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# Efficacy of methylanthranilate and anthraquinone against house crow (*Corvus splendens*) from maize seeds and seedlings in aviary conditions in Pakistan

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**Key words:** House crow (*Corvus splendens*), Anthraquinone, Methylanthranilate, Maize.

**Abstract**

The prevalence of vertebrate pests particularly birds and mammals bring about massive depredation to crops and fruits throughout the world. Among the birds, rose-ringed parakeets, house crows, house sparrows, common myna and a few others are very important from economic point of view in Pakistan. House crow is unquestionably the ruthless bird pest causes extensive damage not only to the seeds of valuable crops but also to seedlings. Different chemical repellents have been reported to manage the bird damage throughout the world. Present study was aimed to investigate the efficacy of methylanthranilate and anthraquinone against house crow to control the damage of maize seeds and seedlings in the captivity. By providing seeds and seedlings treated with different concentrations of repellents the best concentration was evaluated 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 in the aviary conditions. In whole experiment among trial and control group highly significant difference ($P<0.01$) was seen. Among repellents anthraquinone was found more effective than methylanthranilate and showed highly significant ($P<0.01$) difference when seeds of maize were offered to house crows while both methylanthranilate and anthraquinone have statistically non-significant ($P>0.05$) difference when seedlings of maize were provides to house crows. Among concentrations a highly significant ($P<0.01$) variation was computed. Videotaped examination pointed out that house crows were influenced quickly by consuming maize seeds treated with higher concentration of both repellent.

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**Introduction**

Various bird pests like crows, rooks, sparrows, pigeons, parrots, blackbirds, starlings, grackles and mynas cause serious economic losses to valuable crops and orchards all over the world. Cereal crops and fruit orchards are seriously affected fields of birds, their damage varies from field to field, area to area, country to country and also from climate to climate and the depredation also depends upon the type of bird's species in a particular area. Blueberries, grapes, apple, gooseberries and cherries and later on seed of green cherry fruits trees are more at risk of birds attack (Simon, 2008). Way (1968) observed more than 90% losses on cherry fields where as in Northeastern United States farmers of blueberry calculated 30% bird damage and according to Dellamano (2006), 10 % damage was recorded in USA at a cost of $10 million. Bird depredation has been found not only at mature fruits and crops but also at seeds and seedlings stages, for example house crows (*Corvus splendens*) causes severe damage to wheat seedlings in India (Dhindsa and Saini, 1994) and rooks (*Corvus frugilegus*) in Ireland (Kennedy and Connery, 2008). In subcontinent including Pakistan the house sparrow (*Passer domesticus*) and house crow (*Corvus splendens*) is very destructive pest in their nature and caused heavy damage to wheat and maize crops not only at milky and mature but also at seedling stages. In case of maize seedling damage due to house crow has become so severe in some areas that farming of certain crops is threatened. It is observed as important pest all over the regions where it found. It is highly reported species in cities, towns and villages where it generated significant noise and caused many hazards to human health. They damage fruits such as guava, pawpaw, mango, fig, stone fruits, grapes, apple, pear and also attacked on grain crops, including corn, wheat, and sunflowers (Department of Agriculture and Food, 2003; 2008). In many studies significant damage of 55% was recorded in wheat crops whereas 81% destruction was noticed in corn fields (Reddy, 1998; Dhindsa and Saini, 1994). Some growers reported the 100% losses to crops and replanting was required in some cases (Cummings *et al.*, 2002a). In the United States, top sunflower producing state is North Dakota and harvested at 404,68 ha area annually (Peer *et al.,* 2003) and currently maize also become a major crop. Throughout the world, farmers tolerate the birds depredations on cereal crops, vegetable, grain, and fruit. However, because of the difficulty of estimation losses due to birds, it hardly ever been calculated. Most researchers have placed losses at less than 5% in grain and seed crops, and less than 20% in vegetable crops and fruit (Boyce *et al.,* 1999; Coleman and Spurr, 2001; Avery, 2002).

In case of wheat crops damaged caused by house sparrow ranges from 2-11% being more prominent at maturity stage of crop (Rizvi *et al.,* 2002), whereas damage due to house crow has become so severe in some areas that tillage of certain crops is threatened. 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).

Different mechanical methods like reflecting ribbons, multi-mirror reflectors, bird scaring models, acetylene and gas exploders, horrible and explosive sound producing devices, netting and many chemical repellents of natural and artificial nature have been used to avert bird damage to different crops (Gilsdorf *et al.*, 2002; Day *et al.*, 2003). Other studies have proved that a single gas cannons is less effective to reduce bird damage. Potvin and Bergeron (1981) found no reduction in avian damage on corn field even a single gas cannons fired at every 2 minutes. In European, North American and Australasian region, mechanical repellents performed well where as in Pakistan their working is inadequate (Akram *et al.*, 2013). The treatment of seeds and seedlings with bird deterring chemical substances could be more beneficial, if we want to protect the crops grown on large scale areas. Agriculture is the backbone of Pakistan and the economic losses to crops and fruits

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. So, there is a need of active research to manage the bird damage. Therefore, this study was designed to ascertain the relative effectiveness of anthraquinone and methylanthranilate against house crow (*Corvus splendens*) on maize seeds and seedlings in captive conditions and the relative concentration of both repellents to repel best from treated seeds and seedlings of maize. Also the behavioural response of house crow against the untreated and treated food items was evaluated during the present studies.

**Materials and methods**

The study was conducted from July 2013 to November 2013 in two aviaries (large bird cages) placed in the vicinity of Wildlife and Fisheries Research Station and Botanical Garden at New Campus of Government College University Faisalabad. Aviary-I was taken as trial while aviary-II as reference (control) group. There was somewhat natural and undisturbed environment to the birds. Twenty house crows of undetermined sex and age were captured from the local area and tagged and released in two aviaries (ten in each) having dimension 12×12×8 feet (length × width × height). All birds were weighed at the beginning of the experiment on 01-07-2013.

*Acclimatization*

In the each aviary wooden bars, tree branches, and stones were provided for roosting and perching the birds. Two closed circuit cameras were also adjusted in the corners of each aviary to monitor the feeding behaviour and responses against the untreated and treated seeds and seedlings. Through the entire period of research, the water was provided *ad libitum* in each aviary to the crows. All the birds were provided grains, fruits, garden plants, and maize seeds *ad libitum* for a week of acclimatization period. Four food bowls were placed in each aviary.

*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 crows were taken, of these ten in aviary-I were treated as experimental group and ten in aviary-II as control group. After a week of acclimatization period treatment tests were carried out from July, 2013 to November, 2013 for three consecutive days for each concentration of both the repellents and each treatment was given for about three hours in every morning, whereas 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 crows by providing the seeds of maize 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 maize to the experimental birds in aviary conditions. For this purpose the 35g seeds of maize were grown in the pots. Four pots were placed in each aviary having seedlings and 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.

*Behavioral observations*

To observe the behavioral response of house crows against the different doses of both the repellents two closed circuit cameras in opposite corners of each aviary were adjusted in such a way that all the activities of birds were recorded in it.

*Statistical analysis*

For each experiment daily consumption was estimated by subtracting the weight remaining in bowls from the initial weight and also considered the weight of spilled seeds and the change in seeds weight as a result of desiccation every day. 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 with initial 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 maize seeds and seedlings against birds and then evaluated in a CDR (three factor) analysis of variance (ANOVA; Keppel, 1973) with repeated measures over measurements were concentrations (four levels) and treatments (two levels). LSD test were further used to isolate the significance difference among means. In each experiment change in body mass of birds when were released in the aviaries to the end of experiment was analyzed using the student t-test. Histograms were used for graphical presentation of present findings. All analyses were performed with Statistix version 10.

## Results

*Effect of both repellents on maize seeds against house crow*

Statistically highly significant ($P<0.01$) results were obtained between chemicals, treatments and concentrations. Interaction of treatment with chemical (T × Ch) was highly significant ($P<0.01$) while a non-significant ($P>0.05$) value was obtained between the interaction of concentration with treatment (T × C) and between chemical and concentration (Ch × C). A non-significant difference was recorded among the three way interaction of treatment, concentration and chemical (T × C × Ch) (Table 1).

**Table 1.** Analysis of variance for both repellents against house crow on maize seeds.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F-value |
|---|---|---|---|---|
| Treatment (T) | 1 | 593.75 | 593.754 | 44.78** |
| Chemical (Ch) | 1 | 590.38 | 590.382 | 44.53** |
| Concentration (C) | 3 | 289.55 | 96.516 | 7.28** |
| T x Ch | 1 | 480.70 | 480.700 | 36.26** |
| T x C | 3 | 40.10 | 13.368 | 1.01$^{NS}$ |
| Ch x C | 3 | 40.71 | 13.572 | 1.02$^{NS}$ |
| T x Ch x C | 3 | 34.44 | 11.480 | 0.87$^{NS}$ |
| Error | 32 | 424.26 | 13.258 | |
| Total | 47 | 2493.90 | | |

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

The mean consumption of maize seeds treated with anthraquinone and methylanthranilate was (30.81±1.73) and (37.82±0.68), respectively showed that anthraquinone is good bird repellent than methylanthranilate. While 30.80±1.69 and 37.83±0.77, mean consumption value of trial and control groups, respectively observed during the comparison (Table 2) and maximum repellency (19.40±2.30) observed at 1% concentration of anthraquinone (Table 3 & Fig.1). Statistical analysis verified that anthraquinone was more competent against the devastation of house crow on maize seeds instead of methylanthranilate.

**Table 2.** Comparison of means of both repellents for maize seeds against house crow.

| Chemical repellent | Treatment | | Mean |
|---|---|---|---|
| | Trial group | Control group | |
| Anthraquinone | 24.13±1.57a | 37.49±1.38a | 30.81±1.73B |
| Methylanthranilate | 37.47±1.17a | 38.18±0.75b | 37.82±0.68A |
| Mean | 30.80±1.69B | 37.83±0.77A | |

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 both repellents for maize seeds.

| Repellent | Concentration | Treatment | | Mean |
|---|---|---|---|---|
| | | Trial group | Control group | |
| AQ | 0.25% | 32.15±1.13 | 40.51±0.41 | 36.33±1.95 |
| | 0.50% | 22.77±0.59 | 37.09±3.19 | 29.93±3.52 |
| | 0.75% | 22.19±0.90 | 37.09±1.02 | 29.64±3.39 |
| | 1.00% | 19.40±2.30 | 35.26±4.81 | 27.33±4.27 |
| MA | 0.25% | 40.45±3.38 | 40.74±0.42 | 40.59±1.52 |
| | 0.50% | 37.35±1.96 | 36.79±2.17 | 37.07±1.31 |
| | 0.75% | 34.85±1.99 | 38.84±0.51 | 36.85±1.28 |
| | 1.00% | 37.23±1.77 | 36.33±1.00 | 36.78±0.93 |

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.

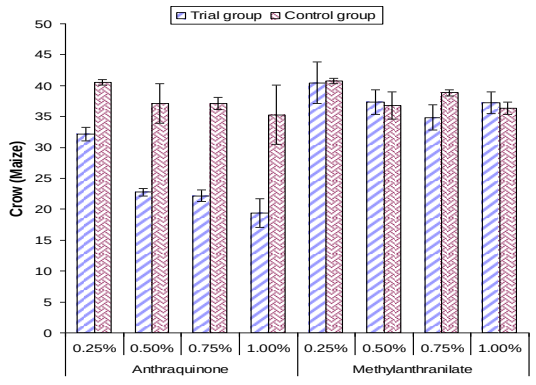


**Fig. 1.** Efficacy of anthraquinone and methylanthranilate on maize seeds against house crow.

*Effect of both repellents on maize seedlings against house crow*

Analysis of variance about maize seedlings showed highly significant differences (P<0.01) between treatment and control group (T), a non-significant difference was determined between different chemical repellents which are anthraquinone and methylanthranilate (Ch) and a highly significant difference (P<0.01) among different concentration (C) of both bird repellents was found. Interaction of treatment with chemical (T × Ch), between concentration and treatment (C × T) and between

chemical and concentration (Ch × C) was non-significant (P>0.05). Similarly a non-significant difference was recorded among the three-way interaction of treatment, concentration and chemical (T × C × Ch) (Table 4).

**Table 4.** Analysis of variance for both repellents against house crow on maize seedlings.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F-value |
|---|---|---|---|---|
| Treatment (T) | 1 | 274.04 | 274.037 | 8.97** |
| Chemical (Ch) | 1 | 4.77 | 4.769 | 0.16NS |
| Concentration (C) | 3 | 438.49 | 146.164 | 4.79** |
| T x Ch | 1 | 38.50 | 38.503 | 1.26NS |
| T x C | 3 | 41.38 | 13.794 | 0.45NS |
| Ch x C | 3 | 26.15 | 8.717 | 0.29NS |
| T x Ch x C | 3 | 92.91 | 30.970 | 1.01NS |
| Error | 32 | 977.13 | 30.535 | |
| Total | 47 | 1893.38 | | |

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

**Table 5.** Comparison of means maize seedlings treated with both chemical repellents against house crow.

| Repellent | Treatment | | Mean |
|---|---|---|---|
| | Trial group | Control group | |
| Anthraquinone | 41.66±1.41 | 48.23±2.20 | 44.95±1.45A |
| Methylanthranilate | 42.82±1.66 | 45.81±1.54 | 44.32±1.15A |
| Mean | 42.24±1.07B | 47.02±1.34A | |

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

**Table 6.** Comparison of means for different concentrations of both chemical repellents for maize seedlings against house crow.

| Chemical | Conc. | Treatment | | Mean |
|---|---|---|---|---|
| | | Trial group | Control group | |
| AQ | 0.25% | 45.29±3.20 | 55.92±4.95 | 50.61±3.55 |
| | 0.50% | 42.18±3.92 | 48.54±1.74 | 45.36±2.39 |
| | 0.75% | 41.38±0.83 | 45.76±5.06 | 43.57±2.49 |
| | 1.00% | 37.80±1.76 | 42.71±2.34 | 40.25±1.71 |
| MA | 0.25% | 47.26±2.24 | 48.60±4.15 | 47.93±2.13 |
| | 0.50% | 45.56±2.94 | 43.46±2.10 | 44.51±1.68 |
| | 0.75% | 41.25±3.73 | 44.95±4.25 | 43.10±2.66 |
| | 1.00% | 37.22±1.47 | 46.24±2.31 | 41.73±2.36 |

When compared the mean ± SE a non-significant difference was observed in the mean consumption of anthraquinone (44.95±1.45) and methylanthranilate (44.32±1.15). While a significant difference in mean consumption of maize seedlings in trial (42.24±1.07) and control (47.02±1.34) group was observed which showed the effectiveness of both bird repellents (Table 5) and at 1% concentration of both anthraquinone and methylanthranilate the smallest number 37.80±1.76 and 37.22±1.47 of maize seedling

consumption by crows respectively was observed (Table 6 & Fig. 2). The difference among concentrations showed that crow's seedling consumption was perceptible when sprayed with both repellents. Statistical analysis of crow maize seedlings treatment showed that anthraquinone and methylanthranilate were equally capable to minimize the damage.

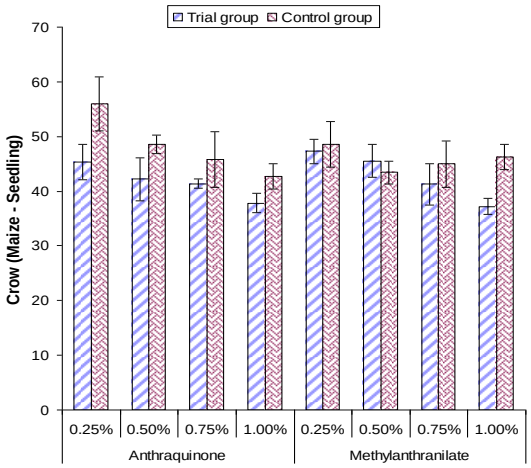


**Fig. 2.** Effectiveness of anthraquinone and methylanthranilate on maize seedlings against house crow.

*Weight of house crows*

Weight of birds was measured at the start and end of the experiment. Statistically non-significant (P>0.05) results were obtained by applying the t-test on the weights of bird. A non-significant result was obtained when compared the initial and final weight which indicated that repellents did not affect the weight of birds. Caged test birds maintained body weight and all seemed healthy when experiment was over (Fig. 3).

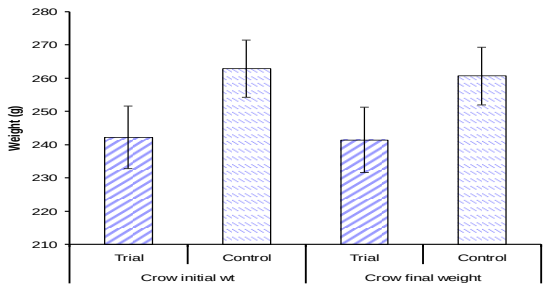


**Fig.3.** Comparison of means between weight of house crows at the start and end of experiment.

*Behavioral observation*

At higher concentrations of repellents a sign of pain, discomfort and feather ruffling was observed in house crow. Vomiting and frustration in the birds were observed with increased concentration of both repellents during the experiment. No change in overall body weight and physical fitness throughout the experiment of house crows was observed.

**Discussion**

The current study clarified that anthraquinone and methylanthranilate had a repellent potential when seeds and seedlings of maize treated with both these chemicals were provided to house crows in aviary condition.

In the first phase of experiment with house crow chemical repellents showed highly significant results between anthraquinone and methylanthranilate along with trail and control group. Greater consumption was notice 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 crow and furthermore, it has been seen that anthraquinone has higher repellent effect than methylanthranilate among these two bird repellents. Similar results were also obtained when methylanthranilate treated seeds were provided to different birds and similarly when anthraquinone treated seeds were offered to ring-necked pheasants (*Phasianus colchicus*), red-winged blackbirds (*Agelaius phoeniceus*), Canada geese (*Branta canadensis*), Dickcissels (*Spiza americana*), ducks and feral pigeons (*Columba livia*) depredations to seeds significantly becomes suppressed (Avery *et al.*, 2001; Werner *et al.*, 2009; Esther *et al.*, 2013). According to Linz *et al.* (2006), even in the absent of alternative food, anthraquinone significantly reduced the damage to seeds. Werner *et al.* (2009) also pointed out that anthraquinone is a typical escaping agent for the wild birds and so the birds can be repelled from the food items.

In the second phase of experiment when seedlings of maize were provided to the house crow a non-significant difference (P>0.05) was seen among the anthraquinone and methylanthranilate that indicate that in case of seedlings both repellents contained similar consequences, this difference in results may be due to evaporation of these repellent when sprayed on the seedlings in the pots. However Esther *et al.*, 2013 and Kennedy and Connery, 2008 got reverse effect in both caged and field study with pigeons and crows, respectively where both deterrent substances were unsuccessful. 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 behavioral responses were seen in some birds during videotaped observation. Avery *et al.,* 1993; Mason and Bonwell, 1993; Avery *et al.,* 1996 and Avery *et al.,* 2001 and studied on red-winged blackbirds, brown headed cowbirds, grackle corroborated results obtained with treatment of turpentine, insecticide, mint derivates and methylanthranilate. Additional fields research with same species under natural condition and cost-benefit evaluation are immediately required for the evaluation of the repellent chemicals to minimize bird spoliation to crops.

**Conclusion**

From all the findings of this study it has been concluded that anthraquinone with 1% concentration for maize seeds and seedlings was more effective against house crow when offered to the birds in an aviary conditions. And it is recommended that this bird repellent can further be utilized in the field study on crops in Pakistan and beyond against house crow.

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**References**

**Akram N, Khan HA, Javed M.** 2013. Inhibiting the house crow (*corvus splendens*) damage on maize growth stages with reflecting ribbons in a farmland. The Journal of Animal and Plant Sciences **23(1),** 182-89. http://www.thejaps.org.pk/docs/v-23-1/27.

**Avery ML, Decker DG, Fischer DL, Stafford TR.** 1993. Responses of blackbirds to a new insecticidal seed treatment. Journal of Wildlife Management **57 (3)**, 652-656.

**Avery ML, Decker DG, Humphrey JS, Laukert CC.** 1996. Mint plant derivatives as blackbird feeding deterrents. Crop Protection **15**, 461–464. http://dx.doi.org/10.1016/0261-2194(96)00010-5

**Avery ML, Tillman EA, Laukert CC.** 2001. Evaluation of chemical repellents for reducing crop damage by dickcissels in Venezuela. International Journal of Pest Management **47(4)**, 311-314. http://www.aphis.usda.gov/wildlife_damage/nwrc/publications/01pubs/01-1.

**Avery ML.** 2002. Behavioural and ecological considerations for managing bird damage to cultivated fruit. In D. J., Levey, W. R. Silva & M. Galetti (eds), *Seed dispersal and frugivory: ecology, evolution and conservation,* CAB International, Wallingford, UK. 467–477.

**Boyce L, Meister A, Lang S.** 1999. An economic analysis of bird damage in vineyards of the Marlborough region. Discussion Paper in Natural Resource and Environmental Economics No. 20. Massey University, Palmerston North, New Zealand.

**Coleman JD, Spurr EB.** 2001. Farmer perceptions of bird damage and control in arable crops. New Zealand Plant Protection **54**, 184–187.

**Cummings JL, Pochop PA, Engeman RM, Davis JE, Primus TM.** 2002a. Evaluation of flight control® to reduce blackbird damage to newly

planted rice in Louisiana. International Bio deterioration and Biodegradation **49**, 169-173.

**Day TD, Matthews LR, Waas JR.** 2003. Repellents to deter New Zealand's north island robin (*Petroica australis longipes*) from pest control baits. Biological Conservation **114**, 309-316.

**Dellamano F.** 2006. Controlling Birds with Netting: Blueberries, Cherries and Grapes. New York Fruit Quarterly **14 (2)**, 3–5.

**Department of Agriculture and Food**. 2003. Risk assessment for house crow (*Corvus splendens*). Department of Agriculture and Food, Perth.

**Department of Agriculture and Food**. 2008. Animal pest alert: house crow. National animal pest alert information sheet 2. Department of Agriculture and Food, Perth.

**Dhindsa MS, Saini HK.** 1994. Thiram protects sprouting wheat from house crows. International Pest Control **36**, 10-12

**Esther A, Tilcher R, Jacob J.** 2013. Assessing the effects of three potential chemical repellents to prevent bird damage to corn seeds and seedlings. Pest management science **69**, 425–430. DOI: 10.1002/ps.3288.

**Gilsdorf JM, Hynstrom JM, Vercauteren.** 2002. Use of frightening devices in wildlife damage management. Integrated Pest Management Review **7**, 29-45.

**Kennedy TF, Connery J.** 2008. An investigation of seed treatments for the control of crow damage to newly-sown wheat. Irish Journal of Agricultural and Food Research **47**, 79–91. http://hdl.handle.net/11019/630.

**Keppel G.** 1973. Design and analysis: a researcher's handbook. Prentice-Hall, Englewood Cliffs. New Jersey.

**Linz GM, Homan HJ, Slowik AA, Penry LB.** 2006. Evaluation of registered pesticides as repellents for reducing blackbird (Icteridae) damage to sunflower. Crop Protection **25**, 842–847. **DOI:** 10.1016/j.cropro.2005.11.006

**Mason JR, Bonwell WR.** 1993. Evaluation of Turpentine as a Bird- Repellent Seed Treatment. Crop Protection **12**, 453-457.

**Peer BD, Homan HJ, Linz GM, Bleier WJ.** 2003. Impact of blackbird damage to sunflowers: bioenergetic and economic models. Ecological Applications **13**, 248–256. http://www.jstor.org/discover/10.2307/3099963

**Potvin N, Bergeron JM.** 1981. Different modifications in the use of the acetylene cannon as a deterrent against blackbird damage to forage corn. Phytoprotection **62**, 22-32.

**Reddy VR.** 1998. Bird damage to maize crop on the student's research farm at Rajendranagar, Hyderabad, Andhra Pradesh. Pavo **36(1–2)**, 77–78.

**Rizvi SWA, Pervez A, Ahmed SM.** 2002. Evaluation of methiocarb 50%-WP as a taste repellent against the house Sparrow (*Passer domesticus l.)*. Turkey journal of zoology **26**, 131-135.

**Simon G.** 2008. A short overview of bird control in sweet and sour cherry orchards – Possibilities of protection of bird damage and its effectiveness. International Journal of Horticultural Science **14(1–2)**, 107–111.

**Way RD.** 1968. Breeding for superior cherry cultivars in New York State. In ISHS Symposium on Cherries and Cherry Growing, Bonn, Germany, 121–137.

**Werner SJ, Carlson JC, Tupper ST, Santer MM, Linz GM.** 2009. Threshold concentrations of an anthraquinone-based repellent for Canada geese, red-winged blackbirds, and ring-necked pheasants. Applied Animal Behaviour Science **121**, 190–196. http://digitalcommons.unl.edu/icwdm_usdanwrc/983.

**Witmer GW.** 2007. The ecology of vertebrate pests and integrated pest management (IPM). In M. Kogan and P. Jepson (eds.), *Perspectives in Ecological Theory and Integrated Pest Management.* Cambridge University Press, Cambridge, UK. 393-410.