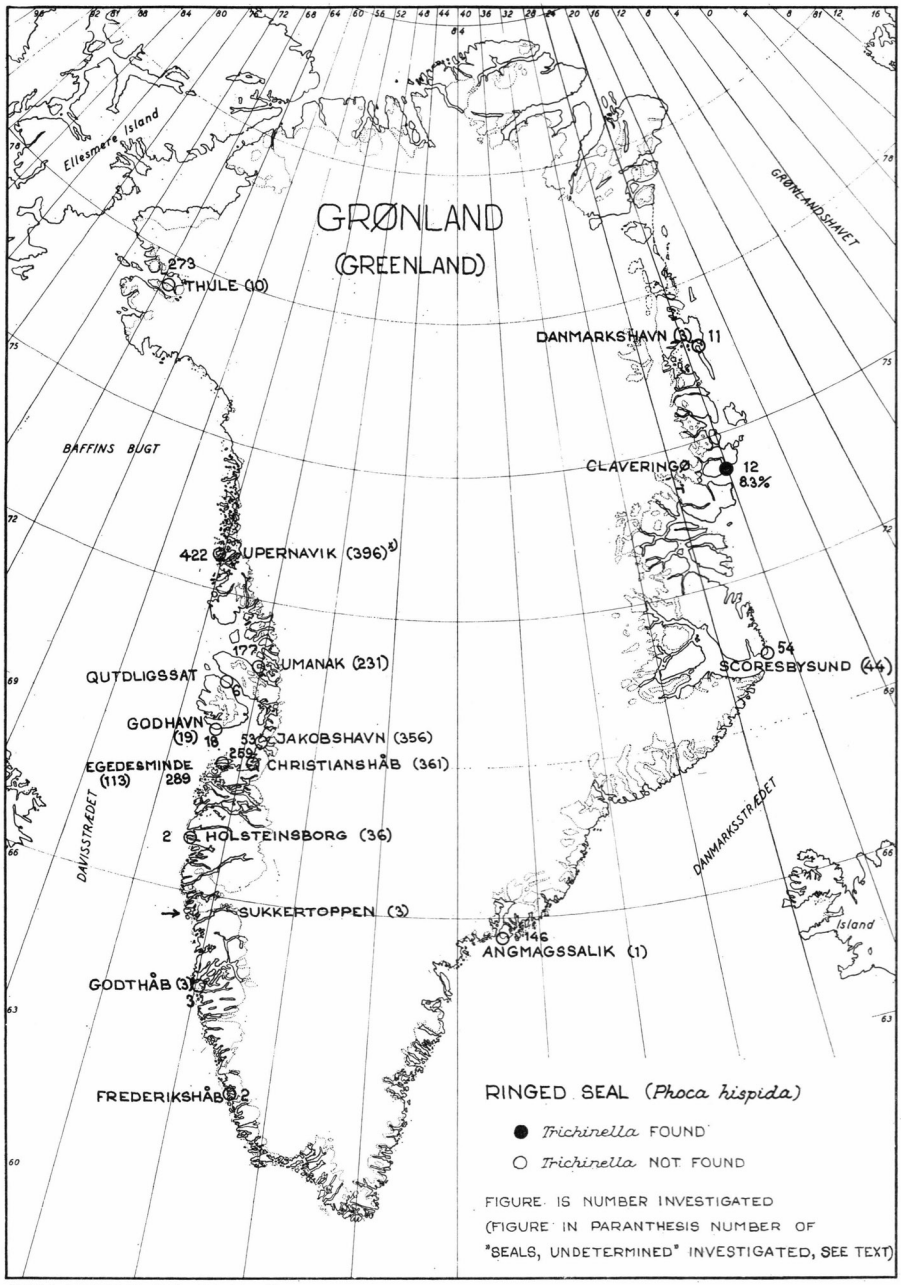
From observations on carcasses sunk to the sea bottom, teaming with and being separated by swarms of amphipods, it was concluded that these animals, together with small pieces of meat, might provide some explanation of the occurrence of *Trichinella* in seals (383, p. 95). To the amphipods other crustaceans like crabs, etc., may be added. That the infection in the ringed seal is so extremely rare may be explained by the fact that this seal is a plankton feeder, whereas the bearded seal is definitely associated with the sea bottom.

The Ringed or Jar Seal (Phoca hispida) and other Seals.

In the samples available to Dr. ROTH (see table 1) the following seals were represented: 52 ringed seals (one positive) and 56 bearded seals (one positive). Of the other seals the following were available: 59 bladdernose or hooded seals, 40 harp seals and 99 undetermined seals, all of them were negative for trichinae. It was quite natural, therefore, that ROTH was of the opinion that trichinae were probably widespread in seals, with the consequential significance for the infection in polar bears. The additional material has changed this view. The fresh collections of more than 1,700 ringed seals did not disclose any trichinae. The same was the case with more than 1,550 undetermined seals, which material undoubtedly comprised also ringed seals, together with bearded seals (among which, as pointed above, one positive was found), hooded seals and harp seals (see fig. 7, p. 36). Of these latter species an additional material of 141 and 2,365 samples respectively, is now available from Greenland. To this can be added samples from 24 spotted or harbour seals.

The three last-mentioned species were all negative. Disregarding in this connection the walrus and the bearded seal, the trichina infection in seals in the Arctic is as follows: The widespread migratory seals, which are to a great extent independent of the shores and feed upon animals living freely in the waters, harbour no *Trichinella.* Only in the ringed seal, which is a stationary coastal species, may infestations quite exceptionally be encountered. The above-mentioned *Gammarus*-hypothesis (383) most reasonably applies precisely to this species and the rareness of infestations might be accounted for in this way.

Other investigations have substantiated the distribution in the seals just described. No trichinae were found in 6 and 224 samples from bearded, ringed and harp seals in the Canadian Arctic (74, 203). On the various western, northern and eastern seal-hunting-grounds no trichinae were found in 8 ringed seals, 192 hooded seals and 1,955 harp seals (375). Among 310 samples of seals taken off the west coast of Alaska



a) ONE POSITIVE FOR *Trichinella*
CERTAINLY BEARDED SEAL (*Erignathus barbatus*)
(SEE MAP FOR THIS SPECIES, AND TEXT)

Fig. 7. Localities of samples, according to Districts, from ringed seal and "seals, undetermined".

(comprising a majority of ringed seals and spotted seals, including a few ribbon seals *(Phoca fasciata)*), two (0.66 %) were found to be positive for trichinae (295). Considering that the spotted seal to a far greater extent than the ringed seal, is a fisheater (105) and considering further the conditions in Greenland, it seems most probable to assume that the two infected animals were actually ringed seals.

In this connection mention may be made of a material examined by Dr. CARLTON M. HERMAN, and published by RAUSCH et al. (loc. cit.). It comprised 101 fur seals *(Callorhinus ursinus)* which were all found to be negative. This was also the case with 101 samples from the following antarctic species of seals: Weddell seal; Leopard seal, and Ross seal (375). All these seals are piscivorous.

Whales, Particularly White Whale (Delphinapterus leucas) and Narwhal (Monodon monoceros).

During the outbreaks of trichinosis in man in West Greenland in 1947, their source could in most cases be traced to the consumption of walrus meat. As regards the outbreak occurring in Qeqertaq in the Jakobshavn District at the beginning of January 1947, this was not the case (372). The only possible source of infection appeared to be flesh of white whale. Also some of the patients in other places denied having eaten walrus meat, but admitted having eaten meat of white whales.

An acquisition by this animal of a trichina infection is still more difficult to understand than that of the ringed seal, since it appears to be almost exclusively piscivorous. An infection of the narwhal would be a little more understandable, for it is known to eat a considerable amount of crustaceans, especially shrimps, in addition to fish, thus being more associated with the sea bottom.

Be this as it may, no trichinae have been found, in our admittedly not very large, material of 235 white whales and 53 narwhals. It is all the more interesting that *Trichinella spiralis* has actually been found in Alaska, off the Arctic coast, in one of 49 white whales examined (295). Nine and fourteen white whales from the Canadian North West Territories, (74, 203), harboured no trichinae. From this it appears that the infection in the said Arctic whales must be extremely rare, at most on the low level found in the ringed seal. However, it might, under the circumstances, present a considerable risk to man.

Thirty-four toothed whales of several species and seven baleen whales were examined with a negative result (see table 2, p. 14). As emphasised above, an investigation of more samples of the killer whale *(Grampus orca)* would be of special interest, because here a definite chance

of infection must be present. An infection of baleen whales must be considered highly improbable. Fifteen baleen whales, killed off Alaska, were found to be negative (295).

Various Carnivores.

That the arctic wolf *(Canis lupus)* presents trichinelliasis in Greenland is apparent from two cases ascertained by Dr. ROTH, in two of four hides from the collections in the Zoological Museum of Copenhagen (see Fig. 3). The infection might be expected to have a wide distribution in the Arctic. This supposition is supported by the demontsration of trichinae in 51 of 154 wolves (33.1 per cent) killed in Arctic Alaska (295). The authors assume from their findings that in the localities examined the wolves must have been infected by eating smaller mammals, since seemingly there is little access to carrion other than of ruminants. However, it should be borne in mind that the infections registered have been acquired over long periods of time, and the roaming of the arctic carnivores may easily be underestimated. Most experience with *Trichinella spiralis* points to the conclusion that high rates of infection in a population will in general only be reached when the source of infection is some kind of carrion.

The only carnivore occurring in Greenland besides the polar bear and the arctic fox is the ermine or stoat *(Mustela erminea)*, which occurs in North and North-East Greenland southward to the Scoresby Sund District. Unfortunately, it has only been possible to investigate a total of 26 ermines from Greenland. To these may be added 14 from the Central Canadian Arctic, taken out by the present writer from the collections of the Zoological Museum in Copenhagen. No trichinae were found. Since the ermine is mainly dependent upon the collared lemming *(Dicrostonyx torquatus)*, these negative results make a widespread occurrence of trichinae in the lemmings in Greenland highly improbable. On the other hand, it is quite probable that an occasional infection, dependent upon occasional feeding on carrion of other animals, might appear in a larger material of ermines from Greenland.

In Alaska no less than 18 of 51 ermines were found to be infested (35.3 per cent) (295). Of these, 40 alone, collected in the Brooks Range (that is, in the northern parts of Alaska), contained 17 of the positive samples (42.5 per cent). Conditions here are evidently different from those met with in Greenland, as shown also by the fact that the authors found one in two least weasels *(Mustela rixosa)* to be positive. On this background it is surprising that 18 martens *(Martes americana)* and 43 minks *(Mustela vison)* in Alaska proved to be negative. It is, however, not stated whence these animals originated and this may explain the

difference. It is less surprising that seven otters *(Lutra canadensis)* and 20 sea otters *(Enhydra lutris)* were found to be non-infected, considering that these latter animals are predominantly piscivorous.

The occurrence of trichinae in ermine and weasel in Alaska seems in some measure to be accounted for by the actual demonstration in Alaska of *Trichinella* in several species of rodents. In any case, there seems to be a great variation in their occurrence. For the present it does not seem possible to attempt to offer any explanation of this variation except that it may be due to the accidental accessibility to infected carrion.

The finding in Alaska of larvae in 17 of 38 wolverines *(Gulo gulo)* examined is, on the other hand, not surprising. It was expressly stated (295, p. 363): "Rates of infection in this series of wolverines did not differ with the locality from which they were taken". This occurrence rather presents a confirmation of the views presented here regarding the spread of the infection in the Arctic. The wolverine is notoriously a very voracious animal, and is known to be an eager consumer of carrion.

Also the lynx *(Lynx canadensis)*, another carnivore of considerable size, of Arctic America showed a considerable rate of infestation in Alaska, four out of 17 animals (23.4 per cent) being found to be positive. This occurrence might be explained in part by the fact that the lynx is highly dependent upon the snowshoe hare *(Lepus americanus)*, which in Alaska exhibits a rather considerable rate of *Trichinella*-infection, viz. about 4 per cent.

Various Rodents.

It can now be considered an established fact that especially in the Arctic, rodents may eat meat, whenever they happen to come across it. Quite naturally therefore, rodents were also taken into consideration when our material was collected.

In Greenland only two rodents are native: the collared lemming *(Dicrostonyx torquatus)* in North and North East Greenland, southwards to Scoresby Sund, and the arctic hare *(Lepus arcticus)*, which is distributed all over the country. Of collared lemmings, only nine specimens were available. To these can be added, from collections in the Zoological Museum of Copenhagen, six specimens from the Central Canadian Arctic. They were all negative. Not very much can, of course, be concluded from these few samples, but is has been emphasised above (p. 38), mainly on account of the non-occurrence in ermines, that if trichinae occur at all in lemmings in Greenland, the infection must be extremely rare.

A corresponding result will be arrived at, if we consider the Arctic hare (see table 6, p. 40), of which almost 200 were examined without result.

Table 6. Number of samples of Arctic hare, according to districts; all negative.

Julianehåb	12
Frederikshåb	3
Godthåb	20
Sukkertoppen	50
Egedesminde	2
Christianshåb	4
Jakobshavn	13
Umanak	20
Thule	54
Danmarkshavn	13
Total...	191

From the high-arctic regions (Thule, North-East Greenland) a total of 67 hares were examined. If we consider this as a random sample, with a level of confidence of 99%, our result might still mean a level of infection up to about eight per cent. But, if this high percentage should actually exist, the percentage infection in foxes might be expected to be even higher than is actually the case. This consideration might seem still more justifiable in the case of the 89 hares, originating from the parts of the West Greenland coast, where not a single trichinous fox has been found (see fig. 4, p. 29).

Anyhow, as yet there is no evidence indicating the occurrence of *Trichinella* in herbivores in Greenland. However, from what is known, also from my own observations in North-East Greenland, of the feeding habits of the hares, an occasional infection in these regions cannot be excluded. Something similar might be said regarding the 25 arctic hares and 21 collared lemmings examined without positive results in Arctic Canada (203).

As was the case with the ermines in Alaska, in respect of the rodents also, conditions are quite different from those in Greenland and possibly in the Canadian higharctic regions. A great many species are infected at a comparatively high rate (295). Although seven collared lemmings proved to be negative, one of 18 (5.6%) brown lemmings *(Lemmus trimucronatus)* harboured trichinae. The same was the case with two of 49 (4.1%) red-backed voles *(Clethrionomys dawsoni)* and one of 57 (1.8%) narrow-skulled or Alaska voles *(Microtus miurus)*. The rate of infection appears to be approximately on the same level as those of the ground squirrel *(Citellus parryi)* (one of 129 examined: 0.8%) and the red squirrel *(Tamiasciurus hudsonicus)* (four of 93 examined: 4.3%). Also the snow-shoe hare *(Lepus americanus)* presented a similar rate of infestation (two of 53 examined: 3.8 per cent). On this background of apparent uniformity and regularity of infection in a number of rodents, the

absence of the parasite in 234 tundra voles *(Microtus oeconomus)* seems surprising. The material is not presented in such a way that it is possible to decide whether the infection occurred in patches, as might be expected.

Rats *(Rattus norvegicus)* are not generally able to establish themselves for a longer period in Greenland. The 18 rats contained in the collections presented here did not contain trichinae. But there can be no doubt that if they might be established in regions in which a high incidence of infection is found in dogs, the rats would also become infected. In Alaska, both in subarctic and in more pronouncedly arctic regions where the rats are able to subsist, they have also contracted an infection. The source of this infection is not discussed (315, 316).

Various Herbivores.

Of wild-living ruminants in Greenland only one specimen of the muskox *(Ovibos moschatus)* has been examined, but without positive results. No samples from reindeer or caribou *(Rangifer tarandus)* were available. About 1000 sheep investigated in South Greenland were found to harbour no trichinae. Samples without trichinae were reported from two moose *(Alces americana)* and eight caribou in Alaska (295). Altogether an infection of ruminants is, of course, not very probable; if at all found, it must be in the Arctic. To my knowledge no natural infection of a ruminant is known and an experimental infection is not very easily made. The record by ZIMMERMANN et al. (417), with DOLMAN (100) as authority of moose and deer as known hosts of *Trichinella* is due to a miscitation by DOLMAN of papers by RAUSCH.

Finally, it may be mentioned that 28 pigs in Greenland have also been examined without revealing any infection. Pigs are not bred in Greenland, but in small numbers imported from Denmark (which is free of trichinae, see below p. 59 ff.), and only raised indoors to be slaughtered. With the exercise of caution and no use of uncooked scrap, the chance of their getting infected is inconsiderable.

A SUMMARY OF OUR PRESENT KNOWLEDGE OF THE DISTRIBUTION OF TRICHINELLIASIS IN ARCTIC MAMMALS

Although our knowledge of the occurrence of trichinelliasis in arctic mammals is based upon more than 15.500 samples of some forty species of mammals from places far apart, supplemented with a considerable number of incidental observations, it must be considered to be of a rather imperfect nature in several respects. Nevertheless, some generalities and predictions may be ventured.

It is a fact that several mammals with a circumpolar distribution, are subject to infestation throughout their whole range. The polar bear is an especially distinct example of this, as we are in possession of direct evidence from both of the big continents reaching up into the Arctic, from the big arctic islands and from the sea ice connecting them. The same can be said, though to a less extent, of the arctic wolf and the arctic fox. From sledge dogs we have direct evidence from Spitzbergen (Svalbard), Greenland, and the American Arctic westward to Alaska. There can hardly be any doubt that also the Russians have observed it in dogs in Arctic Siberia, even though I have not found any reference to it. There seems to be no reason, therefore, to doubt that the situation will be the same whereever sledge dogs are used. Of these animals, the polar bear appears to present the greatest immediate risk to man.

Another serious direct hazard to man in the Arctic is the occurrence of *Trichinella* in marine mammals. Here the walrus quite naturally, if only because of its big size, comes into the foreground. Direct evidence of infections of walrus is available from the Canadian Arctic, Greenland, and the vast icefields between Greenland and the other large arctic islands. It would seem rather safe to assume therefore, that this infection also is circumpolar.

Even though our direct evidence in regard to the bearded seal, the ringed seal and the white whale is very limited, the habits of these animals are mainly the same all over the Arctic. The same may be said of the peoples inhabiting the arctic shores and the hunters, both native and European-American, performing their slaughter on the Arctic

icefields, thereby contributing, probably significantly, to the spread of trichinae. In regard to the seals mentioned above we have direct evidence from places as far apart as Greenland and Alaska and in the case of the white whale direct evidence from Alaska and indirect evidence from Greenland. It would seem probable therefore, that also these infestations are circumpolar, even though the percentage of occurrence in ringed seal and white whale has a sporadic character. The prophecy might be ventured that the narwhal also will some day be found to be infested, and the same might with still greater probability turn out to be the case with the killer whale.

As to Greenland, we have information pointing to the probability, or at any rate a definite possibility, that in some animals the distribution of *Trichinella* is not circumpolar, in the sense of a continous distribution, even though the host may be so. This may be due in part to Greenland's unique position in a zoogeographical respect, in regard to terrestrial mammals. Something similar might apply to the other large arctic islands, but our knowledge of these regions in respect of trichinae is almost nil. Their fauna of terrestrial mammals is poor in species, as compared with the arctic regions of the continents. Apart from caribou and muskox (with which we are not further concerned here) and the highly migrating species: polar bear, arctic wolf, and arctic fox, the only terrestrial mammals in Greenland are the ermine, the collared lemming (both presenting the same distribution, from the Thule region north-eastward and southward to Scoresby Sund), and the arctic hare.

None of these species have been found infected in Greenland, but the possibility of infestation cannot be completely excluded, particularly in the higharctic regions, owing to the comparatively scarce material available. But there is sufficient indications that if it should turn out to be present, the infection will at any rate be very rare. Little is known of these species in other regions, but the studies made in Alaska might give certain clues. There the ermine is evidently rather frequently infected, along with lemmings and other rodents. Only quite few collared lemmings have been examined in Alaska, but it seems probable that this species will in time also be found to be infested along with the other lemmings and several species of voles. This occurrence in Alaska induces us to turn our attention to a possible distribution of the parasite in these animals in other Subarctic regions also, whence practically nothing is known.

Already from an examination of the material in Alaska it seemed probable that great regional differences will gradually become apparent, and probably partly in the form of a tendency for the intensity of the trichina infection to be enhanced, the more purely wilderness conditions prevail. The arctic hare is not found in Alaska, but the related snowshoe

hare exhibited a comparatively high rate of infection. In this connection also, the apparent lack of trichinae in coastal foxes along the southern coast of West Greenland may be mentioned (see p. 28).

A number of other carnivores are also circumpolar, even though they mainly occur on the continents. Of these, mention may be made of various species of bears, the lynx, the red foxes and the wolverine, besides the arctic wolf, which is the same species as the more southern wolves. All these species display high-rate infestations in Alaska, the only arctic region from which we have direct reports (295, 399). But considering the high rate, at all events in the polar bear, along the Sibirian coast, the continous contact of many of the species mentioned, and on the strength of evidence which will be presented below (p. 45 ff), it might be considered probable that the above mentioned species will also prove to be infected in the Sibirian North, which passes gradually into the European Russian North. That a similar condition may prevail along the Scandinavian Arctic coast, is suggested by the finding of *Trichinella* in a brown bear *(Ursus arctos)* in Northern Sweden (55). The smoked meat of this bear caused several small outbreaks in various parts of Sweden.

ON THE DISTRIBUTION *TRICHINELLA SPIRALIS* IN WILDLIVING CARNIVORES, ETC., IN SUBARCTIC AND TEMPERATE REGIONS

Especially from the work done in Alaska it is evident that there is no sharp boundary between the occurrence of trichinae in wild carnivores in Arctic and subarctic regions, and judging by the somewhat scanty and accidental information available in the literature, it seems probable that *Trichinella spiralis* through a direct connection with the Arctic-Subarctic distribution is much more widespread also in Temperate regions than has as yet been realised.

U.S.A. There is evidence at hand showing that trichinae are rather widespread in bears in the mountains of California, that is the southern end of the mountains and wilderness areas, in the northern end of which we know the infection to be extremely widespread. Outbreaks of trichinosis among human beings after the consumption of jerked black bear meat *(Ursus americanus)* were reported on several occasions (125, 248, 393). It must be admitted that in a few of these cases it was especially stressed that the bear had raided pig farms. But it must be borne in mind that this indication is at the same time an attempt at an explanation of the finds, an explanation which at the time must seem the most probable. In some of the cases pigs cannot be completely disregarded as the source of the infection. From another wilderness area in the United States, the Adirondacs in Northern New York State, an outbreak resulting from the ingestion of black bear meat was also reported (397).

Recent papers (417, 419), the first ones published in America turning attention directly to wildlife, have for the first time demonstrated a widespread occurrence of trichinae among wild-living carnivores in the temperate United States, i. e. in Iowa. Particularly high percentages were found in minks (24 out of 354 = 68 per cent) and foxes (72 of 748 = 9.6 per cent). The species of fox involved was mainly the red fox *(Vulpes fulva);* only a few grey foxes *(Urocyon cinereo-argenteus)* occurred in the material. This is especially interesting since the red fox is only to a slight degree associated with human dwellings. Also the opossum *(Didelphis virginianus)* (two out of 152 = 1.3 per cent) and raccoon

(Procyon lotor) (four out of 584 = 0.7 per cent) were lightly infected. It is also significant that trichinae were found in four of 25 (16 per cent) coyotes *(Canis latrans)*. Of this same species, one of eight specimens from Alaska proved to be infected (295). Finally, two out of 92 spotted skunk *(Spilogale putorius)* were found infected. Trichinae were found in one or other species in localities far apart in Iowa.

By these findings, other reports (152, 345) of trichinae in the American badger *(Taxidea taxus)* and the skunk *(Mephitis mephitis)*, respectively, both in Maryland, gain in significance. The same holds good for the not more closely specified occurrences in the American badger and raccoon (353). Also the coyote and the wolf have been mentioned as spontaneous hosts for trichinae. I have not been able to trace the source of this statement (Own observation?) (96). It is true that in some cases an infection from infected refuse could not be precluded and it is evident, as will be clear from numerous experiences from Europe referred to later, that in inhabited regions there will be an interplay between the infections in domesticated and wild animals. The previously baffling occurrence of trichinae in grain-fed pigs might partly get its explanation in an accidental contamination of the food by carcasses of carnivores and possibly, also, to a certain extent by feces of these animals containing undigested capsules (418). The first explanation actually holds good in some places in Europe (see p. 49, 50). In six feral swine from the southeastern United States no trichinae were found (144).

Asia and Russia. If we consider the distribution in Asia-Europe of a number of the previously mentioned mammals (59, 72) which likewise have a widespread occurrence in the North American arctic-subarctic and boreal regions (see e. g. 78), it will be evident that over vast areas of wilderness there is a biological interplay among these species, on the one hand towards the Arctic, on the other towards warm temperate zones. Our actual knowledge of *Trichinella* from the central regions of these distributions is practically nil, but interesting information is at hand from the fringes of these areas of distribution.

The data from America have been commented upon above. As in Alaska trichinae have been found in the Far East, in Kamchatka, in brown bear *(Ursus arctos)* (413). The same species has repeatedly been found to be infected in Caucasus, the southern border region between Russia and Asia (61, 133, 308, 334). Also in other regions of Russia trichinae have been found in the brown bear (245), even though the actual localities are not indicated, in percentages of infection up to 30. From the Moscow region an outbreak caused by ingestion of brown bear meat is reported (45). In this context a find made in a bear in Berlin, in the Offices for Foreign Meat Inspection, may be mentioned (17).

Very high percentages of infection are mentioned (245) in a number of carnivores, especially wolf, fox and badger (see also 41, 243, 337, authors who in various regions and at various times found the badger to be infected), but also various martens. Further, the lynx (53), the sable *(Martes zibellina)* and the wild cat *(Felis catus)* (262) are indicated as hosts. In the White Russian Republic the following animals were infected: 19 out of 33 foxes (58 %), 21 of 24 wolves (88 %), two of 5 lynx, and one of two raccoon-dogs (277). In the region around Saratov (lower Volga) 97 of 152 wolves (54 per cent) were infected (60), and practically all adult wolves in the Kursk region (almost midway between Saratov and Kiev) were infected (150).

Trichinae occur in wild boar *(Sus scrofa)* in the lower Volga region (104, 307). A general percentage of infection of twenty is given (245). Also from Kazakhstan in Caucasus it was recorded (89).

In the Tatar-Republic in Caucasus various fur-bearers were found to be infected in fairly high percentages (232): fox (twenty-three of 187 = 12 %), European mink *(Mustela lutreola)* (four of 101 = 4 %), pine marten *(Martes martes)* (three of 15 = 20 %), stone marten *(Martes foina)* (one of 13 = 8 %) and ermine (one of seven). No less than three caracals *(Caracal caracal)* of 9 examined were infected, in the zoo of Ashkhabad in Turkmenistan (195). In Tadzikistan, on the outskirts of the Himalayas, 936 wild boars in 1953—1955 were found to be without trichinae. Trichinae occurred, however, in one out of four in the Nuregskogo mountain district in 1956. Furthermore, trichinae were found in three out of 69 brown bears examined (7.3 %) (261).

The far Eastern raccoon-dog *(Nyctereutes procyonoides)* has been introduced in recent years into various parts of Siberia and Russia. Trichinae were found in light infections in the Novgorod and Leningrad regions (53). One of five raccoon-dogs examined was infected in the Tatar Republic (232). This species has been found infected in Germany too (see 194). This may have been a farm-animal; the original paper has not been available to me. It may be mentioned here that this species of carnivore is spreading westwards, towards Germany and into Finland and Sweden, and populations are about to establish themselves in these countries also from individuals escaped from fur-bearer farms.

Eastern Europe. In Hungary it is probable that trichinae occur in foxes and badgers (197). In Poland in the Białowieża-Forest, *Trichinella* has been found in wolf, fox and lynx (50, 51). One out of 6012 wild boars were found to be infected (312). Another statistics furnished a percentage of 0.75 (199). Of 66 foxes about 20 per cent were infected (209). It is evidently widespread in Poland, as the map on p. 343 in this latter paper shows. Seven of 68 foxes (10 %) (123) and 17 out

of 75 wild foxes (23 %) were infected (202). Human outbreaks after consumption of meat of wild animals living in the forests are reported (349). Trichinae were found in East Prussia in a badger, living far from human habitations (223).

From Czechoslovakia a find in a stone marten in Neuschloss, Bohemia, is reported (83), and trichinae are indicated to be widespread among upland carnivores and rodents in Slovakia (164). (Regarding the latter hosts, see below p. 52 ff). The following species were found to be infected: 20 out of 74 foxes (27 %), four of 6 lynx, one out of 3 wolves, three of 19 wild cats (15 %). Four badgers, 3 pine martens, 2 stone martens, 8 pole cats, and 121 stoats were negative (250).

Scandinavia. As mentioned above, one case of trichinelliasis in a brown bear is known from Northern Sweden (55). Foxes and badgers are rather commonly infected. Seven out of 16 foxes examined were positive (= 44 %!) (153). The investigation of a big material of foxes from the trichina-inspection offices in Stockholm is reported (165), but unfortunately, no distinction is made between farm and wild foxes. However, 64 out of 2826 examined badgers at the same office (2.3 %) harboured an infection.

In Norway also, foxes and badgers are often trichinous. The work regarding wild carnivores has been summarised (169). According to this summary, 28 of 135 foxes (22 %), and two of three badgers were found to be infected. In Norway and Sweden two other important probable hosts of *Trichinella* occur, viz. the wolverine and the lynx. In the years 1941—1946 3232 samples from human beings in Norway have been examined. Eight of these revealed trichinae (= 0.248 %) (169). The overall infection in hogs appears to be considerably higher in Norway (around 0.01 %) than in Sweden (about 0.0001 per mille) (247). Both in Norway and in Sweden outbreaks among human beings have been described up to these days (40, 119, 341). They were caused by infected hog.

Curiously enough, trichinae do not seem to have been found in pigs in Finland, up to 1940, even though trichina-inspection is regularly performed (365), but in recent years some were found (1954: 4, 1955: 4, 1956: 2), while cases in man have not been reported since 1890 (247). No doubt they will be found in wild animals, if they are looked for.

In a polar bear from a zoological garden trichinae were found under such circumstances that the acquisition in Finland would seem probable. The source of infection is supposed to have been dog meat (155).—Denmark will be considered below (p. 59).

From the data considered above it would appear that *Trichinella spiralis* is distributed with an enormous frequency in wildlife in the fringes of the North European and Asiatic wilderness areas, so to speak

radiating from it. It does not seem unreasonable to predict that the wild carnivores in these vast areas will prove to be highly infected.

Germany. From the above described distribution of trichinae in Eastern Europe there is an even transition to the conditions in Germany, where comparatively intensive studies on their distribution in wild-living carnivores and in the wild boar have been made. Our most complete knowledge is derived from the central and southern mountain regions, while less is known from the eastern and northern plains. Most reports concern its occurrence in wild boar, fox, and badger. Furthermore, the occurrence in polecat *(Putorius putorius)* and pine marten is known from isolated finds. The frequency of occurrence is only noted in rather few instances. Thus 21 (0.075 %) of 27866 wild boars examined in Berlin were positive (69). Also in the decade before the turn of the century wild-boars examined at the inspection office in Berlin were often found to be infected (132). Of 120 foxes from various parts of Germany, five were found to be infected (4.2 %) (83).

Trichinella has been reported from all the major provinces of Germany. As already mentioned, an infected badger was found in Ost-Preussen (East Prussia) (223). From this region a case has likewise been reported, of a group of pigs of which only those that had been feeding in a forest were found to be infected (27). On the plains of Brandenburg the wild boar was found infected, and an outbreak of trichinosis in man after the consumption of meat of a badger is also reported (317). However, trichinae did not occur among 179 foxes near Frankfurt a. d. Oder (210). A trichinous wild boar was found in Pommern (206). From Mecklenburg (Northern Germany) also, only older records are available: on two occasions an infected polecat, furthermore a wild-boar was found (217, 218), and two badgers, which were dug out of the same den, were also infected (367).

In the East, in Schlesien (Riesengebirge), a trichinous fox has been found (219). In Sachsen (Saxonia) along the Erzgebirge, bordering on Czechoslovakia, trichinae have been found in foxes (148, 163, 192) and badgers (15, 103, 194). From both of the latter species other finds are also reported (44, 400), also the occurrence in wild-boar, in which species trichinae had previously been found once in these regions (14, 400). A dog, which had been fed on fox meat, was found to be trichinous (194). Along the mountains west of Czechoslovakia, in Bayern (Bavaria), trichinae have most often been found in foxes (23, 44, 357), but also once in a wild-boar (44). An outbreak comprising 6 persons, occured in 1882. The pig had been fed on fox meat (39).

In Württemberg (between Bayern and the Schwarzwald mountains) infection with trichinae has been found to be extremely widespread and

frequent in foxes, even though no actual percentages are given (19, 20, 23, 27, 28). In the wild-boar it has also been found (26, 44). In Baden, the region of the Schwarzwald mountains along the border to France, both foxes and badgers have been found to be infected (44, 49, see also Deutsche Jagd, 1935, p. 1147).

From the northermost mountaneous regions, the Harz mountains (in Braunschweig), a number of observations from earlier times are available, from polecat, pine marten, and fox (386—387). The occurrence in the latter host was also reported more recently (309, 369). Seventeen per cent of 48 foxes (173) and 1.4 per cent of 139 foxes (335) were found to be infected. In this region also the wild boar has been found to be trichinous (191). In Hessen (with the mountain regions of Odenwald, Taunus, Vogelberg, etc) the foxes are frequently infected (23, 28, 91, 184, 386), sometimes also the badger (184). Another paper indicates 4.6 per cent foxes (out of 260) and two wild boars to be infected. The author treats the distribution in some detail, giving a map (313).

Finally, several reports are available from the Rheinland, along the boundaries to Belgium, Luxemburg, and France, including the Eifel, Hunsrück, and Westerwald Mountains. From the Trier region, near Luxemburg, an interesting case was reported: in a number of groups of domestic pigs some specimens turned out to be trichinous. One group had been driven out to feed in the forests, and infection was noted in this group only (260). The same authors found no less than four of ten foxes infected. High percentages of infection were also found among foxes in the Westerwald Mountains, viz. 11.5 per cent of 330 specimens examined (128). Considerably lower percentages were found in foxes from the Rheinland (no more specified locality is given), viz. 3—4 per cent of 137 specimens (209), and in 335 foxes from the Eifel and Hunsrück Mountains 1.5 per cent was found to be infected (92). A single additional case from the same region has been recorded (22).—A few other papers (122, 131, 257) on trichinae in foxes and badgers in Germany have not been available to me. Attention should be drawn to the spreading of the raccoon-dog (see p. 47) and to the American raccoon in Germany as probable hosts (259).

In Austria infected foxes were found in the regions of St. Pötten, Waidling, and Klosterneuenberg (395—396).

In Belgium an outbreak was caused by meat of wild boar (270). The same was the case in Holland (409). In Luxemburg a trichinous fox was found in 1943 (247).

Switzerland. That trichinae are widespread among wild-living carnivores in Switzerland has only been recognized because compulsory

trichina-inspection of fox meat was introduced during the war. In 1942—43, six of 58 red foxes were infected (ten per cent) (9), in 1943—44 no less than 11 out of 26 examined specimens (42 per cent) (172). In the total material (including the above) of 235, 40 infected specimens were found (17 %) (10). The occurrence has been established in a number of the cantons, in varying percentages, Basel (207), Aargau, and Schaffhausen, bordering on Germany; Graubünden, bordering on Austria and Italy, and from the centrally located canton Zürich. One infected wild boar was also found among 171 investigated (0.58 %). Twenty-nine badgers were found to be noninfected (10).

SOME REMARKS ON THE OCCURRENCE OF *TRICHINELLA SPIRALIS* IN INSECTIVORES AND VOLES, MICE AND RATS,

WITH CONSIDERATIONS ON TRANSMISSION THEORIES

It may be appropriate here to mention some papers, the indications of which are in danger of being generally accepted and might then haunt the textbooks for the following century! High percentages of *Trichinella* in shrews and moles are reported from the Białowieża Forest in Poland (50, 51, 183), and from Slovakia (164). These occurrences were accepted without comment in several recent papers (54, 225, 245).

KOTLÁN (198) the well known, very experienced Hungarian parasitologist, considered it probable that the parasites taken to be *Trichinella spiralis* were not in reality that species, but rather some ascaroid larva. He based this view upon the examination of 635 field mice, 234 voles, and 147 insectivores. KOZAR & WARDA (201) were unable to find *Trichinella* in insectivores in the Białowieża Forest, whereas they frequently found them infected with ascaroid larvae, which they supposed to belong to the genus *Porrocoecum*. They assumed, therefore, that a confusion with these parasites had occurred. Finds of larvae of *Porrocoecum sp.* in moles in Russia were described (284). It is significant in this connection that one of the above-mentioned papers (183) records the occurrence of the larvae in the muscles of the neck and in the peritoneum! I have been unable to find any evidence showing that the occurrence in insectivores has been confirmed by experimental feeding to white mice, as stated in a recent paper (295). The presence of ascaroid larvae as a source of error is mentioned in some textbooks already (see e. g. 117), to say nothing of the earlier authors (see e. g. 127, 385).

It will be remembered that in the sixties of the last century "trichinae" were found in a great many animals right down to amphibians and fishes. As a remembrance from that time e. g. the hedgehog *(Erinaceus europæus)* and the mole *(Talpa europaea)* have for almost a century posed in the lists of *Trichinella* hosts[1]).

[1]) I cannot resist the temptation to quote here a statement by VIRCHOW (1865, p. 352), in regard of host lists, which is still applicable today: "Ich möchte daher den Helminthologen ans Herz legen, etwas weniger verfängliche Ausdrücke zu gebrauchen und zum mindesten die gewöhnlichen oder zufälligen Wohnsitze zu unterscheiden".

One of the sources is by VIRCHOW (1866), who in a brief note cautiously reports the finding of nematodes in the musculature of this latter mammal. The same is the case with a paper which reports "trichina" in the mole *(Scalopus aquaticus)* from Illinois, U.S.A. (68). That the indications of trichinae in mole were erroneous, was pointed out already by the above-mentioned early authors. What I want to point out is that as yet no evidence of the occurrence of *Trichinella spiralis* in insectivores is available. Its occurrence in this group of mammals cannot, of course, be denied on this basis and occasional finds, especially in hedgehogs, might even be possible. But any widespread occurrence appears to be very improbable.

In a material of about 500 mice and voles, presented in the above-mentioned paper (183) the authors found low percentages of "trichinae", which findings were also accepted in the above-mentioned papers. In a still greater material the Polish authors mentioned (201), in agreement with the above-mentioned findings found no *Trichinella*, but only ascaroid larvae. The location of the larvae, as cited above (183), was the same. From this it might appear that trichinae must at least be of very rare occurrence in wild-living rodents.

This is in accordance with several comprehensive investigations in Germany, where the opinion once prevailed that the observed high frequency of *Trichinella* in foxes might be due to infection by small rodents. Ninety-three house mice and shrews were examined without any trichinae being found (173). Voles, in numbers of 196, (128) 521, (254) and 796 (313) were likewise examined without result, from localities where the foxes were heavily infected. Several Russian investigations, among more than 700 house and field mice in human habitations, found less than two per cent to be infected, and more than 1000 voles non-infected (245). Furthermore, 708 specimens of various species of mice and voles were examined without the finding of trichinae (246). In the White Russian Republic 106 voles and 27 moles were found to be negative. The indication of trichinae in two out of 71 red-backed voles, in woodland biotopes, must be met with skepticism (277).

That *Trichinella* may occasionally be found in voles is possible, but no evidence has as yet been produced and there can, therefore, be no question of widespread and frequent occurrence in the temperate regions here treated. That trichinae may occur in house and field mice, living close to human habitations and offal, is a matter of course. The recorded frequencies are generally astonishingly small as compared with that of rats. It may be due to the short life of mice as compared with rats.

In my opinion the development of views upon the epidemiology of trichinelliasis, which is the basis for human trichinosis, would have taken

a more sound course if ZENKER's (1871) view of the swine-to-swine infection had been victorious. As things turned out, however, the rat-theory went into the textbooks on LEUCKART's (1866, 1876) authority, with the result that among scientific workers and practioners the word *trichinae* released up to the present day, like in a conditioned reflex, the concept swine and then rat! All evidence shows, also that presented and quoted above (to say nothing of the enormous amount of experience in the U.S.A. (see e. g. 136), in regard to swine trichinelliasis), that ZENKER was in all essentials right: He considered the rat trichinelliasis as a symptom of the occurrence of trichinae in swine and the real source of infection for both pig and rat to be scrap and offal of hog, that is, carcasses. Hence, trichinelliasis in wild rodents can chiefly be expected to occur in subarctic and arctic regions, where food is scarce, and the animals may experience long periods of hunger. This has been amply demonstrated in Alaska, as dealt with in detail above (p. 40).

In this context it might be pointed out that already GERLACH (1866) states: "In jüngster Zeit ist die Ansicht aufgetaucht, dass die Trichinen besonders von den Ratten ausgingen und unser Schwein sie stets von diesen bekomme. Ich kann die Ratten nicht als die eigentlichen Träger der Trichinen betrachten, weil sie nur bei Mangel an Nahrung, namentlich an Fleischkost, die Leichen ihres Gleichen auffressen und der Kreislauf under den Ratten ohne Schweine nicht würde bestehen können. Wo Trichine unter den Ratten gefunden werden, da müssen trichinöse Schweine oder andere Fleischfresser gewesen sein". He was acquainted with ZENKER's views from personal communication. It is interesting to observe how the germ of the correct view was present from the outset.

ZENKER (1871, p. 391) summarises his view in the following sentence: "Ich betrachte die trichinösen Ratten als ein Symptom des Vorhandenseins trichinöser Schweine". Although acquainted with ZENKER's view LEUCKART (1876) is obstinate "selbst auf die Gefahr hin, dass Andere mein Festhalten an der Rattentheorie völlig unverständlich finden". (This sentence may be a quotation from HELLER, (149)). After an exposition of ZENKER's view, his argumentation goes on in the following way: "Die Trichinen haben voraussichtlich schon in einer Zeit existiert, in der das Schwein noch nicht domesticiert war; in dieser Zeit können dieselben aber nur durch denselben Vorgang, den wir für die Ratten oben in Anspruch genommen haben, erhalten sein. Die Schweine müssen damals also die Leichen ihrer Genossen verzehrt und dadurch die Trichinen fortgepflanzt haben. An sich involviert diese Annahme natürlich keine Unmöglichkeit. Man könnte sie mit demselben apriorischen Rechte auch für die Katzen und Füchse und Marder und die übrigen fleischfressenden

Trichinenträger geltend machen". He thinks that he deals ZENKER's view an especially heavy blow with the following question, which relates to the finding in 1875 of a heavily trichinous wild boar: "Ist derselbe vielleicht auch mit den Abfällen eines trichinigen Hausschweins gefüttert?" With the same right it might be asked: has it, perhaps, been hunting trichinous rats? The former possibility would seem more probable than the latter. He continues: "Die Entscheidung dreht sich bloss um die Frage, ob diese Tiere durch Vorkommen, Zahl und Lebensweise gleich geschickt sind, auf diese Weise einen genügenden Umtrieb der Parasiten zu unterhalten". It will be seen that the question has been decided just that way. It is amazing how close he was to the right answer, being apparently mainly kept back by the preconceived ideas 1) that the intermediate host must be living (see the above quotation: "If they might be versatile enough"), 2) that he had already made up his mind for the rat, even if he had no evidence that rats are able to perpetuate an infection among themselves. GLAZIER (1881, p. 55) writes: "It is now generally admitted that the muscle trichina is -- mostly limited to the carnivora", and HIRSCH (1888) observes "dass, wie ZENKER (1871) nachgewiesen hat, die sog. Ratten-Theorie überhaupt auf einem Irrtum beruht".

In the case of wild-living fur-bearers it appears even more clearly that carcasses are the natural source of trichina infections (cf. p. 56).

It is interesting to observe how difficult it has been even for several of the men who put forward the evidence of this phenomenon in the case of the fur-bearers, to disengage themselves from the spell of LEUCKART. The first to stress the frequency of trichinae in foxes in Germany was STROH (357). He even came to the conclusion that trichinous rats and cats cannot furnish a sufficient explanation of the extent of the infection. Then he takes his resort to voles! This resort did not hold good: Several authors (128, 173, 254) having given up the rats discarded the theory of voles on the strength of their results, and found the main explanation of the infection in the so-called "Luderplätze", places in the forest in which carcasses, especially of carnivores are thrown in order to attract fur-bearers and then trap or shoot them there. But they still keep the door ajar for the assumption, also, of some living intermediate host.

A German author (209) gives the rat an important place in his diagrams of the transmission of the trichinae among foxes, rats and pigs, even though he is aware of the importance of the "Luderplätze". A Russian author's diagrams (245) present a more balanced view of the question, but in my opinion still overstress the importance of living intermediate hosts. Several German authors (313, 332, 326) (the latter observes: "Eine selbständige Rattentrichinose existiert nicht"), and (343) clearly join the above explanation, considering carcasses to be the

only source of any importance. It should be kept in mind that in the "Luderplätze" we are merely confronted, in a more or less marked degree, by a phenomenon which will always occur in nature if some animal dies, namely, that the body will decompose and attract scavengers.

It may be appropriate to take up to discussion here another theory put forward regarding the spread of *Trichinella* in nature (see above p. 27). In several papers one author (318–321) advocates the importance of carcasses for the spread of trichinae among foxes and badgers in Germany. It is astonishing, therefore, to observe that in the case of the arctic trichinelliasis he tries to explain the widespread occurrence as mainly due to the spreading of carcasses, even after passing through their intestinal canal, by predaceous and scavenging birds (4–5, 321–322). He and his coworker admit that they have been unable to procure any evidence of their hypothesis. It is not my intention, of course, to assert that this mode of spreading would never occur, but it seems to me to be rather farfetched to use this as the main explanation, all the more so since I think that I put forward evidence according to which it would be most natural to assume that also in the Arctic carcasses as such constitute the main source of infection. And similarly, in my "campaign" against the rat (rodent) theory, it would, of course, be silly to maintain that an infection through rodents, also living ones, never occurs. Still all evidence points to the probability that it only takes place under exceptional circumstances.

In this chapter another faithful member of trichina host lists may be mentioned, namely the marmot *(Marmota marmota)*, which occurs in the central European mountains. The reference appears to be based upon old reports (395–396). One of two specimens was found to be infected, in Austria. It seems advisable to await a confirmation of this occurrence, considering that the marmot is a rodent. Twentyfour Swiss and 1873 Russian marmots were found to be noninfected (10, 246).

SUMMARY OF TRICHINELLIASIS IN WILDLIFE IN EUROPE, KNOWN AND UNKNOWN, WITH NOTES ON THE DISTRIBUTION IN MAN AND PIG

It is evident that the infection is widespread in carnivores and wild boar in Russia, Poland, Czeckoslovakia, Hungary, Germany, Austria, Luxemborg, Belgium, Holland and Switzerland, to the very borders of Italy, Yugoslavia, Roumania, the Balkan countries and France. From these latter countries no actual finds in wild animals have been reported. However, both fox, badger and pine marten are continuously distributed in all of the above-mentioned countries, including the Iberian Peninsula. The wild boar has an almost continous distribution through France, across the Pyrenean Mountains, to Portugal and Spain.

Of highly infected species in Eastern European countries the wolf regularly makes its way into Eastern Germany, is present in various centres in France, is widespread on the Iberian Peninsula, in Italy and in the northern countries of Balkan, including the Carpathian Mountains. Even the bear occurs in now isolated centres in The Pyreneans, the Alps, the Appennines, the Yugoslavian Mountains and in the Carpathians. It seems reasonable, therefore, to assume that the *Trichinella* infection is widespread also in France and Southern Europe in wild-living carnivores, since whereever actual investigations have been performed, these animals have been found to be infected. This will probably turn out to be true also of the jackal *(Canis aureus)*, which is widespread in the Balkan countries and which is included in several lists of *Trichinella*-hosts. I have not been able to trace the source of these statements. Almost 10 per cent of straying dogs in Bukarest (Roumania) were found to be infected (363).

The view underlined above may apply to the British Isles too. It is true that TAYLOR (1944) (one is tempted so say, led astray by the "rat-theory") examined no less than 636 stoats or ermines, 78 weasels *(Mustela vulgaris)* and two polecats *(Putorius putorius)* without finding any trichinae, but none of the main hosts in Central Europe, badger and fox, the animals which would most likely be infected. As a matter of fact, the worm has now been found in a red fox in Cornwall, South-eastern England (269). Quite probably therefore, trichinae will turn out

to be widespread in badgers and foxes in the British Isles. Attention should also be paid to the wild cat, which still occurs in Scotland, and the pine marten, which especially occurs in Ireland.

In all the above-mentioned countries, also those from which no direct evidence of trichinous wildlife is as yet available, trichinosis in man is known from olden times up to the present day. I will mainly confine myself to citing a few recent papers. From France reports are available that only four cases of trichinosis are known (381), but it is stressed that during the war the Germans found a total of 53 trichinous hogs in Paris (see also 108). In another paper (382) this was reduced to only one known outbreak and that the Germans found one infected hog! In a FAO report (37) the situation in France is characterised in the way that trichinae occur with low frequencies and the disease is sporadic, but still met with. Another paper (64) reports how a German prisoner of war contracted trichinosis from pork given him by a local farmer. This demonstrates in an interesting manner the decisive importance of the eating habits for the development of the disease. That trichinae have been of widespread occurrence in pigs in Paris in earlier years, appears from the fact that no less than 5 rats were found to be infected out of 72 examined (7 %) (134, 135). Big outbreaks in the twenties of the last century were also reported (58, 214). Numerous early reports are available for Elsass-Lothringen (see 354) and the Saar region (333).

Recent outbreaks on the Iberian Peninsula have been reported from Portugal (11) and Spain (224, 279). In Lisbon only 0.002 per mille of pigs have been found to be infected (247), in Spain in 0.018 per cent (323).

Even though no trichinae were found in more than 300,000 pigs, and in about 100 rats and about 120 humans from all over Italy (8), several outbreaks have occurred, also in recent years (56, 222, 297). One author (297) is of the opinion that it is doubtful whether *Trichinella* is endemic in the Italian peninsula, though he admits that it is probably the case in Sicily (see 102). An incident from Montemaggiore was reported in 1945, when no less than 21 of 707 pigs examined (2.7 %) turned out to be positive (247). Another author (101) states that this parasite apparently remains a fairly frequent cause of trouble in Northern Italy. Finally, the finding of trichinae in hog in the abattoirs of Rome has also been reported (233).

From Yugoslavia (43) and from Greece (220) outbreaks have also been reported. In the latter case the authors try to shift the source of infection to Bulgaria, in spite of the statement that the pig responsible for the infection was fed up in the village in which the outbreaks occurred. In the following years several more outbreaks occurred, rousing great alarm among sanitation officers in Greece. By and by trichinoscopy was

introduced and revealed a high incidence of infections. Sixty per cent of the rats in an abattoir in Athens, and still 16—24 per cent on city dumps, were positive. Of 5,052 pigs inspected in Attica in 1952—53 no less than 114 were infected (2.24 %), while from the provinces outside of Attica (this latter being the immediate surroundings of Athens) four out of 10,652 (= 0.037 %) were infected (189).

In the British Isles only rare cases in hogs are on record, but it appears that only few have been investigated. Trichinosis in man has been known ever since the disease was recognised. An English physician named Wood (1835) was the first to recognise the connection between the worm and the disease, as soon as Paget's and Owen's (1835) discoveries of *Trichinella* were published. However, this idea of Wood's was completely overlooked and forgotten until Zenker (1860) definitively established the pathologic picture through his painstaking research. At this early time subclinical infections were known to be quite common in the British Isles, but recent work (411) suggests that they are rather commoner to-day, for in Southern England they are almost as frequent as in the U.S.A., viz. about 10—12 per cent, as against not more than 1.5 per cent in Germany (161, 331).

The number of known outbreaks in England rose during the last war and outbreaks have been reported at any rate as late as 1953—54 (109, 338). In 1957 an outbreak in man was recorded from Eire, but recent trichinoscopic examinations of pigs have as yet revealed no infection (247). From what is known about conditions in England it seems probable that trichinae are more widespread in pigs in England than e. g. in Germany. The prevalence might rather be on a level with that in the United States. There must also be a widespread, but not yet fully recognised, source of infection, probably garbage, with a possible additional, more accidental, source from wild animals such as foxes, etc.

The Special Situation in Denmark.

In order to round off the description of conditions in Europe it will now be necessary to turn to Denmark. Only eight years after the discovery in England, *Trichinella spiralis* was also observed during dissections in Copenhagen (359), and in the early sixties several outbreaks were recognised. In the subsequent years several clinical cases occurred even in the present century. A total of 115 cases are known. The last outbreak which could be traced with certainty to Danish pigs was met with in 1910 (116). The last directly published epidemic was described in 1904 (282). In the latest reported case (18) the origin of the meat

could not be ascertained and the infection with foreign meat cannot, therefore, be excluded.

A few autopsy studies on the occurrence in man are available (116, 162). In 1904—05, 627 were investigated, giving an infection percentage of three. From 1911—15, 491 autopsies disclosed an infection in three cases, or 0.6 per cent, all of them old calcified ones. In the meantime a rather intensive trichina inspection had been going on, revealing a marked decline in the frequency of the infection in pigs. The same trend was evident in dogs, cats and rats (one more argument against the rat theory!) (160). In 1918, still 0.4 per cent of 304 dogs and 251 cats were found to be infected (171), but none were found among 546 dogs and 454 cats in 1935 (160). The last infected pig was found in 1929, and never since have trichinae been found in pigs, even though several millions have been inspected.

During the war the discovery of heavy infections in tame and wild-living fur-bearing animals in Norway and Sweden aroused concern in Denmark, especially because most of the Danish fur-bearing farm animals had their origin in these countries. Therefore a series of investigations were initiated (90, 143, 228). The astonishing result was that of 3003 silverfoxes and 1813 farm minks, none was infected. The same applied to 961 wild-living foxes and 68 badgers. Both materials originated from many localities all over Denmark. Also 1729 dogs turned out to be uninfected. Only one of nearly 1200 rats *(Rattus norvegicus)* presented an infection. It originated from a city dump in the Copenhagen area, and may have been introduced through the intensive transport from Germany during the war. The story of the single cat which was found to be positive among 875 examined ones could not be traced. It may likewise have been introduced.

The situation among fur-bearing farm animals has been kept under control ever since. About every second year all pelted farm fur-bearers are inspected, preferable all specimens introduced for breeding purposes. One of these investigations, comprising almost 5,000 animals has been published (252). In one or two cases trichinae have been found in such imported animals, but in none else. In the period since 1930 some 150 wild boars originating from animal parks in Denmark have been inspected in Copenhagen without revealing any infection (personal communication from the inspection office). Some fifty wild boars imported from Germany in 1930—31 also proved to be negative.

At all events, it is evident from comparisons with the surrounding countries that the trichina situation in Denmark is unique in that the worm appears to be practically non-existent, the chance of widespread occurrence in wild-living animals being inconsiderable, and none having actually been found

to be infected. There are indications in the literature suggesting that similar conditions may prevail in the regions bordering on Denmark. Among the districts in Sweden in which trichinae in badgers have been found, Skåne, Halland and Blekinge are not mentioned (165). From Germany, it was found (326) that in Holstein trichinous pigs are practically non-existent and as in Denmark the habit of using "Luderplätze" is unknown. In the period 1945—50 no trichinae were found in pigs in South Schleswig and Holstein (44). In 1951 one infected pig was found but otherwise none in a total of 4,764,920 inspected ones, including the year of 1956. The same was the case with 2,843,979 pigs inspected in Hamburg. In Bremen, two from the regions along the coast between Hamburg and Holland were found to be infected in 1952 of a total of 927, 955 inspected in 1951—1956 (351). This should be investigated more closely, and in Holstein, as in many other places, this might be rather easily done in connection with current studies on rabies in wild animals.

Possibly similar conditions to those in Denmark prevail in Holland, since in the abattoirs of Amsterdam no trichinae have been found in hogs since 1927 (247). Evidence up to 1940 has been given (238).On the other hand, an outbreak later than anyone recognised in Denmark has been reported (280). Of special interest is a recent outbreak caused by meat of wild boar (409). The boar, being a straying animal, may have acquired its infection outside of Holland. An investigation of foxes and badgers is badly needed to clear up the problem.

Since the decline of trichinelliasis in man, pig, dog and cat in Denmark during the years appears to be dependent upon the activity of the trichina inspection, it is of course tempting to assume that this is also responsible for the apparent absence of trichinae in wild fur animals in Denmark. However, German data (332) do not seem to support this assumption.

As seen in fig. 8, re-drawn from the paper mentioned, as trichina inspection grew more and more common in Germany there was a steady decline in the incidence of *Trichinella* among pigs until 1913. A quite parallel course of events was observed in Sweden (311). A temporary increase apparently occurred in Germany during the first World War, probably owing to the partial disorganisation of the inspection and to a considerable illegal import of pork from Poland and Russia. During all these years there was a tendency to a higher incidence in pigs in the eastern provinces of Germany (79). It may be in place here to mention that in Riga, Letland, a similar decline as in Germany occurred, with a virtual disappearance in the late thirties (305). Since 1926 there does not seem to have been any appreciable decline in Germany.

What especially concerns us here is that during this decline and further on, the infection in the fur-bearers and wild boars has remained

on a level many times higher than that found in pigs. It seems most probable, therefore, that this level is upheld without any appreciable influence from the infection in pigs. Conversely, the low level in pigs, which it seems cannot possibly be reduced further, might in some degree be connected with the occurrence in wild mammals, as has been

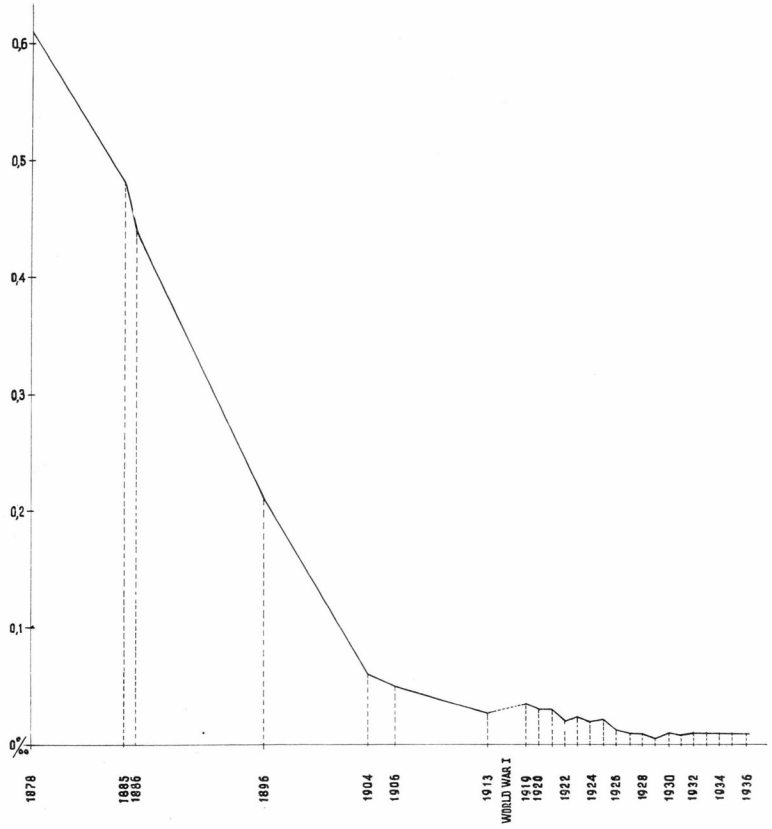


Fig. 8. Decline of incidence of *Trichinella* in pigs in Germany, 1876—1936. (Redrawn from SCHOOP & SCHADE (1939)).

demonstrated directly in several cases cited above. Garbage does not seem to play any great role in Germany, which apparently is a result of the inspection.

In historical times the lynx, wild cats and bears have not occurred in Denmark and the above-mentioned neighbour regions of Sweden and Germany (99) (possibly with the exception of the lynx, which in recent years is spreading to Southern Sweden). For nearly a couple of centuries the wolf and the wild boar has not occurred in the same regions; they are big animals, which attain a comparatively great age and have therefore, a greater chance of getting infected; furthermore, when dead, they

supply large quantities of meat for scavengers. In most places whence actual knowledge of the occurrence in wild mammals is at hand, some or other of the above-mentioned big animals is present.

It might be imagined, that when the source of infection from domestic pig to wild animals was stopped in Denmark (on the one hand owing to new practices in hog raising during the latter half of the last century (almost exclusively stall-feeding), on the other hand owing to the elimination of trichinae from pigs i. a. through the trichina inspection), the foxes and badgers were no longer able to uphold the infection among themselves, for localities like the German "Luderplätze" will only exceptionally be found in Denmark. Incidentally, it might be stressed that a characteristic of trichinelliasis which is often met with, is the occurrence in patches, locally (for rats, see 42). I am inclined therefore, to consider it by no means impossible that a closer examination of the fauna in Denmark and the neighbouring regions will reveal smaller local foci of infection. This absence of big animals might be offered as a possible hypothesis of explanation.

It would then seem to imply that in most regions of Central and Western Europe the wild boar would be the main supporter of the infection, also in carnivores, a contention which it will, for the present, be difficult to prove.

It might be objected that if the above explanation of the disappearence of *Trichinella* from Denmark be true, it would be difficult to assume a widespread occurrence of trichinae in fur animals in Great Britain, as was done above on limited evidence. Here also the above-mentioned big animals did not occur for a very long time.

To such an objection might be observed that one factor, present in Denmark, viz. the lack of trichinae in pigs, is not found in the British Isles. Judging by the available evidence, a much higher prevalence in pigs in Great Britain is probable than has existed for many years in Germany, the classical country for trichinosis, it being so more on account of actual research than on account of a really higher frequency than in other European countries.

Outbreaks may still occur in Germany, though rarely. Light infections may escape the attention of the inspection offices, for which reason an intensification of the inspection has been recommended, based upon modern serological tests (376).

A SURVEY OF THE OCCURRENCE OF *TRICHINELLA SPIRALIS* IN AFRICA, ASIA, AUSTRALIA AND CENTRAL AND SOUTH AMERICA

The Mediterranean. We will return now to the Mediterranean area and try to trace the further occurrence of *Trichinella spiralis*. As shown above it occurs, at any rate in man, in all countries on the European side of the Mediterranean.

In man it has been found also on the African side, Algeria (52, 124, 126, 290, see also: La Vet. Espanola Madrid 58,3, 57 – 58, 1914. (354)), and also in Egypt (354, Amer. Vet. Rev. 3, 199, 1879), even if some of the records are of an older date.

BRUMPT (1936, p. 1047) mentions the ichneumon *(Herpestes ichneumon)* as a spontaneous host. If that originated from North Africa?

In recent years trichinoscopy of hogs has been introduced in Tripolis. As yet no infected pigs have been found. In Morocco pigs, rats and cats in the abattoirs have been examined periodically, and during a three-year period (1942–45) no infected pigs were found in Tunis. No actual figures are given (247).

On the Asiatic side, in Syria–Lebanon conditions are very interesting: here trichinae were found in wild boar (for the third time, the others being in Germany (14, 218)). Three big outbreaks from this source are known, two around 1880 (253, 405), one in 1883 (406). That trichinosis is still found in these regions appears from the fact that a great outbreak occurred in Lebanon in 1939—40 (310) and again several ones in quite recent time (242, 352, 378). The source of infection in these cases was domestic pig which, both in 1940 and 1952, turned out to harbour a tremendous infection, thus among several thousands, 25—30 per cent, which, I think, beats any other record known from pigs! It will be fair to mention that these figures even in these regions may represent exceptional circumstances. In the 1939—40 outbreaks a majority of the pigs examined came from a piggery on the city dump area, where moreover there was a outflow from an abattoir (249). It points to an old ingrained state of infection among pigs in these regions.

Unfortunately nothing new has been published about the occurrence in wild boar. Professor AAGE JEPSEN (Royal Veterinary & Agricultural

College, Copenhagen) has kindly informed me that in recent years Dr. MACHALEI in Damascus has examined somewhat less than 100 wild boars, without finding trichinae. But this does not of course say anything definite about the actual occurrence.

A frequency on a low level might very well be significant in the constant propagation among wild boars and an interplay with various carnivores must be anticipated. As mentioned above, jackals are probably infected in South-Eastern Europe. Jackals are widely distributed also in Asia Minor and the surrounding regions. And the wild boars, which also occur in Egypt, are found on the southern outskirts of the general range of distribution of the species *Sus scrofa*. It does not seem too far-fetched to suppose that the population of *Trichinella* is a part of the infection associated with the species in other regions.

Southern and Eastern Asia. Moving eastwards from the regions just treated, we find that trichinosis occurs in man in Mesopotamia (142), and in a FAO report (37) it is indicated that in Iran its presence in pigs is suspected, but not yet confirmed (a formula used in several cases where the confirmation is available in the literature).

Evidence of the occurrence of trichinae in India is also at hand, though it is based upon extremely few records. During the rise of interest in trichinosis in the sixties of the past century a subclinical infection was accidentally found in an Englishman. This does not, of course, prove anything of its occurrence in India, but in the same paper the disease is said to be quite common in India (13), and a dramatic account is given of the excellent conditions for the spread of the disease in India.

A genuine Indian outbreak was reported in 1907 (370). This report is of outstanding interest in our context, for the source of infection was wild boar. It appears from the paper that such outbreaks have been well known from olden times in the mountain regions of Northern India, (see also above, p. 47). One of 73 cats was found to be infected (1.37 %), while 100 dogs, 100 pigs, and 100 rats upon examination proved to be negative (230). Random samples are periodically inspected in some abattoirs (247). No figures are given. It is evident that when *Trichinella* occurs in India, there will be ideal conditions for its spreading through domestic pigs, dogs, wild boars (which also belong to the southern distribution of *Sus scrofa)*, and all kinds of wild-living carnivores. It may be of significance that an infected tiger was found in the Zoo of Ashchabat (263).

From regions still further to the east only scarce information is available. In the twenties of the last century probable outbreaks were reported from Burma (214). An indigenous case in a European living in the wilderness part of Northern Thailand has been reported (142).

In 1953 an outbreak occurred in Saigon, Indochina (247). This may be the same outbreak as is described in another paper (57). The source of infection was probably some kind of wild animal. The infection was acquired by the native soldiers during a commando raid and they suspected themselves a ruminant, the muntiac *(Cervulus muntjac)*, to be the source of the infection! In the same city one trichinous pig was found in 1929. In the same year two out of 4952 (0.04 %) pigs in Hanoi, Northern Indochina, were found to be infected and as early as 1923, pigs were on several occasions found to be infected in these regions (213). According to the FAO report (37), the occurrence in Laos is suspected and in Vietnam the occurrence in pigs is rare, the disease is of sporadic occurrence.

A few reports are at hand from China, from regions far apart. Again the dominance of the "rat-theory" has tended to turn the attention from the most important animals. The first report on the occurrence of *Trichinella* in China was issued in 1881 (229): in the Fukien district no less than two out of 225 examined pigs were found to be infected (1.9 %). Probably based upon this work, one paper stated that the occurrence in pigs is extremely rare (138), whereas another one (170), upon the same evidence, stated that trichinae are probably rather common, and that the absence of reports is more probably due to erroneous diagnoses than to the actual absence of cases. At that time no cases from man were known. Since then only one case seems to have come to our knowledge, viz. in a Chinese in Peiping (110, 111). In the Fukien region three of 136 Norway rats were found to be infected in one locality, while 114 rats in another locality did not reveal any infection (364). A little farther south, in Canton, 1313 pigs and 84 house and Norway rats were found non-infected (85, 86, 299), and in Hong Kong the incidence in pigs is low and the disease occurs sporadically (37).

From more northern regions, in Manchuria around Mukden, several finds are on record. No less than 14 of 179 straying dogs were found to be infected (eight per cent) (412). This report is of special interest, because it would be virtually unbelievable if, as we now know the spreading conditions of *Trichinella*, other scavengers, (wildliving carnivores and wild boars, which here also constitute a part of the general distribution of *Sus scrofa*) were not infected. A cat is reported to be infected (87), and the same author (88) found trichinae in 6 of 21 dogs, in one cat and in two of 96 Norway rats. Among 99 house rats and 107 *Mus speciosa* none were found infected. The same was the case with 546 pigs.

In Japan, also, trichinae have now been found, in a dog (268), but no case from man is known. Trichinoscopy was introduced in Japan in 1953. No pigs have as yet been found to be infected (247), a fact suggesting a source in wild animals. A great number of rats have been in-

vestigated in Formosa, without trichinae being found (364). Trichinosis does occur in the far Eastern Siberia (181), and, as mentioned above (p. 46), in bears in Kamchatka.

It is still a dogma in most text-books, etc., that *Trichinella* is absent from the Tropics (see e. g. 81). This dogma will be seen to have gradually become rather "riddled". Evidence has already been produced and more will be added. The widespread occurrence of trichinae in Indonesia has already been known for a considerable number of years. The first report appeared in 1930 (389). In Medan, in Sumatra, pigs were raised by two groups of the population: the Chinese, in the lowland, near the City, and the Bataks, on the plateau at altitudes of 1200 metres, about 70 km from the City. In 729 "Chinese" pigs no trichinae were found, whereas nine (13 %) of 67 "Batak" pigs were found to be infected. This might be an indication of some source of wildlife infection.

A few years later (21, 239), a larger number of pigs, 4399, presumably from the same regions as mentioned above, were examined. Of them, 108 (2.5 %) were found to be infected. Of 2413 dogs, 37 were positive (1.5 %), whereas no trichinae were found in 721 rats. The results of the examination of pigs and dogs in the Batakland district, Sumatra, up to 1940 are summarised (336). The consistent absence in rats is stressed, and that even though no outbreaks of trichinosis in man had been observed, this does not preclude its existence in a subclinical form. That the infection is probably widespread on the islands is indicated by the finding of a trichinous cat in Java, (240).

The Pacific Islands and Australia. In Hawaii (7) we have an especially interesting case, because the whole trichinous fauna found there has been introduced by man, and the experience to be gained there might apply to other regions, like New Zealand and Australia, where in respect to *Trichinella* even more dangerous wild animals have been introduced from regions in Europe where trichinae really occur in them, e.g. foxes in Australia and feral pigs and small carnivores in New Zealand.

The only carnivore examined in Hawaii, the mongoose *(Mungos birmanicus)*, proved to be heavily infected, about 10—20 per cent, rather evenly distributed, 15 of 70 on the main island, 2 of 22 on the island of Maui. A rather high frequency was also found in feral hogs, 6 of 40 being infected on the main island, in which also one of 47 domestic pigs proved infected, while 92 domestic pigs from Maui presented no infection. It is stated that garbage is cooked before being fed to swine. Of a total of 2130 rats on the main island, 52 (2.7 %) were positive, while of 1094 on Maui, only one harboured trichinae. Of 306 house mice none were found to be infected.

The species of rats *(Rattus norvegicus, Rattus r. rattus)* which are most closely associated with human habitations, presented a higher degree of infection (3—4 %), while the more free-living species *(Rattus r. alexandrinus, Rattus hawaiiensis)* were found infected in less than one per cent. Even if the difference in incidence between wild pig and domestic pig might be fortuitous, the mongoose exhibits the same phenomenon as is found in Europe over and over again: that the wild-living carnivores maintain among themselves an infection on a much higher level than is generally found among domestic pigs and among rats. Furthermore it is evident here also, that the rats are not able to maintain an infection among themselves, but are dependent upon an "outside" source of infection.

From New Zealand only a single local case of trichinosis in man seems to have been reported (226). It was not possible to trace the origin of the incriminated bacon. No trichinae were found in 20,000 pigs. It is a pity that trichinae were not looked for in studies on the parasites of feral and domestic pigs in New Zealand (168).

From Australia reports on the finding of three subclinical cases among 119 human autopsies are at hand (46). The three subjects were all foreign born. The same applies to another case described (275), and in a material of 20 human diaphragms (47) only old infection in a British born old lady was found. According to (46), in 1911 a number of rats and pigs were examined with negative result, and the Veterinary Officer of meat inspection in New South Wales investigated in vain a large number of pigs. Therefore, it was concluded that up to that time trichinae had not been found in indigenous cases in Australia.

A case reported seems to have been overlooked (177–178), viz. a man who had never been outside of Australia, and who had acquired his infection from eating local pork sausage. Already in several of the early papers the occurrence in Australia is indicated (see e. g. 149). Considering the frequency with which trichinae, especially in former times occurred in pigs in Europe, and the prevalence still found in the U.S.A., it would seem that only a miracle would have been able to prevent *Trichinella* from being carried to Australia on several occasions and from establishing itself there.

It should be remembered, as pointed out above, that England, a main supplier of animals to be imported for breeding purposes, probably still has one of the highest frequencies of trichinae in swine in Europe. One question remains to be solved, viz. to what extent conditions might be present which would allow carnivores to maintain trichinelliasis among them.

Africa. Precisely the same observations apply to South Africa as also pointed out in an article in the German periodical "Die Fleischwirtschaft" (36). In former years pigs and rats have been examined on a small scale with a negative result, and it was assumed therefore, that the infection did not occur (251). These few examinations, using the digestion technique, were made on samples from 1,352 pigs from the abattoirs in Johannesburg. The pigs were drawn from a large area, and all proved to be negative. It is obvious that in such a comparatively small material infections of as low frequencies as are found in several countries in Europe may easily be missed. It is stressed that raw pork offal is very rarely fed to pigs in the Union.

Regarding other parts of Africa south of Sahara, I have been unable to find original reports on the occurrence of trichinae, but text-books indicate their existence in Kenya, Uganda, Tanganyika, and Nigeria (see e. g. 95). It is also stated (129) that they have not yet been found in Kenya, but recommended that they should be looked for because of the increasing importation of hogs for breeding purposes. Trichinae seem to have been considered elsewhere in Southwest Africa. Only a few pigs have been examined, without revealing any infection (298). The occurrence in the Federation of Nigeria and the Nyasaland Protectorate is suspected (37). It may be mentioned here that the number of human cases in Africa was estimated to be about 200,000 (355).

Speaking of Africa, it might be appropriate to mention the hippopotamus which stanchly appears in the host lists of *Trichinella spiralis*. The reference goes back to 1879, (147) when the occurrence was reported in an animal about two years old, which died only four months after its arrival to the zoo in Marseille, France. It was a gift from the khedive of Egypt and supposedly it originated from Sudan. It had only fed on milk and vegetables during its stay in the garden. The trichinae were found accidentally in histological preparations of one of the abscesses which caused the death of the animal. I consider it pertinent to mention this curious case here, since it might be an infection acquired in the open. The hippopotamus is, after all, a relative of the pig.

Southern North America. That hot climates constitute no barriers to trichina infections is seen already in the Southern United States, where it is of the same extent and charachter as in other parts of the U.S.A. (136, 187).

The only place to which the contention of the absence in the Tropics would seem to apply is Brasil (241). In the years 1924—28 about 30,000 pigs in São Paulo were examined, and 1922—32, 8,000 in Rio de Janeiro. In the same period 1600 were examined in Rio Grande de Sul. In human beings 400 intradermal tests were all negative. On the other hand, a

textbook (95) states, without reference, that cases have been reported from Brasil, but trichinae do occur in other parts of the American Tropics. Based upon investigations in Puerto Rico, (278) it is concluded that the rarity of trichinosis in the Tropics might be more apparent than real, and may mainly depend upon lack of investigation. They report the first 8 cases known from Puerto Rico, which find suggests a widespread occurrence at any rate in pigs. In Cuba the frequency in pigs is low and sporadic cases of the disease occurs (37). A great outbreak occurred in 1827 in St. Thomas, the West Indies (130).

In Mexico trichinosis has been known for a long time (38, 221, 414). A recent investigation suggests a level of infection in human beings of the same order of magnitude as in the United States. In 200 necropsies no less than 25 (12 %) cases were found. None of the subjects had any history of trichinosis. A similar percentage, 14.4 (18 of 125 examined), was found serologically. Although the food is generally well cooked in Mexico, raw pork is an ingredient in a certain kind of sausage. Two samples from various localities of 211 of these sausages turned out to be positive when fed to experimental rats. The general infection percentage in pigs in Mexico City is 0,03, but no less than 30 per cent of cats are infected (236). Two per cent of 900 rats were also positive (237).

In Honduras, among 500 not selected hospitalised persons 7,4 per cent reacted positively on intradermal tests (314). That in Costa Rica (390) and in Panama (80) none of 103 and 351 rats, respectively, were infected, does not tell too much about the *Trichinella* situation there. An examination of dogs and cats, to say nothing of wild carnivores, would seem a more promising approach.

South America. Trichinae have been found in most countries of South America. (Regarding Brazil, see above). According to (354), trichinosis has been found in British Guiana (97). I could not verify this statement, even on seeing the pages of Daniels's book to which is referred. Trichinosis was reported in Venezuela (391). No trichinae were found in 360 rats. Unfortunately no carnivores were examined (70). The disease is no longer found in Colombia (247). Trichinoscopy is practised on the abattoirs in Bogota. No figures are given.

In Uruguay trichinae appear to have been found several years ago (12). Of 100 human diaphragms, three were found to be infected, and several clinical cases were observed (361–362). The infection in pigs must be assumed to be widespread, since it is asserted that pig-raising without a certain level of trichina-infection is impossible. Outbreaks have also been reported (286). In recent years some thousand samples from pigs have been examined without positive results. The sampling is being continued (37).

Also in the Argentine have trichinae been known for several years (402). During the years 1898—1933 the level of infection in pigs in Buenos Aires has been around 3 per mille, with a tendency to decline in later years (296). Trichinae were also found in pork products there (344). In recent years the incidence in pigs has remained low, and only sporadic cases of the disease occur (37).

By some curious incident we have early knowledge of the occurrence of *Trichinella* in Chile. A fatal case on board a ship in Hamburg (Germany) was reported in 1863 (377). The infection originated from a pig which had been purchased alive in Valparaiso and was butchered during the travel from South America. A quite similar case was reported from a ship in Bremen (Germany) (394). The pig had been brought from Iquique.

Several outbreaks, also with fatalities, were reported from various localities in Chile (403), and the frequency of subclinical infection in man is indicated to be almost on the level of that in the U.S.A., viz. a little above 10 per cent (264). Surveys were taken of the results of the trichina inspection of pigs in Santiago, from the years 1936—1957 (114, 265). There appears to be a decline in the level of infection through the years with a rather sudden drop around 1943. During the last ten years the incidence of infection was generally below three per mille, with no noticeable decline. It is pointed out by the last-mentioned author that feeding with uncooked garbage is now prohibited.

CONSIDERATIONS ON THE OCCURRENCE OF *TRICHINELLA SPIRALIS* IN FARM FUR-BEARERS

In 1933, an author in Germany cautioned against eating flesh of silver foxes and minks (267). They might, he stated, contain trichinae, because rats are abundant in many fur-bearing animal ranges. The first actual find in farm fur-bearers seems to have been reported from Germany (258). The same year the occurrence in the coypu *(Myocastor coypus)* was reported from Switzerland (306), and even an outbreak among human beings after the consumption of coypu meat. On the basis of this case, there was again a warming against meat of fur animals in Germany (324). How ingrained the "rat theory" was, appears from the fact that the author tries to explain the infection of the coypus as due to contamination of their food with rat feces (!) in spite of the fact that RUBLI himself gives the correct explanation: that they acquired their infection from meat scrap picked up under the cages of minks (likewise infected) kept on the same farm.

Further reports on farm fur animals were given (326–327, 329, 332). A total of 41,522 farm foxes have been examined in Germany. Forty of these foxes were infected, that is, less than 1 per mille. Of 11,908 coypus none was found positive. Another survey, also in Germany (30), in a single farm found only one infected among 6,000 blue foxes and silverfoxes. Also in other investigations only few silverfoxes were found to be infected (340, 400). In Switzerland the infection appears to be much more frequent (9, 10, 172). Among 164 silverfoxes 21 (13 %) were found infected, and among 50 minks 20 (42 %).

In Sweden the frequency seems to be somewhat higher than in Germany (but lower than in Switzerland and Norway) since 277 of 7,025 farm foxes examined were found to be infected (4 %) (153, 165). Just before the war, intestinal trichinae were found in some range foxes in Norway (373). This turned the attention to the question, and during the war trichinae were found to occur with a tremendous frequency. During the years 2,853 foxes of 45,967 (6 %) and 252 of 2,255 minks (11 %) have been found to be infected. Fourteen per cent of the farms harboured trichinous animals (1, 145, 300, 374). The infection has not yet been eradicated (3). The high level of infection in Norwegian fur

ranches was built up through the habit of feeding up the carcasses of the pelted animals. The freedom from trichinae in farm fur animals in Denmark has been dealt with above (p. 60).

In Poland one out of 335 farm foxes (199), on three farms 0.9 % and 4.2 % of 252 foxes (141), were found to be infected. In Russia none of 350 European minks were found to be infected (246).

In many meat samples from fur farm animals in Canada no trichinae were found (188). Their diet had exclusively been beef, horsemeat and fish. This is the only report I have come across regarding trichinae in farm furbearers in other regions than those treated above.

Although the possible origin of the infection in farm fur animals from wild foxes (carcass-feeding) has been considered in Scandinavia, it is generally regarded here as most probable that the infection was originally introduced from America with the original breeding stocks (See e. g. 146). It appears funny, therefore, that an American (84) cautions against *Trichinella:* "It is well to be aware of this condition in instances of future import of fur animals from Scandinavia". He also states that "as far as is known, this parasite is not at present of importance in ranch-raised fur animals of the U.S. and Canada", without, however, indicating his basis for this statement.

The problem of trichinae in farm furbearers can, of course, be comparatively easily solved in principle, as is the case with trichinae in pigs, through regulations (legislation) as to the treatment of the food-stuffs before feeding. It is even easier in the case of furbearers than in the case of pigs because of the modern technique of raising, when the animals have no access to the ground. An infection in fur animals will only in rare cases represent a direct hazard to man, but an eradication of the infection will be of significance to the public health by stopping the accidental spread to other animals, especially to the wild scavenger fauna. It should be pointed out also that rodent furbearers are liable to be infected, but only if they have access to infected meat offall (185, 186).

CONSIDERATIONS ON THE OCCURRENCE OF *TRICHINELLA SPIRALIS* IN ZOO ANIMALS

As already touched upon above, many cases of trichina infections in polar bears have been reported, the first being from 1910 (62) (see further p. 23 ff). Many could be proven to have acquired their infection before confinement, and no doubt many others actually did the same. Also many infections in brown bears are on record, even still earlier, the first from 1881 (392). Further reports are given, all from German Zoo's (4, 154, 175–176, 180, 182 (grizly bear); also in a zoo in Salzburg (Austria) (398)). Brown bears were also found to be infected in Russian zoo's (140, 263). Furthermore, the wild boar has been found infected in German zoo's (174, 206).

Of other species mention may be made of the badger in Hungary (197), the American badger (353, zoo in Philadelphia), the arctic fox (140, 263), and the lynx in Russia (263), furthermore the raccoon in Germany (Dresden) (212). Also exotic species are on record: the palm civet *(Paradoxurus sp.)* (353), a mongoose *(Mungos paludinosus)* (330), jaguar *(Felis onca)* and tiger (246, 263). From the zoo of Basel (Switzerland) infected tigers were reported (207).

There are several observations of infections in brown bear and polar bear, which must have been acquired during confinement (107, 115, 155, 176, 180, 398).

Most often rats are taken to be the source of infection. A story is told (180) about bears which, being on travel from one show to another, were placed in a cellar, in which they (supposedly!) caught infected rats, and a report of another case in which about one month after a rat campaign in a circus, some polar bears died, and on autopsy were found to contain numerous freshly capsulated trichinae. However, no intestinal trichinae were found.

Another story goes that brown bears, found to be trichinous had been seen to kill some rats (154). The bears were slaughtered because of scarcity of food. At the same time the author describes in detail how these very bears, with fresh infections for which he supposes the rats to be the source, a few months previously had fed upon meat of their parents and of a polar bear. Shortly afterwards feeding with this meat

was abandoned because several other animals in the zoo were said to get ill from it. The trichinous young bears had shown no symptoms. The rat-theory is still maintained in a recent paper (287): calcified capsules were found in a polar bear which had been two years in the zoo of Warsaw. The author points out as alternatives the acquisition of the infection before confinement or in confinement, the bear having eaten rats.

In a number of cases infected meat fed to animals has been recognised as the probable source of infection, either the flesh of fox and badger (330) or of dog (155, 207).

A curious incidence in Denmark. In this connection I should like to describe, with the kind permission of Veterinærdirektoratet (State Veterinary Service), a case which happened in Denmark a few years ago.

In the city of Århus the meat inspection ordinance forbids the sale of meat of wild boar, bears, and fur animals without previous trichina inspection. On this basis, on Nov. 11, 1955, two-thirds of a brown bear and about half of a wild boar were confiscated in the shop of a fish- and game dealer (see 35). He was later prosecuted and fined. On inspection, both of the animals turned out to be trichinous, the bear to a high extent. "The finding of the trichinae was immediately reported to the Veterinary Service (Veterinærdirektoratet) and the chief of police and since the dealer was not able to state the names of the customers who had bought the trichinous meat, a warning was broadcasted against eating the meat and an order was given to deliver possible remnants to the sanitary police. During the following days so much of the infected meat was sent in that only small quantities of the bear meat could possibly have been eaten, while, on an estimate, some few kilograms of the wild boar was missing. Probably only 3—4 families had eaten of the trichinous flesh. Of these, one family (two adults, and two children) were hospitalised for observations. The mistress of the house, who stated she had tasted the raw ground meat, fell seriously ill with typical symptoms of trichinosis. In addition, information was received of another person who had fallen ill with the same symptoms" (translated from the Danish).

Every effort was thus made to destroy all remnants of the animals, even the skin of the bear. The animals could be traced back to a small nearby zoo which was in the process of liquidation. "The present leaseholder gave the information that when he took over the garden in 1952, it contained among other animals a polar bear, imported from Germany. This bear was ill with paralysis of the hindparts. It was shot, and the meat fed raw to the other carnivores of the zoo. Among these animals were the above-mentioned ones".

A number of other animals had been sold to known persons, and those left in Denmark must not be resold without the permission of the police, and must not be killed or buried without trichina inspection.

A number of the animals still left in the garden were killed and inspected. Two wild boars, which had come to the zoo after the feeding with polar bear meat took place, were found free of trichinae, and given free after being kept at – 15° C for 60 days. One brown bear, two silverfoxes, and one blue fox, which all had participated in the polar bear feast, were found positive. The meat was destroyed, and the skins put into cold storage. One coypu did not reveal any infection. Rats from the zoo, a nearby dump, and the city dumps of Århus were not found infected. The same was the case with all the pigs from the neighbouring farms, and from piggeries using garbage from the city of Århus.

I have reported this incident in detail because it seems to me to show how easily infections in Zoos can be spread, if nobody is aware of the danger involved. As is the case in fur animal ranges, there will be an imminent danger of secondary infections, partly of man (if no trichina inspection is performed, or if regulations are violated), partly of domesticated and wild-living scavengers.

In regard to parasites as such, I have pointed out on another occasion (HOLGER MADSEN, 1952) that much information as regards distribution and host specificity might with advantage be gained in zoological gardens. Also in the case of *Trichinella spiralis* much interesting information regarding the occurrence in wild animals from many regions of the world could be acquired, if all potential hosts were investigated and infections arising were traced as far as possible to their origin.

Very little is known of spontaneous (clinical) trichinosis in animals. Some of our knowledge is available precisely from zoo animals. What is otherwise known is summarised in a paper from 1942 (193). A skin affection in a polar bear (62) was found as a symptom of trichinosis. the same disease was observed in two polar bears in the Basel Zoo, and considered to be of an allergical nature (207). The same author also found, connected with the trichinosis, a case of self mutilation (which may be of a nervous nature, too) in a tiger. In agreement with this is an observation (63) of a polar bear which refused to go into the water, evidently because the change of temperature caused pain. What appears to be an early stage of trichinosis was described in a brown bear, with loss of appetite, diarrhoea and a growing stiffness of the limbs (398). It was emphasised that feeding with infective material can be excluded, because the other bears, getting the same food did not get ill and again, another bear from the same animal-show was not infected. Therefore, rats are incriminated, without however any having been examined. Nevertheless, the author might for once be right.

SOME GENERAL REMARKS AND CONCLUSIONS

It can now be regarded as established beyond any doubt that *Trichinella spiralis* has a tremendous distribution among domesticated and wild carnivores in all arctic regions. This fact involves interesting aspects because we are here confronted with a situation which clearly demonstrates that trichinae are able to establish themselves in various populations of animals without the interaction of the domestic pig and of rats, which besides man, have for about a century been considered to be the main hosts of the parasite. Especially significant evidence of the perplexing ability of this parasite to establish itself in unexpected habitats is the demonstration of its occurrence in marine mammals. The consequences of all these facts have not yet been fully acknowledged.

In the preceding sections it has been demonstrated that this, for the Arctic indubitable, situation holds good for many other regions also. Plenty of evidence has been accumulated, especially from research in some parts of Scandinavia, Russia, Poland, Germany and a number of surrounding countries. From this evidence it was concluded that there can hardly be any doubt that the situation is the same all over the vast wilderness regions of Siberia, even though direct evidence does not seem to be at hand, except from the arctic and southern parts of the regions.

It might be objected that we do not know to what extent an infection from pig may play a rôle in the above-mentioned regions of Europe. It may even be added that there is no reason to doubt that some transfer of trichinae from pig offal to wild animals does actually occur in places. But the high incidence in wildlife in many regions with a low, or even an extremely low, incidence in hogs makes it clear that the infection in the wild-living carnivores is maintained chiefly among themselves. The intricate interplay is also emphasised by the fact that hogs rather commonly acquire infections from wild-living carnivores.

This very fact may explain, at any rate to some extent, why in several regions it has not yet been possible to reduce the incidence in hogs below a certain low level in spite of control measures (especially trichina inspection) which already towards the end of the last century produced a rapid decline in incidence, e. g. in Germany.

Rodents, to say nothing of insectivores, do not, evidently, play any role in the above treated interaction, except under special circumstances and in certain regions (see above, p. 53). It was demonstrated, in contradiction to some recent papers, that as yet there is no evidence of the occurrence of trichinae in insectivores.

It was emphasised above that the presence of *Trichinella* in wild animals must be considered to be continous from Russia into the Scandinavian Peninsula, and through Eastern Europe to Germany, Holland, Belgium, Luxemburg, Czechoslovakia, Austria, and Switzerland, to the very borders of France, Italy, and the Balkan Peninsula. Hence it seems justifiable to assume that if somebody would look out for trichinae, he would find them in all these countries, at least in the fox, the badger, and the wild boar, and even more probably in wolves and bears in mountain regions where these animals still occur. Actually a fox was recently found infected in England, which country has sometimes been considered to be free of trichinae.

Now and then in contradiction to official statistics, it has been shown that evidence has been available showing its occurrence in pig and man, and also often in domestic carnivores in all the above-mentioned countries. On the Iberian Peninsula trichinae likewise occur in these hosts, on which account it might seem reasonable to assume their presence in wildlife there also. Thus it might appear, in contrast to the views held at present, that broadly speaking an infection in wildliving carnivores and in wild boar occurs all over Europe. There is some reason to assume that moving eastwards to the Russian and Siberian wilderness regions, the situation will be aggravated in the form of higher and higher incidence.

An exception from this general statement appears to be formed by Denmark, where it has not been possible, in spite of fairly intensive studies, to find trichinae in foxes and badgers. Trichinae have been absent in man and pig for 30 years, presumably partly as a result of the trichina inspection. That little which is known about Southern Sweden, the German coast along the North Sea, and, possibly, of Holland, points to the possibility that a similar situation prevails there.

As stated above, it may be reasonable to consider the trichinae in wild boars in Syria, southern Siberia and Northern India as possible offshoots of the general distribution in wild boar in more northern regions. Evidence is also presented showing that trichinae are more widespread in Southern and Eastern Asia than generally assumed, for cases in man and (or) pig, and sometimes also in rats and domestic carnivores are known from Syria, Iraq, the Indian and Indo-chinese peninsulas, Indonesia, China, Japan, and the far eastern U.S.S.R., whence, furthermore, a case in bear is known.

From the evidence presented above from regions in which the problems has altogether been investigated, it might seem reasonable to assume that it must be considered a kind of miracle if trichinae should not occur also in wild animals in these regions.

It is most often stated, sometimes in contrast to published evidence, and sometimes on the basis of scanty research, that trichinae do not occur in man and pig in New Zealand, Australia, and South Africa. But, considering the extent to which pigs have been introduced into these regions from various parts of Europe where trichinelliasis is endemic in hogs (and were even more so in former times), there can be no doubt that trichinae have repeatedly been introduced into these countries, and more extensive investigations would without much doubt reveal their presence, as has been the case in all instances where such investigations have been performed.

Furthermore, the situation in Hawaii raises problems which apply to the regions mentioned, and which have not yet been taken into consideration in that connection. In Hawaii the infection was undoubtedly introduced by man, probably with the pig. It has established itself in feral pigs and in the mongoose. Since various kinds of wild carnivores of European origin have been introduced into the above-mentioned countries, there might be every reason to find out whether trichinae have not been introduced or established in these hosts. It would seem obvious that there is a definite possibility for such a situation.

To sum up, it may be stated that it is decidedly possible, and even probable, that wild carnivores and boars all over Asia and the islands in the Indian and Pacific oceans and in South Africa will turn out to harbour infections of *Trichinella.*

Regarding Africa, information is extremely scanty, and it does not seem possible to find out with certainty whether the parasite has been found south of Sahara, even if such an occurrence is probable, when altogether positive statements are given. It might seem to be of some importance to public health to find out how the situation actually is. There does not seem to be any evidence suggesting that Africa should form an exception in regard to *Trichinella.*

Turning now to America, we shall find, as already stated, that in arctic regions we are confronted by a perpetuation of the infection within the various populations of wild animals without the interaction of pigs. In Alaska the situation is unique since trichinae are prevalent in rodents. (No evidence of such an occurrence is at hand from Arctic Canada and Greenland. In the latter region we have evidence of another situation, viz. that the infection, if at all present, is extremely sparse, while from Canada too little is known). This situation is probaly related to the wellknown fact that in arctic-subarctic regions these animals

are more liable to devour flesh than in temperate regions. Here the rats must be excepted, which are of only sparse occurrence in arctic-subarctic regions. Their infection evidently depends almost entirely upon infections in pigs. There seems to be reason to take into consideration a possible occurrence in rodents in subarctic regions in Canada and in Eurasia.

The existence of trichina infections in bears also in other wilderness areas in the United States than Alaska points to the possibility that we are here confronted by the same situation as in wilderness areas in Europe, but the available evidence does not permit us to decide with certainly what rôle hogs play in this connection. This applies also to the scanty information as yet available from other regions of the U.S.A. regarding wildlife (for particulars, see p. 45 above).

As long as trichinae have the present high incidence in pigs there, a continuous transmission from this source to wild-life will no doubt occur, but judging by experience from Europe, a progagation within the populations of carnivores must likewise be taken into consideration as a probability. These considerations apply also to the temperate Canada.

It might be regarded as significant that whenever an investigation of wild carnivores has been carried out in countries where trichinae are found in man and hog, their presence has been confirmed. Trichinae are widespread in Mexico and the West Indian Islands, and have been found in practically all countries in South America, partly already a century ago and ever since. Therefore it seems necessary to point out the probability that in many places, if not everywhere, trichinae may also occur in wild animals, and that such an occurrence explains why the decline in incidence among pigs slows down more and more, in regions where an inspection is performed, and the development can, therefore, be followed.

One of the reasons why it was so long before the imminent danger to the public health presented by infections transferred from wild carnivores was generally acknowledged (in spite of a century-old knowledge of the existence of such infections) seems to be the fact that the rat theory, put forward by LEUCKART, became victorious over the correct notion advanced by ZENKER, viz. that the *Trichinella* infection is transferred through carcasses or carrion (for details, see above p. 54 ff.). The psychological fact that, historically, the existence of intermediate hosts was quite new knowledge is probably in the main responsible for the victory of the rat theory. So many cases of living intermediate hosts were discovered that it was not sufficiently noticed that in the case of *Trichinella spiralis* the point is that the intermediate host is normally dead, even though the remarkable power of resistance of the larvae to putrefaction has been known for many years.

One feature might be overlooked when judging percentages of occurrence of trichina larvae. There is here the peculiar fact in parasitology that, once an infection has become established, it can be diagnosed for the whole remaining lifetime of the host. Consequently, it is a general point of observation that the rate of occurrence rises with the age. Therefore, in nature, (in contradistinction to the immediate surroundings of man, where the contamination may be heavy), the highest frequency of infection is found in longlived animals.

The objection might be raised against the assumption that carnivores acquire their infection from carrion of carnivores, that they generally do not touch meat of their specific fellows. But it is generally known that this does not apply in times of want. Furthermore, in most places, carrion of several species of carnivores will be available, and when putrefying, the meat must be expected to loose to some extent its specific scent. The conditions of want will prevail precisely in arctic-subarctic regions and during severe winters in the interior of the continents. Therefore, high incidences are found under such circumstances.

During the second half of the last century there was much discussion, and several more or less well founded hypotheses, of the history of origin of the infection in man. There was a tendency to consider the presence of the larvae in the muscles as a new phenomenon in Europe. It is, indeed, often almost inconceivable that a phenomenon, when once discovered, has so long been overlooked. Therefore, some people supposed the trichinae to have been introduced with the supposed invasion of Europe by the Norway rat, whereas others held that they had been introduced with Chinese or Indian pigs, which had recently been introduced into Europe for breeding purposes.

At the same time, the opinion was put forward that the infection was of old standing. Attention was called to a case history reported already in 1675 (112), from the vicinity of Württemberg, Germany. A peasant family had eaten the salted and smoked meat of a pig. After about a week the people fell ill with headache, nausea, and a swollen face (intumescit facies). The man and the twelve-year-old son had several fits of unconsciousness and soon died, whereas the wife survived. The complete case history is cited in the original wording in a paper from 1864 (166). It has been much discussed, but it seems probable that it was actually trichinosis. The histories of several outbreaks in Germany (274) and France (58, 214) from the early years of the 19th century, could in retrospect be demonstrated to be trichinosis. The same was the case with a large outbreak in St. Thomas, the West Indies, in 1827 (130) and in Burma about the same time (214). According to the symptoms it was most probably trichinosis. The former author is even of the opinion that trichinosis existed among the Carthagenians in 427 B. C.

I have not seen his evidence for this contention, the paper has not been available to me in full.

About the middle of the last century the afterwards much discussed contention was started (385) (the matter was dealt with at length in a fairly recent paper (71)) that the Mosaic proscription of eating the flesh of the swine was based upon the observation that human illness sometimes followed the eating of such flesh and a confirmation of this was seen when in the eighties of the last century outbreaks were observed in Syria. However, the significance of the Mosaic law in this respect must probably remain a conjecture. It is a matter of course that when such proscriptions are followed, no trichinosis in man will ensue.

Quite apart from this more or less certain evidence, the high age of the infection, also in Europe, might be concluded with reasonable certainty on the following grounds: 1) High incidences of the trichinae in both man and pig were found all over Europe and in the U.S.A within 25—30 years of the discovery, and the occurrence in South America was recognised too. Even on the assumption that trichinae were carried to America by the Europeans, it must be an early occurrence. 2) Already in the sixties trichinae were found in wildliving carnivores, in which they have a tremendous distribution. This is evidently an ecological interplay which has established itself centuries, if not millenia, ago.

It appears that the occurrence of trichinae in a country was felt like something of a disgrace. "For many years countries accused one another of exporting infected pork" (291), a tendency which is alive even at the present day, and reflects itself in several official statistics. Many strong arguments and reports of diplomatic quarrels can be found in the literature. Many cases of consternation among health officers are reported when, upon actual investigation, trichinae were found in countries and regions where they had previously been surmised to be non-existent.

The existence of trichinae in arctic regions has likewise been regarded as a phenomenon of recent date. ROTH (1950), however, demonstrated undoubted occurrences in polar bear in the late nineties, and considered the arctic infection to be at least several centuries old. According to our present knowledge of the distribution, as outlined in the present paper, and as suggested in other recent literature, it seems likely that trichinae have occurred there for millenia.

Interesting light might be thrown upon the problem if Egyptian and American mummies of both man and animals were examined (compare also 285). The question whether trichinae were carried to the non-arctic Americas by the Europeans, might also be clarified by such investigations, and by a comprehensive survey of carnivores in the transitional zone between arctic-subarctic and temperate regions. At

the outset I would consider it probable that trichinae were present in wild animals in North America, at any rate, before the arrival of the Europeans.

It would be extremely interesting to investigate wild animals in regions with a pure Moslem populations, if such areas can be found. This might give further clues to an elucidation of the interdependence of pigs and carnivores in regard to *Trichinella*.

Because of the many problems which still remain to be solved, I can fully agree with the following statement found in "Recommendations adopted by the 1954 National Conference on Trichinosis" (34): "Inasmuch as the sylvatic occurrence of *Trichinella spiralis* probably plays an important role in the life history of this parasite, it is highly desirable to obtain information concerning instances of trichinosis in wild animals. It is recommended that an appeal be made to organizations and groups of workers who are accustomed to examine wild animals, including the U.S. Fish and Wildlife Service, various biologic survey groups, the American Society of Parasitologists and the American Society of Mammalogists, and through these agencies to their members, to examine, whereever possible, any wild animals".

It would only be useful if this kind of work were not confined to the United States, but were extended to all countries, for instance in connection with the studies on rabies performed in many regions. Such an arrangement would primarily be a matter of organization, since facilities for such investigations would be present in a great many veterinary and medical institutes, and often in abattoirs. Serological methods might often be useful.

It is evident that the incidence of *Trichinella* in man is not merely a reflection of the incidence in pigs and other infected food animals. The eating habits play a decisive rôle too. This is very clear if we compare e. g. the conditions in Canada and the United States. The incidence in man in Canada is apparently much lower than in the U.S.A. (ca. 3 %, as against ca. 15 % in the U.S.A.), though probably not as much lower as previously supposed (288). Also cases of trichinosis probably occur more frequently than generally assumed (347).

The incidence in pigs is, however, approximately on the same high level (about 4 %) in both countries (255, 256). Greater regional differences might be expected in Canada than in the U.S.A., because of the less uniform civilisational conditions in the former country. The decisive difference in eating habits responsible for the difference in incidence in man has not, to my knowledge, been established.

That trichinosis does not reach a more catastrophic extent in the Arctic (where the habit of eating raw or, because of fuel shortage, insufficiently cooked meat is widespread) than is actually the case, must

probably in the first place be ascribed to the relative sensibility of trichina larvae to low temperatures of frost, secondly to a resistance (immunity) acquired from repeated weak exposures, a factor which may play a rôle wherever high incidences of infection are found. Differences in the individual resistance should not be overlooked in this connection. They may account for many cases of puzzling differences in incidence during outbreaks, which cannot easily be explained by differences in exposure. The influence of low temperatures on the larvae has been treated in a number of recent papers (118, 137, 292, 339, 356, 407—408).

In times of peace the widespread occurrence of trichinae in wildlife is, in respect to the public health, a menace which hampers the control in pigs, and in times of disaster may mean a catastrophe. The rôle played by trichinosis during wars, especially in former centuries, has probably not been realised (71, 214). The impact on the troops of typhoidlike diseases is well known. It has been stressed (234) that during the First World War "typhus" was a common erroneous diagnosis for trichinosis.

The intrinsic infections in wild animal populations cannot be influenced directly, but public health measures on a broad scale, intending to stop any unnecessary conveyance of infective material to wildlife might be indicated. As in all aspects of the trichina problem it is a question of safe disposal of infected carrion, and the protection for the individual person must consist in subjecting the meat for a sufficient long time to either high or very low temperatures. The recent suggestion (208) of treating pigs with cadmium oxide to prevent infection, seems to me to be a downright perversion. Nowadays human food is already being poisoned in the most ingenious ways by many other chemicals.

STOLL (1947) in his famous and brilliant paper "This Wormy World" calculated the probable number of human infestations to be nearly 30 millions. Even if we disregard the increase of the world's population which has taken place since his paper was published, it would appear from the evidence put forward in the present paper that this estimate was in all probability much too low. If one would try to estimate the number of animal infections, one would arrive at quite astronomic figures.

SUMMARY

1. A material of more than 10,200 samples of meat from 25 species of mammals in Greenland examined for the presence of *Trichinella spiralis* is presented in full details here. It was examined by the late Dr. HANS ROTH and his late widow, Mrs. URSULA ROTH. A survey of the material is presented in table 1, p. 13, and table 2, p. 14 and the maps, figs. 1–7.
2. The animals found infected were: sledge dog, wolf, polar bear, arctic fox, walrus, bearded seal, and ringed seal.
3. No evidence was found showing that the free-living rodents in Greenland, the arctic hare and collared lemming, are infected.
4. The dogs presented the highest frequency of infection, averageing about 70 %. The origin of their infection is in all probability dog carrion.
5. The polar bears were found infected in about 25 % of the animals examined. As compared with other materials published, this rather low frequency is probably due to the presence of many young animals in the Greenland collection. The source of the infection is probably polar bear and seal (particularly walrus) carrion.
6. The arctic foxes were astonishingly rarely infected, in about one per cent of the cases examined. Definite differences according to races and regions were found: The infection was mainly demonstrated in regions where lemming foxes prevail, viz. in North-West, East, and South-West Greenland. The rather copious material of coastal foxes from the western mainland south of the Nûgssuaq Peninsula showed no infection. The lack of infection in the coastal foxes is probably associated with the very specialised feeding habits of this race. The source of the infection is probably in the main carrion of polar bears and their meals. The low percentage probably reflects the short life of the foxes. In higharctic regions where the infection percentage attains its highest level, the foxes generally reach a greater age than in more subarctic regions.
7. The first actual demonstration of trichinae in marine mammals was based upon part of the material presented here (301—303). In walrus and bearded seal, both bottom animal feeders, an infection

percentage of about one was found. The infection in ringed seal was considerably more infrequent. In all of them the source of infection is most probably carrion, especially of dogs, in the two last-mentioned species perhaps with the interaction of gammarids and other crustaceans, which tear to pieces carrion in the sea (383).

8. The circumpolarity of the trichina infection in polar bears was already established by ROTH (1950). On the basis of our present knowledge it is demonstrated that the same must be considered to be the case with the other above-mentioned known infected animals, including the white whale, which was found infected in Alaska and caused an outbreak among human beings in Greenland.
9. Especially based upon investigations from Alaska (293—295), and on considerations regarding the distribution of the animals found infected there, and their opportunities of contact with the arctic trichina infections supplied with isolated finds in the Scandinavian and Siberian Subarctic, it is concluded that in all probability especially the carnivores in the continental subarctic regions will exhibit an all over infection.

   Since many rodents in the subarctic Alaska proved to be infected, the possibility must be taken into account that the same will be the case in other subarctic wilderness regions. That this was not the case in the subarctic Greenland, may be due to Greenland's unique position in a zoogeographical respect.
10. A meticulous survey of the literature on the occurrence of trichinae in wild-living mammals, (carnivores, wild boar) in temperate regions shows that the infection is enormously widespread in Russia, the Scandinavian peninsula, Eastern and Central Europe, and that it is probably similarly widespread in the rest of Europe and in the temperate North America, no doubt in direct connection with the subarctic infections. The infections are, at any rate in many regions, maintained within the wild populations without any essential influence from the infections in domestic pig. In Europe the wild boar has been found infected whereever it has been investigated. Probably it is infected throughout its total range. This contention is supported by the prolific occurrence demonstrated in the Middle East, Southern Sibiria and Northern India.
11. In contrast to the current belief it is demonstrated that trichinae are widespread in domestic pigs all over the world, also in tropical regions. Wildliving scavengers in all regions examined (other than Denmark, see p. 60) have been found to be infected. Therefore, trichinae may be expected to be encountered in these animals in any region where trichinae occur in domestic animals. Furthermore, infected wildlife (like foxes, martens, etc.) have in all

probability been introduced from Europe into many regions, like e. g. Australia and New Zealand.

12. It is demonstrated that so far there is no evidence whatsoever to show that trichinae occur in insectivores. Apart from certain arctic and subarctic regions where rodents are known to eat meat, and apart from those mainly dependent upon human habitations, there is no evidence that free-living rodents harbour infections. Since there is plenty of evidence showing that no rodents are able to sustain trichina infections among themselves, it should now be possible to eliminate the rat theory for ever. It appears to have hampered the *Trichinella* studies enough already. It must be stated that, typically, the infections of *Trichinella spiralis* are dependent upon carrion.
13. The whole *Trichinella* situation, as outlined above, and historical evidence show that neither trichinosis (the disease) nor trichiniasis (the occurrence of the worm) at the time of their discovery were new phenomena, neither in Europe nor in America.
14. Control of the infection in wild animal populations will hardly be possible. The only means of control would be the safe disposal of carrion. This should definitely be considered in more densely populated areas, where the degree of interplay between the infections in wild animals and domestic pig has still to be determined. To establish direct human protection, either prolonged freezing or thorough cooking will be the means.
15. In appendix 1 (p. 92) all known occurrences of trichinae in wild-living animals have been tabulated. In appendix 2 (p. 94), some observations on the shape and size of trichina capsules are presented.

РЕЗЮМЕ

РАСПРОСТРАНЕНИЕ ТРИХИНЕЛЛЕЗА

1. Здесь полностью освещается исследование наличия трихинеллеза в 10200 пробах мяса, взятых в Гренландии от 25 разных видов млекопитающих животных. Исследования были осуществлены умершими доктором Гансом РОТ и его женой Урсулой РОТ. Обзор материала следует из таблиц 1-й на 13 стр., 2-й на 14 стр., а также из карт – рис. 1-7.

Поводом к сбору материалов были тяжелые эпидемии трихинеллеза среди населения западной Гренландии в 1947 году. Более поздние вспышки болезни имели место в 1949, 1953, 1959 годах. Источником этих вспышек было мясо моржа и, в некоторых случаях, мясо белухи (*Delphinapterus leucas*). Слишком ранняя смерть доктора РОТ не позволила ему обработать свой материал окончательно.

2. Животные, оказавшиеся зараженными, были: санная собака, волк, полярный медведь, полярная лисица (песец), тюлени (*Phoca hispida*) и тюлени (*Erignathus barbatus*).

3. Не было обнаружено никаких признаков заражения у дикоживущих грызунов в Гренландии, как-то: полярный заяц (*Lepus arcticus*) и лемминг (*Dicrostonyx torquatus*).

4. Чаще и больше всего были заражены собаки, в среднем около 70 % и этот процент возрос до 90 % в районе Тулэ, единственной местности, где собаки имели большой доступ к мясу полярного медведя и моржа. Заражение собак было, очевидно, вызвано отбросами мяса и собачьей падалью.

5. Из полярных медведей были заражены приблизительно 25 % исследованных зверей. Причиной этого, относительно малого процента по сравнению с остальным материалом, является, вероятно, большое количество молодых животных, исследованных в Гренландии. Заражение медведей было, очевидно, вызвано медвежьей, тюленьей и (в особенности) моржовой падалью.

6. Полярные лисицы (песцы) были удивительно редко заражены, приблизительно 1 % исследованных случаев, ясно варьируя в зависимости от породы и местности. Заражение было, преимущественно, обнаружено в местностях, где преобладали песцы, которые

едят леммингов, а именно: Северо-Запад, Восток и Юго-Запад Гренландии. Довольно богатый материал исследования прибрежных песцов западной части континента, к югу от Нугссуак, не показал никакого заражения. Отсутствие заражения среди прибрежных песцов находится, вероятно, в связи с весьма специфичными привычками питания этой породы песцов. Источником заражения, преимущественно, является падаль медведей и в остатках их еды. Редкость трихинеллеза здесь связана с коротким временем жизни песца. В районах крайней Арктики, где заражение встречается чаще всего, песцы живут дольше, чем в более субарктических областях.

7. Первое действительное доказательство наличия трихин у морских млекопитающих животных было основано на части представленного здесь материала (301–303). У моржа и тюленя (Erignathus barbatus), которые оба питаются живущими на дне моря животными, был обнаружен лишь 1 % заражения. У тюленя (Pusa hispida) заражение встречалось еще реже. Для всех пород источником заражения, наиболее вероятно, является падаль, в особенности собачья. Что касается двух последних – тюленя (*Erignathus barbatus*) и тюленя (*Phoca hispida*) – то была выставлена гипотеза, что заражение получается, мохет быть, от гаммаридов и других ракообразных (скорлупных) животных, питающихся встречающейся в море падалью (383). Большой материал, взятый от пелагических тюленей, не показал никакого заражения.

8. Распространение в окружности зоне полюса трихинеллезной заразы у полярных медведей – было уже доказано доктором РОТ в 1950 году. На основании современных знаний доказано, что то же самое относится и к другим вышеупомянутым животным, у которых установлено заражение и которые были причиной вспышки трихинеллеза среди людей в Гренландии, а также к белуге (*Delphinapterus leucas*), оказавшейся зараженной на Аляске.

9. Предпринятые исследования на Аляске (293–295), соображения, относительно найденных там зараженных зверей и их возможного контакта с арктическими трихинными заражениями и, наконец, изолированные находки в скандинавской и сибирской субарктике, дают основания заключить, что, по всей вероятности, роды хищных животных континентальной субарктической области поголовно заражены. Это предположение поддерживается, между прочим, русскими исследованиями, принятыми во внимание в приложении.

Так как многие грызуны в субарктической Аляске обнаружены зараженными, то нужно принять во внимание возможность аналогичной заразы и в других субарктических областях. Что это не имело места в субарктической Гренландии, может быть следствием особого положения Гренландии в зоогеографическом отношении.

Жизненные условия грызунов на Аляске отличаются от условий грызунов на севере североевропейского континента.

10. Подробное исследование литературы о нахождении трихин у дикоживущих млекопитающихся (плотоядные, дикие свиньи) в областях с умеренным климатом показывает, что заражение очень сильно распространено в России на Скандинавском полуострове, в Восточной и Центральной Европе, Англии и Италии и что оно, вероятно, столь же распространено в остальной части Европы и в районах Северной Америки с умеренным климатом и имеет, без сомнения, прямую связь с субарктическими заражениями. Заражение диких животных имеет, во всяком случае, место во многих районах без существенного влияния со стороны заражений у домашних свиней. Дикая свинья оказывалась зараженной всюду в Европе, где она была исследована. Она, очевидно, заражена во всей области ее распространения. Это предположение находит поддержку в частой встрече заражений, обнаруженных на Среднем Востоке, в Южной Сибири и в северной Индии.

11. В противоположность общему мнению показано, что трихины широко распространены среди домашних свиней по всему земному шару, а также и в тропических областях. Дикоживущие животные, питающиеся падалью, во всех исследованных местностях /кроме Дании, см. стр. 60/ оказались зараженными. Поэтому можно ожидать, что трихины будут встречены у этих животных во всех областях, где трихины находятся у домашних животных. Кроме того, надо иметь ввиду, что зараженные дикие животные (например: лисицы, куницы и др.), по всей вероятности, вывезены из Европы в другие районы, например: в Австралию, Новую Зеландию.

12. Судя по опубликованной литературе, нет до сих пор никаких доказательств, что трихины встречаются у насекомоядных животных. Рекомендуется опубликовать возможные открытия в этой области, в таком виде, чтобы было исключено всякое сомнение в этом. За исключением определенных арктических и субарктических областей, где грызуны, как известно, питаются мясом и, кроме грызунов, зав исимых от человеческих жилищ, нет никаких доказательств, что трихины встречаются у грызунов, живущих на воле. Так как имеются бесчисленные доказательства, что грызуны не могут поддерживать заражение среди самих себя, то следовало бы теперь навсегда отбросить теорию зара жения крысами, которая уже достаточно тормозила исследование трихины. Можно утверждать, что заражение трихинеллезом происходит от падали.

13. Все положение трихинеллеза, как оно обрисовано здесь, и исторические примеры показывают, что ни болезнь "трихинеллез", ни "трихиниазис" (присутствие червя) не были чем-то новым в

Европе или в Америке, но что дело в экологическом комплексе, который существовал уже в течение тысячелетий.

14. Борьба с заражением диких животных едва ли возможна. Единственным средством борьбы с ним было бы безопасное удаление падали. Это должно быть определенно принято во внимание в густо населенных местностях, где взаимоотношение заражения между дикоживущими животными и домашними свиньями еще не установлено. Для непосредственного предохранения человека от заражения, необходимо или более продолжительно замораживать или основательно варить всякое применяемое в пищу мясо.

15. В дополнении I (с. 92) указаны в таблице все известные до сих пор случаи нахождения трихины у дикоживущих животных. В дополнении 2 (с. 94) показаны некоторые наблюдения касательно формы и величины трехинных капсул-ь.

16. В приложенном добавлении (с. 100) высказывается известная критика против применения слова "фокус" или "очаг", так как это слишком узкое понятие для постоянного универсального явления, каким есть заражение в природе. Обращается внимание на то, что уже по причине короткого срока жизни грызунов (и возможно насекомоядных животных), они не могут играть решающую роль в трихинных эпидемиологиях.

Appendix 1.

WILD-LIVING MAMMALS FOUND INFECTED WITH *TRICHINELLA SPIRALIS*

Opossum, *Didelphys virginianus*. U.S.A. (Iowa).

Snowshoe hare, *Lepus americanus*. Alaska.
Arctic ground squirrel, *Citellus parryi*. Alaska.
Red squirrel, *Tamiasciurus hudsonicus*. Alaska.
Brown lemming, *Lemmus trimucronatus*. Alaska.
Tundra red-backed vole, *Clethrionomys dawsoni (rutilus)*. Alaska.
Alaska vole, *Microtus miurus*. Alaska.
Black rat, *Rattus rattus alexandrinus*, Hawaii.
Hawaii rat, *Rattus hawaiiensis*, Hawaii.

Wolf, *Canis lupus*. Greenland, Alaska, Russia, Poland, Roumania, Bulgaria, Yugoslavia, Italy, Western and Central Siberia,
Coyote, *Canis latrans*. U.S.A.: Alaska, Iowa, Colorado.
Arctic fox, *Alopex lagopus*. Greenland, Arctic Canada, Alaska, Russia Sweden.
Red fox, *Vulpes fulva*. Alaska, Iowa, Colorado.
Vulpes vulpes. Sweden, Norway, Finland, Russia, Western and Central Siberia, Poland, Hungary, Germany (Bayern, Württemberg, Baden, Rheinland, Braunschweig, Hessen, Sachsen, Schlesien), Austria, Switzerland, Czechoslovakia, Roumania, Bulgaria, Yugoslavia, Italy, Luxemburg, England.
Vulpes corsac. Central Siberia.
Raccoon dog, *Nyctereutes procyonides*, Russia, Germany (? see p. 47).
Grey fox, *Urocyon cinereoargenteus*. U.S.A. (Iowa).

Brown Bear, *Ursus arctos*. Alaska, Sweden, Roumania, Russia, Caucasus, Kamchatka.
Black Bear, *Ursus americanus*. Alaska, U.S.A. (California, Pennsylvania, N.Y. State).
Polar Bear, *Thalarctos maritimus*. Greenland, Arctic Canada, Alaska, Spitsbergen (Svalbard), Frantz Joseph Land, Arctic Siberia, the Polar Sea.
Raccoon, *Procyon lotor*. U.S.A.

Badger, *Meles meles*. Norway, Sweden, Finland, Russia, Hungary, Bulgaria, Germany (Ost Preussen, Brandenburg, Mecklenburg, Braunschweig, Sachsen, Hessen, Baden, Bayern).
American badger, *Taxidea taxus*. U.S.A. (Maryland).
Spotted skunk, *Spilogale putorius*, U.S.A. (Iowa).
Striped skunk, *Mephitis mephitis*. U.S.A. (Iowa, Maryland, Louisiana).
Ermine, stoat, *Mustela erminea*. Alaska, Sweden, Russia, western and central Siberia.
Least weasel, *Mustela rixosa*. Alaska.
American mink, *Mustela vison*. U.S.A. (Iowa). Norway,

Siberian mink, *Mustela sibirica*, western Siberia.
Weasel, *Mustela vulgaris*, Bulgaria.
Pigmy Weasel, *Mustela minuta*, western Siberia.
European mink, *Lutreola lutreola*. Russia. Roumania.
Polecat, *Putorius putorius*. Germany (Mecklenburg, Braunschweig). Roumania, Bulgaria.
Pine marten, *Martes martes*. Russia, Germany (Braunschweig). Sweden.
Stone Marten, *Martes foina*. Russia, Czechoslovakia.
Sable, *Martes zibellina*. Russia.
Wolverine, *Gulo gulo*. Alaska.
Otter, *Lutra lutra*, Roumania.

Ichneumon, *Herpestes ichneumon*. North Africa (? See p. 64). Israel.
Mongoose, *Mungos birmanicus*. Hawaii.

Wild cat, *Felis catus*. Russia. Czechoslovakia. Roumania.
Lynx, *Lynx lynx*. Alaska, Russia, Poland, Czechoslovakia.
Bobcat, *Lynx rufus*, U.S.A. (Colorado).

Walrus, *Odobaenus rosmarus*. Greenland, Arctic Canada, Polar Sea. Alaska.
Ringed seal, *Phoca hispida*. East Greenland, Alaska.
Bearded Seal, *Erignathus barbatus*. Greenland, Alaska.

White whale, *Delphinapterus leucas*. Greenland, Alaska.

Wild boar, *Sus scrofa*. Russia, Poland, Germany (Brandenburg, Braunschweig, Pommern, Mecklenburg, Sachsen, Hessen, Bayern, Württemberg), Hungary, Roumania, Bulgaria, Holland, Belgium, Switzerland, Syria, Northern India, Siberia.
Feral swine, *Sus scrofa domestica*, Hawaii.
Hippopotamus, *Hippopotamus amphibius*. Africa (Sudan) (See p. 69).

Appendix 2.

SOME OBSERVATIONS ON THE SHAPE AND SIZE OF THE CYSTS OR CAPSULES OF *TRICHINELLA SPIRALIS*

As mentioned above on p. 12, Dr. Roth measured almost 800 cysts, and made some observations on their shape. This latter is known, in a broad sense, to vary according to the host. The information in the literature on these things appears to be meagre.

The typical shape, as is seen so often in the "classical" figures of the cysts of capsules in the muscles, containing the larvae, appears to be lemon-chaped, more or less oblong, but oval shapes are also common, in pig and in man. In many hosts the capsules are often rounded, getting short elliptoid to circular in the microscopic picture, e. g. in rats and carnivores.

In the present material the lemon-shape occurred with a considerable frequency in the dog and to a less degree in the polar bear, and was furthermore met with in the arctic fox and the walrus. It did not occur in the rather few cysts measured in the bearded seal and the ringed seal. The occurrence of this shape was correlated with the age of the cysts, since it was present in the dogs with a significantly higher frequency

Table 7.

Host	Age of capsules	Total	+	%+
Dog	"young"	103	64	62.2
	"old"	53	13	24.5
Bear.....	"young"	19	6	31.5
	"old"	25	2	8.0
Bear.....	—	51	11	21.6

Number of host specimens with and without lemon-shaped cysts or capsules of *Trichinella spiralis*. In the case of dogs, Chi- quare on young and old cysts is highly significant (18.43***).

in "young" than in "old" cysts (Table 7) (Regarding the meaning of these designations, see above, p. 12). In the bears the same tendency

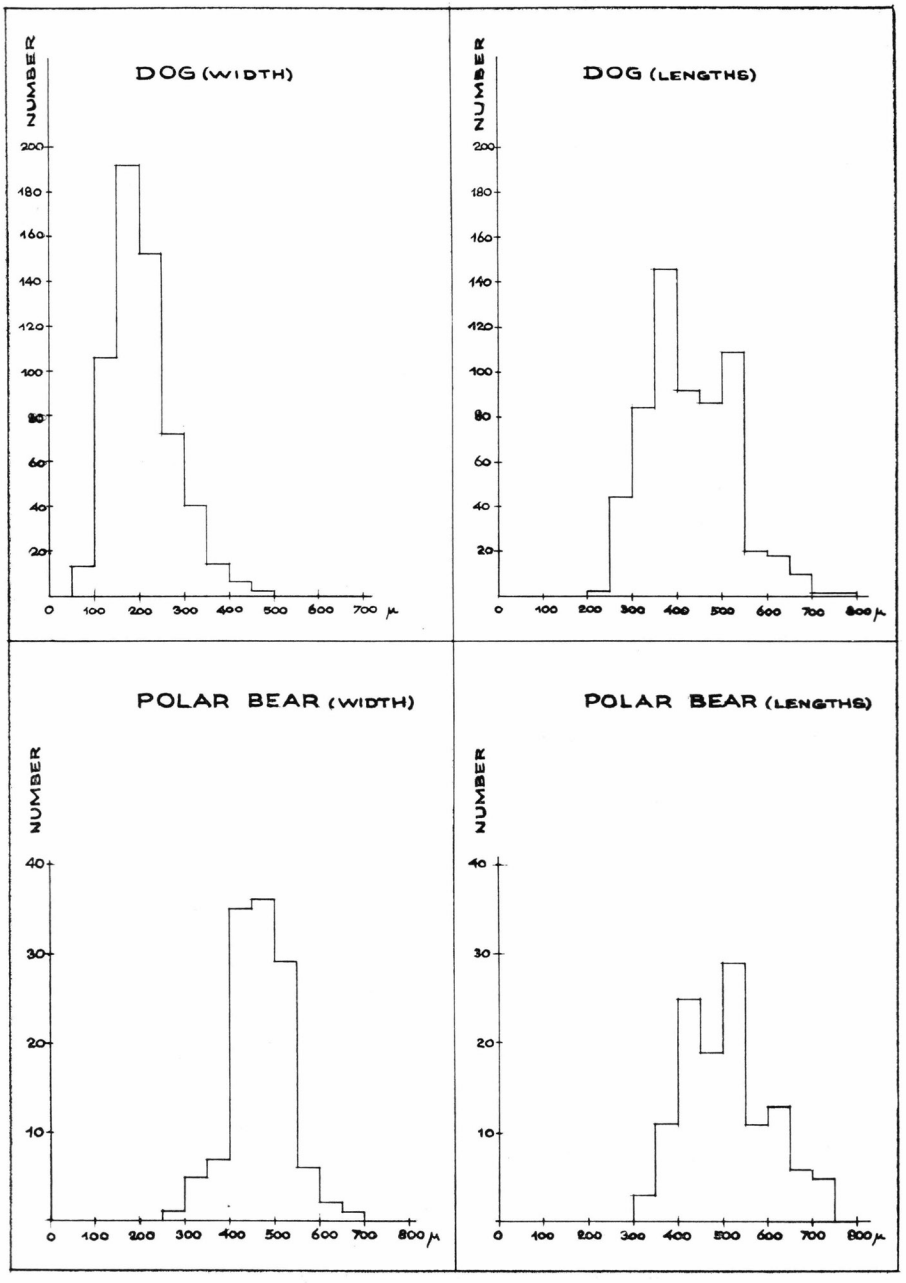


Fig. 9. Length and width of *Trichinella spiralis* capsules in muscle.

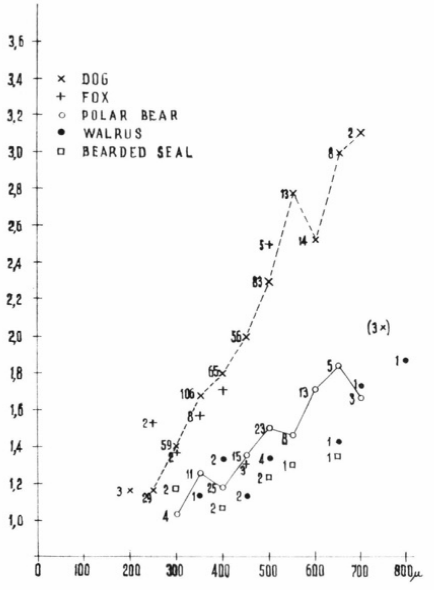


Fig. 10. Average form index of cysts set up against length. Numerals signify number of cysts measured. The three cysts from dogs (x), which have dropped down into the "bear range", were all old.

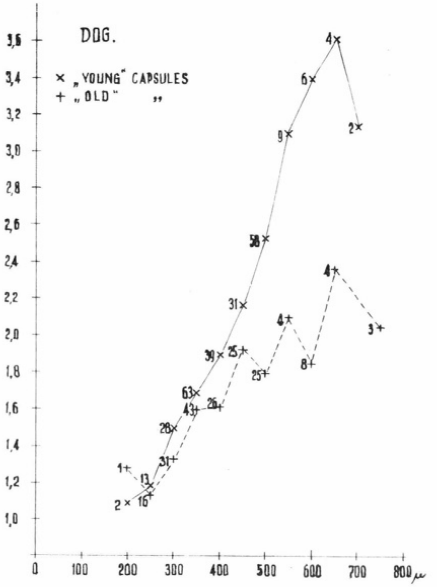


Fig. 11. Young and old cysts from dogs compared. Average form index set up against length. Numerals signify number of cysts measured.

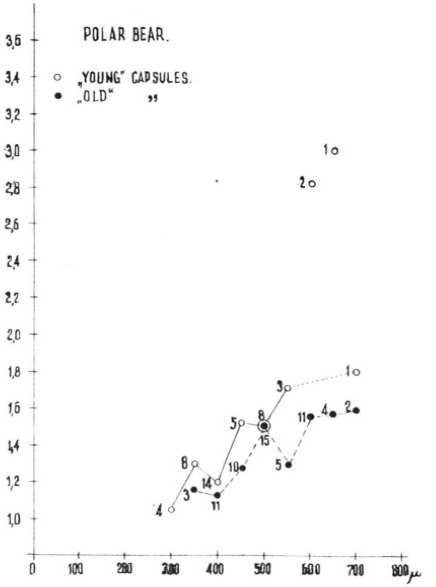


Fig. 12. Young and old cysts from polar bears compared. Average form index set up against length. Note a few cysts (upper part of figure) which have remained in the trend normal for cysts from dogs (see fig. 10). Numerals signify number of cysts measured.

Table 8.

Host Measurement	n	$\bar{x}$	Range	s	t	F
Dog length, old	187	405	200—750	106.0	1.75	1.18***
— — young	255	421	200—750	97.6		
— width, old	187	264	125—500	74.0	6.91***	1.85***
— — young	255	219	125—425	55.2		
— form index, old	187	1.63	1.00—3.71	0.53	73.60***	2.10***
— — young	255	2.07	1.00—4.80	0.76		
Bear length, old	61	513	375—700	87.7	3.71***	no diff.
— — young	45	448	300—700	90.1		
— width, old	61	378	250—550	58.5	4.77***	no diff.
— — young	45	321	150—450	63.6		
— form index, old	61	1.38	1.00—2.00	0.08	9.34***	4.36***
— — young	45	1.46	1.00—3.00	0.54		
Dog length	442	416	200—750	101.0	6.77***	n. s.[1]
Bear —	106	485	300—700	93.0		
Dog width	442	238	125—500	68.0	16.05***	n. s.[2]
Bear —	106	354	150—450	66.9		
Dog form index,	442	1.88	1.00—4.80	0.67	91.30***	2.92***
Bear —	106	1.41	1.00—3.00	0.28		
Fox length	26	392	175—525	85.4	–	–
— width	26	247	150—425	67.6	–	–
— form index	26	1.67	1.00—3.50	0.60	–	–
Walrus length	11	443	375—800	103.7	–	4.18**
— width	11	339	250—450	93.8	–	
— form index	11	1.38	1.07—1.88	0.56	–	2.56*
Bearded seal length	12	523	300—650	130.7	–	10.70***
— width	12	379	200—475	60.1	–	
— form index	12	1.39	1.00—2.00	0.91	–	

Measurements of cysts or capsules of *Trichinella spiralis*. (Regarding "young" and "old" cysts, see p. 12).

[1]) If only old cysts are compared: F = 1.44*. [2]) If only old cysts are compared: F = 1.64**.

was evident, even if the lemon-shape was met with more rarely here, in conformity the relative rareness of oblong forms.

Elongate forms were more frequent in dogs (average form index 1.88) and foxes (1.67) than in the bear (1.41), the walrus (1.38), and the bearded seal (1.39), (see table 8, form index, and figure 10), but the shape is also dependent upon the age, since the round forms are more frequent among old than among young capsules (table 8, form index, figs. 11—12).

Following the shape variations, the average size (length of cysts) was significantly larger in cysts from polar bear (485 μ), walrus (443 μ),

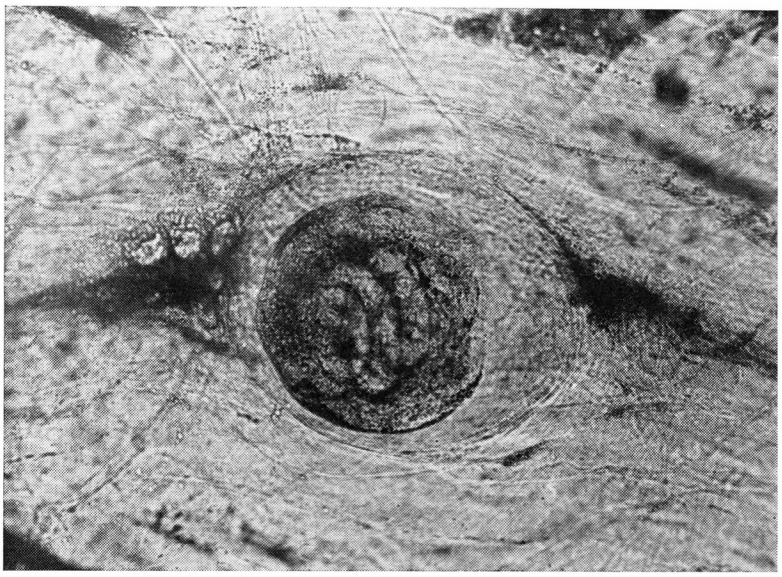


Fig. 13. Trichina capsule in flesh of polar bear. In center the coiled worm is seen. (100 X).

and bearded seal (523 μ) than in the dog (416 μ) and the arctic fox (392 μ). (Figure 9 and table 9). Old cysts are larger than young cysts. As regards width, these differences are significant in the case of both dog and bear, whereas only in bears the length is greater in old than in young cysts. In dogs, however, as in the case of the width, there is a significant difference in the variance, this being greater in old cysts. By significant differences in mean length and width between old and young cysts in bears, no corresponding difference in variance was observed, even if in the case of the form index the variance was significantly larger in young cysts than in old ones, both in dogs and bears. No explanation of these facts can be offered. The cysts in dogs exhibit a higher variability in regard to both length, width and form index than those in bears, in these respects behaving as "younger" (table 8) (See also fig. 10 and 11, where the cysts from dogs maintain their more elongated forms on a higher level than those from bears, presenting a similar difference as young and old cysts, respectively, especially in dogs).

According to measurements recorded in the literature (see 139, 151) the range of zise of the cysts in man and pig seems, generally, to fall within that found in dog here. However, generally the cysts in man would seem to be narrower; but the figures available do not permit a direct comparison. The cysts of the polar bear are often stated to be large, and the largest measurement recorded even exceeds those found

in our material (in 139, p. 173, table , there is a misprint, in that the length is given as 0.38 mm instead of 0.88 mm). The isolated measurements of cysts in mice indicate that they are about as oblong as in dogs, but considerably smaller. The facts available do not permit any reasonable correlation between the size and shape of the cysts and the size of the host or the strength of the musculature, even if it is obvious that the texture of the musculature is somehow decisive (see 368).

ADDENDUM

Since the completion of the manuscript a considerable amount of fresh information has been published, and some earlier data have likewise come to my attention. The information is chiefly derived from reports (more especially No. 445) and abstracts obtained on and from the First International Conference on Trichinosis held in Warszawa on September 12—13, 1960, in which I had the opportunity to participate, and at which I presented a report (454).

The fresh information that has come to light concerning the conditions in the Arctic is only sparse. Apart from some additional evidence of the occurrence of trichinae (in precentages around 50) in the polar bear in Spitsbergen (549) and in the Arctic fox in Sweden (430), a recent paper by FAY (434) may be mentioned. It is interesting in several respects. Its main importance lies in the additional evidence which it supplies with regard to the carnivorous, and especially carrion-feeding, habits of the walrus. Of special significance is the pointing out of the fact that there is a tendency for single individuals only to display this habit. This would explain the sporadic occurrence of trichinae in the walrus, as mentioned above (p. 32). As this was clearly pointed out for the first time in the present paper, it has quite naturally escaped his attention that the main source of trichina-infections in nature is carrion. In his assumption that the transmission is dependent upon predation he is therefore still influenced by LEUCKART, assuming e.g. the source of infection for the polar bear to be the bearded seal and the spotted seal. He even maintains that the eating of carrion "occurs too infrequently to be the principal method of transmission". He evidently overlooks the well-known, above (see e. g. p. 26, 81). stressed, fact that once acquired, an infection may be infective during the entire lifetime of the host. The same fact is overlooked when (in his table 2) he tries to correlate the finding of flesh remnants in the stomachs of walrusses with the occurence of trichinae.

On one point he has made a mistake. This is understandable in some measure, considering the information which was available to him: he doubts that the main cause of the outbreaks of trichinosis in West Greenland was walrus meat. It will appear from the present paper (see e. g. p. 37) that this is simply a fact. One reason for the widespread

occurence along the coast, at which he wonders, is that meat of walrus, a comparatively rare thing in southern West Greenland, is widely distributed, whether sold or in the form of gifts. Another circumstance which he thinks difficult to explain is "the lack of infections in settlements immediately north of the area of the epidemic where walrus, apparently from the same migrant population, were also harvested and eaten annually". The sporadic occurence of trichinae in walrus may furnish part of the explanation. Furthermore, in the meantime epidemics have occurred in these regions also. Finally, he reports himself how such a situation may arise, in the extremely interesting case when meat of an infected walrus (in Alaska) caused symptoms only in young, but not in old, dogs, and not in man either (cf. above p. 84).

The other fresh information to be cited below supports in every respect my thesis of the extremely wide spreading of the natural infection, especially in carnivores, and some more countries can be added to the list given above (p. 45 ff.).

That the infection in wild-living carnivores in Norway is a regular normal phenomenon, is emphasised again by some interesting observations (439), according to which trichinae have now also established themselves in the populations of American mink (*Mustela vison*) which have gained a footing in recent years, a case corresponding to the infections in the raccoon dog in Russia (cf. p. 47).

In Sweden trichinae have been found in recent years in ermine and pine marten (430), besides in fox and badger (see p. 48). In this connection a case in a lynx in a zoological garden may be mentioned.

There is now direct evidence of the occurence of trichinae in brown bear (429), and in foxes (6 out of 38, or 15.8 per cent) in Finland (472) (see p. 48).

A number of additional reports from the U.S.S.R. are likewise at hand. In the Roshchinsky area three out of 36 European mink (*Lutreola lutreola*) were infected (428); in various regions brown bears were found to be positive (438, 442, 479). In the Charkov region again a number of wild-living carnivores — wolf, fox, and raccoon dog — were found to be infected (466). In the Kursk region a number of animals were investigated, partly based upon meat remnants on hides. Out of 174 foxes, 56 were infected (32.2 per cent), and almost 100 per cent of a large number of wolves. Six out of 22 raccoon dogs were also infected. As in the Greenland material, though in other species, double infections were observed in wolves and foxes (485).

Very important are some recent reports from Western Siberia: 5 out of 5 wolves, 69 (20 per cent) of 337 foxes, 3 of 33 ermines, 9 of 87 *Mustela sibirica* and 2 out of 18 *Mustela nivalis* (= *minuta*) were found to be infected (450). Of particular importance are some reports

from the central parts of Siberia (see p. 49): heavy infections in wolf; the fox (33 of 132 inv. = 25.8 per cent), and 2 of 42 ermines were positive, in the Novosibirsk region (451). In the Omsk region, 9 out of 9 wolves examined were positive (440), and varying incidences were found in red foxes; trichinae were also found in the new host *Vulpes corsac* (471).

Notably from a series of East European countries, additional or fresh evidence has been reported. In Poland, 5 out of 5 wolves and 17 of 60 foxes (26 per cent) were positive (446). In Czechoslovakia considerable additional materials have been investigated. In western Slovakia one of 17 foxes, one of 10 wild cats, and two of 5 lynxes displayed infections (424, 433). In the surroundings of Prague, three out of 15 foxes were found to be infected (483). In Hungary, foxes and wild boars were positive (463).

From Roumania a number of reports were presented, based in part upon large materials. Of 1,078 foxes, 235 (21.8 per cent), 115 of 273 wolves (42.1 per cent), 19 of 72 wild cats (26.4 per cent), and 14 of 199 *Putorius putorius* were found to be infected. Curiously enough, 95 badgers were examined without one positive result. Three out of 21 (14 per cent) *Lutreola lutreola* were infected. For the first time, trichinae were found in an otter (*Lutra lutra*), one out of 15 (452, 453, 468). An outbreak in human beings after the consumption of brown bear meat was also reported (437).

In Bulgaria, a high percentage (8 out of 39, or 20 per cent) was found in the wild boar (477). Out of a total of 312 foxes, 113 (35.6 per cent) contained trichinae. In addition, trichinae were found in one of 4 wolves, two of 22 badgers, one of 19 *Putorius putorius*, and four of 25 *Mustela vulgaris* (422, 456, 464, 465). From Yugoslavia direct evidence (cf. p. 58) of the occurence of trichinae in wild-living carnivores is now available, trichinae having been found in 22 out of 126 (17.4 per cent) foxes, and in 4 of four wolves investigated (444, 474).

In Germany a few more wild-living carnivores of the usual species were found infected (471), thus in Braunschweig, in the late forties of this century: badgers, foxes and wild boars (435). In Hessen, an outbreak in man was caused by an unexamined wild boar (475). In Italy trichinae have also been found to be of widespread occurrence in red foxes (432); in one case, 195 out of 594 foxes (32.8 per cent were found to be infected (448). Also a wolf was found to be infected (436). Recently a more comprehensive paper treating the situation in Italy was published (455 a).

Also from regions outside Europe fresh evidence supporting my thesis of the wide distribution of the infection is now at hand. Sylvan animals in the Rocky Mountains, U.S.A., were found infected (Four out of 394 bobcats (*Lynx rufus*), (1 per cent), 1 of 194 coyotes (0.5 per

cent), and one of 33 red foxes (3 per cent)) (467), and Dr. DE WITTE reported at the conference that trichinae had been found in a wild-living black bear in Pennsylvania. Finally, trichinae were found in one out of 126 skunks investigated in Louisiana (423).

Especially interesting in our context is the occurrence of trichinae in *Herpestes ichneumon* in Israel (461, 484). According to a recent report (441), trichinosis is rare (!?) in man and animals in India (see p. 65). Additional reports on trichinae in pigs, dogs, cats, and rats in various parts of China were also presented (443, 476, 480). Trichinosis was also reported from Japan (478). The same was the case in the Canary Islands (476) and the Philippines (460). Rumours were current at the Conference that trichinae had been found in wild-living carnivores in China and in Africa!

In regard to the intricate question of the alleged occurrence of trichinae in rodents and insectivores, some fresh information has turned up (cf. p. 52). A quite cryptic report was given from India (470), according to which *Trichinella* sp. was found in a desert hedgehog. This has evidently nothing to do with *Trichinella spiralis*. In Poland (481) 24 insectivores and 583 voles were investigated without positive results. In Italy (448) the same was the case with 39 moles, and in She Nian, China (480) with 107 voles. But also positive finds are on record: In the Omsk region, Siberia, in a hedgehog (469), in Roumania in 11 out of 182 *Cricetus cricetus*, the common hamster (6.4 per cent) (452, 453), and in India in a squirrel (441).

In its relation to man, the infection of trichinae (zoonosis) is an anthropozoonosis (462). In recent years special attention has been paid to the ways of transmission (besides the papers mentioned above, p. 55, see also 425, 427, 447, 466, 485). A main concept in these studies is the herd or focus. These expressions seem to me to be misleading to some extent, since they give an impression of something restricted, whereas available facts, as pointed out repeatedly above, show that the transmission from animal to animal is a regular, widespread phenomenon.

It may be pertinent to point out again here the main factors responsible for this condition. In the first place, it is only exceptionally that the transmission depends upon predation, whereas the main mechanism is scavenging eating habits, which are evidently more widespread among carnivores than generally realised. Secondly and naturally, even though this fact has hitherto been overlooked to some extent, the older the animal, the greater will be its chance of being a source of further spreading of the infection.

If this is clearly kept in mind, the significance of infections in insectivores (if they occur at all) and in rodents will come into its right

light. Since all these animals are shortlived, they are doomed to be of minor significance.

There are obvious sources of error in regard to the diagnosis of trichinelliasis in insectivores and rodents (see above p. 52). This is emphasised once again in a recent paper (465), in which trichinae are reported to have been found in owls ! This can be said, with a considerable degree of certainty, to be a misdetermination. Even though it was stated by BEREZANTSEV that some cases in insectivores were verified by feeding experiments with mice, the matter has not generally been published in such a way as to preclude any doubt. It would be extremely useful, if it were stated expressly in publications dealing especially with other animals than carnivores that the larvae found were identified microscopically (an easy thing to do), or if the exact procedure of feeding experiments were given in detail.

On the other hand, it may be said that in Alaska, at any rate, trichinae have repeatedly been found in many kinds of rodents (but not hitherto in insectivores), and there does not seem to be any reason to doubt the determination in this case. In other regions, however, as in Germany, Hungary, Poland, and in certain regions in Russia, it is evident that a situation like that met with in Alaska does not exist. But it must be remembered that Alaska may be considered a wilderness area. A similar situation might quite well be found in other pronounced wilderness areas, as for instance Siberia. A systematic survey with this possibility in view would be useful.

From the exposition given above, it will be understood that I am still of the opinion that the importance of the accidental spreading of carcasses through insects and birds has been extremely over-emphasised (see p. 56) (457, 458, 459). Also the transmission of the infection with feces appears to have been over-estimated, since the chance of infection by this means is only a matter of hours (473).

In conclusion, it may be mentioned that a few recent reports on trichinae in farm fur animals have come to my attention (430, 451, 469, 472, 482) mainly from East European countries (see also p. 72). In order that the above (p. 84) list of papers on the reaction of trichinae to low temperatures should be as complete as possible, three more papers may be mentioned (421, 431, 455). A few indications of the size of trichina "cysts" in various animals are to be found in a recent Russian paper (469) (cf. p. 90).

It is interesting to observe how recent knowledge begins to leak out so that it is considered probable, even in recent official statistics, that trichinae occur e. g. in several regions in Africa, and the occurrence is acknowledged in regions from which no other information was formerly available, like in Malaya. But the veterinarian reticency (cp. p. 82) is still strongly felt in many cases (486).

LITERATURE CITED[1])

1. Aaser, C. S., 1941. Undersøkelse over trikinose hos pelsdyr. Norsk Veterin. Tidskr. 53, 198—226, 7 figs.
2. — 1950. in Roth, 1950, (303).
3. — 1956. La lutte contre la trichine. Bull. Off. Internat. Épizoot. 46, 300—306.
4. Abs, O. & Scmidt, H. W. 1954. Wie infizieren sich arktische Tiere mit Trichinen; vorläufige Mitteilung. Z. Ges. Inn. Med. 9, 15, 758—760.
5. — 1954. Die arktische Trichinose und ihr Verbreitungsweg. Norsk Polarinstitutts Skr. nr. 105, 1—34.
6. Alicata, J. E., 1937. Recent contributions to the knowledge of human parasitism in Hawaii. Proc. Hawaiian Acad. Sci. Bernice P. Bishop Museum, Special Publication 33.
7. — 1938. A study of *Trichinella spiralis* in the Hawaiian Islands. Publ. Health Rep. U. S. Publ. Health Service, 53, 10, 384—393. 2 figs.
8. — & Ricci, M., 1951. Recerche sulla trichinosi in Italia. Riv. Parassit., 12, 2, 113—118.
9. Allenspach, V., 1943. Trichinen bei Füchsen. Schweiz. Arch. Tierhk., 85, 380—382.
10. — 1950. Die Trichinose in der Schweiz. Schweiz. Arch. Tierhk., 92, 2, 134—136.
11. Alvez da Cruz, A., 1956. La lutte contre la trichinose. La trichinose au Portugal. Bull. Off. Internat. Épizoot., 46, 291—292.
12. Andrade Rodriguez, E., 1911. Trichina espiralis Owen. Rev. Vet. Escuela Montevideo, 2, 8—9, 376—377.
13. Anon., 1864. *Trichina spiralis.* Lancet 1864, II, 732—733.
14. — 1875. Das Vorkommen der Trichinose beim Wildschweine. Wschr. Tierhk. Viehzucht., 19, 104.
15. — 1897. Trichinose des Dachses. Z. Fleisch-Milchhyg., 7, 205.
16. — 1908. Trichinen bei Wildschweinen. Z. Fleisch- Milchhyg., 18, 38.
17. — 1908. Trichinen beim Bären. Z. Fleisch- Milchhyg., 18, 239.
18. — 1924—25. Tilfælde af Trikinose hos et Menneske i Odense. Maanedsskr. Dyrl., 36, 510.
19. — 1931. Trichinen beim Fuchs. Z. Fleisch-Milchhyg., 41, 135.
20. — 1931. Weitere Fälle von Trichinen beim Fuchse in Württemberg. Z. Fleisch-Milchhyg., 41, 204.
21. — 1932. Korte gegevens over de geschiedenis der Trichinosis in Nederlandsch-Indië. Nederl. Ind. Blad. Diergeneesk., 44, 467—469.
22. — 1932. Trichinen in einem Fuchs. Rdsch. Fleischbsch., 33, 23.
23. — 1934. Trichinen bei Füchsen. Z. Fleisch-Milchhyg., 44, 259.
24. — 1934. Trichinen bei Bären. Z. Fleisch-Milchhyg., 44, 339.
25. — 1934. Trichinose bei einem Eisbären. Z. Fleisch-Milchhyg., 44, 356.

[1]) Please notice that the alphabetical sequence is repeated on p. 122.

26. ANON, 1935. Trichinenfunde in Württemberg. Z. Fleisch-Milchhyg., 45, 298.
27. — 1935—36. Über Trichinen. Veröff. (Jahr-Vet.-Ber.) beamteten Tierärzte Preussens 1935—1936, 24, II., 147.
28. — 1936. Trichinen beim Fuchse. Z. Fleisch-Milchhyg., 46, 116.
29. — 1942—1947. Summary of Statistical Information regarding Greenland I—VII, pp. XLVII, 608, 125 figs. (Grønlands Styrelse).
30. — 1943. Ein trichinöser Fuchs bei 6000 untersuchten Füchsen. Z. Fleisch-Milchhyg., 53, 98.
31. — 1943. Trichinenfund beim Eisbären. Z. Fleisch-Milchhyg., 53, 168—169.
32. — 1948. Veterinærvesenet, Norges offisielle statistikk., p. 5—7, Trikiner.
33. — 1948. Trichinose nach Genuss von Wildschweinfleisch. Deutsch. Tierärztl. Wschr., 55, 31—32, 251.
34. — 1954. Recommendations adopted by 1954 National Conference on Trichinosis, Proc. 2., Nation. Conf. Trichinosis A. M. A., Chicago. Ill. March, 1954, 67—71.
35. — 1955. Arbejdet på Sundhedskommissionens laboratorium. Århus Kommunes Beretning 1955, p. 448.
36. — 1956. Wie kann man der Trichinengefahr bei Genuss von Rohfleischwaren entgehen, wenn keine amtliche Untersuchung auf Trichinen stattgefunden hat? Fleischwirtschaft 8, 26.
37. — 1957. FAO/OIE; Animal Health Year Book.
38. ARMENDARIS, E., 1898. Un caso de triquinosis intestinal. Mem. Soc. Cientif. "Antoine Alzate", 12, 397—402.
39. ARNOLD, J. A., 1910. Zur Trichinose und Trichinenschaufrage in Bayern. Inaug. Diss. Giessen, pp. 1—55.
40. ARVIDSSON, S. O., 1954. En trichinosepidemi. Svensk. Läk. Tidn., 31, 23, 1547—1561.
41. AYUPOV, CH. V., 1951. Trichinelliasis in the badger *(Meles taxus)* in B.A.S.S.R. Trud. Bašk. Nau. Issl. Vet. O. P. Stanzij, 6, 152., (Russ.).
42. BAHR, L., 1907. Ueber das Vorkommen von Trichinen bei der Ratte. Z. Infkrh. Haustiere, 2 62—65.
43. BANIĆ. M. & KENDEREŠKI, S., 1953. Trikinoza kod ljudi i žotinja (Trichinosis in man and animals). Higijena Beog., 5, 3, 205—215.
44. BARTELS, H., 1952. Ist eine Intensivierung der Trichinenschau erforderlich? Die Fleischwirtschaft., 4, 12—13.
45. BAUER, O. E., 1957. Outbreak of trichinellosis caused by ingestion of brown bear meat. Sovet. Med., 21., 11. Nov., 133—134., (Russ.).
46. BEARUP, A. J., 1937. A search for *Trichinella spiralis* in cadavers in Australia. Med. J. Australia, year 24, v. 1, 504—505.
47. — 1949. *Trichinella spiralis:* further search for infections of man in Australia. M. J. Australia, 2, 673—675.
48. BEESON, P. B., 1941. Factors influencing the prevalence of trichinosis in man. Proc. R. Soc. Med., 34, 584—594.
49. BEHR, FR., 1932.Trichinenfunde beim Fuchs auch in Baden. Z. Fleisch-Milchhyg. 42, 217.
50. BELIAEVA, M. YA. 1954. (Natural foci of trichinellosis in the region of the "Belovezhskaia Pushcha"). Zool. Zhurn. 33, 3, 714—715. (Russ.).
51. — 1955. (Natural foci of trichinelliosis). Veterinarija 32, 1, 39—40 (Russ.).
52. BELLON. 1879. Trichines et trichinose. Alger Méd. 7, 5, 146—153.
53. BEREZANTZEV, J. A. 1954. (Raccoon dog as a new host of *Trichinella*). Doklady Akad. Nauk. S. S. S. R. 94, 4, 791.

54. Berezantzev, J. A. 1956. Data on the natural herds of trichinellosis. Akad. Nauk. S. S. S. R. Zool. Žurn. 35. 1730—1733. (Russ. w. Engl. Summ.).
55. Berglund, H. 1917. Meddelande angående den senaste trikinepidemien. Svensk Läkaresälk. Förh. 1917, 133—138.
56. Bernia, & Massi, O. 1957. Un episodio di trichinosi, considerazioni cliniche, epidemiologiche e profilattiche. Nuovi Ann. Igiene Microbiol. 8, 5, 471—480.
57. Blanc, F., Collomb, H. & Armengaud, M. 1956. Étude de six cas de trichinose. Ann. Médicine 57, 4, 201—261, 26 figs.
58. Blanchard, R. 1887. Trichine. Trichinose. Dictionnaire Encyclopédique des Sciences Médicales, pp. 113—170.
59. Bobrinskoy, N., Kuznetzov, B. & Kuzyakin, A. 1944. Mammals of USSR. Moscow. pp. 1—440, 256 figs., 32 pls., 62 maps.
60. Bobrov, B. F. 1955. (*Trichinella* infection of wild animals). Med. Parazit. Moskva 24, 1, 77—78.
61. Bockum-Dölffs. 1888. Trichinen im Bärenschinken. Tiermed. Rundsch. 1888, 167.
62. Böhm, J. 1910. Zum Vorkommen der Trichinen bei Ratten und Eisbären. Z. Fleisch-Milchhyg. 20, 103.
63. — 1913. Zum Vorkommen der Trichinen beim Eisbären. Z. Fleisch-Milchhyg. 23, 208, 384.
64. Boucher, H. (1948): Trichinose avec manifestations allergiques importantes Lyon Méd. An. 80, 180 (89), 637—641.
65. Bræstrup, F. W. 1941. A study on the arctic fox in Greenland, immigrations, fluctuations in numbers, based mainly on trading statistics. Medd. Grønl. 131, 4, 1—98, 7 figs.
66. Brandly, P. J. & Rausch, R. 1950. Preliminary report on trichinosis in Alaska. Arctic 3, 105—107.
67. Brandt, O. 1942. Bidrag till kännedomen om trikinosfrekvensen hos räv, mink och grävling i Sverige. Våra Pälsdjur 13, 404.
68. Brendel. 1867. Trichinen bei *Scalops aquaticus*. Z. Naturw. Leipz. 29, 3—4, 323—324.
69. Brenner, K. 1932. Über die Bekämpfung der Trichinose. Inaug. Diss. Tübingen, pp. 1—35.
70. Briceño Iragorry, L., Ugueto, C. & Delgado, V. 1955. Hemoparásitos y trichinas de la ratas salvajes en Caracas. Gac. Méd. Caracas. 62, 1—2, 37—38.
71. Brimm, C. J. 1936. Trichinosis: flesh of the hog. A chapter in the medical culture of the ancient Hebrews. Med. Life 43, 515—530.
72. Brink, F. H. van den 1956. Die Säugetiere Europas westlich des 30. Längengrades. (Verl. Paul Parey). Hamburg & Berlin. Pp. 225, 470 figs.
73. Brown, M. 1949. Medical investigation at Southampton Island. Arctic. 2, 1, 70—71.
74. — Cronk, B., de Sinner, F., Green, J. E., Gibbons, J. E., & Kuitunen-Ekbaum, E. 1949. A note on trichinosis in animals of the Canadian Northwest Territories. Canad. J. Publ. Health. 40, 20—21.
75. — 1949. Trichinosis on Southampton Island. N. W. T. Canad. J. Publ. Health 40, 508—513.
76. — Green J. E., Boag, T. J. & Kuitunen-Ekbaum, E. 1950. Parasitic infections in the Eskimos at Igloolik, N. W. T. Canad. J. Publ. Health, 41, 508—512.
77. Brumpt, E. 1936. Précis de Parasitologie. 5 édit. (Paris. Masson et Cie) vol. 1, XII, 1082, 1085 figs., 4 pl.

78. BURT, W. H. & GROSSENHEIDER, R. P. 1952. A field guide to the mammals of North America. The Peterson Field Guide Series (Houghton Mifflin Co., Boston).
79. CAESAR, J. 1922. Ueber die Verbreitung der Trichinose in Deutschland während der Jahre 1910—1912, getrennt nach Stadt und Land, mit besonderer Berücksichtigung der durch den Krieg bedingten Veränderungen der Fleischversorgung. Veröff. Gebiete Medizinalverwalt. XV. Bd. 4. Hft. (Verl. Rich Schoetz).
80. CALERO, M. C. & ORTIZ, O. P. 1949. Triquinosis en Panama. Rev. Inst. Salub. Enferm. Trop. Mex. 10, 4, 355—358.
81. CAMERON, TH. W. M. 1958. Parasites of animals and human disease. Ann. N. Y. Acad. Sci. 70, 3, 564—573.
82. CANAVAN, W. P. N. 1929. Nematode parasites of vertebrates in the Philadelphia zoological garden and vicinity, I. Parasitology 21, 63—102, 5 pls.
83. CASPARIUS. 1919—20. Trichinen bei wildlebenden Tieren, und ihre Bedeutung für die Bekämpfung der Trichinenkrankheit bei Menschen. Jahrb. Inst. f. Jagdkunde IV, 1—22.
84. CHADDOCK, T. T. 1947. Veterinary problems of the fur ranch. Occurrence of trichinosis in mink. Vet. Med. 42, 8, 283.
85. CHEN, H. T. 1933. A preliminary report on a survey of animal parasites of Canton, China, rats. Lingnan Sci. J. 12, 65—74.
86. — 1936. Parasites in slaughter houses in Canton. Part 1. Helminths of Kwangtung hogs. Lingnan Sci. J. 15, 31—44.
87. CH'IN, YAO-TING. 1937. *Trichinella* infection in a cat in Mukden. Chin. Med. J. 51, 500—501, 3 figs.
88. — 1951. *Trichinella* infection in dogs, cats, rats, mice and pigs in Mukden, China. Peking Natur. Hist. Bull. 19, 2—3, 297—300.
89 CH'UNG-SUNG, F. 1958. (Case of *Trichinella* infection caused by boar *(Sus scrofa)* meat in Kazakhstan). Med. Parazit. Moskva. 27, 4, 447—449.
90. CHRISTIANSEN, M. & MEJLBO, E. 1943. Forekomsten af Trikiner hos Pelsdyr, Hunde, Katte, vildtlevende Ræve m. m. samt Rotter i Danmark. Mlbl. danske Dyrl. Foren. 26, 609—619.
91. CLAUS, 1931. Zum Vorkommen von Trichinen bei Füchsen. Z. Fleisch-Milchhyg. 41, 250.
92. CLEVISCH,. 1943. Trichinenfunde bei Füchsen. Z. Fleisch-Milchhyg. 53, 79.
93. COFFEY, J. E. & WIGLESWORTH, F. W. 1956. Trichinosis in Canadian Eskimos. Canad. M. Ass. J. 75, 4, 295—299.
94. CONNELL, FR. H. 1949. Trichinosis in the Arctic: a review. Arctic 2, 2, 98—107.
95. CRAIG, CH. F. & FAUST, E. C. 1943. Clinical Parasitology. 3. edit. (London: Henry Kingston). 767, 284 figs., 4 pls.
96. CRAM, E. B. 1941. *Trichinella spiralis*. In: Chitwood, M. B.: An introduction to nematology. Sec. II, part 2, 316—318. (Babylon, N. Y.).
97. DANIELS, C. W. 1914. Tropical medicine and hygiene, Part 2. Diseases due to the Metazoa. 2. edit. VIII, 278, 107 figs, 1 pl.
98. DEGE, W. 1953. Trichinen-Infektionen in der Arktis und S. A. Andrées Tod. Naturw. Rdsch. 6, 8, 332.
99. DEGERBØL, M. 1933. The prehistoric mammals of Denmark, compared with recent forms. Vidensk. Medd. Dansk Naturh. Forening 96, 357—641, 21 figs., 13 pls. (Danish with Engl. Summ.).
100. DOLMAN, C. E. 1954. Some ways in which animal health affects human health. Canad. J. Comp. Med. 18, 35—50.

101. Dolman C. E. 1957. The epidemiology of meat—borne diseases. In: Meat Hygiene, FAO Agricultural Studies No. 34, 7—108.
102. Donzelli, F. 1946. Su di un focolaio di trichinosi in Sicilia (note cliniche ed epidemiologiche). Policlinico (Sez. prat.). 53, 1149—1155.
103. Drechsel. 1904. Trichinenfunde beim Dachse. Tierärztl. Centralbl. Wien 27, 3, 46.
104. Dubinin, V. B. 1952. Parasiten-Fauna des Wildschweines in der Wolgadelta. Trud. Leningr. Občest. Estest. T. 21 B. 4.
105. Dunbar, M. J. 1949. The Pinnipedia of the Arctic and Subarctic. Fisheries Res. Board, Canada, Bull. No. LXXXV, 1—22.
106. Eieland, E. 1948. Trikinose hos isbjørn. Norsk Vet. Tidsskr. 60, 414—415.
107. Eilmann, H. 1934. Verkalkte Trichinellen im Bärenfleisch. Deutsch. Tierärztl. Wschr. 42, 633—635, 9 figs.
108. Euzebv, J. 1957. La trichinose. Concours Méd. 79, 42, 4475—4478.
109. Evans, A. D. & Lennox, M. 1953. An outbreak of trichiniasis in Barry, Glamorgan, Wales. Improved technique for demonstration of *Trichinella* in muscle. Brit. Med. J. 1953, 2, 4828, 131—133.
110. Faust, E. C. 1921. Preliminary survey of the parasites of vertebrates of North China. China Med. J. 35.
111. — 1923. The distribution and differentiation of human helminths in China and adjacent territory. A Syllabus for clinicians. 49. pp., 3 pl. 2 tables. Shanghai. Presbyt. Mission Press.
112. Fehr, J. H. 1675. De noxa carnis aminalium aegrotantium. Acta Naturae Curiosorum. 5. Ephemerides Med. Phys. Decur. I. Ann. VI. Obs. 191, 269—270.
113. Fenger, T. 1950. in Roth, 1950. (303)
114. Fernandez, E. & Rodriguez, H. 1958. Incidencia de triquinosis en el Matadero Municipal di Santiago durante los años 1936 a 1957. Bol. Chileno Parasitol. 13, 3, 53—54.
115. Feuereissen, 1930. Bärenfleisch als Trichinenträger. Deutsche-Schl. Z. 30, 114—115.
116. Fibiger, Joh. 1917. Om Forekomsten af Trikiner hos Mennesket i Danmark. Hospitalstidende 60, 1021—1043.
117. Fiebiger, Josef 1923. Tierische Parasiten (Berlin, Wien. Urban & Schwarzenberg), pp. XVI, 441, 353 figs. 1 pl.
118. Filipp, K. 1957. Versuche zur Feststellung der Invasionsfähigkeit der Muskeltrichine auf Grund des mikroskopischen Verhaltens ihres Zellkörpers im Dunkelfelde. Vet.-Med. Diss. München.
119. Flatmark, T. 1958. Trikinosens stilling i Norge i dag. Tidskr. Norske Lægeforen. 78, 17, 841—848, 2 figs.
120. Freund, 1910, in Böhm, 1913.
121. Froehner, 1951. Eine Erhebung über die Trichinenfunde seit 1945 im Lande Niedersachsen. Lebensmittelarzt 2, 10, 158.
122. Fuchs, 1911. Trichinenfund bei einem Dachse. Rdsch. Gebiet. Fleischbeschau 12, 36.
123. Furmaga, S. & Wysocki, E. 1951. On helminthfauna of the foxes in the Lublin territory. Ann. Univ. Mariae Curie-Skłodowska. Sect. DD. 6, 5, 97—123, 12 figs.
124. Gaillard, G. 1867. Cas d'infection trichineuse à l'hôpital civil. Bull. Soc. Méd. d'Alger 6.
125. Geiger, J. C. & Hobmaier, M. 1939. Trichinelliasis and carnivorous mammals (bears). Calif. West. Med. 51, 4, 249—250.

126. GÉRARD, R. 1946. Petite épidémie de trichinose en Algérie. Rev. Méd. Nav. 1, 353—362.
127. GERLACH, A. C. 1866. Die Trichinen, pp. 1—90, 6 pls. Hannover.
128. GIESSMANN, W. 1939. Beiträge zum Studium der Fuchstrichinose mit besonderer Berücksichtigung der Uebertragungsmöglichkeit der Fuchstrichine auf das Schwein. Inaug. Diss. Hannover. pp. 1—46, 6 figs.
129. GINSBERG, A. 1958. Helminthic Zoonoses in meat inspection. Bull. Epizootic Dis. Africa 6, 2, 141—149.
130. GLAZIER, W. C. W. 1881. Report on trichinae and trichinosis. U.S. Marine Hospital Service. Treasury Department. Document No. 84, pp. 212.
131. GOERTTLER, 1936. Trichinenfunde bei Füchsen. Rdsch. Fleischbesch. 37, 179.
132. GOLDSTEIN & THIES, 1929. Zur Fleischbeschau bei Wildschweinen. Z. Fleisch Milchhyg. 39, 319—320.
133. GOTZADZE, D. K. & ZIMIN, J. A. 1953. Case of trichinosis in bear. Med. Parazit. Moskva. No. 3. May-June, 278.
134. GOUJON, L. 1866. Expériences sur la *Trichina spiralis*. Thèse, Paris.
135. — 1867. Expériences sur la *Trichina spiralis*. J. Anat. Physiol. Paris 4, 5, 529—533.
136. GOULD, S. E. 1945. Trichinosis, pp. I—IX, 1—356, 128 figs. 10 tables. (Ch. C. Thomas) Springfield, Ill.
137. — & KAASA, L. 1949. Low temperature treatment of pork. Effect of certain low temperature on viability of *Trichina* larvae. Amer. J. Hyg. 49, 1, 19—24.
138. GRAY, D. 1912. Medical reports from Consulates in China. Brit. Med. J. 1912, 1, 846—847.
139. GRUBER, G. B. 1926. Trichinellen, Trichinose und ihre Abwehr. Ergebn. Hyg. Bakt. 8, 165—265, 5 figs.
140. GRÜNER, S. A. 1915. Die Trichinose eingesperrter wilder Tiere. Ark. Vet. Nauk. Petrogr. 45, 745—754 (Russ.).
141. GRZYWÍNSKI, L. 1956. The internal parasites of furred animals on farms in the western territories in Poland. Wiadom. Parazytol. 2, 5 (Suppl.), 155—156. (Polish w. Engl. Summ.).
142. HANSEN, IB 1924. Et Tilfælde af Trichinosis behandlet med Neosalvarsan. Ugeskr. Læger 86, 626—628.
143. HANSEN, A. C. & MADSEN, H. 1941. Om forekomsten af trikiner hos sølvræve, minks og rotter. Maanedskr. Dyrlæger 53, 136—138.
144. HANSON, R. P. & KARSTAD, L. 1959. Feral swine in the Southwestern United States. J. Wild Management 23, 1, 64—74, 4 figs.
145. HAUGE, ST. 1944. Trikinose. Norsk Vet.-Tidsskr. 56, nr. 12, 364—382. 3 figs.
146. — 1956. Trikinosens epidemiologi i Norge. Norsk Pelsdyrblad 30, 33—35.
147. HECKEL, E. 1879. Sur un cas de trichinose observé chez un jeune hippopotame du Nil, mort en captivité. C. R. Séance Acad. Sci. Paris 88, 1139—1140.
148. HEIDRICH, 1919. Trichinen beim Fuchs. Z. Fleisch-Milchhyg. 30, 12.
149. HELLER, A. 1874. Invasions-Krankheiten, in H. v. ZIEMSEN (Edit.): Handbuch der speciellen Pathologie und Therapie, 3. Bd., pp. 291—394. (Trichinen: pp. 348—394).
150. HELLER, E. R. 1957. Trichinellosis of wolves in the Kursk region. Med. Parasit. Moscow 26, 2, 161—163. (Russian with English Summary).
151. HEMMERT-HALSWICK, A. & BUGGE, G. 1934. Trichinen und Trichinose. Ergebn. Allgem. Path. Pathol. Anatom. 28, 313—392.

152. Herman, C. M. & Goss, L. J. 1940. Trichinosis in an American badger, *Taxidea taxus taxus*. J. Parasitol. 26, 2, 157.
153. Hermansson, K. A. 1943. Några erfarenheter vid mikroskopisk undersökning av rävkött på trikiner. Skand. Vet. Tidsskr. 33, 281—301, (w. Engl. Summ.).
154. Hesemann, 1942. Trichinenfunde bei Bären. Deutsch. Schlachthofzeitg. 42, 227—228 (See also Z. Fleisch-Milchhyg. 52, 274).
155. Hindersson, R. 1942. Trikiner i Isbjörnkött. Finsk Vet.-Tidsskr. 48, 25—30.
156. Hirsch, A. 1888. Handbuch der historisch-geographischen Pathologie. 2. vollst. Bearb. 2. Abt., pp. VI, 467 (Stuttgart).
157. Hitchcock, D. J. 1950. Parasitological study on the eskimos in the Bethel area of Alaska. J. Parasitol. 36, 232—234.
158. — 1951. Parasitological study on the eskimos in the Kotzebue area of Alaska. J. Parasitol. 37, 309—311.
159. Hjort, J., Knipowitsch, N. & Wollebæk, A. 1907. Bericht über die Lebensverhältnisse und den Fang der nordischen Seehunde. Cons. Perm. Intern. Expl. Mer, Rapp. Proc. Verb. 8.
160. Hjortlund, S. 1935. Fortsatte Undersøgelser over Forekomsten af Trikinen hos Hunde og Katte i København samt en Oversigt over dens Forekomst hos Mennesket og Svinet i Danmark. Skand. Vet. Tidsskr. 25, 501—543. (With English Summary).
161. Hökl, J., Cervinka, F. & Klauz, A. 1940. Beitrag zur Feststellung der Verbreitung der Trichinose bei Menschen und Tieren. Z. Fleisch-Milchhyg. 50, 112.
162. Høyberg, H. M. 1912. Bidrag til Trikinosens Forekomst i Danmark. Ugeskr. Læger 74, 30, 1077—1085.
163. Hornickel, 1921. Trichinen beim Fuchse. Z. Fleisch-Milchhyg. 32, 67.
164. Hovorka, J. 1957. Contribution to the discovery of natural foci of *Trichinella spiralis* in Slovakia (ČSR). Wiadom. Parazytol. Wars. 3, 2—3, 231—236 (Polish w. Engl. Summ.).
165. Hülphers, G. 1943. Trikiner hos räv och grävling. Svensk Jakt, 1943. Hft. 6, 250—251, (Ref. Sv. Vet. Tidsskr. 48, 312).
166. Husemann, Th. 1864. Beiträge zur Kenntniss der Erkrankungen durch den Genuss von Nahrungsmitteln aus dem Thierreiche. Deutsche Klinik 16, 76—78, 87—88, 99—100.
167. Ifland, R. 1924. Über die bisherigen Beobachtungen des Abtötens der Trichinen. Z. Fleisch-Milchhyg. 34, 294—296.
168. Ineson, M. J. 1954. A comparison of the parasites of wild and domestic pigs in New Zealand. Trans. Roy. Soc. New Zealand 82, 2, 579—609, figs.
169. Iversen, M. 1948. Trikinosens utbredelse og bekjempelse i Norge. Norsk Vet. Tidsskr. 60, 8, 303—310.
170. Jeffreys, W., Hamilton & Maxwell, J. L. 1911. The diseases of China (including Formosa and Korea), Philadelphia.
171. Jensen, C. O. 1919. Forekomsten af Trikiner hos Hunden og Katten i København 1918. Maanedsskr. Dyrl. 31, 211—219.
172. Jörg, A. & Britschgi, Th. 1944. Über das Vorkommen der Fuchstrichinose in der Schweiz, mit einem Beitrag zum mikroskopischen Nachweis. Schweiz. Arch. Tierhk. 86, 513—519.
173. Johann, M. 1938. Über Trichinen im Allgemeinen — sowie über ihre Verbreitung unter den Füchsen der freien Wildbahn im Speziellen (Auf Grund von Massenuntersuchungen im Kreise Sangerhausen) Inaug. Diss. Leipzig. pp. 1—23.

174. JOHNE, H. A. 1885. Trichinose bei einem Wildschwein. Ber. Veterinärwesen Königsreich Sachsen 29, 72.
175. — 1885. Zur Trichinose bei Schweinen. Deutsch Z. Tiermed. 11, 213—216.
176. — 1887. Trichinosis bei Bären. Ber. Veterinärwesen Königreich Sachsen 1886, 31, 57—58.
177. JOHNSON, E. A. 1902. *Trichina spiralis*. Australas. Med. Gaz. Sydney (246), 21, 3, 120—121.
178. — 1902. Additional notes on a case of trichinosis. Australas. M. Gaz. Sydney (251), 21, 8, 415.
179. JOHNSTON, T. H. & CLELAND, J. B. 1911. The helminth parasites of man in Australia. Proc. Austral. Ass. Advancement Sci. 13, 305.
180. JUNACK, M. 1930. Die Eisbärentrichinose und andere Trichinosefragen. Z. Fleisch-Milchhyg. 40, 363—365.
181. KADENADZE, A. H. 1941. On the spontaneous trichinellosis in the Far East. Žurn. Veterinaria No. 4.
182. KALLMANN, 1918. Trichinen beim Bären. Z. Fleisch-Milchhyg. 28, 287—288.
183. KARPINSKI, J. J. & KAMINSKA, L. 1948. Contribution à l'écologie de *Trichinella spiralis* Owen et autres endoparasites des micromammifères du Parc National de Białoviéza. Ann. Univ. Marie Curie-Skłodowska, Sect. C, 3, 15, 427—437 (Polish-French Summ. 435—437).
184. KELLER, H. 1933. Trichinen beim Fuchs. Z. Fleisch-Milchhyg. 42, 137.
185. — 1952. Trichinen bei Sumpfbibern und Kaninchen. Deutsch. Pelztierzüchter 26, 2, 28—29.
186. — & LCWO, K. 1949. Kaninchen als Fleischfresser und Trichinenträger. Die Fleischwirtschaft 1, 128—129.
187. KERR, K. B. 1940. Public health aspects of the trichinosis problem in the South. South Med. J. 33, 511—516.
188. KINGSCOTE, A. A. 1950. La trichinose dans la région arctique boréale. Bull. Off. Internat. Epizoot. 34, 221—222.
189. KINNAS, K. & KARAMARIAS, D. 1953. Trichinosis (Greek: 205 pp.; Athens). (Summ. Fleischwirtschaft 8, 631—633).
190. KITT, TH. 1931. Trichinen bei Bären. Z. Fleisch-Milchhyg. 41, 157.
191. KLOCKOW. 1938. Trichinen bei Wildschweinen. Z. Fleisch-Milchhyg. 48, 397.
192. KNABE, 1942. Trichinenfund beim Fuchs in Sachsen. Z. Fleisch-Milchhyg. 53, 49.
193. KOLBE, F. 1942. Spontane Trichinose bei Tieren. Z. Fleisch-Milchhyg. 52, 9, 99—101.
194. — 1944. Neueres über die Trichine VII. Kritischer Übersichtsbericht. Z. Fleisch-Milchhyg. 54, 14, 131—133, 15, 141—145.
195. KORNIENKO, Z. P. & PELEVIN, V. K. 1944. *(Trichinella spiralis* in *Caracal caracal)*. Veterinaria 21, 22.
196. KORYAŽHNOV, V. P. 1946. (Trichinelliasis in the polar bear). Veterinarya 23, 12, 18—19 (Russ.).
197. KOTLÀN, A. 1927. Die Bedeutung der fleischfressenden Tiere bei der Übertragung der Trichinose. Prager Arch. Tiermed. 7, 142. (See also: Jhber. Vet. Med. 47, 1118 (1928)). (Summary of article in Hungarian in Alatorvosi Lapok 1927, No. 2, p. 14).
198. — 1952. Ergebnisse der 1. ungarischen parasitologischen Inlandexpedition. Act. Vet. Acad. Sci. Hungar. 2, fc. 4, 337—341.
199. KOZAR, Z. 1959. Problem of trichinellosis in Poland and plan of control of this invasion. Wiadom. Parazytol. 5, 2—3, 280—291.

200. Kozar, Z. & Warda, L. 1956. A contribution to the epizootology of trichinellosis in the neighbourhood of Gdansk and Gdynia. Wiadom. Parazytol. 2, 5, (Suppl.), 173—174.
201. — 1957. Search for a reservoir of trichinellosis in small mammals of the Białowieża Forest. Acta Parasitol. Polon. 5, 19, 481—485 (Polish w. Engl. Summ.).
202. — (in litt.).
203. Kuitunen-Ekbaum, E. 1950. Trichinosis in the Canadian North. Canad. J. Publ. Health, 41, 34.
204. — 1954. Walrus meat as a source of trichinosis in Eskimos. Canad. J. Publ. Health 45, 1, 30.
205. — & Fleming, Z. W. 1949. A note on trichinosis in dogs of the Canadian north. Canad. J. Publ. Health 40, 514—515.
206. Landois, H. 1895. Eine mit Trichinen durchsetzte Wildsau. 23. Jahresb. Westfäl. Prov. Ver. Wissensch. Kunst. Münster 1894—95, 66—67.
207. Lang, E. M. 1955. Beitrag zur Frage der Trichinose und Selbstverstümmelung bei Zootieren. Schweiz. Arch. Tierhk. 97, 246—251, 1 fig.
208. Larsh, J. E. jr., Goulson, H. T. & Yarinsky, A. 1958. The control of repeated infections with *Trichinella spiralis* in mice by the use of feed containing cadmium oxide. J. Elisha Mitchell Sci. Soc. 74, 2, 137—140.
209. Lehmensick, R. 1942. Ueber die Trichinose in der freien Wildbahn (Weiterer Beitrag zur Epidemiologie der Trichinose). Ztbl. Bakt. I. Orig. 149, 338—344, 1 fig.
210. Leinemann 1941. Fuchstrichinose. Tierärztl. Rsch. 47, 398.
211. Leiper, R. T. 1938. Trichinosis in arctic animals. Proc. Zool. Soc. London Ser. C. 108, 13—14, 1938.
212. Leisering, A. G. T. 1868. Trichinen in Ratten und in einem Waschbären. Ber. Veterinärw. Königsr. Sachs. (1867), 12, J., 38—39.
213. Le Louet, G. M. & Broudin, L. 1923. Parasites habituels des muscles du porc. Bull. Soc. Méd. Chir. Indochine, Nov. 9, 1923. (Abstr.: Arch. Inst. Pasteur Indochine (1) Avr. p. 92, 1925).
214. Le Roy de Méricourt, A. 1865. Note tendant à démontrer l'identité probable de l'acrodynie et de la trichinose. Gaz. Hebd. Méd. 2. ser. 2, 44, 692—695.
215. Leuckart, R. 1866. Untersuchungen über *Trichina spiralis*. (Verl. C. F. Winter, Leipzig u. Heidelberg). 2. Aufl. pp. IV, 121, 7 figs., 2 pls.
216. — 1876. Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten (C. F. Winter'sche Verlagsbuchhandlung, Leipzig und Heidelberg). Vol. 2, pp. 509—609.
217. Linstow, O. v. 1868. Ueber das Vorkommen von *Trichina spiralis* in einem Scirrhus der weiblichen Brust und in den Muskeln des Iltis. Arch. Path. Anat. 14, 4. F., 4, 2—3, 379—381.
218. — 1875. Beobachtungen an neuen und bekannten Helminthen. Arch. Naturg. Berlin 41, 1, (2), 183—207, 32 figs.
219. — 1876. Helminthologische Beobachtungen. Arch. Naturg. Berlin 42, 1, (1), 1—18, 38 figs.
220. Livierato, S., Danapoulo, E. & Logothetgroulo 1949. De la première apparition de la trichinose en Grèce (Observations cliniques et de laboratoire). Sem. Hôp. Paris. 25, 2, 51—52.
221. Llanes, M., Puyos, E. & Castellanos, L. 1881. De la trichinosis ó enfermedad de las trichinas. Escuéla Med. Mexico 3, 2, 23—24, 43—45.

222. LO NIGRO, M. 1958. Primo caso di trichinosi in Lucania. Giorn. Malatt. Infett. Parasit. 10, 5, 414—416, 4 figs.
223. LUEBKE, 1903. Ueber das Vorkommen von Trichinen beim Dachs. Z. Fleisch-Milchhyg. 13, 4, 116—117, 1 fig.
224. LUENGO MIRÓ, E. 1953. La triquinosis ignorada en Madrid. Rev. San. Madr. 27, 7—8, 448—468.
225. LUKASHENKO, N. P. 1953. (The epizootology of trichinelliasis). Raboty Gelmintologii k 75. K. J. Skjabina. Moskva. pp. 366—371.
226. Lynch, P. P. 1932. Trichiniasis, with report of a case. New Zealand Med. J. 31, 216.
227. MADSEN, H. 1941. Helminter og helmintiasis, en kort oversigt over kendt og ukendt. Bibl. Læger 133, 113—145.
228. — 1943. Trikinfund hos rotter i Danmark. Maanedsskr. Dyrlæger 55, 2, 61—65.
229. MANSON, P. 1881. *Trichina spiralis* in Chinese Pork. China Imp. Customs. Med. Rep. Shanghai (1880—81), 21 Issue, 26.
230. MAPLESTONE, PH. A. & BHADURI, V. N. 1942. A record of *Trichinella spiralis* (Owen, 1835) in India. Indian Med. Gaz. 68, 554—556.
231. MARTIN 1935. Trichinen beim Fuchs. Z. Fleisch-Milchhyg. 45, 185.
232. MASHIROV, E. T. 1955. *Trichinella* in wild animals in the Tartar Republic. Zool. Zh. 34, 1008—1011.
233. MASSI, O. 1957. Un caso di trichinosi nel suino osservato al mattatoio di Roma. Nuovi Ann. Igiene Microbiol. 8, 2, 168—170.
234. MATHES, M. 1921. Russische Trichinose. Handb. d. Ärztl. Erfahrungen aus dem Weltkrieg 1914—18. Bd. 3. Innere Medizin, pp. 335—339.
235. MASTERTON, J. P. & LEWIS, U. E. 1955. Trichinosis in Greenland. Lancet, 269, 2 (6890), 591.
236. MAZZOTTI, L. 1953. Triquinosis en México. Bol. Ofic. Sanit. Panamer. 35, 4, 418—420.
237. — & ALCANTAR, O. 1954. Incidencia de *Trichinella spiralis* en 900 ratas *(Rattus norvegicus)* en la ciudad de México. Rev. Inst. Salub. Enferm. Trop. Méx. 14, 4, 201—202.
238. MEER, G., VAN DER, GRAAF, J. F. H. DE & BRUG, S. L. 1941. Trichinosis in Nederland. Nederl. Tijdschr. Geneesk. 85, 4710—4716.
239. MEIJER, W. C. P. 1933. Extracten uit de maand — en jaarverslagen der gouvernements en provinciàle veeartsen. No. 62, I. Cysticercosis. II. Trichinosis. Nederl. Indié Blad Diergeneesk. Dierenstellt 45, 165—175.
240. — 1933. Over spontane en experimenteele trichinosis bij de kat. Nederl. Indié Blad Diergeneesk. Dierenstellt 45, 544—546.
241. MENDES, E. 1953. Resultado de 400 testes intradermicos para verificação de triquinose. Hospital Rio 44, 1, 87—89.
242. MÉRAB, A., MELKI, L., BROUNOT, Q. & SIOUFI, H. 1952. Quelques considérations sur une épidémie récente de trichinose au Liban-Nord. Presse Méd. 60, 53, 1131—1132.
243. MERKUŠEV, A. V. 1951. On the *Trichinella* invasion in Ural. Trud. Voronež Zoovet. Inst. 12, 69—72 (Russ.).
244. — 1953. Trichinellosis of wolves and foxes. Med. Parazitol. 1953, 99—100 (Russ.).
245. — 1955. (Rotation of *Trichinella* invasions in natural conditions and their natural foci). Med. Parazit. Moskva 24, 2, 125—130 3 figs. (Russ.),
246. — 1956. On the *Trichinella* invasion in the Voronež gouvernement. Trud. Voronež Zoovet. Inst. 15, 233—234 (Russ.).

247. MERLE, A. 1957. Enquête sur la trichinose. Off. Internat. Épizoot. Publ. 48, 95—103.
248. MEYER, K. 1930. Trichinose nach Genuss des Fleisches eines Bären aus freier Wildbahn. Z. Fleisch-Milchhyg. 40, 405—406, 2 figs.
249. MILLISCHER, P. & DUBARRY, J. 1942. Remarques à l'occasion d'une épidémie de trichinose sur la clinique, la thérapeutique et l'hygiène de cette affection. Biol. Méd. 32, 23—48, 4 figs.
250. MITUCH, J. 1957. Volnz žijuce masožravce nosiče trichinelozy v prirode. Helmintologia, Prace I konf. Ceskosl. Helmintol. 1957, 104—109.
251. MÖNNIG, H. O. 1944. Trichinosis in South Africa. South Africa Med. J. 18, 24, 420.
252. MOMBERG-JØRGENSEN, H. C. 1953. Hvad kom der ud af trikinundersøgelserne sidste vinter? Dansk Pelsdyravl 16, 165—166, 1 fig.
253. MONSALLY, S. 1881. Report of the first outbreak of trichinosis in Syria. Med. Rec. N. Y. 19, 16, 430—431.
254. MORITZ, W. 1939. Ist die Trichinose der Füchse auf Trichinelleninfektion der Feldmäuse zurückzuführen? (Diss. Hannover).
255. MOYNIHAN, I. W. & MUSFELDT, I. W. 1949. A study of the incidence of trichinosis in rats in British Columbia. Canad. J. Comp. Med. 13, 152—155, 2 figs.
256. — 1949. A study of the incidence of trichinosis in swine in British Columbia. Canad. J. Comp. Med. Vet. Sci. 13, 9, 224—227, 1 fig.
257. MROSS, M. 1936. Ueber Trichinenfunde bei wildlebenden Tieren. Rdsch. Fleischbesch. 37, 197.
258. MÜLLER, A. 1936. Trichinenfund bei Silberfüchsen. Tierärztl. Rsch. 42, 141.
259. MÜLLER-USING, D. 1959. Die Ausbreitung des Waschbären *(Procyon lotor* (L)) in Westdeutschland. Z. Jagdwiss. 5, 3, 108—109, 1 fig.
260. MÜSSEMEIER & GAEDE (edit.) 1938. Ueber Trichinenfunde. Veröff. Jahr. Vet. Ber. beamt. Tierärzte. Pr. 1935—1936, II, 147—148.
261. MURATOV, E. A. & VYSOTSKIJ 1956. On trichinelliasis in wild animals in Tadžikistan. Dokl. A. N. Tadžik. SSR, 1956, No. 19, 47—50 (Russ.).
262. NALETOV 1941, see LUKASHENKO 1953.
263. — 1948. Ueber Trichinose bei wilden Tieren, die in Gefangenschaft gehalten werden. Zbornik Rabst Gelmint.
264. NEGHME, R. A. 1944. Epidemiologia de la triquinosis. Biológica, Santiago de Chile (1) Sept. pp. 127—140.
265. — 1949. Present status of trichinosis in Santiago, Chile. J. Parasitol. 35, 136—137.
266. — FAIGUENBAUM, J., PIZZI, T., ROMAN, J., DONOZO, R., HOECKER, G., BRNCIC, D., AGOZIN, M., CLERISTEN, R., SOTOMAYOR, D. R., SILVA, C. R. & VILCHES, R. 1947. Epidemia de triquinosis en la Escuela Militar de Chile. Rev. Méd. Chile 75, 8, 519—524, 1 fig.
267. NÖRR, J. 1933. Einige Bemerkungen zum Genuss von Silberfuchs- und Nutriafleisch. Z. Fleisch-Milchhyg. 43, 307.
268. OHBAYASHI, M. & SATOH, H. 1957. Discovery of a case of trichinosis in Japan. Jap. J. Vet. Res. 5, 2, 39—42.
269. OLDHAM, J. N. & BERESFORD-JONES, W. P. 1957. *Trichinella spiralis* in the wild red fox in England. Brit. Vet. J. 113, 1, 34—35.
270. OSTERTAG, R. VON 1899. Handbuch der Fleischbeschau. 3. Aufl. (Ferd. Enke, Stuttgart).

271. OSTERTAG, R, VON 1930. Die Trichinose nach Genuss von Bärenfleisch in Stuttgart und die Folgerungen hieraus für die Organisation der Trichinenschau. Z. Fleisch-Milchhyg. 40, 289—291.
272. — 1938. Neuzeitliche Fragen der Fleischbeschau. Z. Fleisch-Milchhyg. 49, 1—6, 21—23, 66—67, 81—82. 101—103,
273. OZERETSKOVSKAYA, N. N. & USPENSKY, S. M. 1957. (Group infection by trichinellosis from the meat of white bear in the Soviet Arctic Region). Med. Parasitol. Moscow 26, 2, 152—159, 2 figs.
274. PAGENSTECHER, H. A. 1865. Die Trichinen (W. Engelmann, Leipzig) pp. 116.
275. PALMER, A., CLELAND, J. B. & FERGUSON, E. W. 1914. A case of *Trichinella spiralis* in man in Australia. Australas. Med. Gaz. (492), 35, 25, 546.
276. PARNELL, I. W. 1934. Animal parasites of North-East Canada. Canad. Field Nat. 48, 111—114.
277. PASZUK, W. P. 1958. O prirodnoj oragowosti trichinelleznoj invazii v BSSR. Tezis Dokt. Wsieoj Obsz. Gelmint. Moskva, pp. 112—119.
278. PEPPER, O. H. P. & DIÁZ RIVERA, R. S. 1945. Trichiniasis. A review of the clinical picture and laboratory diagnosis of the disease, with an analysis of several cases. Puerto Rico J. Publ. Health Trop. Med. 20, 3, 367—388.
279. PÉREZ, BRYAN, M., REYES TÉLLEZ, J. C., & RODRÍGUEZ NAVARRETE, A. 1954. Considéraciones clínicas y terapéuticas con motivo de un brote epidémico de triquinosis estudio de siete (7) casos. Rev. clín. Espaň. 52, 4, 264—271.
280. PERK, L. VAN DER 1932. Een trichinose-epidemie te Utrecht. Nederl. Tijdschr. Geneesk. 76, II, 1949—1956.
281. PERRIN, T. G. 1942. Algunos estudios sobre triquinosis ignoradas. Rev. Med. Trop. Parasit. Habana 8, 59—64.
282. PETERSEN, TH. 1904. En Trikinoseepidemi. Ugeskr. Læger 1904, 679—686.
283. PETROPAVLOVSKII, N. I. 1905. (Trichinae and trichinosis) Arkh. Vet. Nauk. S. Petersb. 35, 595—638, 714—743, 841—879, 7 figs.
284. PETROV, A. M. & SAVINOV, V. A. 1956. The helminthic fauna of moles from the Vologod region. Sborn. Rabot. Vologod Nauk Issl. Vet. Opytnoi Stant. 1956 (3), 107—115 (Russ.).
285. PÉWÉ, TR. L. & RIVARD, N. R. 1959. Mummified seal carcasses in the Mc Murdo Sound region. Antarctica. Science 130, 3377, 716.
286. PIAGGIO BLANCO, R. A., FERNANDEZ CHAPELA, A. & PASEYRO, P. 1948. Triquinosis. An. Fac. Med. Montevideo 33, 135—160.
287. PIUSINSKI, W. 1957. Trichinelliasis in a polar bear. Wiadom. Parazytol. Wars. 3, 5, 467—471 (Polish w. Engl. Summ.).
288. POOLE, J. B. 1953. The incidence of human trichinosis in Canada. Canad. J. Publ. Health. 44, 295—298.
289. POPOVIC, B., SRETENOVIC, B. & VELICKOVIC, C. 1958. Trichinosis in the environs of Kraljevo and Ivanjica. Bull. Inst. Hyg. Belgrade 7, 3—4, 29—34, (Serb.), (Trop. Dis. Bull. 56, 7, 754, 1959).
290. QUIVOGNE 1894. Une épidémie de trichinose. Arch. Méd. Pharm. Mil. 24, 294—301.
291. RAPPAPORT, J. 1951. Trichinosis In: GRADWOHL, R. B. H., SOTO, L. B. & FELSENFELD, O. (edits). Clinical Tropical Medicine (Mosby Comp. St. Louis), pp. 847—870, 12 figs.
292. RASCHKE, E. 1955. Neues in der Trichinenschau. Deutsch Tierärztl. Wschr. 62, 23—24, 236—239.
293. RAUSCH, R. 1951. Biotic interrelationships of helminth parasitism. In: Public Health problems in Alaska, Publ. Health Reports 66, 29, 928—934.

294. Rausch, R. 1954. Trichinosis in marine mammals. Proc. 2. National Conf. Trichinosis. Chicago Ill. March 1, 1954, 16—17.
295. — Babero, B. B., Rausch, R. V. & Schiller, E. L. 1956. Studies on the helminth fauna of Alaska XXVII. The occurrence of larvae of *Trichinella spiralis* in Alaska Mammals. J. Parasitol. 42, 3, 259—271.
296. Renteria, Y. R. 1937. Inspección y decomisos triquinoses. Estudistica e inutilizaciones. Rev. Med. Vet. Buenos Aires 19, 569—583.
297. Ricci, M. 1951. La trichinosi in Italia. Arch. Ital. Sci. Med. Trop. Parassit. 32, 6, 602—612 (Engl., French & Germ. Summ.).
298. Rickmann, W. 1908. Tierzucht und Tierkrankheiten in Deutsch-Südwestafrika. Berlin. pp. XI, 364, 4 figs.
299. Riley, W. A. & Chen, H. T. 1932. Trichinosis in China: negative results of examination of pigs and rats at Canton. Lingnan Science J. 11, 465—467.
300. Rochmann, R. 1950. Trikinosen er en fare, som kan og skal fjernes. Norsk Pelsdyrbl. 24, 17, 283—284.
301. Roth, H. 1949. Trichinosis in arctic animals. Nature 163, 805. (Reprinted in full in: Canad. J. Comp. Med. 13, 227—228, 1949).
302. — 1950. Trikinosen i Grønland. Grønl. Selsk. Årsskr. 1950, 57—68, 4 figs.
303. — 1950. Nouvelles expériences sur la trichinose avec considérations spéciales sur son existence dans les régions arctiques. Bull. l'Off. Internat. Épizoot. 34, 197—220, 1 fig.
304. — & Madsen, H. 1956. Die Trichinose in Grønland, abschliessender Bericht der Jahre 1948—1953. Proc. XIV. Intern. Congr. Zool. Copenhagen 1956, 340—341.
305. Rubert, H. 1944. Stand der Trichinen- und Finnenfunde in Riga. Z. Fleisch-Milchhyg. 54, 198—199.
306. Rubli, H. 1936. Trichinose beim Sumpfbiber, *Myocastor coypus*. Mol. Schweiz. Arch. Tierhk. 78, 420—424.
307. Ruchljadev, D. P. 1952. Zur Kenntnis der Wurmfauna des Wildschweines. Trudy Gel'mintol. Laborat. 6, 331—333.
308. — & Ruchljadeva, M. P. 1953. (Zur Kenntnis der Wurmfauna des braunen Bären). Raboty po gel'mintol.k. 75-let. Skrjabina. Moskva.598—602.
309. Ruppert 1935. Trichinen beim Fuchs. Z. Fleisch-Milchhyg. 45, 238.
310. Saad, B. 1940. La trichinose à propos d'une épidémie observée à Beyrouth. Presse Méd. 48, 49—50, 556—557.
311. Sandberg, J. 1928. Trikiner i Sverige förr och nu. Skand. Vet. Tidsskr. 18, 73—81.
312. Schaaf, J. 1941. Vorkommen und Verbreitung der Trichinose im Generalgouvernement Polen. Berl. München Tierärztl. Wschr. 1941, 131—133.
313. Schade, M. 1939. Ueber Trichinen und andere Parasiten des Rotfuchses in Kurhessen und angrenzenden Kreisen. Inaug. Diss. Hannover pp. 43.
314. Schapiro, M. M. 1951. Trichinosis in Honduras—preliminary report. Mil. Surgeon 109, 200—204.
315. Schiller, E. L. 1952. Studies on the helminth fauna of Alaska. V Notes on rats (*Rattus norvegicus* Berkenhout) with special reference to helminth parasites. J. Mammal. 33, 1, 34—49.
316. — 1956. Ecology and health of *Rattus* at Nome, Alaska. J. Mammal. 37, 2, 181—188, 1 fig.
317. Schmaltz, 1899. Trichinose beim Dachs. Berl. Tierärztl. Wschr. 1899, 171.
318. Schmidt, H. W. 1941. Der Uebertragungsmodus der Trichinose: Fuchs, Dachs, Schwarzwild, Hausschwein, Mensch. Münch. Med. Wschr. 88, I, 449—453.

319. SEHMIDT, H. W. 1941. Trichinenübertragung durch Fuchs und Dachs unterbinden. Tierärztl. Rundsch. 1941, 311—314.
320. — 1947. Fuchs und Dachs als Trichinenüberträger. Deutsch Tierärztl. Wschr. 54, 7—8, 55—57.
321. — 1950. Vögel und Trichinose (Pathologie und Übertragung). Ther. Gegenw. 89, 5, 155—156.
322. — 1956. Die Uebertragung von Trichinen im Natur- und Kulturhaushalt. Prakt. Tierarzt 1956, 222—224.
323. SCHÖNBERG, I. 1956. La lutte contre la trichinose. Bull. Off. Internat. Épizoot. 46, 283—290. 3 figs.
324. SCHOOP, G. 1937. Trichinenschau bei Pelztieren. Dtsch. Pelzt. Ztg. 1937, 271.
325. — 1939. Fuchs und Dachs als Trichinenträger. (Discussion to a lecture). Deutsch Tierärztl. Wsch. 47, 1939, 456.
326. — 1941. Derzeitiger Stand der Trichinellenfrage. Z. Fleisch-Milchhyg. 51, 315—318.
327. — 1942. Verbreiten die deutschen Edelpelztierzuchten die Trichinellen? Tierärztl. Rsch. 48, 37—38, 311—313.
328. — 1942. Fuchs und Dachs heute Hauptverbreiter der Trichinen in Deutschland. Der Deutsche Jäger 64, 5—6.
329. — 1943. Trichinenfälle bei Zuchtfüchsen und Sumpfbibern. Deutsch. Pelztierzüchter 1943, 126.
330. — 1944. Trichinenfund bei einer Sumpfmanguste. Z. Fleisch-Milchhyg. 55, 1, 3, 1 fig.
331. — 1955. Gibt es latenter Trichinenbefall unter der deutschen Bevölkerung? Monatsh. Vet. Med. 7, 12.
332. — & SCHADE, M. 1939. Der Fuchs als Verbreiter der Trichinosis. Deutsch Tierärtzl. Wschr. 47, 553—561, 11 figs.
333. SCHÜLLER 1931. Bemerkenswerter Trichinenfund. Z. Fleisch-Milchhyg. 41, 204.
334. SCHULZ, R. S. & KASTORSKIJ, D. J. 1949. Zum Studium der Helminthen beim kaukasischen Bären und die Entdeckung bei ihm von *Gongylonema pulchrum* (MOLIN, 1860). Dokl. Akad. Nauk Armjanskoj S.S.R. 11, 3, 99—104.
335. SCHULZE, H. 1941. Ueber das Vorkommen von Fuchstrichinose in den Kreisen Peine und Zellerfeld. Inaug. Diss. Hannover.
336. SEIJFFERS, S. M. 1940. De trichinenbestrijding in de Afdeeling Bataklanden der Residentie Tapanoeli. Nederl. Indië Blad. Diergeneesk. Dierensteelt 52, 222—244.
337. SEMENOVA, N. E. 1947. (Ein Fall von Erkrankung an Trichinellose durch Dachsfleisch). Med. Parazitol. 16, No. 6, 92.
338. SEMPLE, A. B., DAVIS, J. B. M., KERSHAW, W. E. & ST. HILL, C. A. 1954. An outbreak of trichinosis in Liverpool in 1953. Brit. Med. J. No. 4869, 1002—1006.
339. SHAVER, R. J. & MIZELLE, J. D. 1955. Effects of rapid and ultra-rapid freezing on *Trichinella spiralis* larvae from guinea-pigs and rats. Amer. Midl. Natural. 54, 65—77.
340. SILLIG 1943. Trichinenfund bei Silberfüchsen in Thüringen. Z. Fleisch-Milchhyg. 53, 79.
341. SILVER, J. 1954. Trichinos. Nord. Med. 52, 37, 1278—1279.
342. SKELLER, E. 1948. Trichinose i Kutdligssat. Ugeskr. Læger 110, 21, 602—607. (Engl. Summ.).
343. SÖNTGEN, K. 1939. Zur Frage der Fuchstrichinose. Z. Fleisch-Milchhyg. 49, 334—336.

344. Soriano, A. M. de 1943. La presencia de Triquina en algunos embutidos que se expendea en la ciudad de Buenos Aires. Rev. Asoc. Argent. Dietol. 1, 216—220.
345. Spindler, Ll., A. & Permenter, D. O. 1951. Natural infections of *Trichinella spiralis* in skunks. J. Parasitol. 37, Suppl. 19—20.
346. Stäubli, C. 1909. Trichinosis. pp. I—X, 1—295, 18 Abb., 14. Tafeln. Wiesbaden (J. F. Bergmann).
347. Stanion, J. H. 1951. Trichinosis in Sudbury, Ontario. Canad. J. Publ. Health 42, 174—184.
348. Stefánsson, V. 1914. The Stefánsson-Andersen Arctic Expedition of the American Museum. Preliminary Ethnological Report. Anthrop. Papers Amer. Mus. Natur. Hist. 14, 1, 386, 445—458.
349. Stegawski, T. 1956. (Cases of trichinosis following consumption of meat of wild animals living in forest). Polsk-Tygod. Lek. 11, 47, 2005—2008.
350. Stehle, M. 1931. Ueber Trichinose bei wilden Tieren und ihre Uebertragung auf den Menschen. Z. Inf.krh. Parasit. Krh. Hyg. Haustiere 39, 320—329.
351. Steigler 1958. Trichinenfunde bei Schweinen. Fleischwirtschaft 10, 8, 549.
352. Stephan, E. & Mamo, A. 1952. Nouveaux cas de trichinose au Liban. Libanese Med. J. 5, 4, 236—248.
353. Stiles, C. W. & Baker, Cl. E. 1935. Key cataloque of parasites reported for carnivores, (cats, dogs, bears, etc.). Nat. Inst. Health. Bull. No. 163.
354. — & Hassall, A. 1920. Index-catalogue of medical and veterinary zoology. Subject: Roundworms. Hyg. Lab. Bull. No. 114, Wash., 1—886.
355. Stoll, Norman, R. 1947. This wormy world. J. Parasitology 33, 1, 1—18.
356. Strobel, F. 1954. Versuche über das Gefrieren von trichinösem Schweinefleisch als Grundlage für eine Gefriervorschrift. Vet.-Med. Diss. München.
357. Stroh, G. 1936. Trichinose beim Fuchs der freien Wildbahn. Z. Fleisch-Milchhyg. 46, 293—294.
358. Struck, M. 1953. Ein Beitrag über das Vorkommen von Trichinen. Lebensmitteltierarzt. 4, 3, 27—28.
359. Svitzer, E. 1843. Et Tilfælde af *Trichina spiralis*. Bibl. Læger 38, (Ny Række: 8), 336—353, 1 pl.
360. Szelinski 1930. Zu den Trichinosefällen in Stuttgart. Z. Fleisch-Milchhyg. 40, 355.
361. Talice, R. V. 1950. Épidémiologie de la trichinose. Bull. Soc. Path. Exot. 43, 288—290.
362. — & Fiandra, O. A. 1943. Estudios sobre la triquinosis I Primeres hallazyos en el Uruguay de triquinas en cadáveres humanos. Arch. Uruguayos Med. Cirug. Espec. 23, 6, 521—534.
363. Talos, V. 1935. Das Vorkommen von *Trichinella spiralis* in der Muskulatur der vagabundierenden Hunde von Bukarest. Inaug. Diss. Bukarest (Roumanian). (Summary: Jahresber. Vet. Med. 58, 1936, 398).
364. Tang, C. C. 1939. *Trichinella* infection in rats in Fukien. Chin. Med. J. 55, 537—541, 4 figs.
365. Tarnaala, K. 1940. Von der Lebensmittelhygiene in Finland. Z. Fleisch-Milchhyg. 50, 12—14.
366. Taylor, E. L. 1944. A search for endemic areas of trichinosis in Great Britain. Nature 153, 745.
367. Teetz 1897. Trichinen beim Dachs. Z. Fleisch-Milchhyg. 7, 83.
368. Thomas, F. 1932. Fütterungsversuche mit trichinösem Fuchsfleisch an Mäuse. Z. Fleisch-Milchhyg. 42, 398—399.

369. THOMAS, F. 1932. Trichinen beim Fuchs. Z. Fleisch-Milchhyg. 42, 217.
370. THOMPSON, C. G. 1907. An outbreak of trichinosis in Garhwal. Indian Med. Gaz. 42, 10, 373—374.
371. THORBORG, N. B., TULINIUS, S. & ROTH, H. 1948. Trikinose på Grønland. Ugeskr. Læger 110, 21, 595—602, 3 figs.
372. — 1948. Trichinosis in Greenland. Acta Path. Microbiol. Scand. 25, 4, 7 78—794, 3 figs.
373. THORSHAUG, KN. 1939. Trikinose *(Trichinella spiralis)* hos ræv. Norsk Vet. Tidsskr. 51, 253—255.
374. — 1940. Trikinose i Norge. Norsk Vet. Tidsskr. 52, 11, 475—492.
375. — & ROSTED, A. F. 1956. Researches into the prevalence of trichinosis in animals in Arctic and Antarctic waters. Nord. Vet. Med. 8, 2, 115—129.
376. TRÜB, C. L. P. & GAASE, A. 1951. Eine Gruppenerkrankung und eine Epidemie an Trichinose und ihre Lehren für die Verhütung und Bekämpfung der Trichinose. Arch. Hyg. 134, 163—172.
377. TÜNGEL, C. 1863. Ein tödtlich verlaufender Fall von Trichinenkrankheit beim Menschen. Arch. Path. Anat. Physiol. 27, 421—424.
378. TURQUIEH 1945. La trichinose en 1945. Rev. Méd. Francaise Moyen-Orient 3, 1, 347—351.
379. URBAIN, ACH., NOUVEL, J. & RINJARD, J. 1952. Trichinose d'un ours blanc *(Thalassarctos maritimus* DESM.*)* en captivité depuis plus de 16 ans. Bull. Mus. Nation. Hist. Nat. 24, 2, 204—205.
380. VARTANOV, A. J. 1882. (Trichinosis in Tiflis). Protok. Zasaid. Kavkauzsk. Med. Obsh. Tiflis 29, 2, 23—24 (Russ.). (Abstr.: Ctbl. Bakt. Jena 13, 17, 563). 1893.
381. VERGE, J. 1951. La trichinose humaine dans ses rapports avec les trichinoses animales. Rev. Pathol. Comp. Hyg. Gén. 51, 629, 361—363.
382. VERGE, D. G. & DUTEIL, G. 1954. Notes sur la trichinose. Presse Méd. 62, 10, 208.
383. VIBE, CHR. 1950. The marine mammals, and the marine fauna in the Thule District (North-West Greenland) with observations on the conditions in 1939—41. Medd. Grønl. 150, 6, 1—116, 35 figs., 1 pl. (*Trichinella*, p. 93—97).
384. — 1958. Den blå og den hvide ræv i Grønland. Beretninger vedrørende Grønland, No. 2., 1958, 270—276.
385. VIRCHOW, R. 1865. Zur Trichinenlehre. Arch. Path.-Anat. Physiol. 32, 332—371.
386. — 1866. Ueber das natürliche Vorkommen von Trichinen. Arch. Path. Anat. Phys. 35, 201—203.
387. — 1866. Trichinen beim Iltis, beim Fuchs und bei der Ratte. Arch Path. Anat. Phys. 36, 149—152.
388. — 1866. Darstellung der Lehre von den Trichinen. 3. Aufl. (Georg Reimer, Berlin), pp. 87, 1 pl.
389. VISSER, P. 1930. Trichinen bei Schweinen, erstmalige Feststellung in Niederländisch-Ostindien. Z. Fleisch-Milchhyg. 40, 202—203.
390. VIVES, N. & ZELEDÓN, R. 1957. Observaciones parasitológicas en ratas de SanJosé, Costa Rica. Rev. Biol. Trop. 5, 2, 173—194, figs.
391. VOGELSANG, E. G. 1945. Triquinosis en Venezuela. Trab. d. Centro Invest. Cient. 1945, No. 3, 147—150.
392. VOIGTLÄNDER 1881. Fleischbeschau und Rossschlächterei. Ber. Veterinärwesen Königsreiche Sachsen 26, 131.
392a. WAGNER, O. 1942. Fortschritte der Trichinoseforschung in epidemiologischer und diagnostischer Hinsicht. Z. Physiol. Chem. 274, 116—128.

393. Walker, A. T. 1932. Trichiniasis. Report of an outbreak caused by eating trichinous bear meat in the form of "jerky". J. Amer. Med. Ass. 98, 24, 2051—2053.
394. Wasserfuhr, H. 1891. Zur Trichinenkrankheit an Bord der »Nixe« in Iquique. Deutsch. Med. Wschr. 17, 35, 1043.
395. Wedl, C. 1866. Bericht der über die Trichinose niedergesetzten Kommission. Wien. Med. Presse 7, 1110—1111.
396. — 1866. Comitébericht bezüglich der Trichinose. Allg. Wien. Med. Ztg. 11, 376—377.
397. Westphal, R. S. 1943. Human trichinosis following ingestion of bear meat. J. Amer. Med. Ass. 122, 4, 227—228.
398. Wickingen, H. 1953. Trichinose bei einem Bären. Wien Tierärzt.-Monatschr. 40, 12, 728—730.
399. Williams, R. B. 1946. Bears and trichinosis. Alaska's Health 4, 7, 5—6.
400. Winter, R. 1943. Trichinenfunde bei Füchsen und Dachsen. Z. Fleisch-Milchhyg. 53, 110.
401. Woerden, van 1941. Trichinellosis bij een ijsbeer. Tijdschr Diergenessk. 68, 390.
402. Wolfhügel, K. 1910. Los zooparásitos de los animales domesticos en la Republica Argentina, Rev. Centro Estud. Agronom. Vet. Buénos Aires 3, 24—26, 63—98.
403. — 1919. Epidemia de Triquinosis en el sur de Chile, observada por el Dr. Augusto Riffard. Rev. Med. Vet. Uruguay 3, 17, 1 fig.
404. Wood, H. 1835. Observations on the *Trichina spiralis* with a case. London Med. Gaz. 16, 190—191.
405. Wortabet, J. 1881. Eine Trichinenepidemie am Jordan. Briefliche Mitteilung an den Herausgeber. Arch. Path. Anat. 83, 8, F. 3 (3), 553—554. (Also: Lancet (3003) 1, 454—455). (An outbreak of trichinosis (?) from eating the flesh of a wild boar).
406. Wortabet, J. 1883. Another epidemic of trichinosis near the sources of the Jordan. Lancet (3127), 2, 183.
407. Wright, W. H. 1954. Control of trichinosis by refrigeration of pork. J. Ann. M. Ass. 155, 16, 1394—1395.
408. — 1954. The refrigeration of pork as a measure for the control of trichinosis. Proc. 2. Nation. Conf. Trichinosis. Chicago Ill. March 1, 1954, 32—35.
409. Wyers, H. J. 1956. Trichinosis. Ned. Tijdschr. Geneesk. 100, 41, 2954—2955.
410. Yokogawa, S. & Morishita, K. 1933. Handbook of Human Parasitology. Vol. 2. (Japanese).
411. Young, May R. 1947. The incidence of *Trichinella spiralis* at necropsies in England. J. Helminth 22, 1, 49—60.
412. Yugawa, T. 1934. *Trichina* found in dogs in South Manchuria. J. Oriental Medicine 21, 805—810.
413. Zak, M. R. 1955. (Infection with trichinosis with brown bear meat). Med. Parazit. Moskva 24, 2, 130—131 (Russ.).
414. Zambrana y Vázquez, S. 1876. Estudio sobre la triquinosis, enfermedad de los triquinos ó enfermedad de Zenker. Mem. Soc. Méd.-Farm. Toluca, Mexico 1, 129—136.
415. Zenker, F. A. 1860. Ueber die Trichinenkrankheit des Menschen. Arch. Path. Anat. 18, n. F. 8, 5—6, 561—572.
416. — 1871. Zur Lehre von der Trichinenkrankheit. Deutsch. Arch. Klin. Med. 8, 387—421.

417. ZIMMERMANN, W. J., HUBBARD, E. D. & BIESTER, H. E. 1959. Studies on trichiniasis in Iowa wildlife (1955—56 and 1956—57 seasons). J. Parasitol. 45, 1, 87—90, 1 fig.
418. ZIMMERMANN, W. J., HUBBARD, E. D. & MATHEWS, J. 1959. Studies on fecal transmission of *Trichinella spiralis*. J. Parasitol. 45, 4, 441—445, 1 fig.
419. ZIMMERMANN, W. J., SCHWARTE, L. H. & BIESTER, H. E. 1956. Incidence of trichinosis in swine, pork products, and wildlife in Iowa. Amer. J. Publ. Health 46, 3, 313—319.
420. ZÜRN, F. A. 1882. Die tierischen Parasiten, 2. Aufl. (Weimar).
421. ANON., 1955. Temperature control and salt treatment of meat containing trichinae or cysticerci. WHO Tech. Rep. Ser. No. 99, pp. 44—47.
422. AVLAVIDOV. 1960. In litt. to Dr. Kozar.
423. BABERO, B. B. 1960. A survey of parasitism in skunks (*Mephitis mephitis*) in Louisiana, with observations on pathological damages due to helminthiasis. J. Parasitol. 46,5 (sect. 2), 26—27.
424. BARTIK, M. & DYK, V. 1959. Prispěvek k poznam vyskytu svalovcu u našich šelem. Sborn. Vysoke Školy Zemědelske v Brně 7,4 437—441. (Czech.).
425. BEREZANTSEV, Y. A. 1960. The role played by rodents and insectivorous mammals in the maintenance of natural nidi of trichinellosis. Zool. Žurn. 39,6 832—837, 1 fig. (Russ. w. Engl. Summ.).
427. — 1960. The ways of spread of *Trichinella* in nature. Wiadom. Parazytol. 6,4 315—317, 1 fig. (Russ.).
428. — & FELMAN, I.A. 1958. Izncenije otschaga trichinelleza v Leningradskoj oblasti. Ter. Dokl. Wies. Obszcz. Gelm. Moskva 1958, 19—20.
429. BLOMBERG, H. 1952. Trikinejä karhunlihassa. Suom. El. Lehti 58, 544.
430. BORG, KARL. 1960. In litt.
431. BRANDT, O. & HÜLPHERS, G. 1948. Undersökningar rörande trikinlarvernes resistens mot kyla, samt över deras utbredning i muskulaturen hos svin. Svensk Vet. Tidskr. 53, 310—319.
432. CAGNOLATI, G. C. & MERIGHI, B. 1959. Reperto di larve di *Trichinella spiralis* (Owen, 1835) in una volpe catturata nella provincia di Roma. Parassitologia, Roma 1,1, 78—79.
433. CHROUST, K. 1960. *Trichinella spiralis* u divoce žijicich masožravcu. Sborn. Skoly Zemeděske v Brně 1, 154—157.
434. FAY, FR. H. 1960. Carnivorous walrus and some Arctic zoonoses. Arctic 13,2, 111—122, 1 fig.
435. FRÖHNER. 1951. Eine Erhebung über Trichinenbefunde seit 1945 im Lande Niedersachsen. Lebensmitteltierarzt 2, 153.
436. GENTILE, A. & CORZIANE, B. 1959. Contributo allo studio della trichinosi in Italia: su di un caso di trichinosi riscontrato in un lupo dell'altipiano silano (*Canis lupus*). Atti Soc. Ital. Sci. Vet. 13, 343—347.
437. GHERMAN, J., HIRDAN, V., BOBOS, M., LUSCALU, A. & BUTAN, I. 1959. Un episod epidemic de trichinoză determinat de consumarea unei carni infestate de urs. Microbiol. Parazitol. Epidemiol. Bucharest 4, 5, 453—456. (Engl. Summ.).
438. GODSADZE & ZIMIN. 1953. Slutšaj trikhinelleza u medvedia. Med. Parazitol. Moskva 3, 278.
439. HAGEN, Y. 1959. Villmink og iller. (Vilt og viltstell, Småskrifter utgitt av Viltstyret og Statens Viltundersökelse, No. 1, pp. 1—48, 15 figs.
440. KADENAZIJ. 1954. In 445.

441. Kalapesi, R. M. & Rao, S. R. 1954. *Trichinella spiralis* infection in a cat that died in the zoological gardens, Botubay. Indian Med. Gaz. 89,10, 578—580.
442. Kaljus, V. A. 1947. Materialy po epidemiologii trikhinelleza. Diss. na Stepien Kand. Med. Nauk, Kiev, 1947, pp. 322.
443. Kou. 1941. In 445.
444. Kozanić. 1959. In 445.
445. Kozar, Z. 1960. Incidence of *Trichinella spiralis* in the world. (Mimeographed report to 1. Internat. Conf. Trichin. Warszawa, Sept. 1960).
446. Kozar, Z. & Warda, L. 1960. Further investigations on the incidence of *Trichinella spiralis* in animals in Poland. Wiadom. Parazytol. 6,4 310—311.
447. Leikina, E. S. 1957. Natural foci of infection of some helminthoses. Med. Parazitol. Moskva 26,2, 140—152. (Russ. w. Engl. Summ.).
448. Leinati, L. & Marazza, V. 1959. La trichinosi negli animale selvatici in Italia. La Clin. Vet. 82,1 1—4 (Engl. Summ.). See also XVI Congr. Mund. Vet. 1959).
449. Lønø, Odd. 1957. Om isbjørnen. Fauna 10,2 65—78, 4 figs.
450. Lukašenko, N. P. 1960. In 445.
451. — & Brzesky, V. V. 1959. A contribution to the study of natural trichinellosis foci in the Barabinsk forest-steppe areas of the Novosibirsk Region. Med. Parazitol. Moskva 28, 415—418.
452. Lupu, A. & Cironeanu, I. 1958. Probleme zootechnice si veterinaria. Bucuresti 6, 61—62.
453. — 1960. La trichinellose chez les animaux dans la republique populaire Roumaine. (Mimeogr. Summ. to 1. Internat. Conf. Trich. Warszawa, Sept. 1960).
454. Madsen, Holger. 1960. On trichinae in wild-living carnivores. (Mimeographed Report to 1. Internat. Conf. Trich. Warszawa Sept. 1960).
455. Marazza, V. 1960. Ändert sich die Wiederstandsfähigkeit der Muskel-Trichinen, wenn die Gefriertemperatur während der prophylaktischen Desinfektions-Behandlung des Fleisches herabgedrückt wird? Wiadom. Parazytol. 6,4 311—312.
455a. — 1960. La trichinosi delle volpi in Italia. Osservazioni ricerche e considerazioni di ordine diagnostico ed epizoologico. Arch. Vet. Ital. 11,6, 507—566, 5 figs.
456. Matoff, K. 1950. Trichinelozata na lisicite, pazprostranienijetow Bulgarii i borbata protiv neja (Bulg.) Godisznik na Sielsktop. Akad.
457. Merkušev, A. V. 1960. The rôle of birds in *Trichinella spiralis* circulation in nature. Zool. Žurn. 39,2 161—164, 2 figs. (Russ. w. Engl. Summ.).
458. — 1960. The rôle of birds as possible vectors of trichinellosis. Wiadom. Parazytol. 6,4, 318—319. (Russ.).
459. — 1960. The role of insects in the spread of trichinellosis. Wiadom. Parazytol. 6,4, 319—320. (Russ.).
460. Moorehead, M. T. 1946. Roentgentherapy and trichiniasis; report of unusual case of trichiniasis treated with apparent success by irradiation, with study of quality of X-rays used, and review of subjects. Maine Med. Ass. J., Portland 37, 141.
461. Mumford, E. Ph. 1960. The distribution of some parasites in man in the Near and Middle Eeast. J. Trop. Med. Hyg. 63,4 77—85.
462. Nelson, G. S. 1960. Schistosome infections as zoonoses in Africa. Trans. Roy. Soc. Trop. Med. Hyg. 54,4, 301—316, 2 figs. (Discussion: 317—324).

463. NEMESERI, L. 1960. Trichinellosis in Ungarn. Wiadom. Parazytol. 6,4, 305.
464. NENOV, ST. 1960. In litt. to Dr. Kozar.
465. — 1960. Trichinellosis in Bulgaria (Mimeogr. Summ. 1. Internat. Congr. Trich. Warszawa Sept. 1960).
466. NOSIK, A. F., LITVISHKO, N. T. & GOLUBOV, »V. N. 1959. Epizootology of trichinellosis. Med. Parazitol. Moskva 28,411—413. (Russ. w. Engl. Summ.).
467. OLSEN, O. W. 1960. Sylvatic trichinosis in carnivorous mammals in the Rocky Mountains Region of Colorado. J. Parasitol. 64,5 (Sect. 2), 22.
468. OPRESCU, A. & GHEORGHIU, I. 1956. Cercetări asupra foca relor naturale de trichinoza in regiunea suçzava si considatiuni asupra epizootologiei. Probl. Vet. 2, 18.
469. POZDNIAKOVA, K.M. 1959. The incidence of trichinellosis among rodents and carnivorous animals in Omsk and in some districts of the Omsk Region. Med. Parazitol. Moskva 28, 214—216. (Russ. w. Engl. Summ.).
470. PRAKASH, I. 1956. Studies on the ecology of desert hedgehogs. Proc. Rajasthan Acad. Sci. 6, 24—30.
471. RASCHKE, E. 1955. Ein Vergleich der Wirksamkeit deutscher und amerikanischer Massnahmen zur Verhütung der menschlichen Trichinose. Tierärztl. Rdsch. 10, 11, 385—389.
472. RISLAKKI, V. 1956. The incidence of trichinosis in Finland. Duodecim 72,5, 317—329. (Finnish).
473. ROBINSON, H.A. & OLSEN, O. W. 1960. The role of rats and mice in the transmission of the porkworm, *Trichinella spiralis* (Owen, 1835) Railliet, 1895. J. Parasitol. 46,5, 589—597, 2 figs.
474. RUKAVINA, J. & DELIĆ, S. 1960. Trihineloza. Sadanje stanje nekih pitanja njezinog širenja, održavanja i profilakse. Veterinaria 9,2 237—245.
475. SCHÖNBERG, F. 1950. Über die Notwendigkeit der sorgfältigen Trichinenuntersuchung bei Hausschweinen und sonstigen Trichinenträger. Lebensmitteltierarzt 1, 70.
476. SIMMONS, J. S., WHAYNE, T. F., HOROCK, H. M. & THOMAS, R. A. 1945, 1951, 1954. Global Epidemiology. I. India and the Far East. Pacific Area. II. Africa and adjacent islands. III. The Near amd Middle East. (Lippincot Co., Philadelphia).
477. STANOEV, S. 1955. Slucaj na trichineloza no divite soine. Izwiestia C. H. L. pri BAN 1, 267—275.
478. THOMAS, 1932. In 445.
479. TRETIAKOVA, O. N. 1956. V trikhinelleze dikich zhivotnych Baszkirii. Tr. Baszkir. S-ch, in-ta, 7, 175, 183.
480. TSIN. 1950. In 445.
481. UMIŃSKI, J. & STROCZYŃSKA, M. 1960. Badania drobnych ssaków w k erunku włosnicy w pov. Tomaszow lubelski. Wiadom. Parazytol. 6,4, 309—310.
482. USZACKA, M. 1960. Incidence of trichinellosis in a mink (*Lutreola lutreola*). Wiadom. Parazytol. 6, 2—3, 203—204, 1 fig. (Polish w. Engl. Summ.).
483. WEISER, J. 1947. Zprava o trichinose u naši škodne v zimé 1947—1948. Čas. Čs. Veterinaru 3, 388.
484. WITENBERG, G. G. 1933. Zur Kenntnis der Verbreitung von Echinokokkus und Trichinen in Palästina. Arch. Schiffs- u. Tropenhyg. 37,1 37—41,1 fig.
485. ZIMOROV, I. Y. 1959. Natural trichinellosis foci in the Kursk region. Med. Parazitol. Moskva 28, 5, 586—589. (Russ. w. Engl. Summ.).

Færdig fra trykkeriet den 8. november 1961.