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Epidemiological Survey and Assessing Control Models against Warble Fly Infestation in Goats and Cattle at Various Ecologies of Pakistan

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ABSTRACT

Hypodermosis is a significant parasitic infection in cattle and goats in hilly and semi-hilly areas of Pakistan, Warble fly larval migration and emergence cause hide and skin perforation, leading to major economic losses in livestock and leather industries. The present research is designed to explore, Field epidemiology, Remote Data Collection and treatment control model of warble fly infestation in federating unit's i.e. (Punjab, Gilgit-Baltistan, Balochistan, Khyber Pukhunkhwa and Azad Jammu and Kashmir) of Pakistan. The Veterinarians from 43 districts of Balochistan, AJK and Sindh gathered information regarding, epidemiology, life cycle, treatment from 171 livestock famers on pre- designed questionnaire. The warble fly larval prevalence trend showed lower prevalence (10.6%) than the previous ten years (13.02%). The prevalence was higher (between 2-27%) recorded in goats from Balochistan followed by Sindh (10%) and AJK (1%). Breed-wise higher prevalence was recorded in Cholistani cattle followed by Lohani, Red Sindhi. Friesian and Jersey breeds cattle were fond free of warble fly larvae infestation. In addition, the warble fly prevalence was also reported in Naserabad and Sibi areas of Balochistan. Three villages in each federating units were selected for establishing the therapeutic control models. In each federating units the animals were randomly divided into 4 groups i.e. A, B, C and D having 50 goats and 12 cattle in each group. The animals in A, B and C group were administered ivermectin 1% (1 ml/50 kg body weight) subcutaneously during August–September, while the D group was kept as a control. All the animals in treated groups were found free of warbles, while goats and cattle in control/untreated group showed (17-66%) prevalence. Warble fly prevalence was reported in Naserabad and Sibi areas of Balochistan, and Ivermectin during August and found 80-90% effective against warble fly larval infestation.

INTRODUCTION

The livestock sector in Pakistan is a vital contributor to its economy, especially in rural areas, where it forms a key element of agricultural livelihoods. This sector annually yields substantial quantities of hides7.5 million, and skins 36.3 million, which are significant export commodities accounting for approximately 12% of total exports. The leather and associated industries represent a major source of foreign currency earnings for Pakistan (Ahmad et al., 2023).

Warble fly infestation (WFI) is an important disease of economic significance affecting livestock throughout the world. *Hypoderma spp.* under the family Oestridae is responsible for causing subcutaneous myiasis that affects both wild and domestic ruminants across the northern hemisphere. There are various species affecting the various animals like *Hypoderma bovis and Hypoderma lineatum* in cattle and *Przhevalskiana silenus* in goats. (Ayaz et al 2004). This is an endemic disease of livestock (including goats and cattle) which results severe economic impact on tanning industries, impaired milk and meat production, growth retardation and also carcass depreciation. The poor quality of hide and skin is the most important constraint affecting the marketing of hides and

skins which is due to warble fly infestation along with other factors including poor flaying techniques and improper preservation. (Oryan et al 2009). Export of leather and leather products are Pakistan's one of the major source of foreign exchange. The warble fly infested skin reduces the prices up to 70% depending upon the numbers of holes formed by the larvae of warble fly. (Taylor et al., 2016). The life cycle of bovine hypodermosis (*Hypoderma* spp.) is obligate and complex, involving distinct ectoparasitic (adult and egg stages) and endoparasitic (larval stages) phases. Gravid female *Hypoderma* flies oviposit their eggs, typically in linear rows of 5-8, onto the individual hairs of the host, preferentially targeting the lower limbs but also other accessible body regions. These eggs are firmly cemented to the hair shafts. A single female can deposit up to approximately 800 eggs over her short lifespan, which generally spans about one week. Larval eclosion occurs within 3-7 days post-oviposition. The newly hatched larvae (L^1 instars) then actively migrate downwards along the hair shaft and penetrate the host's skin, a process that can induce acute irritation and discomfort in susceptible bovids like cattle and goats. (Jamil et al 2023). Warble fly prevalence is influenced by geography, host density, and environmental conditions. Historically, *Hypoderma* spp. infestations constituted a significant veterinary and economic burden for livestock production systems across Europe and North America. (Ahmad et al 2016). While extensive integrated pest management strategies, including the application of systemic acaricides, have led to substantial reductions in infestation rates and even regional eradication in many areas, localized persistence or sporadic resurgence of warble fly populations can still occur, necessitating ongoing surveillance and control efforts. (Yadav et al 2011). Bovine hypodermosis, an obligate myiasis caused by the larval stages of *Hypoderma* spp. (e.g., *H. bovis*, *H. lineatum*), constitutes a historically significant veterinary and economic burden on cattle production systems. While extensive eradication programs have substantially reduced its prevalence in many regions of the Northern Hemisphere, it persists as an endemic parasitic disease in specific temperate zones, notably in certain mountainous and lowland agro-ecological areas. Its host range extends beyond domestic cattle to include other bovids, such as yaks and buffaloes, as well as various cervid species. (Hassan et al 2007). A cross-sectional epidemiological survey in Pakistan indicated an overall warble fly infestation prevalence of 3.2% across the studied livestock population. Notably, caprine and bovine hosts exhibited significantly higher infestation rates, recorded at 18.4%. In contrast, many European and North American nations have successfully employed chemotherapeutic interventions targeting the adult fly and the early first instar larval stage, contributing to the substantial reduction or eradication of *Hypoderma* spp, infestations in those regions. (Arshad et al 2014)

Keeping in view the importance of disease the present research is therefore designed to explore Remote Data Collection, Field epidemiology, and treatment control model of warble fly infestation in four federating units of Pakistan.

MATERIALS AND METHODS

Field Epidemiological Survey of Warble Fly in Various Areas of Pakistan

A questionnaire was designed for gathering information on warble fly prevalence and its associated risk factors. A team of scientists from the Animal Health Program and Animal Sciences Division, PARC, visited eight villages in four federating units (Punjab, Balochistan, Khyber Pakhtunkhwa, and Gilgit) of Pakistan for the physical examination of animals on an already developed questionnaire during spring (March- May 2023) and again during autumn (September- November 2023).

Remote Data Collection using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Pakistan

For the remote data collection, veterinarian in-charge with at least two years of field experience from 41 districts were briefed about the research study, obtain information about the prevalence of warble fly in goats and cattle's and its associated factors like age, breed, sex, season, and life cycle.

Treatment Control Models of Warble Fly in Field Conditions

Three villages in each federating units, i.e., Balochistan, Punjab, and Gilgit, were selected for therapeutic control trials. The distance between the selected villages was more than 10 km. Young animals were selected for the study to rule out their previous exposure to the warble fly.

In addition, one village was kept as a control group for comparison. For each model, 50 goats and 12 cattle were involved. The first control model was based on medication with ivermectin (1 ml/50 kg body weight) subcutaneously once a year during the first larval stage before appearing nodules in goats and cattle of a selected village. In addition, a village was selected as control group, and no medications were given

RESULTS

Field Epidemiological Survey of Warble Fly in Various Areas of Pakistan

Table 1

Field Epidemiological Survey of Warble Fly in Various Areas of Pakistan

Province/District	Season	Clinical observation of animals		Number of Farmers
		Goats	Cattles	
Balochistan (Ziarat)	Spring	485	37	20
	Autumn	215	12	9
DG Khan (FortMunro)	Spring	337	108	43
	Autumn	58	12	13
Gilgit (Gorikot/Astore)	Spring	240	149	57
	Autumn	50	12	16
Khyber Pakhtunkhowa (DI. Khan)	Spring	188	237	43
	Autumn	112	86	24
	Total	1685	653	225

The table1 showed field epidemiological survey, from four federating units of Pakistan n= 225 livestock farmers holding n=1685 goats and n=653 cattle were clinically examined for warble fly infestation

Table 2

Prevalence% of Warble Fly Larvae (Przhevalskiana silenus) in Goats during Two Seasons at Various Areas of Pakistan

Province/ District	Season	No. of goats examined	No. of goats infected	Prevalence (%)
Balochistan (Ziarat)	Spring	485	2	0.41
	Autumn	215	18	8.37
Punjab (Fort Munro)	Spring	337	0	0
	Autumn	58	8	13.79
Gilgit (Gorikot/Astore)	Spring	240	0	0
	Autumn	50	33	66
KPK (DI. Khan)	Spring	188	0	0
	Autumn	112	5	4.4
	Total/overall	1685	49	2.9

The table 2 showed warble fly larval prevalence higher (up to 66%) during autumn as compared to spring season (0-0.4%) in goats. Area wise higher prevalence was recorded in Gilgit followed by Fortmunro, Ziarat and D.I Khan (Table 3). As per farmer's perceptions, the warble fly prevalence was higher in last few years (20–80%) as compared to the current trend.

Table 3

Field Epidemiological Survey of Warble Fly in Various Areas of Pakistan during Spring Season in Cattles

Province/ District	Season	No. of cattle examined	No. of cattle infected	Prevalence (%)
Balochistan (Ziarat)	Spring	37	0	0
	Autumn	12	0	0
DG Khan (FortMunro)	Spring	108	2	1.85
	Autumn	12	0	0
Gilgit (Gorikot/Astore)	Spring	149	0	0
	Autumn	12	4	33.33
KPK (DI. Khan)	Spring	237	2	0.84
	Autumn	86	11	12.79
	Total/overall	653	23	2.52

The table 3 showed prevalence% of warble fly larvae (*Hypoderma lineatum*) in cattle during two seasons at various areas of Pakistan

The warble fly larval prevalence was higher (up to 33%) during autumn as compared to spring season (0-1.85%) in cattle. Area wise higher prevalence was recorded in Gilgit followed by DI Khan, Fortmunro. The cattle in Ziarat area were found free of warble fly larvae.

Life Cycle of Warble Fly and its Control Measures

The life cycle of hypodermosis is complex, involving both ecto- and endoparasitic stages. Adult female warble flies deposit their eggs on hairs of the host, often targeting the legs but also other areas during March/April. These eggs are securely attached to the hairs on a host. The eggs hatch into larvae within 3-7 days. The larvae penetrate the skin, and travel under the skin to the back. The warbles (nodules) grow there until early summer, when they break through the skin and drop to the ground where it pupates and emerged into fly. The life cycle of the warble fly was physically observed in goats and cattle from 10 sites/villages of Pakistan. It seems that the farmers are controlling with suitable medicine, but the time of injection is wrong, as if they use at L_2 stage during July or August, it will be more fruitful. As the L_2 larvae remain under the skin and can be controlled easily, afterward, at the L_3 stage, the larvae perforate the skin.

Table 4

Warble Fly Larval Nodules Appearance, Dropping Stage and Control Practices

Province/District	Time of first appearance month	Larval dropping months	Type of treatment
Balochistan (Quetta, Ziarat, Sanjavi)	Sep-Oct	Oct-Dec	Ivermectin
DG Khan (Fortmunro)	Aug-Sep	Nov-Dec	Ivermectin
Gilgit (Gorikot/Astore)	Sep-Oct	Oct-Nov	Local oil/spirit
KPK (DI Khan, Shorkot, Haji mora and Rangpur)	Aug-Sep	Oct-Nov	Ivermectin

The table 4 showed life cycle trend generally comprised warble (nodules) appearance between August and November and the dropping of L_3 larvae from October to December. Ivermectin was mostly used by most of the farmers as the drug of choice for the control of warble fly larvae during November and December.

Remote data collection using pre-designed questionnaire to determine the distribution of warble fly infestation in various regions of Pakistan

Distribution of warble fly infestation in Goats in various regions of Pakistan

Among the 43 districts, veterinarians confirmed the prevalence of warble fly in 21 districts, and the rest of the districts were reported free of warble fly during 2022-23. Almost all veterinarians were in view that the warble fly prevalence's decreased due to heavy use of accaricidal spray and ivermectin in the last two years (Table 6). The trend comparing warble fly prevalence has seen significant shifts. The warble fly prevalence was also reported from Naseer Abad and Sibi areas in Balochistan, while no any such previous information available. Conversely, there are now 14 districts where prevalence isn't shown, despite being displayed earlier. The life cycle trend was prevalent in all the areas that comprised warble (nodules) appearance between September to March and the dropping of L_3 larvae mostly during November/March. According to the farmer's perception, there is no difference between the prevalence trend in both sexes and various breeds of goats, while a higher prevalence was observed in young animals. However, it is prevalent, particularly in range-grazing goats.

Figure 1

The Figure Showed Remote Data Collection of Prevalence % in Goats and Cattle Present and Past Ten Years Trend using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Punjab

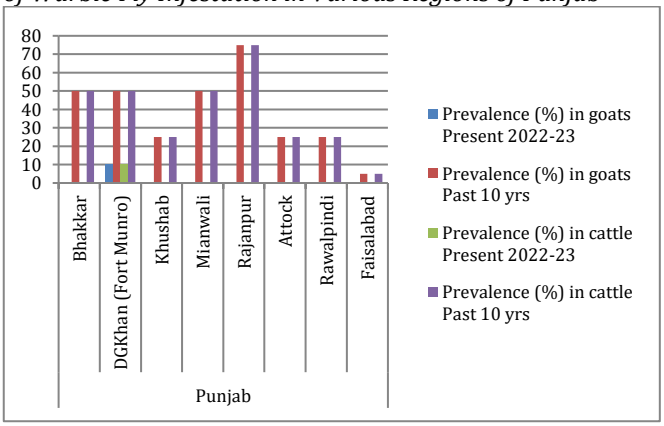


Figure 2

The Figure Showed Remote Data Collection of Prevalence % in Goats and Cattle Present and Past Ten Years Trend using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Sindh

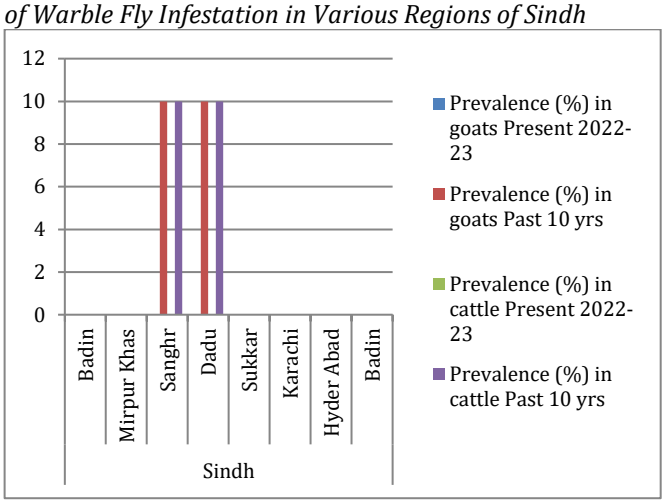


Figure 3

The Figure Showed Remote Data Collection of Prevalence % in Goats and Cattle Present and Past Ten Years Trend using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Balochistan

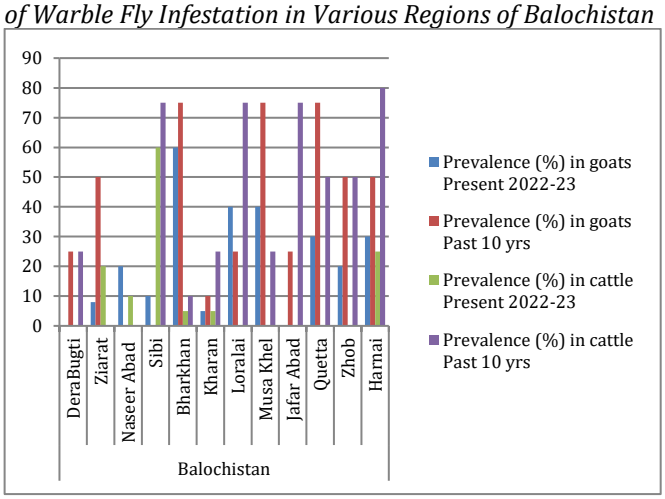


Figure 4

The Figure Showed Remote Data Collection of Prevalence % in Goats and Cattle Present and Past Ten Years Trend using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Khyber Pukhunkhwa

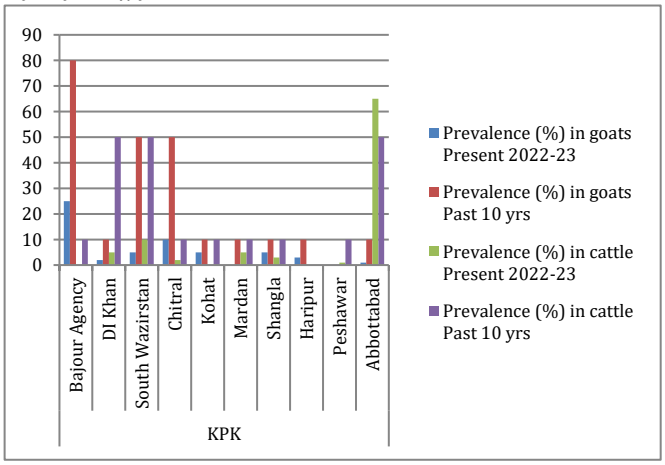
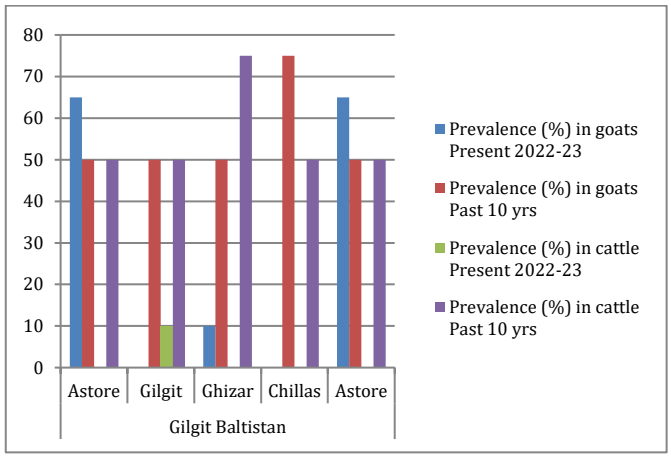


Figure 5

The Figure Showed Remote Data Collection of Prevalence % in Goats and Cattle Present and Past Ten Years Trend using Pre-Designed Questionnaire to Determine the Distribution of Warble Fly Infestation in Various Regions of Gilgit Baltistan



Distribution of Warble Fly Infestation in Cattle in Various Regions of Pakistan

Among the 41 districts, veterinarians confirmed the prevalence of warble fly in 15 districts and the rest of the districts were free of warble fly in cattle. Almost all were in view that the warble fly prevalence's decreased due to heavy use of Acaricidal spray and ivermectin in the last two years. The life cycle trend was prevalent in all the areas that comprised warble (nodules) appearance between September and March and the dropping of L_3 larvae during November and March.

Develop and Demonstrate Three Control Models of Warble Fly in Field Conditions

Three villages in each federating units, i.e., Balochistan, Punjab, and Gilgit, were selected for therapeutic control trials. The distance between the selected villages was more than 10 km. Young animals were selected for the study to rule out their previous exposure to the warble fly.

In addition, one village was kept as a control group for comparison. For each model, 50 goats and 12 cattle were involved. The first control model was based on medication with ivermectin (1 ml/50 kg body weight) subcutaneously once a year during the first larval stage before appearing nodules in goats and cattle of a selected village. The second model was based on the same medication once a year for two consecutive years, and the third model was also based on medication once a year for three consecutive years. In addition, a village was selected as control group, and no medications were given (Table 5).

Table 5

Establishment of Three Control Model in Selected Villages

Province	Animals	Model-I	Model-II	Model-III	Control
		No. of animals	No. of animals	No. of animals	No. of animals
Balochistan (Ziarat)	Goat	50	50	50	50
	Cattle	12	12	12	12
Punjab (Fortmunro)	Goat	50	50	50	50
	Cattle	12	12	12	12
Gilgit (Astore)	Goat	50	50	50	50
	Cattle	12	12	12	12

Table 6
Results on Therapeutic Control Models against Warble Fly

Province	Animals	Model-1		Model-2		Model-3		Control	
		No. of Animals	Post medication infected cases	No. of Animals	Post medication infected cases	No. of Animals	Post medication infected cases	No. of Animals	Infected cases
Balochistan (ziarat)	Goat	50	0	50	0	50	0	50	20 (40%)
	Cattle	12	0	12	0	12	0	12	8 (66%)
Punjab (Fortmunro)	Goat	50	0	50	0	50	0	50	22 (44%)
	Cattle	12	0	12	0	12	0	12	5 (41%)
Gilgit (Astor)	Goat	50	0	50	0	50	0	50	33(66%)
	Cattle	12	0	12	0	12	0	12	4 (16.66%)

DISCUSSION

Warble fly infestation is a major economic concern for cattle and goats in Pakistan, particularly in hilly and semi-hilly areas. In this study, four sites were selected in federating unit's i.e. (Punjab, Gilgit-Baltistan, Balochistan, and Azad Jammu and Kashmir) of Pakistan. The activities initiated under this study, Field epidemiology, Remote Data Collection and treatment control model of warble fly infestation. The Veterinarians from 14 districts of Balochistan, AJK and Sindh gathered information from 171 famers and also examined the 14987 goats and 3621 cattle for the warble fly infestation. The present warble fly larval prevalence trend during the 2024 showed lower prevalence (10.6%) than the previous ten years (13.02%). The prevalence was higher (between 2-27%) recorded in goats from Balochistan followed by Sindh (10%) and AJK (1%). Overall the doe (female goats) above one year also showed higher prevalence compared with one year male animals. Breed-wise higher prevalence% was recorded in Khurasani followed by Lehri, Kamori and Teddy, while the Beetal breed were found free of warble fly larvae infestation. The mix breed (more than one breed flock) presented low prevalence% while higher prevalence% were noted in un-descriptive breeds. The appearance of warble nodules comprised L^3 stage of life cycle on the back of animals was observed during August in AJK, during October in Sindh and during September/October in Balochistan. The drop of L^3 larvae from animals to soil was recorded during November-December in AJK, during November in Sindh and during November-January in Balochistan. The farmers belong to AJK and Sindh mostly used Ivermectin during August and found 80-90% effective against warble fly larval infestation. However, the farmers from Balochistan used copper, Ivermectin and Trichorfon during September/October with 90% effectiveness. A total 145 farmers holding 2727 number of cattle were interviewed for warble fly larval infestation. In these animals the present warble fly larval prevalence% trend during the 2024 showed lower prevalence% (5.26%) than the previous ten years (9.39%). The prevalence was higher (between 2-27%) recorded in cattle from Balochistan followed by AJK and Sindh. The mean prevalence% of warble fly larval infestation was recorded higher in Balochistan followed by AJK and Sindh. Overall the female cattle above one year also showed higher prevalence compared with less age and male animals. Breed-wise higher prevalence was recorded in Cholistani cattle followed by Lohani, Red Sindhi. Friesian and Jersey breeds cattle were found free of warble fly larvae infestation. Similar findings were reported by (Ahmad *et al*. 2012, Arshad *et al*. 2014, Khan *et al* 2012). The life cycle of the warble fly was physically observed in goats and cattle from 10 sites/villages of Pakistan (Table 5). The life cycle trend in these villages generally comprised warble (nodules) appearance between August and November and the dropping of L_3 larvae from October to December. Three villages in each federating units were selected for establishing the therapeutic control models. In each federating units the animals were randomly divided into 4 groups i.e. A, B, C and D having 50 goats and 12 cattle in each group. The animals in A, B and C group were administered ivermectin 1% (1 ml/50 kg body weight) subcutaneously during August–September, while the D group was kept as a control. All the animals in treated groups were found free of warbles, while goats and cattle in control/untreated group showed (17-66%) prevalence. Similar results were reported by (Khan *et al* 2012).

CONCLUSION

Field and remote data collection on warble fly infestation revealed a significant decrease in prevalence, dropping to 32% from previous rates as high as 80%. Additionally, warble fly prevalence was reported for the first time in the Naseer Abad and Sibi areas of Balochistan. This change in trend is attributed to the extensive use of acaricidal sprays and ivermectin for controlling lumpy skin disease, which also significantly reduced warble fly infestation. The farmers belong to AJK and Sindh mostly used Ivermectin during August and found 80-90% effective against warble fly larval infestation. However, the farmers from Balochistan used copper, Ivermectin and Trichorfon during September/October with 90% effectiveness.

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