Bird Deterrent Solutions for Crop Protection

Subjects: Agricultural Engineering

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Weeds, pathogens, and animal pests are among the pests that pose a threat to the productivity of crops meant for human consumption. Bird-caused crop losses pose a serious and costly challenge for farmers.

birds deterrents agriculture crops

1. Introduction

Pests, especially weeds, pathogens, and animal pests, pose a threat to the productivity of human-consumable crops. Bird-caused losses to fruit crops pose significant and expensive problems for farmers. Estimates on potential and actual losses caused by different bird species were discussed in a study carried out in Sweden between 2000 and 2015 [1]. During those years, there were 2194 complaints of crop damage, corresponding to a total loss of approximately 34,500 tons of various crops. The bird species that caused the most damage were, in order of the percentage of total losses from highest to lowest, the common crane (*Grus grus*) (33.7%), the barnacle goose (*Branta leucopsis*) (33.5%), the greylag goose (*Anser anser*) (26.6%), the bean goose (*Anser fabalis fabalis*) (2.6%), and the whooper swan (*Cygnus cygnus*) (2.2%). The remaining 1.4% of the total losses were caused by other birds.

Another study [2] aimed at finding out which bird species were directly related to crop damage. Visual damage was collected on 60 randomly selected plants: 12 at each cardinal point and 12 inland in New York State. It was focused on four different crops from 81 field locations: sweet cherry—23; blueberry—12; apple—24; and vine—22. Damages were estimated at 2.3% for apple fields, 3.6% for grapes, 22% for blueberries, and 26.8% for sweet cherries. In addition, surveys were also conducted on farmers with those crops via the Internet, mail, and telephone in New York, Michigan, Washington, Oregon, and California. New York farmers alone pointed out that, all together, they lose about $6.6 million per year and that 65.6% of them are taking measures to scare the birds away. Half of the farmers confirmed that birds are the biggest factor in crop loss.

A study conducted in Poland [3] concluded that, in the years 1974 and 1980, 22% and 16%, respectively, of cherry crops were destroyed by sturnids (*Sturnidae*). The same study also conducted another survey in four districts of Poland aimed at all crops. In Gdansk, 471 surveys were filled out, of which 27% stated with certainty that their fields were damaged by rooks (*Corvus frugilegus*), and 59% had suspicions that the damage that appeared on their crops was also caused by rooks. In Warsaw, 51% of 378 questionnaire respondents were certain that they had damage caused by rooks. In Kielee, 56% of 351 questionnaire respondents reported damage, and, in

Wroclaw, 58% of 276 questionnaire respondents also confirmed damage caused by rooks. In that same survey, overall bird damage was also collected for four crops: wheat, oats, corn, and barley. In the four districts, corn losses ranged from 22% to 32%, wheat losses from 10% to 13%, barley losses from 3 to 18%, and oat losses from 8 to 15%.

2. Visual Deterrents

Visual deterrents present a visual stimulus to the birds that can trigger fear or curiosity. The dangerous feeling can be triggered by a real or simulated predator. In the case of real predators, this can lead to birds' deaths. By contrast, there can be the use of something birds are not familiar with, such as scarecrows, dyes, lights, reflecting tape, optical gel, kites, balloons, or others. Some of these visual repellents can incorporate audio deterrents as well.

A summary of the studies that have considered visual deterrents is provided in **Table 1**.

Table 1. Summary of the studies using visual deterrents.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[4]	1990	Phalacrocoracidae	Aquaculture	Scarecrows/Sirens	Effective	N/A	The more realistic the facial and body shape, the more effective scarecrows are likely to be. They can be more detectable if they are painted in bright colors.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[5] [6]	1995, 1997	N/A	N/A	Scarecrows/ Lights/Sound	N/A	N/A	N/A
[7] [8] [9] [10] [11] [12]	1976, 1979, 1983, 1985, 1980, 1982	N/A	N/A	Scarecrows	Ineffective	Birds get used to it easily.	Short time application, needs to be used with other techniques.
[13] [14] [15]	1990, 1983, 1987	N/A	N/A	Scarecrows	Ineffective	Birds get used to it easily.	Relocate every 2–3 days.
[16]	1997	Streptopelia orientalis	Flight Cage	Scarecrows	Effective	N/A	Better than stuffed crows or kites.
[17]	1989	Turdus merula, Anas platyrhynchos, Anser anser	4–6 acres sunflower fields	Scarecrows/ Propane cannon	Effective	N/A	Ducks and geese spook more easily than blackbirds.
[18]	1974	Charadriiformes	Fishponds	Scarecrows	Ineffective	N/A	Birds get used to it after two hours.
[19]	1986	N/A	Various crops	Reflective Tape	Effective	May interfere with	Tape 0.025 mm thick and 11 mm wide.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
						walking on the terrain.	High winds may increase efficiency.
[20]	1986	Turdus merula	Crops	Reflective Tape	Effective	May interfere with walking on the terrain. If the tape gets twisted, it can be less effective.	Tape 3 m apart from each other at 0.5 to 1 m from the ground.
[21]	1990	Anser anser	20.2 hectares of winter wheat	Reflective Tape	Effective	May interfere with walking on the terrain if the tape gets twisted; it can be less effective.	20 mm thick red fluorescent tape. The lines were tied at 40 to 60 m between rows of wheat.
[22]	1998	N/A	Vineyards	Hawk Kites and Balloons	Ineffective	Birds get used to it easily.	Short-term utilization.
[23]	1983	N/A	Agricultural	Dead Bird Models	N/A	N/A	N/A

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[14] [24] [25]	1983, 1976, 1980	N/A	Airports	Dead Bird Models	N/A	N/A	N/A
[26] [27] [28] [29]	1985, 1986, 1987, 1990	Larus delawarensis	City	Dead Bird Models/Pyrotechnics/Falconry	Effective	N/A	The use of this method is recommended, but the positive results are partly due to the use of pyrotechnic material.
[22]	1984	N/A	Agriculture	Aircraft	N/A	Dangerous to the tripulants.	Not recommended
[14] [30] [31]	1983, 1967, 1990	N/A	Farms/Airports	RC Aircraft	N/A	N/A	N/A
[32] [33]	1975, 1981	Sturnidae, Charadriinae, Anser anser, Anas platyrhynchos	Airport, City	RC Aircraft	Very effective	Requires a highly skilled operator.	Birds may habituate slowly to a model aircraft that actively hazes them, especially if it has a falcon shape.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[34]	1987	Sturnidae	Roost	Lights/Predator Model	Effective	N/A	N/A
[24]	1976	Anas platyrhynchos	Grain Fields	Searchlights	Effective	May attract birds if it is nighttime or if the weather is cloudy or foggy.	It is recommended in certain weather conditions.
[35]	1975	Vanellinae, Larinae	Airport	Lights	Effective	N/A	N/A
[36]	1982	N/A	Airport	Lights	Ineffective	N/A	Whether the plane had its lights on or not, the results were the same.
[37]	1986	Corvus Corax, Pica, Cyanocitta cristata	Airport	Lights	Ineffective	N/A	Birds were more frightened by the plane than by the lights.
[38]	1992	Falco sparverius, Leucophaeus atricilla	N/A	Lights	May be effective	N/A	Lights that flash faster increase the birds' heart rate more in the short term,

March 2013; p. 180.

3. Pinowski, J.; Zając, Z.R. Damage to Crops Caused by Bird in Central Europe. In Granivorous Birds in the Agricultural Landscape; PWN: Warszawa, Poland, 1990; pp. 333–345.
4. Littauer, G. Avian Predators. Frightening Techniques for Reducing Bird Damage at Aquaculture Facilities; Southern Regional Aquaculture Center: Uvalde, TX, USA, 1990; Volume 401.
5. Stickley, A.R.; Mott, D.F.; King, J.O. Short-Term Effects of an Inflatable Effigy on Cormorants at Catfish Farms. Wildl. Soc. Bull. 1995.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
							but lights that flash more slowly manage to keep the average heart rate higher.
[39]	1976	N/A	N/A	Lights	N/A	N/A	Frequencies should not exceed 100 Hz.
[40] [41]	1976, 1976	Larinae, Sturnidae, Columba livia	N/A	Lights	Effective	No repellant effect was observed when the strobe light flashed at higher frequencies to 60 Hz.	Gulls delayed approaching a feeding point by 30 to 45 min.
[42]	1993	Falco sparverius, Leucophaeus atricilla	Laboratory	Lights	Ineffective	N/A	Birds did become attentive to the lights, but it did not necessarily mean that it frightened them away.

17. Nomsen, D.E. Preventing Waterfowl Crop Damage; Knittle, C., Parker, R.D., Eds.; United States Fish Wildlife Service: Washington, DC, USA, 1989.
18. Naggiar, M. Man vs. Birds; Florida Wildlife: Melbourne, FL, USA, 1974.
19. Bruggers, R.L.; Brooks, J.E.; Dolbeer, R.A.; Woronecki, P.P.; Pandit, R.K.; Tarimo, T.; Hoque, M. Responses of Pest Birds to Reflecting Tape in Agriculture. Wildl. Soc. Bull. 1986, 14, 161–170.
20. Dolbeer, R.A.; Woronecki, P.P.; Bruggers, R.L. Reflecting Tapes Repel Blackbirds from Millet, Sunflowers, and Sweet Corn. Wildl. Soc. Bull. 1986, 14, 418–425.
21. Summers, R.W.; Hillman, G. Scaring Brent Geese Branta Bernicla from Fields of Winter Wheat with Tape. Crop. Prot. 1990, 9, 459–462.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[14] [43]	1983, 1977	Anseriformes, Charadriiformes, Passer, Larinae, Turdus merula, Sturnidae	Oil Spill	Lights	Limited effectiveness	Ineffective to gulls (Larinae), blackbirds (Turdus merula), and starlings (Sturnidae).	50–60% success rate.
[11]	1980	Anseriformes	Oil Spill	Lights	Ineffective	N/A	N/A

Enterprises for Metropolitan Toronto and Region Conservation Authority: Downsview, ON, Canada, 1985; p. 24.

27. Watermann, U. Ring-Billed Gull Control Programme at Tommy Thompson Park; Report by U.W. Enterprises for Metropolitan Toronto and Region Conservation Authority: Downsview, ON, Canada, 1986; p. 26.

3. Auditory Deterrents

These are methods that use auditory techniques to deter birds. Most auditory deterrents also have a visual component.

A summary of the studies using auditory deterrents is provided in **Table 2**.

Table 2. Summary of the studies using auditory deterrents.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[44] [45] [46] [47]	1939, 1968, 1986, 1989	N/A	Fisheries operations	Shotguns and Rifles	Ineffective	Sometimes the birds die.	N/A
[17]	1989	N/A	Agricultural fields	Shotguns and Rifles	Ineffective	Sometimes the birds die.	N/A

Douglas Corp: Columbus, OH, USA, 1975; Volume 1.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[14] [48]	1983, 1988	N/A	Airports	Shotguns and Rifles	Ineffective	Sometimes the birds die.	N/A
[49] [50]	1988, 1991	Phalacrocoracidae, Ardeidae	Fish farms	Shotguns and Rifles	Ineffective	Sometimes the birds die.	Killing some birds only had temporary effects.
[22]	1998	N/A	Airport	Pyrotechnics	Effective	Birds get used to it easily.	Only used in an initial approach.
[24]	1976	N/A	N/A	Flares	May be effective	Fire hazard	In conjunction with other techniques, it can help to disperse the birds in a certain direction.
[51] [52] [53]	1980, 1981, 1986	N/A	Landfill sites	Pistols	Effective	N/A	Small area and short-term usage.
[54]	1991	Branta canadensis	Urban parks	Screamer shells	Very Effective	N/A	Long-term effects, the concentration of geese in the area was

Control of Bird Predation in Aquaculture and Fisheries Operations. 1988. Available online: https://tc.canada.ca/en/aviation/publications/evaluation-efficacy-products-techniques-airport-bird-control-03-1998-tp-13029/literature-cited (accessed on 15 December 2022).

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
							reduced by 88%.
[24]	1976	N/A	N/A	Mortars	May be effective	Highly skilled operator. Safety hazard; there have been several accidents related to the use of mortars.	If they produce a loud bang, they are more effective at daytime and in a larger area than other pyrotechnic devices.
[55] [56]	1974, 1990	N/A	N/A	Gas cannon	N/A	N/A	The noise of the explosion resembles or is louder than that of a 12-gauge shotgun.
[52] [53]	1981, 1986	N/A	Areas up to 4 ha	Gas cannon	Effective	N/A	Proven to be effective deterrents for areas up to 4 ha in the cases of nongame species.

65. Devenport, E.C. Wild Bird Control. County Program Addresses Health and Nuisance Problems. Environ. Health 1990, 53, 25–27.

66. Thompson, R.D.; Johns, B.E.; Grant, C.V. Cardiac and Operant Behavior Response of Starlings (Sturnus Vulgaris) to Distress and Alarm Sounds. In Proceedings of the Bird Control Seminar.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[57] [58] [59]	1984, 1990, 1990	Laridae	Landfill	Gas cannon and others	Effective	N/A	Gas cannons, in combination with other dispersal methods such as pyrotechnics, have been found to reduce numbers of gulls.
[14] [24]	1983, 1976	N/A	Various Crops	Av-alarm	Effective	N/A	AV-alarms appear to have been used successfully to reduce numbers of small birds.
[60]	1985	Sturnus vulgaris, Passer melanurus, Ploceus velatus	Grape culture	Av-alarm	Effective	N/A	Can be effective in reducing the damage to grapes.
[61]	1970	Sturnidae	Blueberry crops	Av-alarm and others	Effective	N/A	It worked better in conjunction with shotguns or

78. Conover, M.R. Comparative Effectiveness of Avitrol, Exploders, and Hawk-Kites in Reducing Blackbird Damage to Corn. J. Wildl. Manag. 1984, 48, 109.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
							propane cannons.
[62]	1978	Telluraves	Cornfields	Av-alarm and gas cannon	Effective	N/A	Better results were obtained by combining both methods.
[63]	1983	N/A	N/A	Av-alarm	Ineffective	N/A	AV-alarm was not as effective as distress calls in repelling birds.
[64] [65]	1990, 1990	N/A	N/A	Av-alarm	Ineffective	Birds accustomate to this sound.	Birds accustomate to this sound.
[66]	1979	Sturnidae	N/A	Av-alarm	Ineffective	N/A	Starlings only increased slightly the heart rate when they were exposed to AV-alarm.
[67] [68]	1973, No	Aequornithes	Aquatic terrain	Av-alarm	May be effective	N/A	Insufficient details to

https://www.legislation.gov.uk/uksi/1981/1653/contents/made (accessed on 25 December 2022).

92. Ueckermann, E.; Spittler, H.; Graumann, F. Technische Maßnahmen Zur Abwehr Des Graureihers(Ardea Cinerea) von Fischteichen Und Fischzuchtanlagen. Z. Jagdwiss. 1981, 27,

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
	date						assess changes in bird numbers.
[69] [70]	1973, 1968	Laridae	Airport	Predator Sounds	Effective	N/A	The playback of a Peregrine Falcon call was effective at dispersing gulls.
[71]	1957	Anas platyrhynchos	Ponds	High-intensity Sounds	Effective	Can cause hearing damage and other human health effects.	Some birds vacate the pond after two or three days.
[72]	1986	Laridae	N/A	Ultrasounds	Ineffective	N/A	Found no evidence that gulls either heard or reacted to ultrasounds.
[73]	1992	N/A	N/A	Ultrasounds	Ineffective	N/A	Bird population did not decrease in more than 5%.

Hazards National Research Council Canada; Kuhring, M.S., Ed.; Cambridge University Press: Cambridge, UK, 1970.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[74]	1996	N/A	N/A	Infrasounds	Ineffective	N/A	Birds do not associate these sounds with danger.

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National Research Council Canada: Ottawa, ON, Canada, 1976; pp. 41–47.

4. Chemical Deterrents

Chemical aversion techniques have been used in a variety of contexts, from residential areas [75][76] and cities, to agriculture and airports [77][78][79]. Birds do not tend to get used to these types of techniques.

A summary of the studies that have considered chemical deterrents is provided in **Table 3**.

Table 3. Summary of the studies using chemical deterrents.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[75] [76]	1988, 1990	N/A	Residential area	Chemical	N/A	N/A	Birds tend to not get used to it.
[77] [78] [79]	1976, 1984, 1988	N/A	Cities, agriculture, and airports	Chemical	N/A	N/A	Birds tend to not get used to it.
[80]	1997	Sturnidae	Laboratory	Tactile repellents	May be effective	N/A	It may be possible to develop non-lethal, plant-based dermal repellent.

10. Eastick, S.H. Wetting as a Means of Bird Control. In Proceedings of the Bird Control Seminar 7; National Research Council Canada: Ottawa, ON, Canada, 1976; pp. 41–47.
10. Glahn, J.F.; Stickley, A.R., Jr.; Heisterberg, J.F.; Mott, D.F. Impact of Roost Control on Local Urban and Agricultural Blackbird Problems. Wildl. Soc. Bull. 1991, 7, 511–522.
10. Dolbeer, R.A.; Mott, D.F.; Belant, J.L. Blackbirds and Starlings Killed at Winter Roosts. In Proceedings of the Eastern Wildlife Damage Management Conference 7; National Research Council Canada: Ottawa, ON, Canada, 1997; pp. 77–86.
11. Mikx, F.H.M. Goshawks at Leeuwarden Airbase. In Proceedings of the World Conference on Bird Hazards; Kuhring, M.S., Ed.; National Research Council Canada: Ottawa, ON, Canada, 1970; pp. 203–205.
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11. Blokpoel, H. Gull Problems in Ontario; Canadian Wildlife Service: Ottawa, ON, Canada, 1980.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[22]	1998	N/A	N/A	Tactile repellents	May be effective	N/A	Plant compounds that have been tested caused agitation and hyperactivity in the birds.
[22]	1998	N/A	N/A	Behavioral Repellents	N/A	Can cause disorientation and erratic behavior.	N/A
[14] [81] [82]	1983, 1983, 1990	N/A	N/A	Behavioral Repellents	Effective	If the dose is too high, it can lead to the bird's death.	Unaffected birds from the flock eventually escape due to the warning signal from the flock mate.
[14] [81] [82] [83] [84] [85]	1983, 1983, 1990, 1970, 1973, 1970	Sturnidae, Turdus merula, Passeriformes, Laridae, Corvus Corax	Air bases	Behavioral Repellents	Effective	N/A	N/A
[22]	1998	Branta Canadensis, Laridae, Sturnidae	Laboratory, sanitary landfill, airports	ReJeX-iT	Effective	N/A	ReJeX-iT can be effective at deterring birds in certain situations, but

131. Knorr, O.A. The Effect of Radar on Birds. Wilson Bull. 1954, 66, 264.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
							the doses used in some studies were not effective.
[86]	1992	Anas platyrhynchos, Branta Canadensis	Laboratory	Dimethyl and Methyl anthranilate	Very Effective	N/A	When subjected only treated grain, both ducks and geese reduced their food intake.
[87]	1995	Larus delawarensis, Larus argentatos, Anas platyrhynchos	Pools of water in fields	Methyl anthranilate	Effective	N/A	N/A
[88]	1996	Branta Canadensis	N/A	Methyl anthranilate	Ineffective	N/A	Product concentration used in [87] did not repelled this species.
[89]	1993	N/A	Ponds at airports	ReJeX-iT	Effective	N/A	Bird numbers decreased in treated ponds.

5. Exclusion Deterrents

These are devices or materials used to serve as a physical barrier. If access to a certain area, for example, where there is food or shelter, is restricted, the birds will leave the area and move on. There are also apparent barriers (i.e., there is no actual barrier).

Physical barriers are normally made up of wire mesh, polyethylene, or other synthetic materials and serve to prevent birds from approaching a specific area. They also serve to prevent them from nesting in these areas. The metal mesh can also be interconnected with electrified wires so that when birds land there they receive a harmless shock [90][91][92].

A summary of the studies that have considered exclusion deterrents is provided in **Table 4**.

Table 4. Summary of the studies using exclusion deterrents.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[90] [91] [92]	1978, 1981, 1981	N/A	N/A	Exclusion	N/A	N/A	N/A
[93]	1936	Aequornithes	Aquaculture ponds	Overhead Wires and Lines	Effective	N/A	Recommended as a method of deterring waterbirds from fishponds.
[52]	1981	N/A	Fish-rearing facilities	Overhead Wires and Lines	N/A	N/A	N/A
[94]	1990	Aequornithes	N/A	Overhead Wires and Lines	Effective	N/A	The effectiveness of overhead wires or lines varies widely among species and circumstances.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[22]	1998	N/A	Fruit trees	Overhead Wires and Lines	Effective	High costs and difficult application in large areas.	It solves the problem of the presence of birds in a permanent way.
[22]	1998	N/A	Sanitary landfill	Foam	May be effective	Its effectiveness would be reduced in rainy or windy weather.	It could be used to cover small areas that are particularly attractive to birds.
[22]	1998	N/A	Lakes, ponds…	Bird Balls	May be effective	N/A	Are very easy to install and require significantly less maintenance.

6. Habitat Modification

Habitat modification is the removal or alteration of the natural characteristics of a site. It may include trees and shrubs, the removal of ponds, planting in areas without flora, planting crops that are not attractive to birds, such as tall grass, eliminating possible nesting areas, the use of exclusion methods barriers, and even chemical agents used in the birds' natural foods.

A summary of the studies that have considered habitat modification methods is provided in **Table 5**.

Table 5. Summary of the studies using habitat modification methods.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[95]	1968	N/A	N/A	Tall Grass	N/A	Long grass can attract	Prevents some birds from accessing food.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
						rodents and birds of prey.	
[96]	1996	N/A	Airport	“Poor grass”	Effective	N/A	Bird numbers on poor grass were as low or lower than on long grass.
[97]	1996	N/A	N/A	Mowing at nighttime	Not Tested	N/A	Mowing late in the day or overnight can reduce the attractiveness of this activities.
[98]	1997	N/A	Airport	Mowing at nighttime	Effective	N/A	Mowing late in the day or overnight can reduce the attractiveness of this activities.
[99]	1988	Laridae	Landfill	Changing water/feeding zones	Effective	N/A	By removing the water/food, the area is no longer attractive to birds.

7. Removal Deterrents

This method consists of catching birds and releasing them away or eliminating them, either with traps, poison, or the use of lethal ammunition. It is a method that requires skills to be used, because it may use materials that can be lethal to humans as well. Using lethal methods would only work in the short term and only reduce the bird’s local population.

A summary of the studies that have considered removal deterrents is provided in **Table 6**.

Table 6. Summary of the studies using removal deterrents.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[100]	1968	Agelaius	Corn fields	Traps	Ineffective	N/A	Due to the number of birds in the group, it is impossible to catch them all.
[101] [102] [103]	1974, 1987, 1990	N/A	N/A	Traps	N/A	N/A	N/A
[90]	1978	Butorides virescens	Fish farm	Traps	Effective	Transportation costs	The birds were released 40 km from the point where they were trapped, and never came back.
[7] [104] [105]	1976, 1970, 1986	Larinae	Airport	Live Ammunition	Ineffective	Birds habituate easily.	It was seen that in the short term it was effective
[106] [107] [108] [109]	1968, 1970, 1976, 1991	N/A	N/A	Surfactants	N/A	N/A	N/A
[110]	1997	Turdus merula, Sturnidae	N/A	Surfactants	Effective	38.2 million blackbirds and starlings were killed between 1974–1992.	PA-14 did solve local roost problems.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[104]	1976	Laridae	Airbase	Falconry, Pyrotechnics	Effective	It was necessary to replace two falcons each year.	Four goshawks were successfully used at an airbase in Holland to clear the runways from gulls.
[111]	1970	Laridae	Airbase	Falconry	Effective	N/A	Gulls showed no signs of habituating to the goshawks during the two-year study.
[112]	1996	Laridae	Military Airfield	Falconry	N/A	N/A	Not recommend as a routine method for bird control at civil airfields.
[113]	1978	Laridae	Airfields	Falconry, Pyrotechnics, Model Gulls	N/A	N/A	N/A
[26] [27] [28]	1985, 1986, 1987	Branta Canadensis	Airfields	Falconry	Ineffective	N/A	N/A

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[114]	1983	Columba palumbus	Brassica fields	Falconry	Ineffective	N/A	After repeated attacks by the goshawk, the pigeons usually resettled and continued to feed.
[115]	1978	Laridae	Landfill	Falconry	Very effective	Some birds died	The effectiveness seemed to derive from the cumulative effects of several bird control episodes.
[22] [116] [117]	1998, 1965, 1980	Laridae	N/A	Falconry	N/A	Falcons cannot fly with bad weather.	Dealing with gulls with bad weather is a problem.

8. Other Deterrent Techniques

A summary of the studies that have considered other deterrent techniques is provided in **Table 7**.

Table 7. Summary of the studies using other deterrent techniques.

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
[118]	1976	Anseriformes	Agriculture	Lure Area	N/A	N/A	Attracting and holding birds

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
							so that they will not go elsewhere.
[119] [120] [121] [122]	1975, 1974, 1978, 1981	N/A	N/A	Magnetic Field, Microwaves	N/A	N/A	N/A
[123]	1997	Sturnus vulgaris	N/A	Magnetic Field	Ineffective	N/A	Only been proven to disorient birds and not to disperse them.
[124] [125]	1971, 1973	N/A	N/A	Microwaves	N/A	N/A	N/A
[126]	1985	N/A	N/A	Microwaves	N/A	N/A	N/A
[127] [128]	1965, 1969	Laridae, Melopsittacus undulatus, Gallus gallus domesticus, Columbidae	Laboratory	Microwaves	N/A	The radiation levels are considerably higher than the levels that are safe for humans.	N/A
[74] [129] [130] [131] [132] [133]	1996, 1946, 1949, 1954,	N/A	N/A	Microwaves	N/A	N/A	Few studies have reported that radars have caused behavioral

Author	Year	Bird Species	Area	Deterrent Technique	Success Rate	Negative Aspects	Conclusions
	1971, 1972						changes in flying birds.
[134] [135]	1972, 1965	Sturnidae, Anas platyrhynchos, Laridae	Laboratory	Laser	N/A	Could cause hemorrhage in birds' eyes.	Not recommended
[136]	1980	Laridae	Landfill	Laser	Ineffective	N/A	Not recommended