Journal of Bioresource Management

Volume 10 | Issue 4 Article 6

Biology, Ecology, Infestation, and Management of Warble Flies (Diptera: Oestridae)

Muhammad Jamil
PARC Arid Zone Research Center, Dera Ismail Khan-29050-Pakistan, jamilmatrah@gmail.com

Abdul Razzaq
Animal Health at Pakistan Agricultural Research Council, Islamabad, Pakistan, abdulrazzaqazrc@gmail.com

Noman Latif
PARC Water and Agri waste Management Institute, Tandojam, Pakistan, nomanlatif2013@gmail.com

Mariam Fatima
Department of Entomology, University of Agriculture Faisalabad, Pakistan, agrarian.201418@gmail.com

Muhammad Saqib
Department of Entomology, University of Agriculture Faisalabad, Pakistan, mohammad.saqib1990@gmail.com

See next page for additional authors

Recommended Citation

Jamil, M., Razzaq, A., Latif, N., Fatima, M., Saqib, M., Jaffar, M., Rehman, H. Z., & Ramzan, F. (2023). Biology, Ecology, Infestation, and Management of Warble Flies (Diptera: Oestridae), *Journal of Bioresource Management, 10* (4).
ISSN: 2309-3854 online
(Received: Apr 21, 2023; Accepted: May 30, 2023; Published: Dec 26, 2023)

Biology, Ecology, Infestation, and Management of Warble Flies (Diptera: Oestridae)

Authors

Muhammad Jamil, Abdul Razzaq, Noman Latif, Mariam Fatima, Muhammad Saqib, Matiullah Jaffar, Hafiz Zille Rehman, and Faiqah Ramzan

BIOLOGY, ECOLOGY, INFESTATION, AND MANAGEMENT OF WARBLE FLIES (DIPTERA: OESTRIDAE)

MUHAMMAD JAMIL[1], ABDUL RAZZAQ[2], NOMAN LATIF[3], MARIAM FATIMA[4], MUHAMMAD SAQIB[4], MATIULLAH JAFFAR[4], HAFIZ ZILL-E-REHMAN[5], FAIQAH RAMZAN[6]

[1]PARC Arid Zone Research Centre, Dera Ismail Khan, Pakistan
[2]Animal Health at Pakistan Agricultural Research Council, Islamabad, Pakistan
[3]CSO/ PARC Water and Agri waste Management Institute, Tandojam, Pakistan
[4]Department of Entomology, University of Agriculture Faisalabad, Pakistan
[5]Department of Entomology, PMAS Arid Agriculture University, Rawalpindi, Pakistan
[6]Faculty of Veterinary and Animal Sciences, Gomal University Dera Ismail Khan-29050-Pakistan

Corresponding author's email: jamilmatrah@gmail.com

ABSTRACT

The range grazing livestock (cattles and goats) are afflicted by a significant skin/hide issue known as warble fly larval infestation, which is caused by the larvae of *Hypoderma lineatum* and *Hypoderma bovis* species which resulted in substantial economic losses to the leather industries. The life cycle of hypodermosis is complex, involving both ecto- and endoparasitic stages. Female warble flies deposit their eggs in rows of 5-8 on individual hairs of the host, often targeting the legs but also other areas. These eggs are securely attached to the hairs and a single female fly may lay as many as 800 eggs on a host within a week, which is typically their lifespan. Egg hatching occurs 3-7 days after the eggs are laid. The larvae then move down under to the skin and actively penetrate it, causing great irritation for cattle and goats. Some tactics used to control warble flies on animals are chemical insecticides which are available in the form of sprays, pour-ons, and injections. These chemicals can kill or repel adult flies and prevent larvae from developing into mature flies. Predatory insects e.g., wasps can be used to control warble fly populations. Physical methods i.e., fly traps, fly swatters, and sticky tapes can be used to capture or kill adult flies. Practices such as maintaining clean living conditions, grazing management, and reducing animal stress can help prevent warble fly infestations. It is important to consult with a veterinarian to determine the best control method for incidences of warble fly infestation.

Keywords: Bio-chemical control, life cycle; warble flies, fly management, economical losses

INTRODUCTION

The infestation of warble flies is a significant economic disease that affects livestock globally. The term warble has an Anglo-Saxon origin, meaning boil, and larvae of *Hypoderma* spp. caused myiasis. The parasite affects herbivorous animals such as cattle, goats, reindeer, and deer, with seven species of *Hypoderma* impacting animals. Various scientists have researched the distribution, prevalence, epidemiology, significance, and management of hypodermosis worldwide due to its high economic importance (Taylor et al., 2016)

Although livestock production has increased over the past decade, parasitic diseases remain the most significant constraint, with ectoparasitic infestation being a severe veterinary health problem worldwide. *Hypoderma* spp., from the family Oestridae, causes subcutaneous myiasis affecting animals. This endemic disease leads to a decline in the quality and quantity of animals. *Hypoderma* larvae cannot adapt to Australia and South Africa's climatic conditions due to their seasonal life cycle (Patra et al., 2018).

Distribution

Warble flies belong to the type of insect that is known to infest the skin tissues of various large and small ruminants i.e., cattle, goats, and deer. These flies are typically found in regions with temperate climates and especially in areas habituated with their preferred hosts "cattle" and goats, and they are known to cause significant damage to the animal's skin/hide they infest. The distribution of warble flies can also be affected by factors i.e., climate, weather, and other environmental conditions.

Warble flies typically lay their eggs on the skin of their host animals, and once the eggs hatch, the larvae burrow into the skin and begin to feed on the tissues and suck the animals' fluids or blood. As the larvae develop, they can cause a variety of symptoms in the host animal, including swelling, pain, and reduced mobility. In some cases, warble fly infestations can be fatal to the host animal. In order to prevent warble fly infestations, the farmers and ranchers often use a variety of techniques including insecticide treatments, physical barriers, and other preventative measures. In addition, it is important to monitor animals for signs of warble fly infestation so that treatment can be initiated as soon as possible if an infestation detected (Arshad et al., 2014). While having a global distribution, *Hypoderma* species are more frequently found in tropical and subtropical regions of the planet. Different parts of the world and the region being examined have various prevalence rates of the hypodermal condition. The pest has been distributed in several Asian, European, and African countries. In India, Africa, and Pakistan, it has been widely distributed.

Prevalence of Warble Flies on Animals

Bovine hypodermosis is commonly called warble fly or cattle grub infestation. This epidemic is a widely prevalent and problematic veterinary issue across the world. The life cycle of hypodermosis is intricate, involving both ecto- and endo-parasitic stages. The parasitic stage can last up to a year in both domesticated and wild animals. *Hypoderma lineatum*, has been identified in India, as affecting bovidae, with a prevalence rate of 50-90 %. This article focuses on the outbreak of bovine hypodermosis, and biology, exploring its pathobiology, prevalence, and distribution of warble flies with management, significance, control, and treatment. Warble fly infestation is a common problem in various animal species, including cattle, goats, and deer (Ahmed et al., 2012).

The prevalence of warble flies can vary depending on several factors, such as geography, host population density, and environmental conditions. In Europe and North America, the prevalence of warble flies is relatively high, and they are considered a significant problem for livestock farmers. In some regions, a100 % infestation rate was recorded in cattle and goats populations. In contrast, in areas with a warmer climate or where the host population is limited, the prevalence of warble flies is relatively low. This is because the eggs are laid by females on the skin of the hosts during this time, and the larvae develop and feed on the host's tissues during the following winter and spring months. In addition to climate and geography, the prevalence of warble flies can also be affected by management practices. Overall, warble fly infestation is a prevalent problem in many animal species, particularly in regions with temperate climates and high host population densities. Effective management practices, including regular monitoring, are crucial to control and prevent outbreaks of warble fly infestation in animals (Oryan et al., 2009; Yadav et al., 2006).

Both biotic and abiotic factors can reduce the productivity of the livestock sector worldwide. Among the biotic factors, parasitism is a major problem globally in nature. One type of parasite is WFI, which can infect various types of livestock. In Pakistan, hypodermosis is prevalent in semi-hilly, mountainous, and riverine areas, and it is common in

many other parts of the world as well. Studies have shown high prevalence rates of warble fly infestation in countries such as the Czech Republic, Greece, Italy, Spain, the United Kingdom, and Romania. The prevalence of WFI in Pakistan was found to be 3.2% overall, with goats and cattle having higher rates of 18.4 %. Hypodermosis is a major parasitic infection that affects many countries in the northern hemisphere and causes physical damage to the host animal, as well as internal organ damage and a weakened immune system. Chemotherapy treatments have been effective against the adult fly and first larval stage in many European and North American countries. In the Green Mountains of Libya, infestation rates were found to be 14.1 % in cattle, and 24.9 % in goats, with *Przhevalskiana silenus* infesting the goats. The adult warble fly is active from April-June and survives without mouthparts by relying on resources accumulated during the larval period. Eggs are laid directly on the hind legs of the host animal, and the first instar larvae emerge and penetrate the skin to migrate to the flanks and sacrum, remaining subcutaneous throughout the migration (Rafdar and Hajmohammadi, 2012). The prevalence percentage of warble flies on goats in different areas of Pakistan is shown in Figure. 1, while areas wise is given in Table 1.

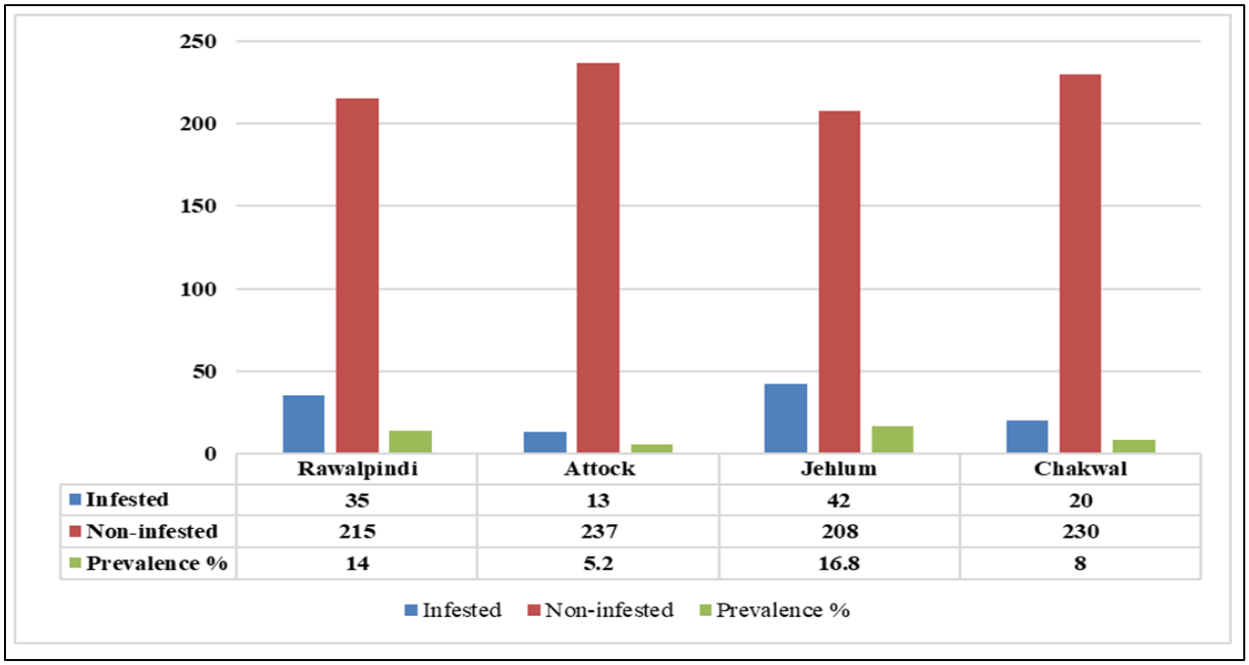

Figure 1: Prevalence percentage of warble flies on goats

Table 1:Location-wise prevalence of warble flies on different hosts

Area	Hosts	Prevalence (%)	References
Turkey	Cows	31.9	Karatepe et al. (2013)
India	Cows		Yadav et al. (2013)
UK	Cows	40	Webster et al. (1997)
Albania	Cows	41.28	Otranto et al. (2005)
Kazakhstan	Cows	30	Mukhtar and Omarkhan (2004)
Pakistan	Cows	18	Yadav et al. (2011)

Signs and Symptoms of Warble Flies on Animals

The infected animals were examined clinically and found to have numerous nodular eruptions on their back, thigh, and flank regions. Some of the nodules on certain animals had

opened up in the middle and revealed the presence of larvae at their posterior end. Upon microscopic examination, the white-colored bots, measured 18 (Ahmed et al., 2012; Tafti et al., 2012). Signs of warble flies' infestation are shown in Figures. 2 (a, b).

Figure 2 (a, b): Infestation of warble flies on animals

Economic Importance

Pakistan's leather industry is a significant industrial unit that exports large products. However, this industry is currently facing economic losses due to the presence of a parasite. The extent of the losses caused by this parasite is difficult to calculate due to several factors, but damage to hides is the most significant consequence of infestation as shown inFig. 3. This results in a lower price for the hides due to the holes formed by the warble fly. Pakistan's annual production of hides and skins is 7.5 million and 36.3 million, respectively. The severe economiclosses caused by flies in different areas of Pakistan such as Rs 12.9 million and Rs 9.9 million estimated losses in D.G. Khan and Rajanpur districts, respectively, with a total loss of Rs 22.8 million from cattle (Khan et al., 2006).

Despite Pakistan's status as an agricultural country with a large number of livestock, the warble fly continues to attack livestock products, but very few studies have been conducted to determine the economic losses and damage to animals. No significant work has been done to calculate the damage caused by this notorious parasite (Sayin et al., 2000). In developing countries like Pakistan, small ruminants are negatively impacted by parasitic diseases, which can lead to reduced health and productivity. One of the most concerning diseases is goat warble fly infestation (GWFI), which affects the goat's hide as well as milk and meat production. GWFI is a type of cutaneous myiasis caused by larvae of *Przhevalskiana silenus*, which leads to the formation of nodules on the lumbar and dorsal areas of infected animals. Infestation with *P. silenus* reduces the value of hides and requires trimming, resulting in a decrease in carcass yield. This disease was first observed in Italy and has since been reported in many other regions of the world, including Pakistan (Liaquat et al., 2021).

Biology and Ecology of Warble Flies on Animals

The length of the adults is approximately 13 mm. The flies possess hair and lack functional mouthparts, relying solely on stored reserves for mating and reproduction.

Figure 3: Indicate the attack of warble flies and hair losses

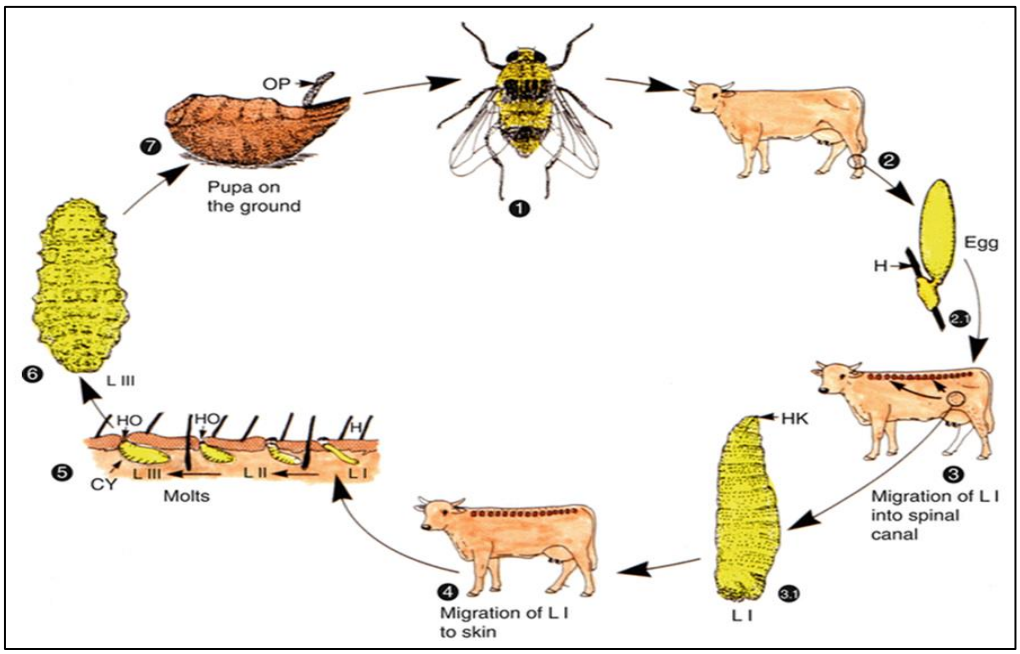

Figure 4: Life Cycle of Warble Flies on Cows

Their lifespan ranges from three to five days. The head and anterior part of the thorax contain yellowish-white hair, while the abdomen has light yellow hair at the front, followed by a band of dark hair, and orange-yellow hair at the back. Adult flies are unable to feed due to their non-functional mouthparts and instead rely on stored nutritional reserves from before birth to survive. The eggs, which are about 1 mm long, are attached to the host's hair by small terminal clasps, mostly on the legs but occasionally on the body. The female lays six or more eggs in a line on a hair and can lay up to 800 eggs on a single host. The eggs hatch within four to seven days, and the larvae migrate down the hair to the skin, causing significant irritation. They then infect the leg and towards the diaphragm, growing up to about 12 mm in length during summer and autumn (Logar and Marinic-Fise, 2008). The life cycle of warble flies are shown in Figure 4.

The larvae breathe through a pore and undergo molting, which lasts about 30 days. The larvae have three instars and change color from almost white to almost black. When they reach full size, they drop to the ground and pupate in the soil. The flies are very persistent in approaching animals, and their life cycle is intricate. The fully grown larvae measure 25 mm in length and possess flat tubercles and small spines on all segments except the last. Upon the arrival of spring, the mature larvae emerge from their cysts and drop to the ground, where they proceed to penetrate the soil to begin pupation, which occur almost immediately in autumn (Logar and Marinic-Fise, 2008).

Moisture content greater than 10 percent will prevent the insect from maturing. The pupal case is black and, after 35 to 60 days, the fly emerges by pushing open an operculum located at the anterior end. The complete life cycle of the insect takes approximately one year, during which the majority of time is spent within the host's body (Hennessey et al., 2019). Variations in the timing of the grubs appearing in the host's back, the emergence of mature larvae and pupation in the soil, and adult emergence are dependent on the weather conditions. However, the occurrence of these events tends to be similar each year for a specific region. Adult flies can be found in the summer, predominantly in June and July. On warm days, they are highly active and seek out cattle to deposit their eggs. The difference in prevalence rates among districts could be caused by factors such as management systems, grazing habits, pastures, and insecticide usage. This was also noted by Ahmed et al., 2012 and Arshad et al., 2014.

The study conducted month-wise revealed that the biological cycle was supported, as the highest seroprevalence was observed in December, and no antibodies were detected in animals before June, as hypo dermosis was in a different developmental stage. Serologically, WFI was found in serum samples from June and July (summer season, 12.5 %). However, manual observation of warble fly infestation showed it was present from November until February (winter season, 18.4 %) after nodules appeared on the goats' flank and back (Oryan et al., 2009; Khan et al., 2006). The highest infestation of flies has been reported in December by many researchers, which could be attributed to the presence of third-stage larvae in infested animals as shown in Fig. 5. Skin perforation appeared in January, and the number of nodules began to decrease in February, resulting in a decreased infestation rate in March, indicating the pupation period in the region. These findings are consistent with other studies (Tavassoli et al., 2010; Yadav et al., 2013).

They remain in these areas for 2 to 4 months, typically until early winter. Following this, they complete their migration to the back of the host, where they perforate the skin to create a breathing hole. They remain there for about 1 to 2 months and molt twice.

Management Strategies of Warble Flies

Warble flies are parasites that can infest various domestic animals, such as cattle, and goats, causing significant economic losses to farmers and animal breeders. Integrated Pest Management: Integrated Pest Management (IPM) is a holistic approach that combines multiple management techniques to control warble fly populations. IPM strategies include monitoring the population levels of warble flies, using thresholds to determine when to initiate control measures, and implementing a combination of chemical, biological, and physical control methods to achieve effective control. Effective management of warble fly infestations is therefore essential for the health and well-being of the animals, as well as for the sustainability of the livestock industry. Here are some of the management approaches for warble flies infesting animals:

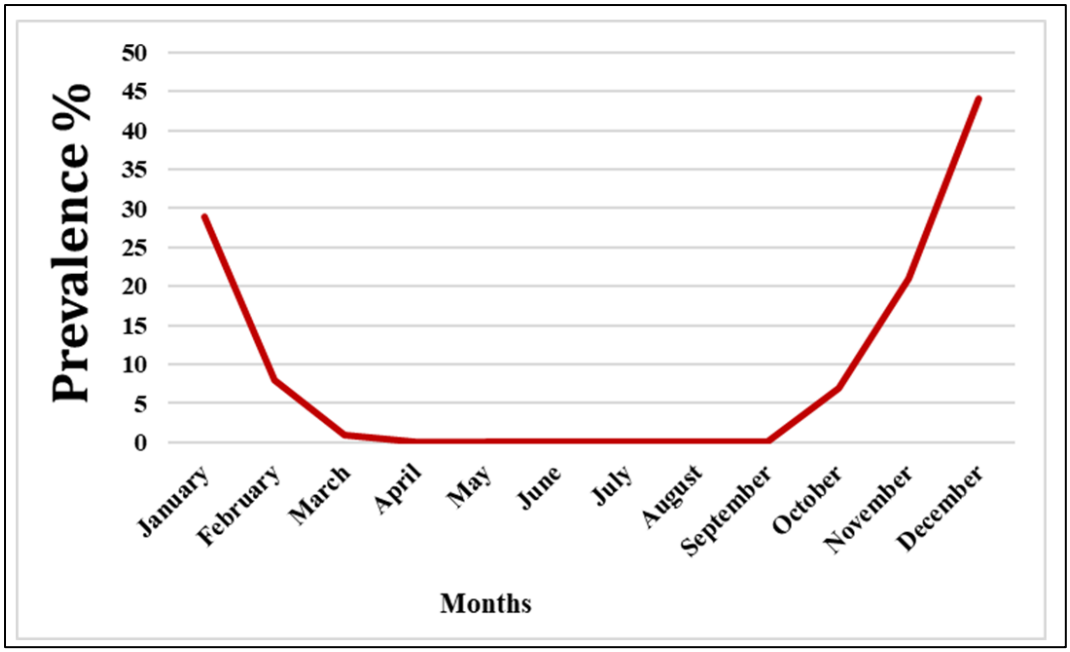

Figure 5: Month-wise prevalence % of warble flies on animals

Cultural and Physical Control

Cultural control of warble flies infesting animals involves the use of management practices that alter the animal's environment or behavior to prevent or reduce the risk of infestation. Some cultural control methods include:

i. ***Grazing Management***

Controlling the timing and location of grazing can reduce the risk of exposure to warble fly larvae. For example, moving animals to higher elevations or areas with less vegetation during the fly's adult stage can help to reduce exposure to the eggs.

ii. ***Herd Monitoring***

Regularly monitoring the herd for signs of infestation can help to identify and control infestations early before they become severe. Cultural control methods are generally non-toxic and do not have negative environmental impacts. However, they may not be sufficient to control infestations on their own and are often used in combination with other control methods, such as chemical and mechanical control.

iii. ***Physical Control***

Physical control methods aim to prevent the warble fly from laying eggs or penetrating the animal's skin. Physical control methods include the use of insecticidal ear tags, traps, and fly repellents. Additionally, farmers can use husbandry practices, such as shearing and grooming, to keep the animals' coats clean and reduce the risk of infestation.

iv. ***Mechanical Control***

Mechanical control of warble flies on animals involves the use of physical means to prevent or remove the flies from the animals. Some of the mechanical control measures include:

v. ***Handpicking***

This involves physically removing the larvae or grubs from the skin of the animal. This method is most effective in small-scale farming where a few animals are kept. However, it can be time-consuming and labor-intensive in large-scale farms.

vi. ***Use of Brushes***

The use of brushes can help to dislodge the larvae from the skin of the animal. Special brushes designed for this purpose are available in the market.

vii. ***Traps***

Traps can be used to catch adult warble flies before they lay their eggs on the animals. These traps are baited with food or pheromones to attract the flies.

viii. ***Sanitation***

Keeping the animal pens clean and free of manure can help to reduce the number of adult flies in the area, and thus, reduce the chances of infestation.

ix. ***Grazing Management***

Changing the grazing pattern of the animals can help to reduce the risk of infestation. For example, rotating pastures can prevent the animals from grazing in areas where flies are common.

Botanicals and Biological Control

Applying fly repellents to the animal's skin can help to prevent flies from laying their eggs. Encouraging natural predators of the flies, such as birds, can help to control fly populations. Biological control methods use natural predators, parasites, or pathogens to control the warble fly populations. For example, the parasitic wasp, *Hypoderma bovis*, is a natural enemy of the warble fly and can be introduced to the environment to control the warble fly infestation. These wasps lay their eggs in the fly larvae, and their offspring consume the larvae from within. Another example is the use of fungi, such as *Metarhizium anisopliae*, to infect and kill the warble fly larvae (Gonzalez et al., 2023).

Chemical Control

The use of insecticides is the most common approach to control warble fly infestations. Insecticides can be applied topically, orally, or as a pour-on, depending on the species of warble fly and the stage of the parasite's lifecycle. The timing and frequency of treatment vary depending on the specific insecticide used. The introduction of systemic organophosphorus insecticides during the 1950s made it possible to control cattle grubs on a large scale at an affordable cost. These insecticides are administered orally, through dips, sprays, drenches, or boluses, with the "pour on" dressing being the most convenient method. With this method, a small volume of concentrated insecticide is applied along the animal's back and is absorbed through the skin to kill the larvae (Qamar et al., 2022; Atelege et al., 2021).

It has been recommended that avoid the use of such chemicals during the months of January-February on animals. In these months, such chemicals or compounds may cause severe external and internal reactions in the hosts. In this situation, the larvae and eggs remain inside the host body and their death inside the esophagus or spinal canal becomes fatal for hosts. Such inflammatory reactions can be treated by the use of sympathomimetic drugs and steroids. Nowadays, systemic macrocyclic lactones such as ivermectin, doramectin, eprinomectin, or moxidectin are commonly used to treat *Hypoderma* infection. Eprinomectin and moxidectin pour-on can be used to treat both beef and dairy cattle. These antiparasitic compounds are more effective than organophosphate systemic because they can kill migrating larvae and are highly effective at low dosages against second and third-instar larvae in warbles. This allows for late-season or pour-on treatment for grub-infested cattle, which is not possible with traditional systemic insecticides, which are ineffective once the larvae are inside their warbles. None of the treated goat's nodules that deteriorated after receiving ivermectin injections had any skin perforations. Yet, warble flies were discovered

to be present in control animals. The findings of the present investigation revealed that warble fly infestation was highly successful, supported by the previous findings (Cicek et al., 2011). The findings of the current study make it clear that Ivermectin was a superior pesticide for the management of GWFI. It's also important to note that, in contrast to the treated animals, where the number of warbles decreased by a percentage, the untreated control group's warble count stayed unchanged (Hassan et al., 2010). Chemicals used to control warble flies are given in Table 2.

Table 2: Chemicals used to control warble flies.

Serial number	Chemicals	References
1	Doramectin	Karatepe et al. (2013)
2	Eprinomectin	Cicek et al. (2011)
3	Ivermectin	Karatepe et al. (2013)
4	Moxidectin	Webster et al. (1997)
5	Phosmet	Otranto et al. (2005)
6	Trichlorfon	Lia et al. (2019)

CONCLUSION AND RECOMMENDATIONS

In summary, managing warble fly infestations in animals requires a comprehensive approach that involves a combination of management techniques. These techniques include chemical, biological, and physical control methods, vaccination, and integrated pest management strategies. Effective control of warble fly infestations can help protect the health and well-being of animals and reduce economic losses for farmers and animal breeders. While mechanical control methods can be effective in reducing the number of warble flies on animals, they are not always sufficient to eliminate the infestation. Therefore, a combination of mechanical and chemical control methods is usually recommended for effective control of warble flies on animals. Warble flies are a common pest of livestock animals such as cattle, and goats. They lay their eggs on the hair of these animals, and when the eggs hatch, the larvae burrow into the animal's skin, causing damage and discomfort. The measurement of warble fly infestations in the animal industry can be done through various methods. One common method is to use traps that attract and capture adult flies. These traps can be placed in fields or pastures where livestock animals graze, and the number of flies captured can be counted to estimate the level of infestation. Another method is to inspect animals for the presence of warble fly larvae. This can be done by examining the skin and hair of the animals for signs of burrowing or lesions. Veterinarians can also take skin samples and examine them under a microscope to confirm the presence of warble fly larvae. In addition, farmers and ranchers can keep track of the number of animals affected by warble fly infestations. This can be done by keeping records of any animals that show signs of infestation, such as decreased weight gain or poor health, and monitoring the effectiveness of any treatments used to control the infestation. Overall, monitoring and measuring warble fly infestations in the animal industry is important for maintaining the health and well-being of livestock animals and ensuring the profitability of the industry.

AUTHORS CONTRIBUTION

All authors equally contribute to review and write the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

REFERENCES

Ahmed H, Khan MR, Fontan RP, Sandez CL, Iqbal MF, Naqvi SMS, Qayyum M (2012) Geographical distribution of Hypodermosis (Hypoderma spp.) in Northern Punjab, Pakistan. Kafkas. Univ Vet Fak Derg., 18 (Suppl-A):A215-A219.

Arshad M, Siddique F, Ahmad S, Mustafa I, Nasir MF, Anwar P, Asif S, Khan MR, Hussain M, Ahmed H (2014) An Epidemiological Study on Prevalence of Goat Warble Fly Infestation (GWFI) from Punjab Province, Pakistan. Kafkas Univ Vet Fak Derg., 20(1).

Atelge M, Inci A, Yildirim A, Sozdutmaz I, Adler PH (2021) First molecular characterization of hypodermin genes of Hypoderma bovis and serodiagnosis of bovine hypodermosis with recombinant hypodermin C antigen and a synthetic peptide containing its linear B-cell epitope. Vet Parasitol., 292:109394.

Cicek H, Cicek H, Eser M, Tandogan M, Sarımehmetoglu HO (2011) Prevalence and economic significance of bovine hypodermosis in Afyonkarahisar province of Turkey. Trop Anim Health Prod., 43:17-20.

González S, Del Rio ML, Diez MN, Hidalgo Md R, Martínez A (2023) Identification of Hypoderma actaeon (Diptera:Oestridae) in red deer (Cervuselaphus) from northern Spain:Microscopy study and molecular analysis. Microsc Res Tech., 86(1):3–11.

Hassan MU, Khan MN, Abubakar M, Waheed HM, Iqbal Z, Hussain M (2010) Bovine hypodermosis-a global aspect. Trop Anim Health Prod., 42:1615-1625.

Hennessey MJ, Hsi DJ, Davis JS, Delgado AH, Allen HA, Jandegian CM, Skoda SR, Watts KG, Gibbs SE, Powell B, Welch JB (2019) Use of a multiagency approach to eradicate New World screwworm flies from Big Pine Key, Florida, following an outbreak of screwworm infestation (September 2016–March 2017). J Am Vet Med Assoc., 255(8):908-14.

Karatepe M, Simsek S, Karatepe B, Cayvaz M, Sevgili M, Balkaya I (2013) Seroprevalence of hypodermosis in cattle in Nigde Province of Turkey by comparison of commercial and indirect-ELISA methods. Israel J Vet Med., 68:38-42.

Khan MN, Iqbal Z, Sajid MS, Anwar M, Needham GR, Hassan M (2006) Bovine hypodermosis:Prevalence and economic significance in southern Punjab, Pakistan. Vet Parasitol., 141:386-390.

Lia RP, Rehbein S, Giannelli A, Fankhauser B, Otranto D (2019). LONGRANGE®(eprinomectin 5% w/v extended-release injection) efficacy against Hypoderma lineatum in an endemic area in southern Italy. Parasit Vect., 12:1-6.

Liaquat S, Qayyum M, Ahmed H, Arfeen RZ, Celik F, Simsek S (2021) RESEARCH ARTICLE Seroepizootiological investigation on Goat Warble Fly Infestation (Przhevalskiana silenus) in Pothwar Plateau, Pakistan. Trop Biomed., 38(2):1-8.

Logar J, Marinic-Fiser N (2008) Cutaneous myiasis caused by Hypoderma lineatum. Wiener Klinische Wochenschrift. Mid Eur J Med., 120:619-621.

Mukhtar B, Omarkhan B (2004) Hypodermosis of domestic and wild animals of Kazakhstan. Chin J Vet Parasitol., 12:80-81.

Oryan A, Razavi SM, Bahrami S (2009) Occurrence and biology of goat warble fly infestation by Przhevalskiana Silenus (Diptera, Oestridae) in Iran. Vet Parasitol., 166:178-181,

Otranto D, Zalla P, Testini G. Zanaj S (2005) Cattle grub infestation by Hypoderma species in Albania and risk for European countries. Vet Parasitol., 128:157-162

Patra G, Behera P, Das SK, Ghosh S, Biswas P, Kumar A, Lalnunpuia C, Lalchhandama C, Alam SS, Bhagawati J (2018) Bovine hypodermosis:A review. Int J Adv Agric Res., 6:18-29

Qamar MA, Shahid S, Javed M, Shariq M, Fadhali MM, Madkhali O, Ali SK, Syed IS, Awaji MY, Shakir Khan M, Hassan DA (2022) Accelerated Decoloration of Organic Dyes from Wastewater Using Ternary Metal/g-C_3N_4/ZnO Nanocomposites:An Investigation of Impact of g-C_3N_4 Concentration and Ni and Mn Doping. Catalysts, 12(11):1388.

Radfar MH, Hajmohammadi V (2012). Prevalence of goat warble fly, Przhevalskiana silenus in south eastern of Iran. Sci Parasitol., 13:73-76.

Sayin F, Kalkan A, Karaer Z (2000). Epidemiological studies on cattle hypodermosis in Turkey. FU Sağlık Bil Derg., 14:115-127.

Tafti AK, Razavi SM, Gorgipour S (2012) Morphopathologic characteristics of myiasis caused by Przhevalskianasilenus larvae in goats. Vet Arh., 82(1):25-33.

Tavassoli M, Tajik H, Yaghobzadeh KR, Javadi S (2010) Prevalence of Goat Warble Fly, Przhevalskiana spp. (Diptera:Oestridae), in West Azarbaijan, Iran. Iran J Vet Sci Technol., 2:33-38.

Taylor MA, Coop RL, Wall RL (2016) Veterinary parasitology. 4th Edition. Wiley Blackwell. USA. 195p.

Webster K, Giles M, Dawson C (1997) A competitive ELISA for the serodiagnosis of hypodermosis. Vet Parasitol., 68:155-164.

Yadav A, Katoch R, Khajuria J, Katoch M, Agrawal R (2011) Prevalence and biology of goat warble fly infestation by Przhevalskiana silenus in Jammu province, India. Trop Anim Health Prod. 43:1487-1492.

Yadav A, Katoch R, Khajuria JK, Godara R, Agrawal R (2013) Prevalence of Hypoderma lineatum in cattle of Jammu region. J Parasit Dis., 2:196-198.

Yadav A, Khajuria JK, Soodan JS (2006) Warble fly infestation in goats of Jammu. J Vet Parasitol., 20:149-152.