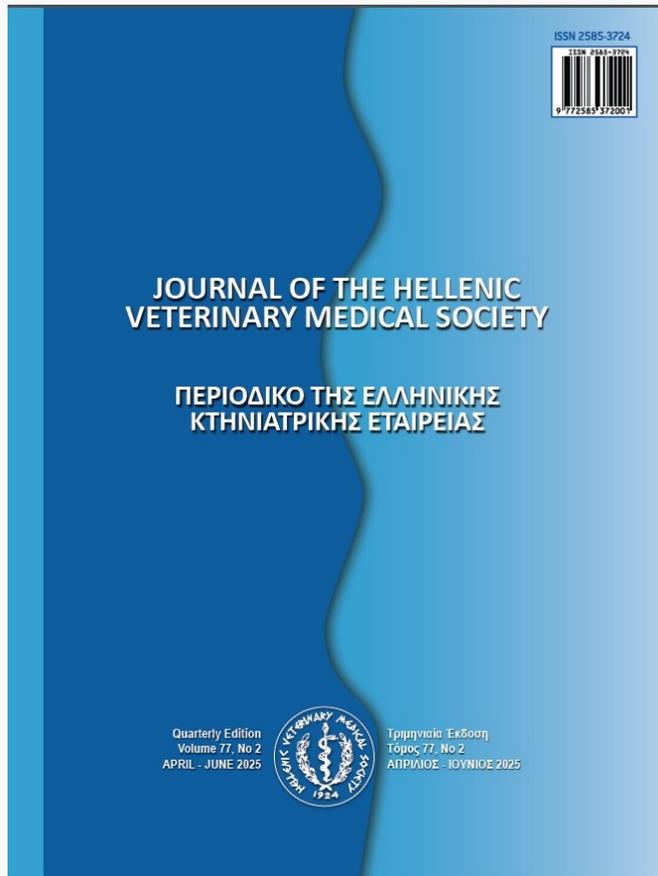


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The prevalence and economic importance of bovine hypodermosis in Ağrı region, Türkiye

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ABSTRACT: In this study, it was aimed to detect the prevalence of hypodermosis, to reveal the role of some epidemiological parameters and to calculate the current economic loss according to hide damage in cattle in Ağrı region of Türkiye. For this purpose, a total of 1857 cattle skin were palpated from 51 farms in 18 locations and 98 cattle were examined postmortemly in slaughterhouses for the presence of *Hypoderma* spp. larvae between March and May 2023. The breeds, ages, genders and skin colours of animals were recorded. The prevalence of hypodermosis in cattle was found to be 16.85% by skin palpation. The total number of larvae was determined as 3521 on 313 infested cattle. Maximum 46 larvae were counted by palpation on a cattle and the mean larvae count was determined as 11.24. The infestation rates were 10.35% one-year-olds, 26.33% in two-year-olds, 16.80% in three-year and older ($P<0.005$), while 16.39% in females and 18.02% in males ($P<0.005$). Infestation rate was higher in native cattle (20.84%) than brown Swiss crossbred (16.50%) and simmental crossbred (15.89%) ($P<0.005$). In postmortem examination in slaughterhouses, 19 out of 98 cattle were found infested with 69 warble larvae. The economic loss caused by hypodermosis was calculated as 15.780 TL = 553.6 USD / 500 EURO (1 USD = 28.5 TL, 1 EURO = 31.5 TL in November 2023) in study area.

Keyword: Ağrı; cattle; infestation; hypodermosis; prevalence.

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INTRODUCTION

Bovine hypodermosis, a pasture-borne infestation, is a skin disease that occurs when the larvae of *Hypoderma bovis*, *H. siense* and *H. lineatum* flies settle and develop under the dorsal skin of cattle. Due to this disease, meat and milk yield decreases and skin damage occurs in cattle (Soulsby, 1986; Boulard, 2002; Colwell et al., 2004; Şaki and Özer, 2013; Darabuş et al., 2023). *Hypoderma bovis* is more common than *H. lineatum* in Türkiye. The life span of the yellowish-black free-living adult flies is limited to 7-15 days between May and October, and their size varies between 11-16 mm. Females lay their eggs singly (*H. bovis*) or in bunches (*H. lineatum*) on the hind leg hairs of cattle. The first-stage larvae hatch within a week and migrate to the spinal canal by piercing the skin with the enzymes they secreted. These larvae settle under the skin of the back and become second-stage larvae. Although it varies according to geographical regions, 2nd stage larvae develop between November-February, and 3rd stage larvae develop between March-May. The larvae are produced hazel-sized swellings under the skin of the back and called warbles. Protein and nutrients taken during the larval stage are sufficient for adult female flies to produce eggs (Şaki and Özer, 2013; Darabuş et al., 2023). The larvae emerging from these swellings fall onto the ground and pass into the pupal stage in 17-70 days. Adult female flies emerge from the pupa between June and August and lay their eggs in the hairs of cattle. Between July and September, the 1st instar larvae hatch from the eggs and settle under the skin by piercing the skin. While the development period of *Hypoderma* larvae in cattle takes 9-10 months, biological development is completed in one year (Sayın et al., 2000; Colwell et al., 2004; Şaki and Özer, 2013; Darabuş et al., 2023). *Hypoderma* larvae pierce the hide and cause its quality to decrease. Holes in the skin are closed over time. However, when the leather is processed, these holes are opened again. Adult flies disturb the animals by making noises as they fly around the cattle. Therefore, animals cannot be fed adequately, and there is a decrease in live weight gain and milk yield. If the *Hypoderma bovis* larvae settle around the spinal cord or die, paralysis or death occurs in cattle due to the secreted proteolase enzyme. If the *Hypoderma lineatum* larvae settle around the esophagus, swellings on the wall of the esophagus cause narrowing and faulty regurgitation. Rarely, anaphylaxis develops in susceptible cattle after multiple larval deaths (Soulsby, 1986; Şaki and Özer, 2013).

Hypodermosis is diagnosed by examination of carcass in the slaughterhouse, while by palpation of skin, PCR and ELISA in live animals (Boldbaatar et al., 2001; Balkaya et al., 2010; Karatepe et al., 2013; Taşçı et al., 2018). The prevalence of hypodermosis was found with different rates in studies conducted in Türkiye and various countries in the world (Sayın et al., 2000; Otranto et al., 2005; Colwell, 2013; Ahmed et al., 2016; Darabuş et al., 2023). Because 25-30% depreciation occurs in the skin, economic loss due to hypodermosis corresponds to serious costs. A greenish yellowish color occurs in the carcass and the quality of the meat deteriorates between 10-25%. The economic loss due to hypodermosis was 192 million dollars in the USA in 1956 and 13 million pounds in 1978 in the UK (Soulsby, 1986), while 18.288 TL (Cicek et al., 2011) and 407.500 TL (Taşçı et al., 2018) due to the decrease of hide value in Türkiye.

Pasture livestock is one of the main livelihoods of Ağrı province. In this province, cattle are grazed on pasture for most of the year. Therefore, hypodermosis is thought to be a serious risk for cattle in this region. Because there is no epidemiological data on the current status and control programme of hypodermosis infestation in Ağrı, the study was aimed to determine the prevalence of hypodermosis, as well as to reveal the role of some epidemiological factors such as race, age, gender, skin color in the spread of infection and to calculate the current economic loss according to leather prices due to hide damage, taking into account the proportion of cattle with *Hypoderma* spp. larvae.

MATERIAL AND METHODS

Ethical approval

The Animal Experiments Local Ethics Committee of Kafkas University approved this research (Approval no: KAÜ - HADYEK / 2022 - 208).

Study area

Ağrı is in the northeast Anatolia region of Türkiye (39° 40' N, 43° 10' E) and has 11.100 km² surface area with an average 1632 altitude. Ağrı is surrounded by Iran in the east, Kars in the north, Erzurum in the northwest, Muş and Bitlis in the southwest, Van in the south and Iğdır in the northeast. Ağrı Mountain is located in this province with 5137 m altitude. In Ağrı province winter is long and harsh, while summer is short and mild. Since the region has extensive pasture grounds, cattle breeding is common.

Detection of hypodermosis

Larva density was determined by counting the swellings on the skin with palpation in infested cattle. *Hypoderma* infestation was investigated on randomly selected 51 farms in 18 locations (Figure 1) between 1 March- 1 June 2023. A total of untreated (declared by farmers) 1857 cattle were palpated for the presence of *Hypoderma* spp. larvae and epidemiological factors such as age (1, 2, and 3 and more years old), sex (male, female), breed (Simmental and crosses, brown Swiss and crosses, Northeastern Anatolian Red-Native) and skin color (light, dark, and piebald) were recorded (Taşçı et al., 2018).

In second stage of study, cattle were examined for hypodermosis in slaughterhouses. The skin, subcutaneous, spinal canal and surrounding areas of slaughtered cattle were examined for *Hypoderma* spp. larvae. Species were identified by looking at the stigmas of the collected larvae under stereo microscope (Zumpt, 1965). In slaughterhouses, 98 cattle were examined postmortemly between 1 March- 1 June 2023.

Calculating economic loss

The hide merchants were reported that the price of healthy hide was 6 TL/kg while damaged hide was 3 TL/kg and the average weights of hide are 10 kg in 1-year-old, 15 kg in 2-year-old, and 20 kg in animals 3 or more years old in Ağrı. The calculation is formulated as; hide kg x number of infested animal x price of damaged hide (Taşçı et al., 2018).

Statistical analysis

Pearson chi-square, Fisher's exact tests and SPSS 20.0 software (Licensed from Kafkas University,

Kars, Turkey) program were used to determine the statistical analysis belongs to the parameters such as age, breed, sex and skin color. The $p < 0.05$ level was accepted as statistically significant for each parameters.

RESULTS

Palpation

Hypodermosis infestation was determined in all foci with 16.85% (313/1857) prevalence rate by skin palpation. Prevalence rates were changed between 8.70% (100. Year neighbourhood) and 23.28% (Kurtuluş neighbourhood) in Ağrı city center and there was no significant relationship between foci and infestation rate ($P > 0.05$). On 313 infested cattle, total larval count was found as 3521. Maximum 46 larvae were counted on a male, 3 years old, brown Swiss cross cattle in Yakinca village. Average 11.24 warble larvae per animal were counted by palpation. The relationships between larval count and epidemiological parameters such as age, breed, sex and skin color were summarized in Table 1.

Abattoir examinations

A total of 98 cattle were examined postmortemly in slaughterhouses for the presence of *Hypoderma* spp. larvae. As a result of the examination, 69 warble larvae were counted on 19 cattle infested with *Hypoderma* larvae.

Economic loss due to the hide damage

According to the mercants in Ağrı, the price of healthy hide was 6 TL/kg, infested with *Hypoderma* larvae hide was 3 TL/kg. The mean weights of hide

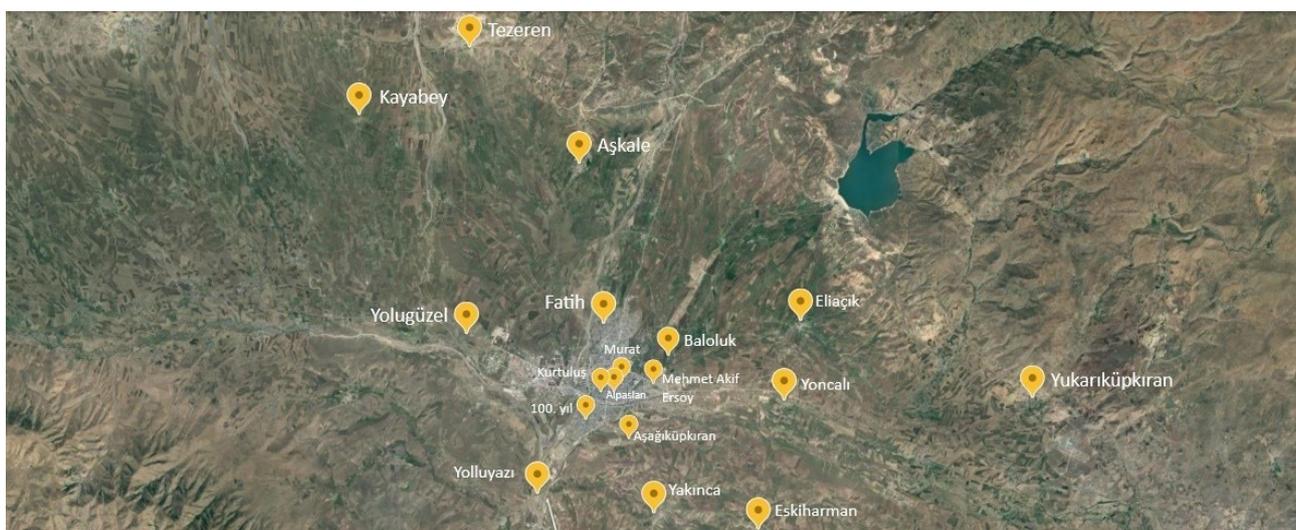


Figure 1. Locations where *Hypoderma* infestation was investigated in Ağrı.

Table 1. The relationships between larval count and age, breed, sex and skin color.

Parameters	Examined	Infested (%)	Larvae Count	Mean Larvae Count	P Value
Age	1	512	53 (10.35)	580	P < 0.005
	2	357	94 (26.33)	1442	
	≥3	988	166 (16.80)	1499	
Sex	Male	527	95 (18.02)	974	P < 0.005
	Female	1330	218 (16.39)	2547	
Breed	Simmental Crossbred	780	124 (15.89)	1404	P < 0.005
	Brown Swiss Crossbred	818	135 (16.50)	1685	
	Native Black	259	54 (20.84)	432	
Colour	Light	569	94 (16.52)	1105	P < 0.005
	Dark	807	150 (18.58)	1656	
	Piebald	481	69 (14.34)	760	
TOTAL	1857	313 (16.85)	3521	11.24	

were learned as 10 kg in 1-year-old animals, 15 kg in 2-year-old animals, and 20 kg in animals 3 or more years old. In study areas, 53 of one-year-old, 94 of two-year-old and 166 of 3-year and older animals were found infested with hypodermosis.

The economic loss caused by the hypodermosis was calculated as 500€ / 553.6US\$= 15.780 TL [(3 × 10 × 53) + (3 × 15 × 94) + (3 × 20 × 166)] (1US\$ = 28.5TL, 1€=31.5TL in November 2023) in study area. At the time of this study, there were 53.261 one-year-old, 68.665 two-years-old and 224.008 three-years and older animals throughout the Ağrı province. When the prevalence rates determined according to age groups are adjusted to the total cattle population (345.934) in Ağrı province, the annual total economic loss caused by hypodermosis was calculated as 109.681€ / 121.227US\$ = 3.454.977 TL [(3 × 10 × 5.486) + (3 × 15 × 18.059) + (3 × 20 × 37.633)].

DISCUSSION

Hypodermosis caused by *Hypoderma bovis*, *H. siense* and *H. lineatum* is a prevalent disease in Türkiye and many countries in the world, especially in cattle breeding regions. The prevalence of infestation was reported between 0.31-100% in Türkiye and other countries (Colebrook and Wall, 2004; Otranto et al., 2005; Simsek et al., 2008; Ahmed et al., 2012; Darabuş et al., 2023). The prevalence of hypodermosis was detected as 16.85% (313/1857) by skin palpation in our study. Our determined prevalence rate was found higher than some studies (Boldbaatar

et al., 2001; Colebrook and Wall, 2004; Sayın İpek, 2016) and lower than others (Sayın et al., 2000; Kara et al., 2005; Balkaya et al., 2010). This result may be due to the no control program for hypodermosis and the cattle were untreated with insecticides (according to the declaration of farmers) in Ağrı region.

It was reported that the distribution of hypodermosis may be affected depending on factors such as altitude, topography, geographical features, climatic conditions, and grazing type (Sayın et al., 2000; Regalbono et al., 2003; Ahmed et al., 2012; Saidani et al., 2016; Darabuş et al., 2023). In Pakistan, the prevalence of hypodermosis was found to be 8.9%, 20.6%, and 30.8% in lowland, hilly and semihilly areas, respectively (Ahmed et al., 2012). In studies in Kars region of Türkiye, higher infestation rates were found at lower altitudes than higher (Kara et al., 2005; Taşçı et al., 2018). In another study in Türkiye, the infestation rate of hypodermosis for cattle grazed was 23.7% in grassy, 25.5% in damp, 27.1% in mountainous, 31.2% in arid, 36.5% in forested, and 38.2% in bare areas (Sayın et al., 2000). In our study, the altitudes of study areas are varied between 1632-1822 and the highest infestation rate was found in Kurtuluş neighbourhood (23.28%) with 1632 m in Ağrı city center.

As seen in studies conducted by Regalbono et al.(2003); Kara et al.(2005); Saidani et al (2016) and Taşçı et al.(2018), the risk of hypodermosis in cattle grazed on pasture is higher than cattle kept and fed indoors. In our study, the highest infestation

rate was found in Kurtuluş neighbourhood in Ağrı city center, where animals were grazed on pasture, kept and fed outdoors.

In hypodermosis, since a degree of immunity develops in older animals and calves are born before the fly season around Türkiye and Romania, infestation rates are increased with age (Kara et al., 2005; Darabuş et al., 2023). In addition, infestation is more frequently seen in young animals (≤ 12 months) than older (Saidani et al., 2016). In a study of Taşçı et al. (2018), hypodermosis was determined at a higher rate in two-year-old cattle compared to three-year-olds. Parallely, in this study, the infestation rates were higher in two-year group, in three-year and older group and in one-year group, respectively.

Similarly the findings of Kara et al. (2005) showed that hypodermosis was detected with a higher rate in the male cattle than females. We were thought that male animals are grazed on pastures longer periods of time for live weight gain and more attractive than females.

It has been determined that cattle breeds may play a role on hypodermosis. In a study conducted by Saidani et al. (2016), a higher infestation rate was found in Flechvieh cattle than other breeds in Algeria. In another study in Romania, the infestation was found higher in an indigenous breed of country named Bruna de Maramures (Darabus et al., 2023). Studies conducted in the Kars region in Türkiye (Kara et al., 2005; Taşçı et al., 2018), the highest infestation rates of hypodermosis were determined in crossbred cattle. However, in contrast to the findings of studies above, we were determined that native cattle had higher infestations, followed by brown Swiss crossbred and simmental crossbred cattle in Ağrı region. This result may be attributed to the examined low number of native cattle. In addition, the number of native cattle is decreasing day by day due to the widespread use of artificial insemination and because of economic reasons, simmental and brown Swiss crossbred animals are fed indoors for longer periods of time than native.

Skin colour may affect the behavior of the warble flies egg-laying. This behavior was evaluated in previous studies in Türkiye. In these studies, it has been declared that warble flies generally laid their

eggs on dark-colored cattle (Kara et al., 2005; Taşçı et al., 2018). Similarly in this study, infestation was found lower in piebald, in light and in dark-coloured cattle, respectively.

The economic loss caused by hypodermosis was calculated as 15.780 TL (~\$553.6 / 500€) in the studied area and 3.454.977,2 TL (~121.227 US\$ / 109.681€) as a whole in Ağrı city. In studies carried out in two provinces of Türkiye, the economic loss due to hypodermosis was estimated as 18.288 TL in Afyonkarahisar (Cicek et al., 2011) and 18.615 TL in Kars (Taşçı et al., 2018). Total annual losses have been estimated at ~\$220 million in Russia (Glazunova et al., 2019) and ~\$15 million in Northern China (Yin et al., 2003).

CONCLUSION

The time of biological cycle of *Hypoderma* species varies from country to country and from region to region due to altitude, topography, geographical features, climatic and seasonal conditions. In Ağrı, warble fly larvae begin to appear on cattle in February and peaks in March and April. Therefore, cattle should be treated by suitable insecticides in the middle of November. As a result, this study and previous studies are presented that hypodermosis is a prevalent infestation in cattle and cause economic loss countrywide. Therefore, this situation reveals that eradication or control programs should be implemented on a national level. Successful results have been obtained from the eradication or control programs implemented in different regions in the world such as Denmark, Switzerland, the United Kingdom, the Czech Republic, Netherlands, Ireland, Germany, and France.

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Conflict of Interest

The authors declared that there is no conflict of interest.

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