Journal of Wildlife Diseases, 31(4), 1995, pp. 486–490

STUDIES ON THE HYPODERMOSIS AFFECTING RED DEER IN CENTRAL AND SOUTHERN SPAIN

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ABSTRACT: From November 1992 to February 1993, 455 red deer (*Cervus elaphus*) were surveyed in order to estimate the prevalence of warble fly (*Hypoderma actaeon*) larvae under the skin of this ungulate species. Material came from Montes de Toledo, Sierra Morena, Sierra de Alcaraz, and Sierras de Cazorla, Segura y Las Villas Natural Park (central and southern Spain). We observed a prevalence of 92%, with a mean ± SD intensity of 35.7 ± 41.3 grubs per parasitized host; there was a maximum of 317 larvae per host. No significant differences in prevalence by host sex were found, although significant differences were observed in prevalences among different host age classes. The main location of feeding larvae in deer was in the back tissues.

Key words: Warble fly, *Hypoderma actaeon*, red deer, *Cervus elaphus*, Spain.

INTRODUCTION

The dipteran genus *Hypoderma* (Latreille, 1818) is restricted to the Holarctic region and comprises a number of species whose larval stages, commonly known as grubs or warbles, are important parasites of Bovidae and Cervidae hosts (Zumpt, 1965). After oviposition, the hatching small first-instar larvae penetrate into the host skin through the hair follicles. Larval development is subcutaneous and during migration larvae can damage several kinds of host tissues and organs, including the central nervous system; occasionally paralysis and host death result (Kettle and Utsi, 1955). In September, October and specially November, first-instar larvae of *Hypoderma lineatum* are located in the submucosa of the esophagic wall of cattle or in the connective tissues of diaphragm (in the southern U.S. this would happen in summer to autumn) and migrate via connective tissues to reach, about February to March (October to November in the southern U.S.) the host back (Keilin, 1944). Then, larvae made an orifice in order to orientate the posterior spiracular plates to the open air and begin to actively feed. When the third-instar larvae are mature they emerge through the orifice, drop to the ground and pupate into the soil. Adults emerge from pupae in about 5 wk (Keilin, 1944). This time, on average, is about 26 days in the case of *Hypoderma actaeon* (Zumpt, 1965).

Species belonging to the genus *Hypoderma* are relatively host-specific. Within wild ungulates high prevalences of hypodermosis have been reported: 98% in roe deer (*Capreolus capreolus*) and 65% in red deer (*Cervus elaphus*) in Hungary, due to *H. diana*, and 93% in red deer due to *H. actaeon* in the same country (Sugar, 1976) or 97 to 100% in Canadian caribou (*Rangifer tarandus*) due to *H. tarandi* (Thomas and Kiliaan, 1990). *Hypoderma actaeon* is a typical parasite of red deer in Europe and strictly host-specific (Zumpt, 1965). In Spain, Martinez et al. (1990) found *H. diana* caused hypodermosis in red deer with a prevalence of 87%

Our objective was to determine the prevalence of *Hypoderma actaeon* among red deer in several locations of central and southern Spain.

MATERIALS AND METHODS

Larval collections were made during hunting season when feeding *Hypoderma* spp. larvae can be found forming warbles. Between November 1992 and February 1993, 455 red deer were shot in non-selective huntings in Sierra Morena, Sierra de Alcaraz, Montes de Toledo and Sierras de Cazorla, Segura y Las Villas Natural Park, central and southern Spain (37°30′ to 39°30′N and 2°00′ to 5°30′E).

Deer were sampled 4 to 10 hr after death. Larvae were collected from the hide, and as the hide was removed a number of larvae remained in deeper tissues (Fig. 1). These larvae were counted and added to those larvae within war-

FIGURE 1. The deeper *Hypoderma* spp. larvae (arrows) remained attached to subcutaneous tissues after removal of the deer skin. Scale bar = 5 cm.

FIGURE 2. Larvae (arrows) within deer skin. Scale bar = 2 cm.

bles and removed with the skin (Fig. 2) and recorded as the total number of *Hypoderma* spp. larvae parasitizing the host (intensity). Intensity as well as mean intensity and prevalence were defined according to Margolis et al. (1982). Sex and age of animals surveyed were recorded. Deer age was estimated according to Larson and Taber (1980) and three age classes were evaluated: 1 to 2 yr, 3 to 5 yr and >5 yr.

Several body regions were considered: head-neck, anterior extremities, back, abdomen, posterior extremities, and hind-quarters. Locations of all larvae were identified within these areas. We defined the term grouping index as the number of larvae in the same developmental stage aggregated or grouped in each area of host skin surface; it was calculated according to Solopov and Zharkov (1988). Possible differences in prevalence of parasitism between different host sex and age classes were tested by means of a chi-square test. Regression analysis was performed using the program BMDP 7.0 (BMDP Statistical Software Inc. 1993, Los Angeles, California) in order to evaluate the relationship between host age and intensity of parasitism.

Larvae were identified as *Hypoderma actaeon* Brauer, 1858 according to Zumpt (1965) and Sugar (1976), by location of the pseudocephalon spinulation of second instar larvae and in the size of posterior peritremes of third instar larvae.

RESULTS

We observed *Hypoderma actaeon* in 419 (92%) of 455 red deer; the prevalence was very similar in both sexes, and increased with host age (Table 1). Nevertheless, no significant differences in prevalence among different host sex were found (chi-square = 0.01, df = 1, $P = 0.898$); however, significant differences in prevalence among different host age classes were found (chi-square = 26.47, df = 2, $P < 0.0001$).

A mean (± SD) intensity of 35.7 ± 41.3 larvae per host (ranging from one to 317) was obtained, with the highest mean number of larvae associated with the older deer

TABLE 1. Parasitism in 455 red deer by *Hypoderma actaeon*, by sex and age class, November 1992 to February 1993, Spain.

	Age					
	1 to 2 yr old		3 to 5 yr old		>5 yr old	
	Males	Females	Males	Females	Males	Females
Number evaluated	62	70	74	113	70	66
Number infected	51	58	70	107	69	65
Prevalence (%)	82	83	95	95	99	98
Range in infected animals	1–157	1–105	2–256	1–317	1–232	2–263
Mean (±SD) intensity	31 ± 32	32 ± 28	38 ± 43	35 ± 42	47 ± 47	50 ± 49

(Table 1). Host age in years (x) and number of larvae (y) were related to each other by means of the equation: $y = 9.05 + 7.50x$ ($R = 0.38$, $P < 0.001$).

The distribution of grubs in host tissues were 84% in the back, and another 12% were found in the hind-quarters (Table 2). Comparatively, few grubs were removed from the remaining host body areas considered. The grouping index of larvae obtained reached 83%.

No data about first-instar larvae were available; all larvae collected were second or third-instars. The percentage of third-instar larvae increased from 73% in November to 100% in late-February; over half of these were nearly ready to pupate.

DISCUSSION

A mean prevalence of 92% parasitism of red deer with *H. actaeon* was observed in this study. This level of parasitism is similar to the prevalence (89%) found by Martinez et al. (1990) for *Hypoderma diana* among red deer in Spain, and the prevalence (93%) for *H. actaeon* in red deer in Hungary found by Sugar (1976); it also was similar to prevalence of different *Hypoderma* spp. affecting other wild cervids (Sugar, 1976; Thomas and Kiliaan, 1990).

TABLE 2. Location of *Hypoderma* spp. larvae into different skin areas of 455 red deer from central and southern Spain (November 1992 to February 1993).

Host body region	Number of larvae	Percent of total	Range in infected animals
Head-neck	58	0.36	1–3
Back	13,598	84.10	1–298
Abdomen	314	1.94	1–24
Hind-quarters	1,954	12.08	1–58
Anterior extremities	80	0.49	1–5
Posterior extremities	165	1.02	1–10

In this study, both the prevalence and intensity of red deer parasitism with *H. actaeon* increased with age, although the level of parasitism was not statistically different from the younger deer. Perhaps older deer, with their larger body, tended to harbor a higher number of larvae than younger deer (Table 1). This observation is in contrast with level of warble fly species noted in cattle (*H. bovis*) and domestic goats (*Przhevalskiana silenus*). In these host species and their associated warble fly parasites, the younger animals were the more susceptible than repeatedly exposed older animals and had a higher mean intensity of parasitism than older animals (Tarry, 1987; Puccini et al., 1987). An acquired resistance is established in older cattle to *H. bovis* and *H. lineatum* after two or three infestations (Boulard, 1987). Yet our observation agree with the trend in parasitism of red deer and other wild cervids such as fallow deer (*Dama dama*) or mule deer (*Odocoileus hemionus*) by pharyngeal bot flies (*Pharyngomyia* spp. and *Cephenemyia* spp.). In these cases both prevalence and intensity of parasitation also increased with host age (McMahon and Bunch, 1989; Ruiz and Palomares, 1993; Ruiz et al., 1993).

Based on the proportion of second and

third instar larvae recovered throughout the sampling period, adult flies activity may start in early April in our latitude. Our observations of larval appearance in the back agree with data given by Martinez et al. (1990) for *H. diana*.

According to Esch and Fernandez (1993) the distribution of *Hypoderma* spp. larvae on the parasitized hosts is overdispersed or contagious, since variance is higher than the mean number of parasites per individual host sampled. Minar (1987) found that the *H. bovis* population can be described as a negative binomial distribution. Based on our results, adult *H. actaeon* can emerge from their puparia during April–May in Spain.

Martinez et al. (1990) identified *H. diana* as the *Hypoderma* species parasitizing red deer in a very similar area of Spain. In direct contrast in this study we found no animals parasitized by *H. diana*, but the prevalence of *H. actaeon* was high. The discrepancy between our observations and those of Martinez et al. (1990) could have been due to their dependence upon Zumpt (1965) for species description. Thus, in our opinion, the material obtained by these authors would need a revision using the descriptions of Zumpt (1965) and Sugar (1976) for identification of the *Hypoderma* species involved, since they studied the same host species in almost the same area. Perhaps in the near future, a classification system of Oestridae and Hypodermatidae, based on biochemical and genetic techniques, can be developed as a tool for identification of these parasites of ungulates.

ACKNOWLEDGMENTS

The authors thank the staff of Valcaza (Ciudad Real, Spain) for providing the deer for this study. Special thanks go to Mr. F. Gómez and Mr. M. Rosillo (Jaen University) for their collaboration in sampling work.

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Received for publication 5 December 1994.