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Economic Efficiency of New Insecticides Used for Protecting Cattle from Zoophilous Flies in Northern Kazakhstan

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Abstract

Results of the economic efficiency of pest control measures for reducing the number of zoophilous flies with the use of new forms of chemical insecticides developed from synthetic pyrethroids are presented in this article. To determine the economic damage to livestock breeding caused by insects, initially data were gathered about the productivity of cattle before and after pest control activities. Animals had been protected on pastures during the seasons of flies' activity. Spraying cows with 0.009% aqueous emulsion of synthetic pyrethroids allowed to obtain extra 0.2 l or 1.4% of milk per day from each cow and reduced losses from zoophilous flies. Within the framework of project "Creating a new high-performance insectoacaricide and larvicidal preparation of synthetic pyrethroids for protecting cattle from zoophilous flies in feedlots and pastures," a new veterinary preparation has been created. Production tests were performed in the conditions of the Northern Kazakhstan.

Keywords

Cattle; Efficiency; Deltamethrin; Synthetic pyrethroids; Insecticides

Introduction

One of the most important reasons for preserving livestock and increasing productivity of cattle is the prevention of harm caused by zoophilous flies. Being entoparasites and carriers of pathogens of many infectious and invasive diseases, they cause a considerable economic damage to the livestock in the Northern Kazakhstan. Out of dipterans, the most maleficent and numerous are flies of the *Musca domestica* L specie, which have the ability to transmit bacterial, viral infections and constantly create the threat of diseases occurrence among animals [1,2].

In livestock farms of the Northern Kazakhstan, for protecting animals from zoophilous flies in pastures and in farms in the period of insects' active summer, there are common methods of animal breeding. These are morning grazing of cows on the hills, near forests, and keeping them near ponds in the second half of the day.

In order to prevent considerable losses of livestock products caused by the attacks of dipterans, many farms practice two approaches. The first one is based on pasture-less grazing of cattle, along with traditional grazing in the summer. It is especially practiced at the breeding farms of highly productive imported dairy cattle. During the summer period, these farm animals are kept indoors and in enclosures.

The second approach aimed at preventing loss of dairy products is based on preventing livestock productivity using protective treatment with insecticides and repellents.

According to some researchers, at the present stage of fighting against flies in pastures, the most acceptable method is spraying animals. Spraying the body hair coat of the livestock with small, medium and large amounts of repellents is widely followed. In order to protect animals from parasitic dipterans, the most effective and safe insecticides based on synthetic pyrethroids are used nowadays; the use of deterring substances, that is, repellents, has been firmly established in the complex measures for protecting animals from dipterans [3,4].

It is believed that the use of chemical preparations is relatively a simple and inexpensive method of fighting arthropods in treating various types of objects and territories. With that, the drugs that are recommended for pest control should meet strict requirements. The insecticides should have low toxicity to humans and farm animals and have a selective effect on harmful organisms.

The method of animal protection should strictly comply with the established regulations and should be safe for humans, animals, and the environment. Given the high demand in the market, new combined prolonged formulations are used, which differ in their target performance, long-lasting residual action and high degree of safety for the specialists performing treatment, and for assisting personnel [4,5].

Our work was aimed at studying the economic efficiency of new chemicals, insecticides used for protecting cattle from zoophilous flies in feeding stations and pastures with various keeping conditions.

The following tasks had been set for achieving these goals:

1. Monitoring changes in milk and meat productivity of animals before and during the attack of dipterans in case of using various technologies to rear animals.
2. Screening the efficiency of various forms of insecticide obtained from synthetic pyrethroids against zoophilous flies in the laboratory and in industrial conditions.
3. Developing a new method of obtaining insect-acaricides for analyzing its composition.

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Materials and Methods

Production tests of new chemicals against zoophilous flies were performed in the period between May and September 2015 in the conditions of the Kostanay region of the Northern Kazakhstan. The research was performed at the LLP "Agro-Toro" in the Karabalyk district. Milk production was assessed with the use of the reporting data of the farms by the average daily milk production per a forage-fed cow. From the beginning of June until the beginning of July, the animals in that farm were milked and kept indoors at night and in the paddock adjacent to the livestock house during the day. In early July, before going to the pasture, cows were sprayed with 0.009% aqueous emulsion of a prototype of the new insecticide, with deltamethrin being the ingredient. The treatment was repeated once in 3 days, with a total of six treatments. The method of medium-volume spraying from the SOLO-434 knapsack gasoline motorized sprayer was used. The method of obtaining the insectoacaricide preparation and its composition was developed at the Kostanay University in the framework of the scientific project "Creating a new high-performance insectoacaricide and larvicidal preparation of synthetic pyrethroids for protecting cattle from zoophilous flies in feedlots and pastures."

The economic efficiency of new chemicals, mainly insecticides that are used to protect cattle from zoophilous flies, was studied in two pastures. The first pasture (the experimental one) was located behind the farm and was a place for grazing cows of the LLP "Agro-Toro" in the period from the first decade of July to the end of summer. The second pasture (the reference one) was 3-5 km from the first one, where during the whole summer season about 150 cows and calves from the personal sector of Stantsionnoye settlement were grazing.

In order to assess the influence of spraying cattle on the number of flies in both pastures, counts were made three times before and three times during the treatments. The entomological efficacy of treatment (Protective Action Coefficient (PAC)) was determined according to guidelines by formula:

$$PAC = 100 - \frac{A \bullet B_1}{B \bullet A_1} \times 100,$$

where A and A_1 are the total number of flies during and before treatment at the experimental pasture;

B and B_1 are the same on the reference pasture.

Besides, the parasitic insects were counted by inspecting 10-15 cows and counting insects sitting on them, followed by the calculation of the abundance index [6].

Results and Discussion

Studying the seasonal dynamics showed that the number of parasitic dipterans that affected the milk production of cows in the pasture varied (Figure 1).

The studied parasitic dipterans started flying in the first decade of June. Until mid-June their number remained low, that is, below the economic threshold of nocuousness. Starting from mid-June, the number started increasing and reached the maximum at the end of the month. A short-time cold snap in early July caused a decrease in the number of dipterans, mainly due to a sharp decrease in the number of gadflies. By the end of the first decade, due to warming, the number of dipterans increased again and remained high until the middle of the third decade of July. Thus, the wide-scale flying of dipterans was observed from mid-June to the middle of the third decade of July.

As one can see from the picture, in case of keeping cattle in the paddocks close to the livestock house during daytime, both before the start of summer flying of dipterans (the first decade of June) and in the period of wide-scale flying (from the second decade of June to the first decade of July), the curve of the average daily milk yield per a fodder cow remained almost at the same level. After the animal started to be grazed in pastures in the period of ongoing wide-scale flying of dipterans from July 13 to 25, the milk production of cows began to decrease rapidly.

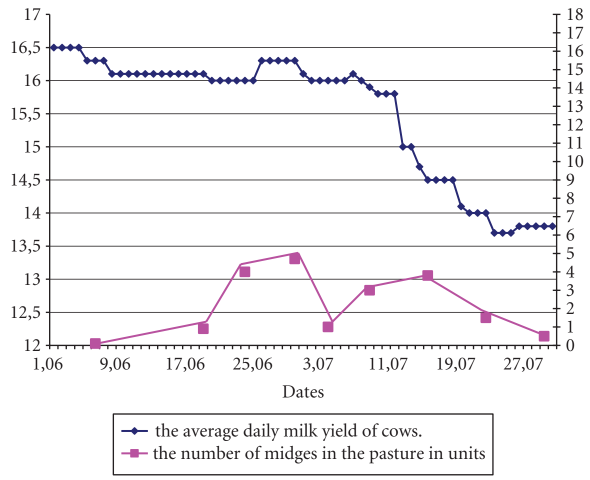

Figure 1: Dairy efficiency of the cows kept in the farm and those grazed in pastures during the wide-scale flying of dipterans

Periods of research	Experimental herd (358 heads)	Reference herd (346 heads)
1. Keeping outside pastures before summer large-scale flying of parasitic dipterans in the first decade of June	16.2	17.1
2. Keeping outside pastures in the first half of the large-scale flying of parasitic dipterans from the first decade of June till the first decade of July	16.1	15.9
3. Keeping with the use of pastures and periodic treating cows with the experimental sample of the insect-acaricidal preparation in the second half of the large-scale flying of dipterans, in the middle of June	14.9	13.4
Throughout the entire period of large-scale flying of parasitic dipterans from the second decade of June till the third decade of July	15.5	14.7

Note: the reference group in all periods of the study was kept with the use of pastures without using protective treatment against parasitic dipterans. The almost complete absence of parasitic dipterans in daytime on animal in summer paddocks may apparently be explained by soil being soaked with animals' urine and accumulation of manure emitting ammonia. In course of grazing on the pasture from the beginning until the third decade of July, the number of parasitic dipterans attacking a cow in the herd changed instantaneously, and with the economic threshold, the attack of parasitic dipterans caused a decrease in milk production by cows during this period. Treating cattle with insect-acaricides before driving them off to pasture ensures protection against parasitic dipterans at the level of 84% for over 24 h [7-13].

Table 1: Average daily milk yield from cows in the experimental and the reference groups in liters

Insects	Number before treatment			Number during treatment			Entomological efficiency, %
	Second decade of June	Third decade of June	First decade of July	First decade of July	Second decade of July	Third decade of July	
Zoophilous flies	762 / 642	585 / 1,194	31 / 21	555 / 830	792 / 2,630	228 / 884	51
Gadflies	49 / 32	114 / 97	65 / 99	31 / 63	21 / 45	27 / 14	41

Table 2: Entomological effectiveness of protecting cattle from parasitic dipterans (experimental – in the numerator, reference – in the denominator)

The statistically processed data from Table 1 show that when the animals were kept in paddock during daytime, the average daily milk yield before the wide-scale flying of dipterans (16.2 l) and during the wide-scale flying of dipterans (16.1 l) had no veracious difference (at $p = 95\%$), although they reduced by 0.1 l (0.6%). Then the animals were grazed on pastures during the period from the beginning till the third decade of July, the average daily milk yield of cows decreased by 1.2 l (7.4%), amounting to the average of 14.9 l. With that, the milk yield of the cows kept in a paddock and that of those in the pasture had veracious difference, with the confidence level of 99.9%.

During the entire period of summer large-scale flying of dipterans, the average milk yield per a forage-fed cow was 15.5 l per day, that is, compared to the period before the start of the large-scale flying, it decreased by 0.6 l, or by 4.1%. Studying the number of parasitic dipterans in the paddock showed that animals were not attacked by dipterans in the daytime before the start of summer large-scale flying.

In the period of large-scale flying of dipterans from the second decade of June until the first decade of July, the number of these insects observed on cows in the paddock was extremely low. Thus, in case of instantaneous measurements, 10-15 animals only had the maximum of 3-5 zoophilous flies, 1 mosquito and 1-2 gadflies, that is, most animals were not attacked even by a single bion.

In the consequent 2 days, the intensity of dipterans' attacks increased and approached the reference value. In addition to direct animals' protection, the insecticidal action of the insect-acaricidal preparation caused reduction in the overall quantity of the insects.

Thus, the comparison of insects' population in the experimental and the reference pastures before and during the treatment showed that in the experimental pasture, due to treating animals, the number of zoophilous flies decreased by 51% and that of gadflies by 41%. The data are shown in Table 2.

Thus, despite the nearly two times decrease in the number of sanguivorous dipterans in the pasture, the natural decrease in cows' milk productivity amounted to 1.2 l, or 7%, which indicates the need for more frequent treatment in the period of the summer large-scale flying of parasitic dipterans.

The appearance of parasitic dipterans in the reference season was noted at the end of May, but until mid-June, due to cold weather, their number was below the economic threshold. The wide-scale flying of dipterans started from mid-June and continued until the end of July. The greatest number was noted at the end of June. The data about the number of parasitic dipterans in the pasture, and about milk productivity of cows, are presented in Figure 2, which shows that in case of keeping cows in the pasture, at the beginning of the period of the summer large-scale flying of dipterans, there was a decrease in the average daily milk yield until the end of this period. According to the data in Table 1, during this season, in the period before the start of the summer large-scale flying of dipterans until mid-June, the average daily milk yield was 17l, and in the period of the summer large-scale flying of dipterans from the second decade of June till the first decade of July, it was 15 l, that is, it decreased by 2 l (6.63%).

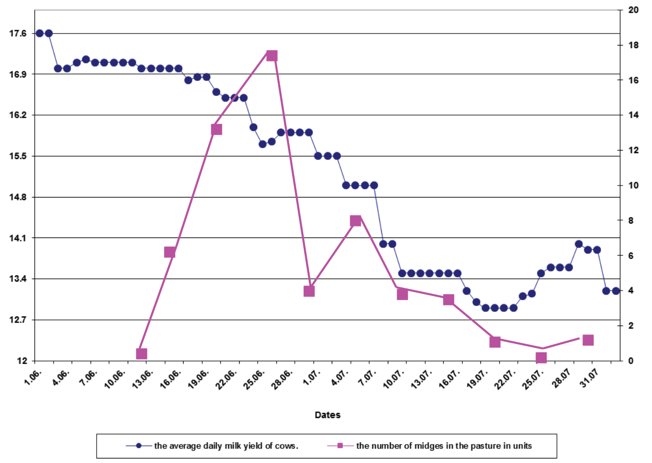

Figure 2: Milk yield of cows in case of keeping them grazing in pastures during the flight of parasitic dipterans

In the period of the ongoing summer large-scale flying of dipterans from July 7 to 25, the average milk yield amounted to 13 l, that is, it decreased by another 2 l (15.9%). On the basis of these data, it is clear that with increasing the duration of the harmful effects of parasitic dipterans, the loss of milk productivity increases. Within the entire period of the summer large-scale flying of parasitic dipterans from June 16 to July 25, 2015, the average daily milk yield per cow was 14.7 l, that is, as compared to the period before the start of summer (until mid-June), it reduced by 2l, or 13%.

From the results of these studies, changes in the productivity of the experimental cows with regard to the productivity of the reference animals grazed in the pasture throughout the entire summer season have been additionally calculated. Table 3 demonstrates the cost of treating animals for their protection against attacks of parasitic dipterans, including the costs of chemicals for manufacturing the insect-acaricides, in the prices of 2015.

Table 3 shows that the composition of the preparation is determined by the fact that the basis of active substance is deltamethrin, same as in known preparations. It disrupts the functioning of insects' nervous system by affecting the sodium-potassium channels and calcium

Ingredients	Amount (mg)	Cost (USD, $)
1. Deltamethrin 98%	6.1	1.4
2. Xylene or benzene	9.9	0.1
3. Piperonylbutoxide	5.0	0.05
4. Polyvinyl alcohol	5.0	0.02
5. Propylene glycol	5.0	0.02
6. Paraffine oil	5.0	0.04
7. Distilled water	64.0	0.03
Total	**100**	**1.66**

Table 3: Composition and the cost of the experimental sample of the "Entomocide"-6% insecticide

metabolism in the synapses. It also contains an additional substance – "synergist" (which increases the "insecticidal effect" of deltametrin), for example, piperonylbutoxide, which blocks protective enzymes in insects.

Other substances are also used for obtaining physical and chemical stability of the proposed solution. The highest cost of manufacturing the preparation is the cost of the active ingredient – $1.66 per 6.1 mg, and the lowest cost is the cost of the emulsifying agents, such as polyvinyl alcohol and propylene glycol – 2 cents per 5 mg. Thus, $1.66 is required for manufacturing 100 ml of the experimental sample of the "Entomocide" -6% insecticide.

The efficacy of this insecticide in the production conditions was assessed during the peak of the summer large-scale flying of zoophilous flies on the pastures and feedlots of the Kostanay region.

The animals were treated with an aqueous emulsion of the insecticide by single spraying from a knapsack gasoline motorized sprayer SOLO-434 in the amount of 1.5 l per animal. The animals treated with water were the reference group. The amount of the preparation for obtaining the required amount of aqueous emulsion was determined from the desired concentration of insecticide by the following formula:

$$X = \frac{A \bullet B}{C}, \qquad \text{where}$$

X is the amount required for preparing the emulsion,
A is the amount (ml) of the solution to be prepared,
B is the required concentration of the emulsion,
C is the content (%) of the active substance in the preparation (concentrate).

For example, for treating animals at the rate of 3 l per head, one has to prepare 3 l of 0.009% water emulsion of the experimental sample of the "Entomocide"-6% insecticide.

Using the formula mentioned earlier, we get:

$$X = \frac{3{,}000 \text{ ml} \bullet 0.009\%}{6\%} 4.5 \text{ ml}$$

Thus, 100 ml of the experimental insecticide is sufficient for 44 heads of young stock, or 22 heads of adult stock, and ensures 100% protection from the attack of zoophilous flies for 24 h. The young cattle were protected from parasitic dipterans by spraying the 0.009% aqueous emulsion of the experimental "Entomocide"-6% insecticide, which showed that the live weight of one head of young cattle in the groups was 110 g higher than that of the untreated animals.

The economic loss of productivity was the sum of various criteria. The average milk yield was 21 l per day. The average amount of milk from 22 cows was 462 l per day.

With that, the purchase price of 1 l of milk at milk factories at the time of calculation was 20 cents.

During the treatment, milk from sick cows was not sent to milk factories, and was completely used for watering young cattle after boiling.

Thus, milk shortage from 22 cows for 1 day was approximately 462 l. For 15 days, the shortage was 6,930 l, or if calculated at the purchase price of 20 cents per 1 l, $1,386.

The prevented damage as a result of the preventive activities was calculated according to Guidelines by the formula:

$$P_D = S_A \times S_R \times P_P - D_T, \qquad \text{where}$$

S_A is the number of sick animals,
S_R – sickness rate (according to the data, it is 0.5%),
P_P is the milk-purchasing price,
D_T is the total economic damage.
Using the formula mentioned earlier, we get:

$$P_D = 22 \times 0.05 \times 1{,}386 - 1{,}386 = \$138.6$$

The economic efficiency of veterinary measures was determined according to the Guidelines by the following formula:

$$E_{E1} = P_D - V_{C1}, \text{ where}$$

P_D is prevented damage by preventive measures,
V_C is veterinary costs.
Using the formula mentioned earlier, we get:

$$E_{E1} = 138.6 - 33.2 = \$105.4$$

The economic effect per $1 of the costs was also determined according to the Guidelines by the formula:

$$E_{T1} = E_{E1}/V_{C1}$$

Using this formula, we get:

$$E_{T1} = 138.6/33.2 = \$4.17$$

Conclusion

The pasture-less technology of keeping cows using daytime grazing grounds at farms where zoophilous flies and other parasitic dipterans almost did not disturb the animals is an efficient method that ensures maintaining their milk yield. In case of keeping animals in pastures, systematic spraying with 0.009% aqueous emulsion of insecticides from the group of synthetic pyrethroids at the rate of 3,000 ml per adult animal and 1,500 ml per young animal ensures protection from zoophilous flies and insects during the day. The cost of manufacturing 100 ml of the 6% experimental insect-acaricide (in the prices for year 2015) was $1.66, which was sufficient for treating 22 heads of cattle to protect them from the attacks of gnats. The growth in the live weight of one calve in the experimental groups was 110 g higher, as compared to the untreated animals. The damage prevented by the measures from June 1 to August 1 amounted to $105.4. The economic effect of the veterinary measures per $1 of costs was $4.17.

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