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Original article

EFFECT OF AN INTEGRATED FLY CONTROL PROGRAMME IN FARROWING HOUSES IN RUSSIA ON MILK YIELD OF SOWS AND GROWTH PERFORMANCE OF OFFSPRING

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Summary

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The aim of this study was to estimate the efficacy of an integrated fly control programme in farrowing houses on milk yield of sows and growth performance of offspring. Four insecticides: Solfak Duo, Solfak Duo + Baycidal, Quick Bayt, and Agita were tested on 160 sows and 1690 pigs. The effectiveness of these drugs against adult flies ranged from 71.22 to 98.84% and against larvae: from 98.96 to 100%. The results of the studies showed the positive effect of the integrated insecticidal programme for combating adult flies and their larvae in the mother-pig barn on the milk productivity of sows and live weight of piglets. After the combined use of Solfak Duo + Baycidal insecticides a tendency for better results was observed with higher milk production of sows (by 71.1%) and improved live weight of piglets (by 40.6%).

Key words: efficacy, flies, insecticide, larvae of flies, pest control, pigs

INTRODUCTION

The mites, lice, zoophilic flies and other ectoparasites are detected in pig farms with different production systems (Balashov, 1982; Akbaev *et al.*, 2008; Tummeleht *et al.*, 2020). A large number of flies often accumulate in summer and autumn in sow houses, biting and disturbing animals, causing decrease in their productivity (Veselkin, 1993). Some flies damage livestock products and animal feeds. Also, some of them are intermediate hosts of parasites that cause infectious diseases (Richardson, 2017; Ahmadu *et al.*, 2018; Zhai *et al.*, 2019). Fly larvae feed on faeces of ruminants and pigs and swallow eggs of nematodes. The development of

larvae and nematodes occurs simultaneously. The first-stage nematode larvae are found in the larvae of flies, the second-stage nematode larvae are found in the pupae, while infective nematode larvae are found in adult flies (Abubakar *et al.*, 2018; Paliy *et al.*, 2018).

Flies of livestock farms and pig farms belong to the order Diptera, the sub-order Brachycera and their biodiversity comes second after beetles, butterflies and hymenoptera. Zoophilic flies are insects with biocoenotic relations (trophic, topic) with domestic animals in premises and pastures (Kerbabaev *et al.*, 2000). A total of 67 families are known, but only *Muscidae, Calliphoridae, Sarcophagidae* families are of veterinary importance. It should be stated that *Musca domestica* Linnaeus, 1758; *Fannia canicularis* Linnaeus, 1761; *Muscina stabulans* Fallen, 1817; *Musca autumnalis* De Geer, 1776; *Musca larvipara* Portschinsky, 1910; *Musca amica* Linnaeus, 1771, species are non-blood sucking flies of *Muscidae* family. Furthermore, *Stomoxys calcitrans* Linnaeus, 1758; small horn fly *Haematobia irritans* Linnaeus, 1758; southern cow lighter *Lyperosia titilans,* Bezzi, 1911, species from blood-sucking flies parasitise on animals (Marchiori, 2014).

The greatest number of zoophilic flies with licking and piercing-sucking mouth apparatus are detected in the second half of summer and in the beginning of autumn. The number of flies varies from 30 to 60 specimens on 1 m² in animal houses and from 10 to 16 specimens on 1 m² in the nearest territory. It should be noted that flies can replicate year-round in closed heated premises.

The largest number of flies are present on livestock and pig farms. The zoophilic flies cause a significant decline in animal productivity, endanger their health and cause economic losses. The productivity of animals decreases during the period of mass flying of insects. Also, the veterinary and sanitary quality of agricultural products deteriorates (Paliy *et al.*, 2019).

The prevention and control measures against flies consist in the elimination of conditions facilitating the replication of flies, extermination of larvae and winged insects. There are a number of methods for integrated control of flies in livestock complexes: environmental protection, biological, chemical and mechanical methods (Baldacchino *et al.*, 2018). The swine premises and the surrounding areas should be kept clean with prompt cleaning of faeces to prevent the accumulation of feed residues. The following insecticides: 0.1-0.2% water emulsion of trichlormetaphos-3; 0.1% water emulsion DDVF; 0.2-0.5% water emulsion of trolene, karbofos, diphos, propoxur (baygon), cyodrin, methation and microbial agents (bitoxybacillin, turingin-1) are widely used for the extermination of fly larvae in places of their detection. The consumption rate of insecticides is 1-5 l/m², depending on the concentration of the substrate (Safiullin, 1995; Pavlov *et al.*, 2006; Roslavtseva, 2011; Safiullin *et al.*, 2011).

In recent years peritroides as ectamine, neostomazan and butox, have often been used. New broad-spectrum drugs including Solfak Duo SK 7.5%, Baycidal WP 25% and Quick Bayt granules (0.5% imidacloprid) were also introduced in the Russian veterinary medicine.

The aim of this study was to estimate the efficacy of an integrated fly control programme with combined use of insecticides in farrowing houses on milk yield of sows and growth performance of offspring.

MATERIALS AND METHODS

Flies, fly larvae and preparation of pig houses

The trials were carried out in September – October 2018 in the Kuznetsovsky pig farm, in Moscow Region. Large white, Duroc and Landrace pig breeds were reared in the farm. At the first stage of the experiment, the initial number of flies and their larvae was determined two weeks before the completion of the technological cycle in two farrowing houses (Table 1). For this purpose, six traps were placed in each sow house at different heights from the floor (1–2 m). Adhesive tapes Flycatcher-Proshka of standard size (75×4 cm), which included glue base with rosin, rubber and mineral oils served as traps.

The number of glued insects was counted 24 hours after hanging the traps, and then once weekly. For convenience, each side of the flycatcher was conditionally divided into five equal sectors of 15 cm. Additionally, scrapings were taken from six points from the floor with a size of 10×10 cm (under the feeders, drinking bowls and along the perimeter of the walls) for each farrowing house. Samples of 5 g were placed in individually numbered plastic mini containers. Then, the material was sent to the laboratory of the All-Russian Scientific Research Institute of Fundamental and Applied Parasitology of Animals and Plants named after K. I. Skryabin.

The sow farrowing houses were cleaned and disinfected according to the approved technology after the end of the technological production cycle and removal of the animals. Farrowing houses were disinfected with a solution of virocide at a concentration of 0.5% as recommended by the manufacturer.

The veterinary service of the farm provided four sectors of sow farrowing houses for determination of the efficacy of the integrated insecticidal programme against adult flies and their larvae. Each sector had an area of 700 m². There were 40 sows with piglets in each sector e.g. a total of 160 sows and 1690 piglets.

Drugs for control of flies and larvae

Solfak Duo SK 7.5% is an insecticidal and acaricidal agent containing beta-cyfluthrin (2.5%) and imidacloprid (5%) as active substances (AS) and emulsifier, dispersant and asolid carrier (up to 100%) as auxiliary components. The active substances have contact and intestinal effects on adult flies and belong to different classes of insecticides. Beta-cyfluthrin 2.5% is a fourth-generation pyrethroid; imidacloprid 5% is a neonicotinoid. The combination (synergy) of the two AS provides a quick knock-down effect and long-lasting protective action.

The Baycidal WP 25% includes triflumuron 1 (2-chlorobenzoyl) -3- [4-trifluoromethoxyphenyl] carbamide (25%) as an active ingredient and emulsifier (22%), dispersant (3%) and solid carrier (up to 100%) as auxiliary components. Baycidal WP has a larvicidal effect, it is a growth regulator for arthropod larvae and disrupts the process of their development. Triflumuron blocks the formation of chitin, has an ovicidal effect, leading to the death of embryos and hatched larvae.

Quick Bayt granules (imidacloprid 0.5%) contains imidacloprid [1-(6-chloro-3-pyredylmethyl) -N-nitro-imidazolidin-2] – 0.5% as active substance and auxiliary components tricozen Z-9 (sex pheromone flies, muscular), LEJ 179 (flavoring), bitrex (bitterness) and sugar. Imidacloprid has a pronounced contact and intestinal effect. Being an antagonist of the nicotinic

acetylcholine receptors, it causes hyperpolarisation of the nerve fibre membrane of arthropods, which leads to a prolonged opening of sodium channels, disturbing the transmission of nerve impulses and death of insects. The sex pheromone of flies provides their intensive attraction to the granules. Sugar and flavour (LEJ 179) increase a taste while Bitrex bitter protects animals from accidental ingestion.

Experimental design

Sector 1 was treated with 7.5% Solfak Duo SK. It was tested on 40 suckling sows and 402 piglets. Solfak Duo SK was used at the rate of 0.5 mL/m². The consumption rate of the working solution was 50 mL/m² for the absorbing surfaces and 100 mL/m² for non-absorbing surfaces. It was sprayed on the walls at a height of 0.5 m to 2.5 m from the floor using a backpack sprayer Gloria in order to avoid contact with animals.

Sector 2 was treated with 7.5% Solfak Duo SK and Baycidal WP 25%. The combination was tested on 40 lactating sows and 404 piglets. Solfak Duo SK was used at the same dose. The Baycidal WP 25% was applied using a large drip sprayer at the rate of 200– 300 mL/m² of floor area. Two weeks after treatment the solution was used again.

Sector 3 was treated with Quick Bayt granules (imidacloprid 0.5%) and was tested on 40 lactating sows and 391 pigs. It was used for pest control at the rate of 250 g of the product per 200 mL of water at room temperature. Then, the working suspension was applied on the walls (a total of 75), where the largest number of insects was accumulated.

Sector 4 was treated with Agita (base preparation) at the recommended dose and concentration and was tested on 40 lactating sows and 395 piglets.

The efficacy of the all drugs was evaluated weekly, using the Flycatcher trap tape.

In this research, 160 mL of Solfak Duo SK 7.5%; 580 g of Baycidal WP 25%; 525 g of Quick Bayt granules (imidacloprid 0.5%) and 6.3 kg of Agita were spent in sow houses.

Evaluation of drug efficacy

The efficacy of Solfak Duo SK and Quick Bayt drugs against adult flies was evaluated weekly using tape traps and flytraps. Tape traps were placed at different levels from the floor. The efficacy of the Baycidal WP against larvae of flies was determined by collecting scrapings 10×10 cm of size from different sections of the floor as previously described.

Efficacy of new insecticides as compared with Agita was calculated based on the percentage reduction of the number of adult and their larvae at different times after treatment using the following formula:

$$E\%=100\times(Nfc–Nfe)/Nfc,$$

where E is the efficacy of the drug, %; Nfc – the average number of adult flies and their larvae in the control sector specimen; Nfe – the average number of adult flies and their larvae in the experimental (first, second and third sectors) specimens.

Evaluation of productive performance of sows and piglets

The productivity of sows and growth performance of their piglets after applying the programmes for control of adult flies and their larvae in farrowing houses were evaluated by recording the milk productivity of sows during the lactation period, survival of piglets and their total weight gain up to 30 days of age, as well as the

average daily weight gain during the study period and feed conversion ratio. The milk productivity of sow was calculated as weight of all piglets at the time of weaning. The survival of piglets was the ratio of the final to the initial number of piglets, expressed as a percentage.

Statistical analysis

The experimental data on the number of flies and their larvae obtained during the testing of drugs were subjected to statistical analysis according to Plokhinsky (1978). Statistical analysis of data was evaluated by using SAS/Stat software (SAS System for Windows v. 9).

Ethics

The study was conducted in compliance with European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (ETS 123, 1986) and the Russian Federation Guidelines for Good Clinical Practice (2003). Also, the current study was in accordance with the guidance for the experimental evaluation of new pharmacological substances (Habriev, 2005).

RESULTS

The number of adult flies was significant during the two weeks before the end of the previous technological cycle in both farrowing houses. There was an average of 257 and 147 flies respectively on one flycatcher for 24 hours after their placement at a height of 1 and 2 m from the floor in both sow houses with 1544 and 882 specimens respectively in six traps. The number of adult flies did not differ at 1 and 2 m of height.

The number of larvae was 267 and 118 in one sample from the floor on an area of 10×10 cm in the first and second farrowing houses, respectively, and it was 1601 and 710 in the six samples (Table 1).

The average number of flies per trap is presented in Table 2. The number of larvae decreased to 0.5 compared to original number of larvae, 24 hours after pest control in the first sector; to 0 in the second; to 0.8 in the third and to 1.7 in the fourth (control) sector (Table 3). No fly larvae were found in all intervals after the combined treatment with Solfak Duo + Baycidal in the second sector. The number of larvae was 0.7; 1.0; 3.2 in the third sector and 1.8; 5.3; 9.2 specimen in the fourth one.

Table 1. Original number of adult flies and their larvae in the two farrowing houses two weeks before the completion of the technological cycle. Data are presented as mean ± SEM

	Number/ sample		Average number/ sample*		Original number*		Average background for both farrowing houses	
	Flies	Larvae	Flies	Larvae	Flies	Larvae	Flies	Larvae
Farrowing house 1	257± 12.67	267± 69.5	218± 29.30	138± 56.75	1307± 170.97	827± 340.84	1213	1156
Farrowing house 2	147± 14.74	118± 20.02						

* average for both farrowing houses.

Table 2. Number of adult flies in farrowing houses during the technological cycle of production and study efficacy of insecticidal programme at the pig farm Kuznetsovsky, Moscow Region. Data are presented as mean ± SEM

Sectors in farrowing house	24-hour number of adult flies per 1 flycatcher					
	In the process cycle	After treatment and before placing sows	After treatment			
			1 week	2 weeks	3 weeks	Average*
Solfak Duo	257±11.5	2.5	3.8	4.3	58.3	17.2±7.35
Solfak Duo + Baycidal	147±6.32	0.8	1.7	1.8	3	1.8±0.56
Quick Bayt	199±7.36	7.5	4.2	8.5	117.8	34.5±17.2
Agita	186±7.63	93	20.2	105.2	261.5	119.9±37.73

* average over the post treatment period.

Table 3. Number of larvae in the two farrowing houses during the technological cycle of production. Data are presented as mean ± SEM

Sectors in farrowing houses	Number of fly larvae per sample from floor area 10×10 cm					
	In the process cycle	After treatment and before placing sows	After treatment			
			1 week	2 weeks	3 weeks	Average*
Solfak Duo	267±12.01	0.5	2.2	3.0	2.3	2.0±0.3
Solfak Duo + Baycidal	118±5.72	0	0	0	0	0
Quick Bayt	195±7.60	0.8	0.7	1	3.2	1.4±0.3
Agita	156±6.24	1.7	1.8	5.3	9.2	4.5±0.8

* average over the post treatment period.

Consequently, Baycidal was the most active insecticide against the larvae of flies from all the drugs for pest control in farrowing houses ($P<0.05$ compared to Agita). Solfak Duo, Quick Bayt granules (imidacloprid 0.5%) and Agita mainly acted against the adult flies.

The average number of adult flies per one flycatcher was 17.2 (efficacy 85.65%) after the treatment growth of suckling pigs in the first sector. The average number of insects was 1.8 (efficacy 98.84%), 34.5 (efficacy 71.22%) and 119.9 in the second, third and fourth sectors, respectively. Statistical analysis of the results showed that the average number of adult flies after treatment with the insecticides Solfak Duo, Solfak Duo + Baycidal, Quick Bayt in farrowing houses was statistically significantly lower ($P<0.05$) compared to the control house, where the treatment was carried out with Agita.

The average number of larvae was 2 (efficacy 55.6%) during the period after the treatment and the growth of suckling pigs in the first sector. The average num-

Table 4. Effect of an integrated insecticidal programme for control of adult flies and their larvae in farrowing houses on the milk productivity of sows and growth of piglets

	Groups and treatments			
	Solfak Duo	Solfak Duo + Baycidal	Quick Bayt	Agita
Number of piglets in the group:				
- born	443	442	435	438
- at weaning (23 days of age)	402	404	391	395
- at 30 days of age	387	393	373	376
Milk productivity of sows, kg	78	102	67.6	59.2
Survival of piglets, %				
- 23 days of age	90.7	91.4	89.9	90.2
- 30 days of age	87.3	88.9	85.7	85.8
Total weight gain, kg,	11.3±0.47	13.6±0.51	10.4±0.52	9.5±0.42
Average daily weight gain, kg,	0.377±0.108	0.453±0.100	0.350±0.112	0.320±0.112
Feed conversion ratio	3.75	3.53	3.87	3.95

ber of larvae was 0 (efficacy 100%), 1.4 (efficacy 68.9%) and 4.5 in the second, third and fourth sectors, respectively. Therefore, the treatment with Baycidal larvicide was 100% effective against larvae. The effectiveness of other drugs used against larvae: Solfak Duo, Quick Bayt, Agita did not differ considerably ($P>0.05$).

The treatment of the farrowing houses against adult flies and their larvae with two effective insecticides showed a tendency towards higher weight gain in piglets ($P<0.05$) compared with the control house. A high efficacy against flies and their larvae was obtained only in the second sector, where the combination of adulticide and larvicide (Solfak+Baycidal) was used ($P<0.05$ compared to Agita).

The results of milk productivity of sow after application of the tested integrted insecticidal programmes are presented in Table 4. It should be noted that the number of born piglets and their survival at 30 days of age did not differ in different groups. The milk productivity of the sows of the second group, whose sector was treated by Solfak and Baycidal drugs, was significantly higher compared to other groups ($P<0.05$), while milk yields in the other sectors were not much different each from the other.

The total weight gain before 30 days of age and average daily weight gain of piglets in the second sector (Solfak and Baycidal), differed significantly from first, third and four groups ($P<0.05$).

DISCUSSION

A large number of flies often accumulate in summer and autumn in farrowing houses. These flies are annoying, they

bite, bother pigs, especially sucking pigs, and as a result pig productivity decreases. Some flies cause spoilage of livestock products and animal feed, and are also intermediate hosts of infectious diseases. Flies are found all year round in farrowing houses of industrial enterprises, because there are comfortable conditions for the development of larvae, pupae and adult flies.

The obtained data showed that the number of flies in farrowing houses was higher than those published in the literature. Apparently, this is due to the fact that the authors used a landing net for catching flies. We used standard flytraps with an area of 600 cm². The surface of the flytraps is covered with a sticky mass, which consists of an adhesive base, pheromones and attractants. Such a composition of traps allowed catching a large number of flies.

The veterinary service of pig farms monitors and constantly works to reduce the number of flies as with a low level of sanitation, a large number of flies develop in pig houses.

A large number of drugs against imago of flies and their larvae are prescribed during the preparation of pigsties for settlement in the form of a spray, and granular formulations are used in the presence of pigs. Our studies showed the positive impact of an integrated insecticidal programme to control adult flies and their larvae in farrowing houses using the Solfak and Baycidal drugs on the milk productivity of sows and average daily weight gain of piglets before 30 days of age. The absence of adult flies and their larvae had a positive effect on the productivity of sows and piglets before 30 days of age in the second sector.

Studies by Russian and foreign researchers indicated the need for the integrated use of insecticides against both adults and their larvae (Diclaro *et al.*, 2012; Safiullin *et al.*, 2018; Levchenko & Selivanova, 2019).

Stringham & Watson (2004) used imidacloprid to effectively control flies in pig farms in the United States of America. The data of our studies on the efficacy of imidacloprid against adult flies in pig houses are consistent with the reports of Pospischil *et al.* (2005) who used this drug against different flies, *Musca domestica* (Linnaeus) and *Stomoxys calcitrans* (L.) in Germany.

Pospischil *et al.* (2005) noted the high efficacy of imidacloprid WG 10 against flies in German pig farms. The drug in the form of a spray showed steady efficacy against flies for 6 weeks, and as a paint for 8 weeks in a pig farm. In our experience, imidacloprid, together with Solfac in the form of a spray, showed high efficacy against flies for 4 weeks in farrowing houses. Birkemoe & Sverdrup-Thygeson (2011) monitored the number of flies by determining the visual index and using sticky traps on pig farms in Pennsylvania, USA. This method was used by us to determine the initial number of flies two weeks before the end of the technological cycle of growing piglets and to determine the efficacy of the control programme for flies in farrowing houses. Diclaro *et al.* (2012) conducted field tests of a 46 cm long, 6 mm in diameter cord in Florida, USA which was immersed in a 2.5 % imidacloprid solution, and then a fly trap was wrapped around it. The trap itself was filled with a commercial attractant for flies. A total of 60–70% flies died 24 hours after using this cord, and 94% – after 48 hours. Fedorova *et al.* (2018) tested the effectiveness of two compositions in laboratory conditions in Russia. The first composition contained fipronil

with chlorophos, and the second – fipronil with fir oil. The first formula with fipronil to chlorophos ratio of 1:10, was more effective than the second composition. In both mixtures, a synergistic effect of insecticidal components was manifested. Levchenko *et al.* (2019) studied the susceptibility of a housefly population in livestock farm in the Tyumen region of Russia and revealed an increased susceptibility of flies to drugs from cypermethrin to fipronil.

In conclusion, the results of our studies showed that complex processing using Solfak Duo + Baycidal provided a high efficacy against adult of flies – 98.84% and against larvae – 100% for the entire period of growing of suckling pigs in the farrowing house. The efficacy of Solfak Duo SK 7.5% against adult flies was 85.65%, and efficacy of Quick Bayt granules (imidacloprid 0.5%) was 71.22%. There were no fly larvae revealed in the samples from the floor for all the time of research in second sector of sow houses (Solfak Duo and Baycidal) evidencing the high efficacy of the treatment.

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