STUDIES ON THE PREVALENCE AND THE TRANSMISSION OF LUNG AND STOMACH NEMATODES OF THE WILD BOAR (SUS SCROFA) IN FRANCE

Authors: Humbert, J.-F., and Henry, C.

Source: Journal of Wildlife Diseases, 25(3) : 335-341

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-25.3.335

Journal of Wildlife Diseases, 25(3), 1989, pp. 335–341

STUDIES ON THE PREVALENCE AND THE TRANSMISSION OF LUNG AND STOMACH NEMATODES OF THE WILD BOAR (*SUS SCROFA*) IN FRANCE

J.-F. Humbert and C. Henry
Laboratoire de Zoologie et d'Ecologie Animale, Université d'Orléans, BP 6759,
45067 Orléans CEDEX 02, France

ABSTRACT: Five species of lung nematodes (*Metastrongylus asymmetricus, M. confusus, M. elongatus, M. pudendotectus, M. salmi*) and two species of stomach nematodes (*Ascarops strongylina, Physocephalus sexalatus*) were found in the wild boars (*Sus scrofa*) in France. Prevalence of lung nematodes was 92% (no significant difference between closed reserve and open areas could be demonstrated) and 97% for stomach nematodes. In both cases, intensity of infection was significantly greater in young wild boars (age <1 yr) than in the older animals. The importance of intermediate hosts in the transmission of these infections is emphasized by the increased prevalences and intensities in certain high risk areas and during certain seasons.
Key words: Lung nematodes, *Metastrongylus* spp., *Ascarops strongylina, Physocephalus sexalatus*, stomach nematodes, wild boar, *Sus scrofa*, prevalence, survey, transmission, intermediate hosts.

INTRODUCTION

The helminth fauna of the wild boar (*Sus scrofa*) in France consists of at least of 14 species of nematodes (Humbert and Ferte, 1986). Most of these species have a wide distribution in Europe (Bernard and Biesemans, 1978; Henne et al., 1978) and their occurrence in the wild boar population may be very important (Jansen, 1967; Kutzer and Hinaidy, 1971; Gadomska, 1981).

The present study deals with quantitative data on heteroxenous parasites: lung nematodes (intermediate hosts: earthworms) and stomach nematodes (intermediate hosts: dung beetles). The aim of this study was to (1) identify the different species, (2) determine the prevalence and the intensity of infection in the definitive host, and (3) determine the prevalence and the intensity of infection in the intermediate hosts of these helminths.

MATERIALS AND METHODS

Study area and data collection

From November 1984 to February 1986, 38 stomachs and 58 lungs of wild boar were collected after shooting animals in the game reserve of Chambord (01°30'E, 47°35'N; altitude, 80 m). This game reserve occupies approximately 5,400 ha of deciduous forest, pine woods, coppice and scrubs. Other lungs ($n = 110$) were collected from boars in different open areas from several regions in France (Fig. 1). Helminths were recovered at necropsy, placed in 70% ethyl alcohol and identified by previously defined techniques (Humbert, 1988). Representative specimens of the helminth species collected in this study are deposited in the Museum National d'Histoire Naturelle de Paris (Paris, France; accession numbers MNHM 408–412 HC, N539).

Between October 1983 and May 1985, 2,380 dung beetles (*Anoplotrupes stercorosus* and *Trypocopris vernalis*), which act as intermediate hosts for the stomach nematodes (Alicata, 1935), were collected in Chambord and placed in 70% ethyl alcohol. They were dissected and the third-stage nematode larvae, encysted in the body cavity of the beetles, were counted and identified.

In 1986 and 1987, 250 earthworms (*Lumbricus* spp., *Aporrectodea* sp., *Allolobophora* sp.) which act as intermediate hosts for the lungworms (Hobmaier and Hobmaier, 1929a, b) were collected in Chambord in two kinds of sample areas (Humbert, 1988): (1) samples on swine feeding centers in areas where food was given to animals and the density of the intermediate hosts (earthworms) was greater than in the rest of the forest (Humbert, 1988), and (2) in areas sampled at random within the forest. Earthworms were incised along their dorsal surface and the anterior parts of the gastrointestinal tract (oesophagus, crop, gizzard and first part of intestine) were removed. The tissues were pressed between two glass slides and examined microscopically. Larvae, when present, were readily visible and these were counted and identified.

TABLE 1. Comparison of prevalences of lung and stomach nematodes in Europe and in the United States.

	Lung nematodes	Stomach nematodes
France		
Humbert and Henry (present study)	92[a]	97[a]
Netherlands		
Jansen (1964a, b)	88	98
Switzerland		
Baettig (1986)	80	—
East Germany		
Henne et al. (1978)	98	33
Tscherner et al. (1984)	81	36
Poland		
Gadomska (1981)	92	74
United States		
Babero et al. (1959)	61	—
Henry and Conley (1970)	56	35
Riddle and Forrester (1972)	6	1
Coombs and Springer (1974)	78	10
Smith et al. (1982)	52	77
Pence et al. (1988)	>75	>13

[a] Prevalence expressed as a %.

Data analysis

In all cases, the confidence limits of the mean or of proportions were used because they are easier to interpret; these limits define the upper and lower values of a range within which the true population mean or proportion lies at the level of 5% risk for infection. The estimate of k was obtained by the maximum-likelihood method (Elliott, 1977) and Chi-square test (goodness-of-fit) was used for agreement with the negative binomial. The method of calculation of probability for becoming infected was as follows: Let s be the prevalence of nematode larvae in intermediate host; therefore, the probability for becoming infected when eating one intermediate host is s and for becoming non-infected is $1 - s$; when eating successively two intermediate hosts, the probability for becoming non-infected is $(1 - s)^2$, etc.; therefore, after eating successively n intermediate hosts, the probability for becoming infected is $1 - (1 - s)^2$.

RESULTS AND DISCUSSION

Five species of lung nematodes were found in the bronchi and bronchioles of wild boars from all collection sites (Fig. 1). Three of these were found in all the lungs that were examined: *Metastrongylus confusus, Metastrongylus salmi* and *Metastrongylus pudendotectus*. *Metastrongylus elongatus*, considered as the most prevalent species in Europe (Jansen, 1964a; Hollo, 1965; Kutzer and Hinaidy, 1971; Baettig, 1986) and in certain areas of the United States (Babero et al., 1959; Smith et al., 1982), was found only in southern France and in Bourgogne. A rare species, *Metastrongylus asymmetricus* described in Japan by Noda (1973), was recovered in Chambord.

The prevalence of metastrongylids in the game reserve of Chambord was 91% ($81 < P < 97$; 95% confidence limits). For the sample collected in the other areas (open areas), the prevalence was 88 ± 6% (95% confidence limits). The difference between these two localities was not significant. In Table 1, the prevalence data obtained during the present study are compared with similar information from wild boar in Europe and in the United States. The results from these studies show that the prevalence of these lung nematodes is greater in Europe (>80%) than in the United States (<80%).

No significant differences in mean intensity of lung nematodes between Chambord and the open areas could be demonstrated. The mean intensity was 167 ± 57 (95% confidence limits) nematodes per animal.

The distribution of parasites in the population of wild boar fits the negative binomial distribution reasonably well (parameters of the model: $\mu = 126.3$; $k = 0.5493$; agreement with the model accepted at the 95% probability level). For Anderson (1986) this negative binomial distribution has proved to be a good empirical model of observed patterns in helminth distribution patterns. This distribution of number of nematodes per wild boar is shown in Figure 2; 15% of the wild boar had 50% of all nematodes. The most heavily infected animals were usually the young. The number of helminths was significantly greater in young wild boars (age

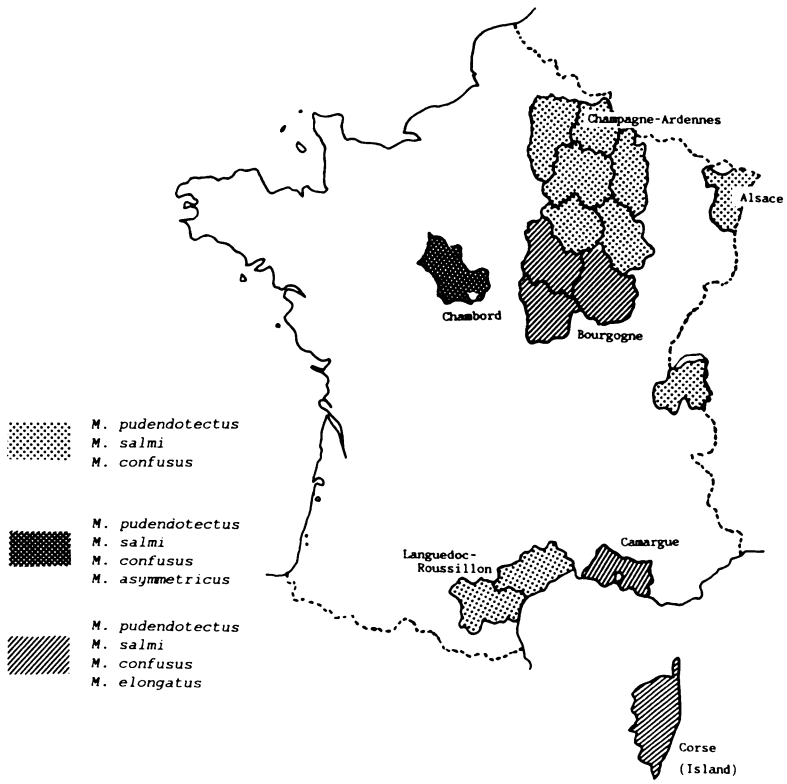

FIGURE 1. Distribution of metastrongylid lung nematodes in some regions of France.

<1 yr) than in older hosts (Chi-square test, $P < 0.001$; Table 2).

The prevalence of infection of lung nematode larvae in earthworms varied greatly according to the study area. On feeding centers, the prevalence of metastrongylid larvae was 91 ± 2% (95% confidence limits; $n = 143$). Parasited earthworms were not collected in the forest (random sampling). Thus, feeding centers constituted areas at higher risk for parasitism by the host because of infected intermediate hosts at these sites.

The mean intensity of larvae in earthworms was 23 ± 4 and the distribution of larvae in earthworm communities fit reasonably well the negative binomial distribution (parameters of the model: $\mu = 20.8$; k = 0.8023; agreement with the model accepted at the 95% probability level). Based

TABLE 2. Intensities of stomach and lung nematodes of wild boar in France.

Age	Stomach nematodes	Lung nematodes
<1 year or ♂ <50 kg or ♀ < 45 kg	minimum 20 maximum 218 mean 120.6 ± 55.2*	minimum 10 maximum 1,600 mean 245.1 ± 104.1*
>1 year or ♂ >50 kg or ♀ >45 kg	minimum 2 maximum 107 mean 22.12 ± 15.0*	minimum 3 maximum 446 mean 83.46 ± 37.5*

* 0.95 confidence limits: mean ± 1.96 SE.

TABLE 3. Life cycle of *Ascarops strongylina* and *Physocephalus sexalatus*: some quantitative data obtained at Chambord in 1983.

Wild boar: density (n/100 ha)	Dung of wild boar: density (n/ha)	Dung beetles (Geotrupidae): density (n/ha)		Stomach worms: number of encysted larvae/infected beetle
		On dung	Total population	
June–October, 31	June–July, 3.1 ± 2.0*	95 ± 61*	June–early August, 300 ± 82*	June–July, 50 ± 4*
(adults, 65%	August–early September, 5.5 ± 2.2*	105 ± 42*	late August–early September, 568 ± 249*	August–September, 52 ± 14*
piglets, 36%)	late September–October, 8.8 ± 4.3*	56 ± 27*	late September–October, 251 ± 68*	late September–October, 58 ± 10*
			(*A. stercorosus* 97%; *T. vernalis*, 2%)	

* 0.95 confidence limits: mean ± 1.96 SE.

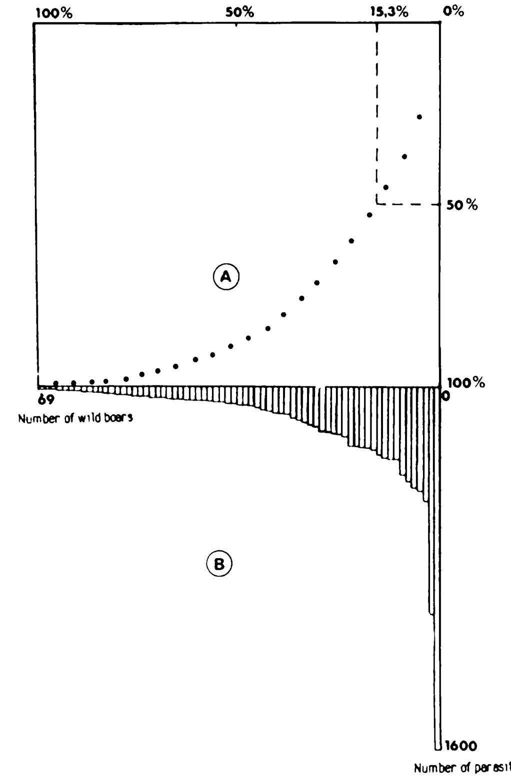

FIGURE 2. Distribution graphs of the 9,519 lung nematodes (*Metastrongylus* spp.) among 75 wild boars indicating relative (cumulative) frequencies (A) and absolute frequencies (B).

on this, wild boar could have become infected ($P > 0.99$) after eating as few as two earthworms on the feeding centers.

Two species of stomach nematodes were observed in wild boars: *Ascarops strongylina* and *Physocephalus sexalatus*. These species are observed commonly in Europe (Jansen, 1964b; Kutzer and Hinaidy, 1971) and in the United States (Smith et al., 1982)

Prevalence of these stomach nematodes was very high: 97% ($P > 84$; 95% confidence limits). Only a 6-yr-old male was not infected. Comparison with similar information from wild boars in Europe and in the United States (Table 1) shows that, like the lung nematodes, the prevalence of stomach nematodes is usually greater in Europe than in the United States.

The mean intensity was 52 ± 24 stomach nematodes per animal. The intensity

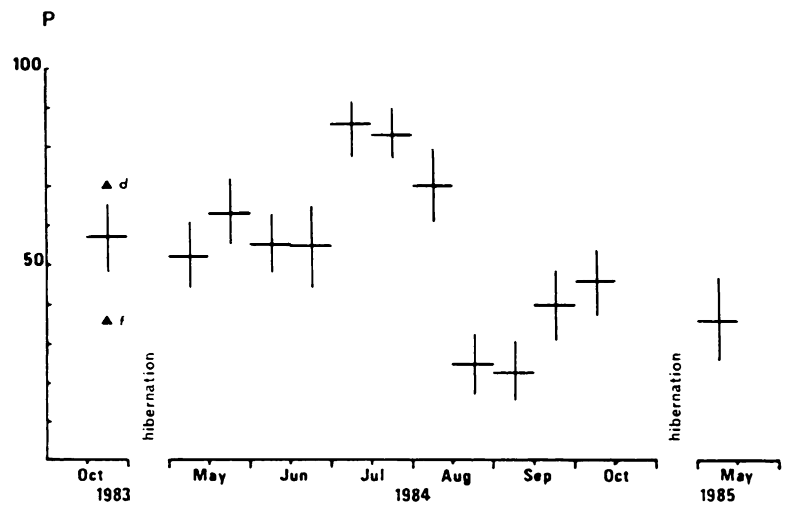

FIGURE 3. Annual changes in the prevalence of stomach nematodes (P) in the intermediate host *Anoplotrupes stercorosus* (horizontal bars, mean infection rate; vertical bars, 95% confidence limits; d, beetles on dung; f, beetles on fungi).

was significantly greater in young wild boars (age <1 yr) than in the older animals (Fisher exact probability test: $P = 0.003$; Table 2).

Two species of beetle intermediate hosts, *A. stercorosus* and *T. vernalis* (Table 3), were observed feeding on wild boar dung, fecal pellets and fungi (Henry et al., 1986). *Anoplotrupes stercorosus* occurred mainly from May to October, but many individuals hibernated and became active in late winter or early spring, depending on climatic factors. The prevalence of stomach nematode larvae in the beetles varied greatly, according to the period of the year (Fig. 3). The seasonal pattern of infection was as follows: (1) similar values were observed in early spring and the previous autumn (after and before hibernation); (2) increasing values occurred in June and July (maximum: 89% in 1983; 86% in 1984); and (3) the lowest values were noted in late August, due to the appearance of a new generation of adult beetles; the newly emerged beetles became slowly infected in September and October but many individuals, feeding mostly on fungi, were significantly less infected. Summer constituted the season of highest risk for the intermediate host to be parasited.

The number of encysted larvae per intermediate host was counted in 400 beetles between June and October 1983; the distribution of larvae was generally contagious and counts fit reasonably well the negative binomial in July (parameters of the model: $\mu = 43.07$, $k = 0.4073$; agreement with the model accepted at the 95% probability level). Consequently, the wild boar could have become infected ($P > 0.99$) after eating only six beetles in May and June, three in July and August and 10 in October. Infection could have occurred even though wild boars only accidentally ingested dung beetles.

CONCLUSIONS

Studies in France and Poland (Jezierski, 1977; Dardaillon, 1984) on wild boar populations have shown a high mortality rate among yearlings. This high mortality rate could be related to parasitism (Wetzel and Rieck, 1966; Henry and Conley, 1970; Fraczak, 1974; Smith et al., 1982). Our results agree with these studies. Pulmonary pathology associated with metastrongylid infections and despoiler action caused by stomach nematodes could be an important factor in the mortality of the young wild boar. Differences in the intensity of these nematodes in young (age <1 yr) and older animals may be explained by an acquired immunity in older animals as a result of repeated exposure to infection (Humbert, 1988).

Studies on the transmission of these nematodes show that: (1) intensity of lung nematode infection depends on the frequenting, by the wild boars, of areas at high risk for acquiring the infection at feeding centers, and (2) intensity of stomach nematode infection by ingestion of beetles depends on the seasonal variations in prevalence of larvae in these beetles. Thus, there is a site and seasonal dependance, respectively, in the transmission of these species.

In comparison with the hypothesis proposed by Crofton (1971), the negative binomial distribution of parasites in wild boar populations can arise (1) as the result of infection decreasing the chances of further infection (existence of an acquired immunity), (2) as the result of infective stages not being randomly distributed (existence of areas and season at high parasitic risk), and (3) as the result of a series of exposures to infection in which each exposure is random but the chances of infection differ at each exposure.

ACKNOWLEDGMENTS

We would like to thank C. Mary for permission to work at the game reserve at Chambord and F. Forget for help with the field work.

LITERATURE CITED

ALICATA, J. E. 1935. Early developmental stages of nematodes occurring in swine. Technical Bulletin 489, U.S. Department of Agriculture, Washington, D.C., pp. 5–32.

ANDERSON, R. M. 1986. The role of mathematical models in helminth population biology. *In* Parasitology, Proceedings of the Sixth International Congress of Parasitology, Quo vadit?, M. J. Howel (ed.). Australian Academy of Sciences, Canberra, Australia, pp. 519–529.

BABERO, B. B., L. H. KARSTAD, AND J. R. SHEPPERSON. 1959. Studies on helminth parasitism of feral swine in Georgia. Bulletin of the Georgia Academy of Sciences 17: 94–104.

BAETTIG, M. 1986. Beiträge zur Schwarzwildforschung in der Schweiz. Inaugural Dissertation zur Erlangung der Würde eines Doktors der Philosophie vorgelegt der Philosophisch-Naturwissenschaftlichen fakultat der Universität Basel, Switzerland, 196 pp.

BERNARD, J., AND W. BIESEMANS. 1978. Comparaison des infestations par les Nématodes du sanglier (*Sus scrofa* L.) en Tunisie et en Belgique. Bulletin de la Recherche Agronomique de Gembloux 13: 23–26.

COOMBS, D. W., AND M. D. SPRINGER. 1974. Parasites of feral pig × European wild boar hybrids in southern Texas. Journal of Wildlife Diseases 10: 436–441.

CROFTON, H. D. 1971. A quantitative approach to parasitism. Parasitology 62: 179–193.

DARDAILLON, M. 1984. Le sanglier et le milieu camarguais. Dynamique coadaptive. Thèse Doctorat 3e Cycle, Toulouse, France, 345 pp.

ELLIOTT, J. M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association, Scientific Publication No. 25, 2nd ed., Great Britain, 157 pp.

FRACZAK, K. 1974. An attempt at determining the role of parasites as a factor controlling the number of a wild boar (*Sus scrofa*) population. Wiadomosci Parazytologiczne 20: 747–749.

GADOMSKA, K. 1981. The qualitative and the quantitative structure of the helminthocoenosis of wild boar (*Sus scrofa* L.) living in natural (Kampinos Natural Park) and breeding conditions. Acta Parasitologica Polonica 21: 151–170.

HENNE, E., S. NICKEL, AND T. HIEPE. 1978. Contributions to the parasite fauna of D.D.R. Communication I. Investigations on the helminths of European wild pigs (*Sus scrofa*). Angewandte Parasitologie 19: 52–57.

HENRY, C., A. PRELLE, AND J. DROUET. 1986. Population density, biomass and spatial patterns in dung beetles (Geotrupidae) in a deciduous forest in France. Acta Oecologica, Oecologia Generalis 7: 3–16.

HENRY, V. G., AND R. H. CONLEY. 1970. Some parasites of European wild hogs in the Southern Appalachians. The Journal of Wildlife Management 34: 913–917.

HOBMAIER, A., AND M. HOBMAIER. 1929a. Die Entwicklung der larve des lungenwurmes *Metastrongylus elongatus* des schweines und ihr invasionweg, sowie vorlaufige mitteilung über die Entwicklung von *Choerostrongylus brevivaginatus*. Münchinger Tierärtzlische Wochenschrifte 80: 365–369.

———, AND ———. 1929b. Biologie von *Choerostrongylus brevivaginatus* aus der lunge des Schweines zugleich eine vorläufige Mitteilung über die Entwicklung der gruppe *Synthecaulus* unsere Haustiere. Münchinger Tierärtzlische Wochenschrifte 80: 433–436.

HOLLO, F. 1965. Investigations on metastrongylosis in swine. I.—Frequency of metastrongylosis and species causing it in Hungary. Acta Veterinaria Academiae Scientiarum Hungaricae 15: 45–60.

HUMBERT, J. F. 1988. Les Metastrongles, Nematodes parasites pulmonaires du sanglier (*Sus scrofa* L.). Biologie, Epidemiologie et dynamique de la transmission. Thèse de Doctorat de l'Université d'Orléans, Orléans, France, 161 pp.

———, AND H. FERTE. 1986. Le parasitisme helminthique du sanglier (*Sus scrofa* L.) en France. Symbioses 18: 75–84.

JANSEN, J. 1964a. On the lungworms of the wild boar (*Sus scrofa* L.) in the Netherlands, with a description of *Metastrongylus confusus* n. sp. Tijdschrift Diergeneesk 89: 1205–1211.

———. 1964b. Stomach worms of the wild boar (*Sus scrofa* L.) in the Netherlands. Tijdschrift Diergeneesk 89: 1277–1279.

———. 1967. The gastro-intestinal nematodes of the wild boar (*Sus scrofa* L.) in the Netherlands. *In* Proceedings VII° Congrès des Biologistes du Gibier. Beograd-Ljubljana, Yugoslavia, pp. 455–458.

JEZIERSKI, W. 1977. Longevity and mortality rate in a population of wild boar. Acta Theriologica 22: 337–348.

KUTZER, E., AND H. K. HINAIDY. 1971. Parasites of the wild boars (*Sus scrofa* L.) in Austria. Zeitschrifte für Parasitenkunde 35: 205–217.

NODA, R. 1973. A new species of *Metastrongylus* (Nematoda) from a wild boar with remarks on other species. Bulletin of University of Osaka Prefecture 25: 21–29.

PENCE, D. P., R. J. WARREN, AND C. R. FORD. 1988. Visceral helminth communities of an insular population of feral swine. Journal of Wildlife Diseases 24: 105–112.

RIDDLE, C. D., AND D. J. FORRESTER. 1972. Prevalence and distribution of helminths of swine in South Carolina. Proceedings of the Helminthological Society of Washington 39: 55–59.

SMITH, H. M., W. R. DAVIDSON, S. VETTLES, AND R. R. GERRICH. 1982. Parasitisms among wild swine in southeastern United States. Journal of the American Veterinary Medical Association 181: 1281–1284.

TSCHERNER, W., R. IPPEN, J. WISSER, D. HENNE, H. D. SCHRODER, D. MOLLER, AND G. RAETZ. 1984. Orientierende Untersuchungen zum gesundheitszustand von Schwarzwildbeständen in der D.D.R. Beiträge zur Jagd- und Wildforschung 13: 245–253.

WETZEL, R., AND W. RIECK. 1966. Les maladies du gibier, Vol. 1. Maloine Edition, Paris, France, 165 pp.

Received for publication 25 May 1988.