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EFFECT OF DRINKING WATER SUPPLEMENTATION WITH *MACLEAYA CORDATA* EXTRACT ON REPRODUCTIVE PERFORMANCE OF PIGEONS AND PREVALENCE OF ENDOPARASITIC INFECTIONS DURING THE BREEDING SEASON

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Abstract

The aim of the study was to evaluate the effect of drinking water supplementation with Macleaya cordata extract on the reproductive performance of pigeons and the prevalence of endoparasitic infections. The study involved 20 pairs of pigeons divided into two equal groups: C and E. During the breeding season, the supplement was added daily to drinking water of group E pigeons at 1 g per 10 L. The numbers of eggs laid, fertilized eggs, squabs hatched, and squabs that survived for 30 days after hatching were determined. Squabs were weighed at 30 days of age. Fecal samples for parasitological analysis were collected three times from each adult bird to determine the prevalence of endoparasitic infections caused by coccidia and nematodes. The *study demonstrated that the water supplementation with Macleaya cordata extract tended to improve reproductive performance and decrease the prevalence of endoparasitic infections in pigeons.*

Key words: Columba livia, Macleaya cordata, reproduction, endoparasites

Introduction

In recent years, the mounting criticism surrounding the use of antibiotics and growth promoters in animal diets, as well as animal feed regulations have led to the search for safe substitutes. At present, phytobiotics/phytotherapeutics, i.e. plant-derived bioactive compounds, are generally regarded as safe feed additives. The five-seeded plume-poppy (*Macleaya cordata*) of the poppy family (Papaveraceae), a plant species native to Asia, is one of the plants that contain phytobiotics. Poppy plants are a source of alkaloids, mostly sanguinarine. Alkaloids are nitrogen-containing compounds that occur as secondary metabolites or natural products in plants. Sanguinarine is also present in *Sanguinaria canadensis*, *Poppy fumaria*, *Bocconia frutescens*, and *Chelidonium majus*. Poppy plants contain also other alkaloids, including chelerythrine, sanguilatine, chelilutine, chelerubine, and sanguirubine (Šimánek, 1985; Tschirner, 2004; Mackraj et al., 2008).

According to Jeroch et al. (2009), phytogenic additives block microbial enzymes that decompose amino acids in the digestive tract of monogastric farm animals, enhance protein metabolism, stimulate digestive enzymes and organs that secrete digestive juices, exert anti-inflammatory effects, boost immunity, and exhibit antimicrobial activity.

The efficacy of feed additives containing *Macleaya cordata* extract has been studied in pigs (Tschirner et al., 2003; Gudev et al., 2004; van Leeuwen and Additives, 2016; Rundle and Stein, 2018), in aquaculture (Rairat et al., 2013; Imanpoor et al., 2015), in rodents and lagomorphs (Zdarilova et al., 2008; Teillet et al., 2012). The highest number of studies were conducted in broiler chickens (Vieira et al., 2008; Zduńczyk et al., 2010; Juśkiewicz et al., 2011; Karimi et al., 2014). In most cases, *Macleaya cordata* extract exerted a minor effect on animal performance, but it improved immunity and gastrointestinal function (Juśkiewicz et al., 2011; Zduńczyk et al., 2010; Karimi et al., 2014). The influence of *Macleaya cordata* extract on growth performance and immune status was also investigated in pigeons raised for meat. Hu et al. (2016) found that *Macleaya cordata* extract can boost immunity and increase the serum levels of total protein, low-density lipoproteins and immunoglobulin G in young pigeons.

Immunity is a very important consideration in squabs, in breeding flocks, in pigeons raising offspring, and in racing pigeons because it helps birds fight off bacterial, viral, and parasitic infections. According to Wysocka-Lipińska et al. (2014), coccidia (*Eimeria* spp.) and nematodes (*Ascaridia* spp., *Capillaria* spp.) are the most prevalent endoparasites in the digestive tract of pigeons. Coccidiosis is most frequently observed in squabs, but it also affects adult birds. *Ascaridia* colonize the small intestine and cause ascariasis (roundworm infection). In pigeons, capillariasis is caused by small, hair-like nematodes *Capillaria obsignata* and *C. columbae* that colonize the small intestine. Many parasitic diseases are asymptomatic, but they compromise the immune status of birds and lead to production losses. Massive parasitic invasions lead to intestinal dysfunction, anemia, progressive cachexia, and death. The indicated parasites are ubiquitous in pigeon farms. In a study conducted in northern Poland by Stenzel and Koncicki (2007a), coccidia were identified in 56.4% of homing pigeon lofts and in 90.9% of fancy pigeon lofts. *Ascaridia* were detected in 5.5% of homing pigeons and in 15.5% of fancy pigeons displayed at exhibitions. *Capillaria* eggs were identified in 3.6% of homing pigeons and in 36.4% of fancy pigeons. Research shows that parasites significantly affect the flight performance of pigeons and can lead to bird losses during competitions and flights. The severity of parasitic infections is also affected by the birds' age and season (Raś-Noryńska et al., 2011; Balicka-Ramisz et al., 2020; Bartosik et al., 2020).

The observation that *Macleaya cordata* extract containing sanguinarine exerts a positive impact on the overall health status and flight performance of homing pigeons has not been validated in a research study to date. There is evidence to indicate that other phytobiotics exert positive effects on pigeon health. Dziewulska et al. (2018) reported that *Aloe vera* and licorice extracts have immunomodulatory properties and can be administered to pigeons to prevent viral diseases and enhance immunity, and as a supplementary measure in viral infections. Therefore, the aim of the present study was to evaluate the effect of a feed supplement containing *Macleaya cordata* extract on the reproductive performance of pigeons and the prevalence of parasitic infections during the breeding season.

Material and methods

The study involved 20 pairs of Old Polish homing pigeons aged 1 to 3 years. Old Polish pigeons are generally reared as fancy birds rather than for racing competitions, and they are characterized by a more developed cere and supercilium than typical homing pigeons.

The pigeons were randomly divided into two groups of 10 pairs each: a control (C) group and an experimental (E) group. The birds were housed in two free-standing lofts with floor dimensions of 5×4 m and height of 2.2 m. The lofts were placed inside aviaries with a cubic capacity of 20 m^3 each. Pigeons were released from cages at 7 a.m. and locked for the night at 7 p.m. The lofts were equipped with standard nest boxes, perches, feeders, and drinkers (Frindt et al., 2000). The birds had *ad libitum* access to a commercial feed for breeding pigeons supplied by a leading Polish feed manufacturer. Feed composition was as follows: yellow peas – 13%, green peas – 12%, wheat – 11%, red corn – 10%, white sorghum – 8%, red sorghum – 7%, field peas – 6%, barley – 6%, rice – 5%, vetch – 4%, safflower – 4%, buckwheat – 4%, small-grained corn – 4%, hemp – 2%. The feed contained 17.3% of total protein and 5.3% of crude fat, and its energy value was 14,656 MJ per kg. Leftovers were removed on the following morning. The birds also had unlimited access to a mineral-vitamin premix that was supplemented once a week. Fresh water was provided in new drinkers each morning. Old drinkers were washed, dried and disinfected before repeated use. Standard preventive treatment was provided before the breeding season: pigeons were dewormed, administered drugs against trichomoniasis, and vaccinated against paramyxovirus and *Salmonella* infections (Szeleszczuk, 1996; Stenzel and Koncicki, 2007b). Pharmaceuticals were not administered during the experiment. Aviaries and lofts, in particular nest boxes, were cleaned twice a week.

The experimental factor was a feed supplement containing *Macleaya cordata* extract that was added daily to drinking water in group E at 1 g per 10 L during the breeding season (from the beginning of March until the end of September). The supplement was produced by a global supplier of phytobiotics. According to the manufacturer, the main active ingredient is sanguinarine in the minimum amount of 1%. The supplement also contains sodium chloride and propylene glycol.

During the experiment, the reproductive performance of each pigeon pair was assessed based on three successive clutches. The number of eggs laid, the number of fertilized eggs, the number of squabs hatched, and the number of squabs that survived for 30 days after hatching were determined. Thirty-day-old squabs were weighed, weaned, and moved to a different loft.

The parents/breeders were weighed before the experiment (0) and after the squabs from each clutch (I, II, III) were weaned. Squabs and adult pigeons were weighed to the nearest 1 g with a digital weighing scale.

Fecal samples for parasitological analysis were collected from each adult bird on four dates (0, I, II, III), around 6 a.m., to determine the prevalence of parasitic infections in successive stages of offspring rearing. In total 160 fecal samples were collected. Coproscopic analyses were conducted with the use of standard quantitative methods, and the number of coccidia (*Eimeria*) oocysts and nematode (*Ascaridia* and *Capillaria*) eggs was determined in the McMaster chamber at 400x magnification. Oocyst/egg counts per gram (OPG/EPG) were determined in all fecal samples (Eckert et al., 1995; Kochanowski et al., 2013).

The results were processed statistically in the Statistica 12.0 program (STATSOFT INC., 2015), and the significance of differences between means was determined in the independent samples t-test.

Results

The reproductive performance of group E pigeons receiving *Macleaya cordata* extract was evaluated, and the results are presented in Table 1. The number of eggs laid, the number of fertilized eggs, the number of squabs hatched, and the number of squabs that survived for 30 days after hatching did not differ significantly between groups C and E, or between clutches (I, II, III). However, certain positive trends were observed in group E which was characterized by a higher number of fertilized eggs, and a higher number of squabs hatched and surviving squabs. The number of squabs that survived to day 30 was 15% higher in group E.

During the experiment, all breeding parameters decreased gradually in successive clutches. This trend was observed in both groups, but it was less pronounced in group E. The noted decrease could be attributed to higher rates of parasite infestation on successive days of the experiment (Tables 3, 4, and 5).

No significant differences were found in the body weights of 30-day--old squabs in both groups or in successive clutches. However, average squab weight was around 10 g higher in group E. A minor decrease in squab weight was noted in successive clutches, in particular in group C. In contrast, the offspring of group E pigeons receiving the experimental supplement were characterized by similar body weights in successive clutches (372–381 g).

Table 1. Reproductive performance of adult pigeons and body weights of squabs

Parameter	Clutch	Group ($\bar{x}$±SD)				*P*
		n	C	n	E	
Number of eggs laid	I	19	1.90±0.32	19	1.90±0.32	*1.0000*
	II	20	2.00±0.00	19	1.90±0.32	*0.3306*
	III	19	1.90±0.32	20	2.00±0.00	*0.3306*
	Total	58	5.80±0.42	58	5.80±0.42	*1.0000*
	$\bar{x}$	19.3	1.93±0.25	19.3	1.93±0.25	*1.0000*
Number of fertilized eggs	I	17	1.70±0.48	19	1.90±0.32	*0.2878*
	II	19	1.90±0.32	19	1.90±0.32	*1.0000*
	III	16	1.60±0.52	17	1.70±0.48	*0.6601*
	Total	52	5.20±0.79	55	5.50±0.53	*0.3306*
	$\bar{x}$	17.3	1.73±0.45	18.3	1.83±0.38	*0.3306*
Number of squabs hatched	I	17	1.70±0.48	19	1.90±0.32	*0.2878*
	II	18	1.80±0.42	19	1.90±0.32	*0.5560*
	III	14	1.40±0.52	16	1.60±0.52	*0.3979*
	Total	49	4.90±0.74	54	5.40±0.70	*0.1373*
	$\bar{x}$	16.3	1.63±0.49	18.0	1.80±0.41	*0.1373*
Number of squabs that survived for 30 days after hatching	I	17	1.70±0.48	19	1.90±0.32	*0.2878*
	II	15	1.50±0.53	18	1.80±0.42	*0.1769*
	III	13	1.30±0.48	15	1.50±0.53	0.3880
	Total	45	4.50±1.18	52	5.20±0.79	*0.1360*
	$\bar{x}$	15.0	1.50±0.51	17.3	1.73±0.45	*0.1360*
Body weights of 30-day-old squabs (g)	I	17	375.76±30.72	19	376.63±44.19	*0.9465*
	II	15	364.27±58.99	18	372.89±46.21	*0.6410*
	III	13	361.54±38.37	15	381.07±38.65	*0.1925*
	Total	45	367.82±43.50	52	376.62±42.68	*0.3185*
	$\bar{x}$	15.0	367.82±43.50	17.3	376.62±42.68	*0.3185*

No significant differences between groups.

Before the experiment, the average body weight of adult pigeons was determined at 476.95 g in group C and 478.50 g in group E (Table 2). The body weights of adult males and females decreased in successive clutches. The body weights of group C pigeons decreased by 5% after the third clutch. In group E, the observed decrease was somewhat smaller, at around 2%.

Table 2. Body weights of adult pigeons (g, n=20, $\bar{x}$±SD)

Clutch	Group		*P*
	C	E	
0	476.95±52.34	478.50±51.40	*0.9252*
1	470.60±48.43	470.65±45.93	*0.9973*
2	467.35±47.47	468.20±44.26	*0.9536*
3	456.10±50.09	467.55±44.04	*0.4474*

No significant differences between groups.

Table 3. Prevalence of *Eimeria* infections

Parameter	Clutch	Group	
		C (n=20)	E (n=20)
Number of infected birds	I	4	5
	II	7	6
	III	11	7
% of infected birds	I	20	25
	II	35	30
	III	55	35
OPG $\bar{x}$±SD	I	1195±2748	1305±2678
	II	4640± 8127	2395±4328
	III	5435±7464	2375±4111
Range	I	(0–10200)	(0–9400)
	II	(0–30000)	(0–13600)
	III	(0–16400)	(0–14200)

Table 4. Prevalence of *Ascaridia* infections

Parameter	Clutch	Group	
		C (n=20)	E (n=20)
Number of infected birds	I	2	2
	II	5	4
	III	5	5
% of infected birds	I	10	10
	II	25	20
	III	25	25
EPG $\bar{x}$ ±SD	I	205±648	215±744
	II	755±2352	540±1384
	III	735±2465	515±1105
Range	I	0–2500	0–3200
	II	0–10400	0–5100
	III	0–11000	0–4000

Table 5. Prevalence of *Capillaria* infections

Parameter	Clutch	Group	
		C (n=20)	E (n=20)
Number of infected birds	I	3	2
	II	4	4
	III	6	6
% of infected birds	I	15	10
	II	20	20
	III	30	30
EPG $\overline{x}$±SD	I	275±855	280±891
	II	920±2510	815±2127
	III	1265±2896	830±1516
Range	I	0–3700	0–3500
	II	0–8800	0–6900
	III	0–11700	0–4600

The prevalence of coccidial infections in pigeons is presented in Table 3. The prevalence of infections increased in successive clutches as the production of crop milk to feed the young gradually depleted the parents' energy reserves. After the third clutch, coccidia were identified in 55% of group C birds and in 35% of group E. The number of oocysts was lower in group E birds receiving the experimental supplement, but significant differences were not observed between groups.

The prevalence of nematode infections in the studied pigeons is presented in Tables 4 and 5. The number of fecal samples containing nematode eggs was similar in both groups, but egg counts were lower in fecal samples from group E. This result confirmed the previous observation that infection severity increased in successive clutches. Similarly to coccidial (*Eimeria*) infections, the prevalence of *Ascaridia* spp. (Table 4) and *Capillaria* spp. infections (Table 5) was lower in group E receiving the *Macleaya cordata* extract.

Discussion

Reproductive performance was generally high in both groups (Table 1). The noted results were higher than those reported by Gugołek et al. (2013) and Majewska and Drenikowski (2016) in various breeds of fancy pigeons. Homing pigeons are generally regarded to be more fertile and fecund than fancy pigeons, and their reproductive performance is similar to that of feral pigeons and selected pigeons raised for meat (Mikulski and Pudyszak, 2002; Nam and Lee, 2006). The body weights of group E squabs were within a healthy range, and similar values (392 g) were reported by Zieleziński and Pawlina (2011) in 28-day-old homing pigeons.

The body weight of the adult pigeons was typical (Table 2). According to Mercieca et al. (2017), adult homing pigeons typically weigh 475.8 to 488.21 g. The decrease in body weights could be attributed to energy depletion during offspring rearing and a higher prevalence of parasitic infections. The greatest decrease in body weights was noted in pigeons that had problems with offspring rearing and in birds with higher rates of parasite infestation.

Bobrek et al. (2012) identified *Eimeria* spp. in 65.7% of fecal samples from homing pigeons. However, the prevalence of *Eimeria* spp. infections was generally low at under 1 000 OPG, and similar results were noted in the present study. In the work of Balicka-Ramisz and Pilarczyk (2014), 93% of fecal samples contained *Eimeria* spp., and oocyst counts exceeded 13 000 OPG. In a study by Tomczuk et al. (2017), oocyst counts were determined at 1 677 OPG. In feral pigeons, the prevalence of coccidial infections was higher at up to 96%, and the mean oocyst count reached 1 870 OPG (Balicka-Ramisz et al., 2020).

Bobrek et al. (2012) identified *Ascaridia* spp. in 10% and *Capillaria* spp. in 17.2% of the analyzed samples. The prevalence of nematode infections was also low and did not exceed 500 EPG in most cases. In a study by Balicka-Ramisz and Pilarczyk (2014), *Ascaridia* spp. were detected in 16% (up to 360 EPG) and *Capillaria* spp. in 35% of the samples (872 EPG). In another study, Balicka-Ramisz et al. (2020) identified *Ascaridia* spp. in 9–16% (360 EPG) and *Capillaria* spp. in 24–41% of the analyzed samples (1 134 EPG). The mean EPG values reported by Tomczuk et al. (2017) were similar at 742 EPG for *Ascaridia* spp. and 1 633 EPG for *Capillaria* spp.

In view of the results reported by other authors, the prevalence of endoparasitic infections in pigeons should be regarded as low in the current study. These satisfactory results could be attributed to preventive treatments before the breeding season, sanitary housing conditions, and relatively low stocking density. According to Bobrek et al. (2012), the number of pigeons in a loft affects bird health and the severity of *Eimeria* spp. and nematode infections. The smaller the flock, the higher the overall health status. It should also be noted that the immune system of young birds is not fully developed, and their exposure to environmental parasites should be minimized (Raś-Noryńska et al., 2011).

The observed increase in the prevalence of parasitic infections in successive stages of the experiment had a negative impact on reproductive performance (Table 1) and led to a decrease in the body weights of pigeons (Table 2). *Macleaya cordata* extract exerted a protective effect on the analyzed parameters. The current study confirmed the findings of other authors who reported that sanguinarine enhanced immunity in poultry, which could contribute to preventing parasitic infections and improving productivity. In the work of Vieira et al. (2008), dietary supplementation with *Macleaya cordata* extract improved the growth performance of broiler chickens. Zduńczyk et al. (2010) demonstrated that the addition of sanguinarine to broiler chicken diets had a beneficial influence on the cecal environment, decreased the activity of pathogenic bacteria, and reduced digesta pH. Juśkiewicz et al. (2011) found that a supplement containing *Macleaya cordata* extract improved cecal metabolism in broilers, but did not affect their final body weights. According to Karimi et al. (2014), sanguinarine stimulates the immune system of broilers and increases carcass yield.

Conclusions

The results of this study indicate that the feed supplement containing *Macleaya cordata* extract tended to improve reproductive performance and decrease the prevalence of endoparasitic infections in pigeons.

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WPŁYW DODATKU DO WODY PITNEJ PREPARATU ZAWIERAJĄCEGO WYCIĄG Z ROŚLINY MAKLEJA SERCOWATA NA WYNIKI ROZRODU I POZIOM ZARAŻENIA GOŁĘBI ENDOPASOŻYTAMI W OKRESIE ROZRODU

STRESZCZENIE

Celem pracy była ocena wpływu dodatku do wody pitnej preparatu zawierającego ekstrakt z rośliny *Macleaya cordata* na wyniki rozpłodowe oraz poziom zainfekowania pasożytami gołębi w okresie rozrodu. Badania przeprowadzono na 20 parach gołębi pocztowych w typie staropolskim, podzielonych na dwie grupy: C i E. Podczas badań preparat zawierający *Macleaya cordata* dodawano codziennie do wody w proporcjach 1 g na 10 litrów i podawano ptakom grupy E w okresie rozpłodowym. Przeanalizowano liczbę jaj zniesionych, zapłodnionych, piskląt wylęgniętych i odchowanych do 30. dnia życia. Ponadto w 30. dniu określono masę ciała piskląt. Próbki kału do badań parazytologicznych od każdego dorosłego ptaka w celu oceny zainfekowania endopasożytami: kokcydiami oraz nicieniami zbierano trzykrotnie. Podsumowując uzyskane wyniki, należy stwierdzić, że dodatek do wody preparatu zawierającego wyciąg z *Macleaya cordata* wywołał u gołębi tendencję do uzyskiwania korzystniejszych wyników rozrodu i niższego stopnia zarażenia endopasożytami.

Słowa kluczowe: *Columba livia, Macleaya cordata*, reproduction, endopasożyty