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HYPODERMOSIS OF RED DEER IN SPAIN

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ABSTRACT: From February 1998 to January 1999, 106 red deer in the Autonomic Organism National Park "Quintos de Mora" (Toledo, central Spain) were evaluated to determine the prevalence and dynamics of infection with *Hypoderma* sp. by detection of subcutaneous larvae. Between six and 13 deer shot in selective hunting were examined monthly. *Hypoderma* sp. larvae were detected throughout the period except in June, July and August of 1998. Excluding the period during which no subcutaneous larvae were detected, the number of animals sampled was 80 (52 males and 28 females), belonging to three age classes: 12 calves (<1-yr-old), 19 yearlings (1-yr-old), and 49 adults (2- to 10-yr-old). All the third instar (L_3) collected were identified as *H. actaeon.* Total prevalence during the period of larval detection was 61%. Prevalence in yearling and adult deer shot during the official hunting season was 89%. Monthly prevalence increased from September to January and decreased from February to May. In September and October, a small percentage of larvae were classified as first instar (L_1). The rest of larvae collected between September and December were second instar (L_2). Third instar (L_3) predominated in January and February and was the only stage collected from March to May. Intensity ranged from 1 to 145 larvae. Intensities were >100 larvae in 6% of animals. Possible relationships of intensity or prevalence of infection with sex or age of the animals were evaluated. Significant differences in prevalence were observed among different host age classes. Prevalence was higher in yearlings (84%) than in adults (63%) and lowest in calves (17%).

Key words: Hypodermosis, *Hypoderma actaeon,* red deer, *Cervus elaphus,* survey.

INTRODUCTION

Bovidae and Cervidae of the Holarctic region can be affected by hypodermosis, a myiasis caused by flies belonging to genus *Hypoderma.* The species of *Hypoderma* in red deer (*Cervus elaphus*) in Europe are *Hypoderma diana* and *Hypoderma actaeon.* Although *H. diana* has roe deer (*Capreolus capreolus*) as the main host, it also has been found in red deer, whereas *Hypoderma actaeon* is restricted to *Cervus elaphus* (Zumpt, 1965). Extensive epidemiological studies on hypodermosis in this wild ungulate have been conducted in central Europe (Brauer, 1863; Sugar, 1976) and, more recently, in southern and central Spain (Martínez-Gómez et al., 1990; Pérez et al., 1995). However, information about the life cycle of deer hypodermosis in western Mediterranean areas is still incomplete.

In the present report we describe the dynamics of infection by *Hypoderma actaeon* in red deer from Autonomic Organism National Park "Quintos de Mora" (Toledo, central Spain) between February 1998 and January 1999. The inner surfaces of the animals' hides were inspected and the results include total prevalence during the period of warble detection, monthly prevalence and intensity of infection, monthly percentages of larval stages collected, and relationship of infection with sex and age of the animals.

MATERIALS AND METHODS

Quintos de Mora (39°25′N, 4°04′W) is a completely enclosed extension of 6,864 ha in the Northeast spurs of Montes de Toledo, with a central valley (2,536 ha, 800 m altitude) and two mountainous areas (1,547 ha and 2,779 ha; maximum height 1,235 m). The extension has a Mediterranean climate, with a dry season (June to September) and maximum rainfalls in spring and, less markedly, in autumn. The thermal regime is basically Continental with high day/night and summer/winter oscillations. Mean annual precipitation is about 550 mm and mean maximum and minimum temperatures are 18 C and 7 C, respectively. Predominant trees in the park are *Quercus rotundifolia* and *Q. faginea,* with typical associated Mediterranean flora in vallies and hillsides, and *Pi-*

nus pinaster and *P. pinea* as recently introduced species in shady mountainous areas. Artificial pastures (632 ha) supplement feeding of animals in summer, and watering places scattered throughout the park mitigate summer drought. Game fauna consists of red deer (*C. elaphus*), fallow deer (*Dama dama*), roe deer (*C. capreolus*) and wild boar (*Sus scrofa*). The population of *C. elaphus* is estimated at 2,500 to 3,000 individuals.

The presence of subcutaneous *Hypoderma* sp. larvae was investigated in 106 red deer. The animals were shot in selective hunting from February 1998 to January 1999. Between six and 13 animals were analyzed monthly (except April, when the animals' hides were accidentally lost). After exclusion of those deer (26 individuals) shot during the period of no larvae detection, the total number of animals examined was 80: 52 males and 28 females. Three age groups were determined as <1-yr-old (calves: $n = 12$), 1-yr-old (yearlings: $n = 19$) and 2- to 10-yr-old (adults: $n = 49$).

Inspection for subcutaneous larvae was by observation of the inner surface of hides (Fig. 1). Most hides were stored at −20 C until observation, except for two which were skinned and immediately observed at the necropsy room of the park. After thawing, larvae were removed from the hides, counted and preserved in 70% ethanol. Classification of larval stages was made according to Zumpt (1965) and identification of *Hypoderma* spp. was by observation of the specific morphological characteristics stated by Zumpt (1965), Sugar (1976) and Colwell et al. (1998) for L_3 larvae.

The percentage of each instar in the total number of larvae collected monthly was calculated. Individual intensity, mean and median intensity, and prevalence of *Hypoderma* spp. were calculated for each month, as well as for sex and age groups, according to the definitions by Margolis et al. (1982). Possible differences in prevalence of infection between different sexes or ages were tested by means of a chi-square test (Siegel and Castellan, 1988). Total prevalence for the whole period of larval detection was calculated. In order to compare results with those from non-selective hunting reports, prevalence also was estimated for yearlings and adult red deer shot during the official hunting season (February 98 and October 98 to January 99).

RESULTS

Hypoderma spp. larvae were detected all the months analyzed (February 1998–January 1999) except in June, July and August. All L_3 larvae collected were identified as *H. actaeon*. Total prevalence of parasitism during the period of larvae detection was 61% (49 of 80 animals). Among yearling and adult animals shot during the official hunting season, prevalence was 89% (39/44).

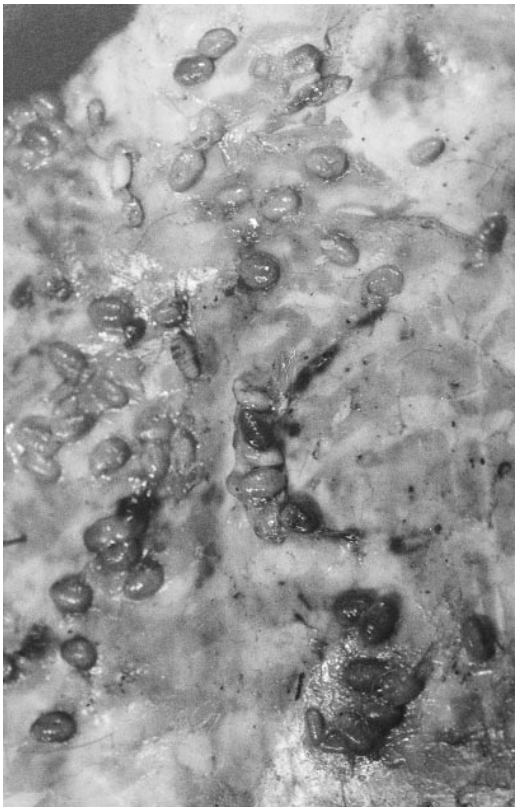

FIGURE 1. Larvae (L_3) of *Hypoderma actaeon* within deer hide. Length of larvae: 1.8–2.1 cm.

Monthly prevalence (Fig. 2) increased from September (36%) throughout October (78%), November (73%) and December (90%) reaching a maximum in January (100%), and decreased during February (79%) and March (33%), reaching a minimum in May (12%). A similar trend was seen in monthly median intensity values (Fig. 2), in spite of the overdispersion observed (Table 1).

We show monthly percentages of instar larvae in Fig. 3. A small percentage (2%) of larvae recovered in September and October were classified as L_1 (1st larva in Fig. 4). The rest of larvae collected from Sep-

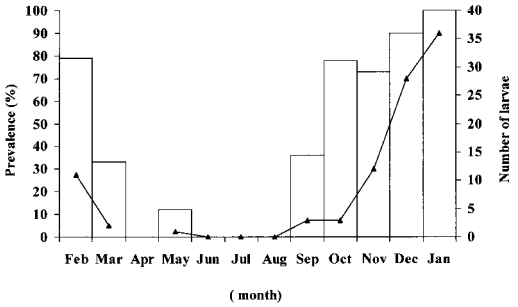

FIGURE 2. Monthly prevalence (bars) and median intensity (triangles) of *Hypoderma actaeon* in red deer (*Cervus elaphus*) from Quintos de Mora (Toledo, Spain). February 1998 to January 1999. Months in abscissa are displayed as if following two consecutive years, to simulate chronological evolution.

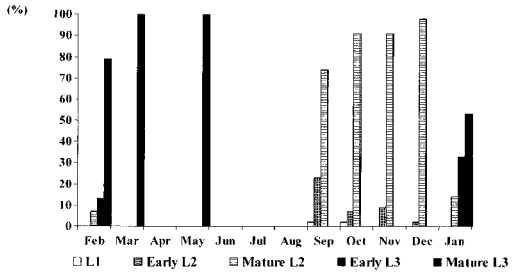

FIGURE 3. Monthly percentages of instar larvae of *Hypoderma actaeon* in red deer from Quintos de Mora (Toledo, Spain). February 1998 to January 1999. Months in abscissa are displayed as if following two consecutive years, to simulate chronological evolution.

tember to December were L_2 in different degrees of development (2nd to 4th larvae in Fig. 4). L_3 larvae in different stages of development (5th to 6th larvae in Fig. 4) predominated in January and February. All the larvae found in March and May were completely-developed L_3 larvae (6th larva in Fig. 4).

Classification of the hosts by intensity indicated that in a high proportion (74%) of individuals, the number of larvae found did not exceed 40. Intensity was higher than 100 larvae in only three animals (6%).

Prevalence and intensity were calculated for sex and age groups (Table 2). Prevalence was not significantly different between males (59%) and females (64%), but a highly significant difference ($\chi^2 = 18.45$;

TABLE 1. Monthly intensity of *Hypoderma actaeon* in 49 red deer from Quintos de Mora (Toledo, Spain). February 1998 to January 1999.[a,b]

Month, year	Sample size	Mean (±SD)
February, 1998	10	30 ± 33
March, 1998	4	2 ± 1
May, 1998	1	1 ± 0
September, 1998	4	9 ± 8
October, 1998	7	8 ± 9
November, 1998	8	30 ± 37
December, 1998	9	44 ± 45
January, 1999	6	53 ± 47

[a] No animals were evaluated in April.
[b] No subcutaneous larvae were detected in June, July or August.

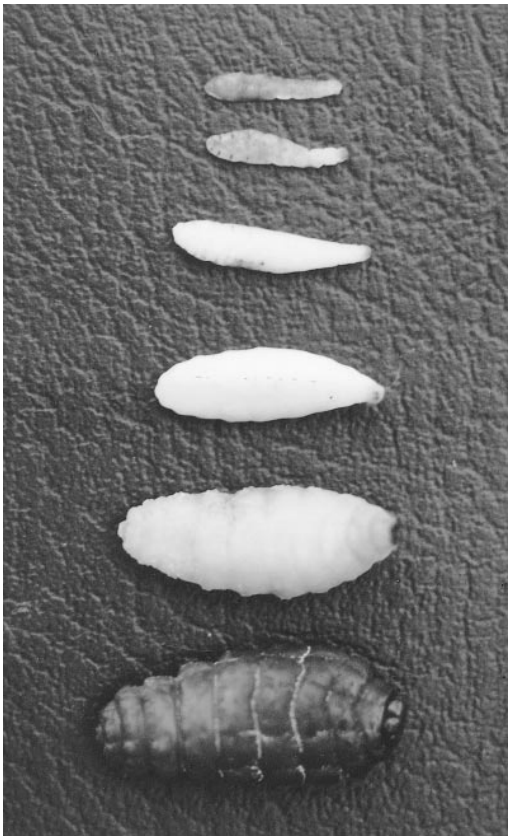

FIGURE 4. Evolution of subcutaneous larvae of *Hypoderma actaeon* from first to third instars (from top to bottom of figure): L_1 (1st); L_2 (2nd to 4th); L_3 (5th to 6th). Length of larvae: 0.8–2.1 cm.

TABLE 2. Prevalence and range of parasitism by *Hypoderma actaeon* in 80 red deer (*Cervus elaphus*), by sex and age class. Quintos de Mora (Toledo, Spain). February 1998 to January 1999.

	Age			Sex	
	<1-yr-old	1-yr-old	2- to 10-yr-old	Male	Female
Number sampled	12	19	49	52	28
Number infected	2	16	31	31	18
Prevalence (%)	17	84	63	59	64
Range	1–21	1–145	1–140	1–145	1–140
Mean intensity (±SD)	11 ± 14	39 ± 45	24 ± 33	34 ± 38	20 ± 34
Median intensity	11	24	8	17	4

df = 2; $P < 0.001$) was found among the prevalences of calves (17%), yearlings (84%) and adults (63%). Although mean and median intensity values were apparently higher in yearlings and in males, no statistical significant differences could be detected between age or sex groups due to overdispersion.

DISCUSSION

The detection of *Hypoderma actaeon* in red deer confirms previous observations by Pérez et al. (1995) for central Spain. This species also was found in southern Spain by Pérez et al. (1995), in contrast to the previous detection of *H. diana* (Martínez-Gómez et al., 1990) in similar southern areas. These two species may coexist in southern Spain, as it has been observed in Hungary (Sugar, 1976).

The prevalence of *H. actaeon* in red deer in the present work (61%) was markedly lower than that estimated during the official hunting season (89%) and to that reported for Hungary (93%) by Sugar (1976) and Spain (92%) by Pérez et al. (1995). In the present study, had we surveyed only during the hunting season, we would have obtained similar prevalence values.

As previously observed in hypodermosis of cattle (Hurtado et al., 1997, Morrondo et al., 1999) and deer (Pérez et al., 1995), no differences between sexes were detected in prevalences and intensities. However, significant differences were detected in prevalence between age groups; lowest prevalence was seen in calves and highest prevalence was found in yearlings. These findings contrast with reports of an increase of prevalence and intensity of parasitism by *H. actaeon* with age (Pérez et al., 1995). A similar trend to that observed by us has been reported for hypodermosis in cattle, in which the decrease of rates and numbers of *Hypoderma* spp. with age has been attributed to immunity (Gingrich, 1980; Baron and Colwell, 1991). The distribution of hypodermosis in adult deer populations would be more influenced by the number of previous infections than by age itself, as it has been stated for bovine hypodermosis (Morrondo et al., 1999). On the other hand, the low infestation rate found in calves in the present work could be related to the time they were born. Probably, when calving takes place in the area, mainly in May, the adult fly season has long begun, thus animals in their first spring would be exposed to a shorter period of oviposition by adult flies than older animals.

The arrival of L_1 to the skin of the animals would begin in September in the area and the emergence of L_3 would take place predominantly during February and March, lasting until May. Detection of the arrival of *H. actaeon* to the skin has not been previously reported in southern Europe, to our knowledge. In our study, L_3 of *H. actaeon* were not observed until January, 2 mo later than reported for southern Spanish areas and 2 mo earlier than in central Europe. This timing is similar to that seen in bovine hypodermosis. Different chronological cycle patterns of bovine

hypodermosis are known to occur between different geographic areas (Boulard et al., 1988; Martínez-Gómez et al., 1988; Benakhla et al., 1993; Morrondo et al., 1999) even for a single *Hypoderma* sp., due to the strong influence of climate on the life cycle of this parasite. Considering 26 days of average pupal period (Brauer, 1863), the flight of adult flies in the area studied (and others of similar climate) would be expected to begin in March and last until June. More epidemiological studies should be conducted in this area to reinforce these observations, considering yearly climatic variations that occur in this and other areas in Spain.

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