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Effectiveness of anthraquinone and methylanthranilate against house sparrow (*Passer domesticus*) from wheat seeds and seedlings in caged conditions in Pakistan

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Abstract

Among avian pests, house sparrow caused serious depredations, not only to seeds, but also seedlings of various crops particularly in the organic farming. Different mechanical and chemical ways have been reported to manage these losses all over the world. The present study was aimed to investigate the efficacy of two bird repellents namely methylanthranilate and anthraquinone to manage the depredations of wheat seeds and seedlings against house sparrow in captivity. For this purpose house sparrows were offered with treated and untreated seeds and seedlings of wheat in two aviaries. By providing treated seeds and seedlings with these repellents, the relative effectiveness was appraised by comparing the consumed and unconsumed seeds and seedlings. Feeding responses of these birds against different doses of these repellents were investigated with the help of the closed circuit cameras adjusted in the aviaries. During the whole experiment among trial and control group highly significant differences ($P<0.01$) were seen in both seeds and seedlings cases. The mean consumption of wheat seeds treated with anthraquinone and methylanthranilate was 24.04±2.50 and 26.28±2.02, respectively, which depicted anthraquinone is relatively good repellent than methylanthranilate and a significant difference ($P<0.05$) was also observed. Different concentrations of both repellents showed a non-significant ($P>0.05$) variance when wheat seeds and seedlings were offered to house sparrows. House sparrows were influenced more quickly by consuming wheat seeds and seedlings treated with both repellents. Sparrows displayed noticeable head-shaking and feather ruffling behavior by consuming the treated seeds and seedlings.

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Introduction

Agriculture has the key role in the economy of any state. Basically, Pakistan is an agricultural country because about 67.5% peoples living in the rural areas are directly involved in agriculture and it is a source of revenue of 52% of the total population in our country. Indeed agriculture sector is the most important and it not only provides foodstuff to the peoples but also raw materials to other industrial sectors. The major crops cotton, wheat, rice, maize and sugarcane are present that contribute 25.2% in overall agriculture in Pakistan (Economic Survey of Pakistan, 2012-13). Per acre yield in this country is one fourth than that of the advanced countries due to lack of modern scientific methods for cropping and unawareness of peoples about the different techniques of pest management.

Vertebrate pests cause significant annual damage to agriculture, natural resources, human health and properties throughout the world. From all vertebrate groups, birds and mammals no doubt cause serious economic losses to valuable crops and fruit orchards. Cereal crops and fruit orchards are seriously affected fields by avian pests, their damage varies from field to field, area to area, country to country and also from climate to climate and the losses also depend upon the type of bird's species in a particular area. Blueberries, grapes, apples, gooseberries and cherries and later on seed of green cherry fruits trees are more at risk of birds attack (Wright and Brough, 1966; Simon, 2008). Upshal (1943) recorded 0.5 - 10% and Way (1968) observed more than 90% losses on cherry fields whereas in Northeastern United States farmers of blueberry calculated 30% damage. Shafi *et al.* (1986) observed house sparrow (*Passer domesticus*), rosy starling (*Sturnus roseus*), common myna (*Acridotheres tristris*), rose-ringed parakeet (*Psittacula krameri*) and house crow (*Corvus splendens*) as pestiferous species that caused serious economic losses to the crops and fruits. Crop damage caused by house sparrow ranges from 2-11% being more prominent at maturity stage of crop (Rizvi *et al.,* 2002). At Haripur, India, the estimated losses caused by pigeon, crow, sparrow and myna were 244 g/day/yard in a 30-day threshing season (Garg *et al.*, 1966). With the increase of human population, the demand of food and fruits has also become increased many folds so, there is a need to increase the per acre production to meet the requirements by introducing and applying the different strategies of pest control (Witmer, 2007).

Previously human has been utilizing various ways to protect their agricultural resources and agro-ecosystems from various bird pests. After some days due to familiarization of birds against the different mechanical devices, in the era of 1960's the work was started to ascertain the repellent activities of different chemical compounds. Furthermore, it will be better that the bird repellent should be from natural sources, easily extractable and environment friendly. Anthraquinone is phenolic purgative, extractable from tomatoes, famous as a competent avian repellent and can be used effectively to protect rice seed from blackbirds under captive and field conditions (Avery *et al.,* 1998; Cummings *et al.,* 2002). Methylanthranilate is a natural compound, present in grapes and other plant materials, found to be effective as bird aversion agents and generally recognized as safe. It acts as chemosensory repellent by irritating pain receptors associated with taste and smell and is approved by the U.S. EPA. It has been found effective in repelling birds from feeding on crops and fruits. Several scientists explored its use for controlling birds on feed lots, horticultural crops, rice and field crops (Mason *et al.,* 1989; Avery, 1992).

Agriculture is the backbone of our country and the economic losses to crops and fruit orchards by birds are in millions every year. So, it is essential to identify the effective chemical repellents that should be economical and environment friendly in particular to wildlife. Therefore, the aim of this study was to ascertain the relative effectiveness of anthraquinone and methylanthranilate against house sparrow (*Passer domesticus*) as well as their relative percentage to repel best from treated seeds and

seedlings and also the behavioural responses of house sparrow against treated and untreated wheat seeds and seedlings in captive conditions.

Materials and methods

House sparrow (*Passer domesticus)* feeding experiments were conducted in the vicinity of Wildlife and Fisheries Research Station and Botanical Garden at New Campus of Government College University Faisalabad, Pakistan. There was somewhat natural and undisturbed environment to the birds. From the local area birds were captured, tagged and placed in two aviaries (large bird cages) having dimension 12×12×8 feet (length × width × height) and weight of each bird was also determined at the start and end of the experiment.

Acclimatization

For roosting the birds tree branches, wooden bars and stones were furnished in the each aviary. Through the entire period of research water was provided *ad libitum* in each aviary. All the birds were offered maintenance diet (grains, fruits, garden plants, wheat and maize seeds) *ad libitum* for a week of acclimatization period. Four food bowls were placed in each aviary. Aviary-I, was taken as treatment group whereas aviary-II as control group.

Feed preparation and repellent concentration

Four different concentrations that is 0.25%, 0.5%, 0.75% and 1.0% of methylanthranilate (*W268208/ ALDRICH***,** found in the grapes and mint registered as bird repellent) and anthraquinone (*A90004 /ALDRICH,* extractable from tomatoes, regarded as potential avian repellent) were prepared and evaluated in the feeding experiments. Acetone was used as commercial adhesive. Both repellents first were dissolved in 12.5ml acetone as they were not soluble in water. To treat the seeds 62.5ml of each concentration having adhesive material was taken and mixed with 250g seeds in beaker and will be stirred well in the electric shaker. Then seeds were air dried and stored in air-conditioned laboratory in darkness in the department of Zoology.

Treatment experiment

In all twenty house sparrows were taken, of these ten in aviary-I were treated as experimental group and ten in aviary-II as control group. After the pre-treatment trials, food choice experiments were conducted for three consecutive days for each concentration of both the repellents and each treatment was given for about three hours in each morning, where as in leftover the day maintenance diet was provided. Each day consumed and unconsumed seeds were collected and weighed from both treated and control group in both the aviaries. There was one day gap in every treatment phase and birds were provided with maintenance diet in whole the day. Whole the time of experiment, in small vacant cage same amount of seeds in a bowl were kept to check the change in seeds weight as a result of desiccation that measured every day.

According to above mentioned methodologies, the efficacy of both bird repellents was evaluated against the house sparrows by providing the wheat seeds treated with different concentrations of methylanthranilate and anthraquinone.

In the same way, during the last phase of this study the effect of different concentrations of both repellents was also evaluated by providing the seedlings of wheat to the experimental birds in aviary conditions. For this purpose the 35g seeds of wheat were grown in the pots. Four pots were placed in each aviary having seedlings. It were sprayed with above mentioned doses of both repellents and then provided to the birds in the treatment group in aviary-I, and similarly the unsprayed seedlings in pots were offered to the control group in aviary-II.

Behavioural observations

To monitor the feeding behaviour and responses against the treated and untreated seeds and seedlings two closed circuit cameras were also adjusted in the opposite corners of each aviary in such a ways that all the activities of birds were tape-recorded.

Statistical analysis

For each experiment daily consumption was estimated by subtracting the weight remaining in pots and of spilled seeds from the initial weight of seeds and also change in seeds weight as a result of desiccation that measured every day also considered. Resultant weight was divided by the initial weight to get the percentage. Similarly, seedlings numbers were counted at start and end of treatment time daily and their percentage were also taken by dividing the initial sprouting numbers. For each single treatment variant, the deterrent effect of both the repellents in the experiments was evaluated by computing the consumption differences between treated and untreated wheat seeds and seedlings against house sparrows by analysis of variance (ANOVA; Keppel, 1973) and LSD test were further used to isolate the significance difference among means. Also change in body mass of birds was analyzed using the student t-test. Histogram was used for graphical presentation of present findings. All analyses were performed with Statistix 8.0.

Results

Effect of chemical repellents on wheat seeds against house sparrow

Statistically highly significant (P<0.01) differences in consumption of wheat seeds between trial and control groups and also in two way interaction among concentration and treatment (C × T) and similarly in three way interaction among chemicals, treatment and concentration (T ×C × Ch) highly significant (P<0.01) results were obtained. While a non-significant (P>0.05) value was observed among different concentrations (C) of both chemical repellents and significant (P<0.05) differences were obtained between chemicals (Ch), among the interaction of chemicals and concentrations (Ch × C), and between interaction of treatment and chemicals (T × Ch) (Table 1). The mean consumption of wheat seeds when treated with anthraquinone and methylanthranilate was 24.04±2.50 and 26.28±2.02 respectively, which showed that former is comparatively more useful bird repellent than later one. Similarly the mean wheat seed consumption in trial and control group was 15.25±1.08 and 35.06± 0.88, respectively for both bird repellents (Table 2) and for different concentrations of anthraquinone the lowest wheat seed consumption was 8.05±1.63 at 1% concentration that showed it is more effective to repel the sparrows (Table 3 & Fig. 1). This result showed that anthraquinone is more useful to control the wheat damage instead of methylanthranilate against house sparrows.

Table 1. Analysis of variance for wheat seeds against house sparrow.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Treatment (T)	1	4708.84	4708.84	470.19**
Chemical (Ch)	1	60.35	60.35	6.03*
Concentration (C)	3	21.01	7.00	0.70NS
T x Ch	1	63.53	63.53	6.34*
T x C	3	207.53	69.18	6.91**
Ch x C	3	99.73	33.24	3.32*
T x Ch x C	3	304.89	101.63	10.15**
Error	32	320.47	10.01	
Total	47	5786.35		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = highly significant (P<0.01).

Effect of chemical repellents on wheat seedlings against house sparrow

Seedlings in pots were offered to the sparrows in both trial and control groups in early morning for three hours period after that the numbers of remaining seedlings were recorded and the obtained data was statistically analyzed which showed that there existed a highly significant differences (P<0.01) between the

trial and control group, because in trial group the seedlings were sprayed with bird repellents, and a significant difference was recorded among both the bird repellents and also non-significant (P>0.05) differences were noticed among different concentrations (C) and between the two and three way interactions (Table 4). By comparing the mean consumption of wheat seedlings when treated with anthraquinone (22.01± 0.80) and methylanthranilate (24.32± 0.74) again it suggested that anthraquinone is more effective than methylanthranilate and the mean wheat seedlings consumption in trial and control group was 21.00± 0.65 and 25.34± 0.68, respectively (Table 5). At 1% concentration of anthraquinone and methylanthranilate a smaller number of seedlings were eaten by birds (Table 6 & Fig. 2). Statistical analysis wheat seedlings consumption against house sparrows provided an idea that anthraquinone was more effective to reduce the spoliation than methylanthranilate. Non-significant (P>0.05) variations were seen from the statistical analysis of body weight of sparrows indicated that applications of two bird repellents did not affect the weight of birds. Captive test birds sustained body mass and all looked healthy when feeding trials finished.

Table 2. Comparison of means for wheat seeds treated with both chemical repellents against house sparrow.

Chemical	Treatment		Mean
	Trial group	Control group	
AQ	12.98±1.57c	35.09±1.25a	24.04±2.50B
MA	17.52±1.23b	35.03±1.30a	26.28±2.02A
Mean	15.25±1.08B	35.06±0.88A	

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Table 3. Comparison of means for different concentrations of anthraquinone and methylanthranilate for wheat seeds against house sparrow.

Chemical	Conc.	Treatment		Mean
		Trial group	Control group	
AQ	0.25%	20.11±0.86c	31.54±1.62b	25.82±2.69ABC
	0.50%	13.20±3.13de	31.53±1.14b	22.36±4.36C
	0.75%	10.56±0.48e	38.91±2.17a	24.74±6.42BC
	1.00%	8.05±1.63e	38.38±0.64a	23.22±6.83BC
MA	0.25%	12.31±1.81de	35.08±2.06ab	23.69±5.24BC
	0.50%	19.83±1.00c	32.68±3.01b	26.25±3.20AB
	0.75%	20.45±2.26c	32.31±2.17b	26.38±3.00AB
	1.00%	17.51±1.86cd	40.06±0.33a	28.78±5.11A

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Videotapes behaviour

Videotaped examination was carried out with the help of two closed circuit cameras adjusted below the roof in the corners of each aviary. It was point out that house sparrows were influenced quickly by consuming wheat seeds treated with both repellents. All house sparrows displayed noticeable head-shaking and feather ruffling after few minutes of treatment exposure and less consumption was observed. House sparrows consumed anthraquinone treated seeds moderately after preliminary exposure, though some sparrows ate gradually for about 25 minutes and signs of discomfort and vomiting were observed. However, throughout the study no death was occurred.

Table 4. Analysis of variance for wheat seedlings against house sparrow.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Treatment (T)	1	226.592	226.592	26.28**
Chemical (Ch)	1	64.010	64.010	7.42*
Concentration (C)	3	50.581	16.860	1.96NS
T x Ch	1	5.929	5.929	0.69NS
T x C	3	73.906	24.635	2.86NS
Ch x C	3	9.930	3.310	0.38NS
T x Ch x C	3	14.292	4.764	0.55NS
Error	32	275.918	8.622	
Total	47	721.158		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01).

Table 5. Comparison of means between trial and control group and bird repellents for wheat seedlings against house sparrow.

Chemical	Treatment		Mean
	Trial group	Control group	
AQ	19.49±0.74	24.54±1.00	22.01±0.80B
MA	22.50±0.91	26.15±0.92	24.32±0.74A
Mean	21.00±0.65B	25.34±0.68A	

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05).

Discussion

The current study disclosed that anthraquinone and methylanthranilate possess a repellent capability when seeds and seedlings of wheat treated with both chemicals were provided to house sparrows in an aviary conditions.

Table 6. Comparison of means for different concentrations of both bird repellents for wheat seedlings against house sparrow.

Chemical	Conc.	Treatment		Mean
		Trial group	Control group	
AQ	0.25%	20.28±0.50	26.69±1.49	23.48±1.60
	0.50%	21.00±2.05	24.79±2.32	22.90±1.62
	0.75%	19.76±0.62	21.09±1.34	20.42±0.73
	1.00%	16.92±1.56	25.59±1.91	21.25±2.23
MA	0.25%	23.88±1.02	25.17±1.33	24.53±0.80
	0.50%	23.22±3.37	27.30±1.85	25.26±1.95
	0.75%	21.96±0.61	23.33±1.81	22.64±0.91
	1.00%	20.95±1.73	28.78±1.21	24.86±1.99

Table 7. Comparison between weight of house sparrow before and after treatment of experiment in control and trial group.

	Group	N	Mean	SD	SE	t-value	Prob.
Sparrow initial weight	Trial	10	22.94	3.91	1.24	0.42NS	0.678
	Control	10	22.17	4.25	1.34		
Sparrow final weight	Trial	10	21.62	3.99	1.26	0.28NS	0.780
	Control	10	21.09	4.35	1.38		
Sparrow weight decrease	Trial	10	1.32	0.89	0.28	0.66NS	0.519
	Control	10	1.08	0.74	0.23		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01)

SD = Standard deviation.

In the present experiment bird repellents showed highly significant results with anthraquinone and methylanthranilate in trail and control groups. Greater consumption was noticed in aviary-II which was control group as compared to aviary-I treated as trial group. It showed that bird repellents have deterrent effects against house sparrows and among chemical repellents, anthraquinone has more significant repellent effects than methylanthranilate. These results are very much coinciding with Avery *et al.* (2001); Werner *et al.* (2009) and Esther *et al.* (2013), who also found anthraquinone as more efficient avian repellent instead of methylanthranilate on different crops against birds.

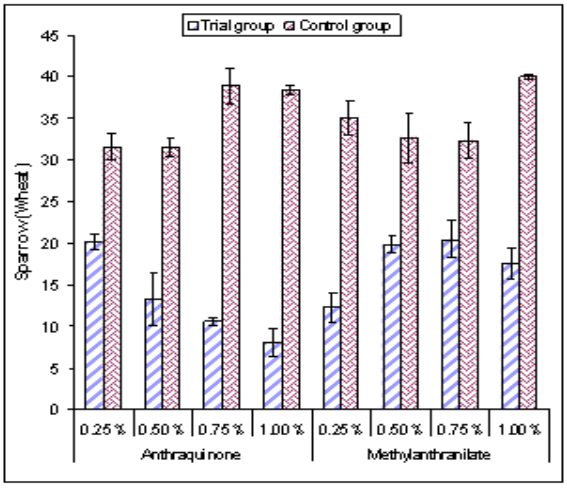

Fig. 1. Effectiveness of anthraquinone and methylanthranilate on wheat seeds against house sparrow.

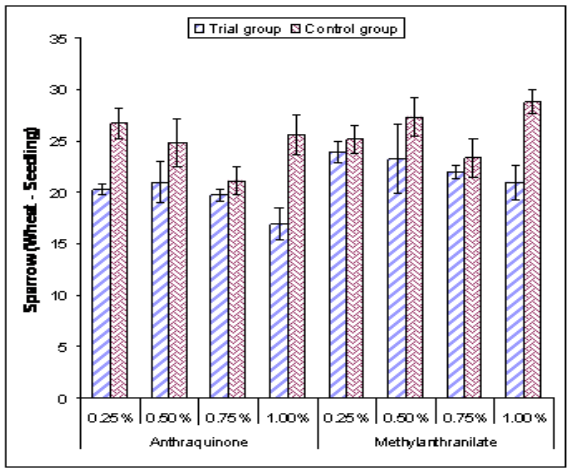

Fig. 2. Effectiveness of anthraquinone and methylanthranilate on wheat seedlings against house sparrow.

In the second phase of experiments when wheat seedlings were offered to house sparrow repellents demonstrated significant differences and anthraquinone displayed deterrent results instead of methylanthranilate this outcome was in harmonized with the finding of Cummings *et al.* (2011) and Werner *et al.* (2011) in which anthraquinone products confirmed sufficient to protect seedlings from blackbirds and pheasants depredations in field and captive experiments, respectively. However Esther *et al.* (2013) and Kennedy and Connery (2008) got reverse effects in both caged and field studies with pigeons and crows, respectively where both deterrent substances were unsuccessful.

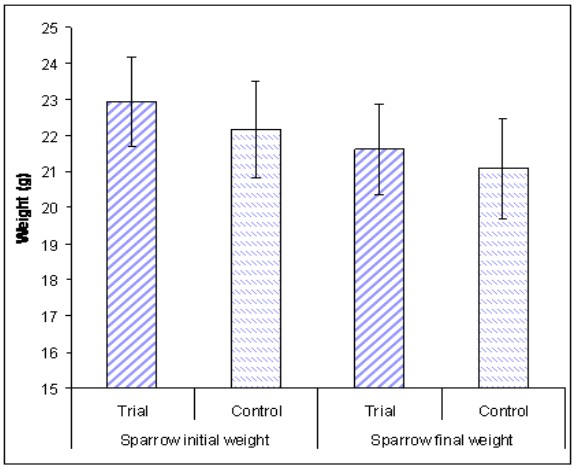

Fig. 3. Comparison of house sparrow's weight at the start and end of experiment.

The body weight of aviary-I birds throughout experiment was significantly not differing that was supported with the Avery *et al.* (1993) work. Insignificant illness, aching and queasiness behaviour was observed in some birds during videotaped observation. Mason and Bonwell, 1993; Avery *et al.*, 1993; Avery *et al.*, 1996 and Avery *et al.*, 2001, studied on red-winged blackbirds, brown headed cowbirds, grackle validated similar results with treatment of turpentine, insecticide, mint derivate and methylanthranilate. Additional fields research with same species under natural conditions and cost-benefit evaluations are immediately required for the evaluation of the repellent chemicals to minimize bird spoliation to the crops.

Conclusion

In caged trials, it has been seen that anthraquinone, is a more effective bird repellent than methylanthranilate against house sparrows when treated wheat seeds and seedlings were offered to the birds. And it is suggested that this bird repellent can be further assessed in the field trials on different crops in Pakistan against house sparrows.

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