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Utilization Sonic Waves for Birds Controlling in Crops Field

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ABSTRACT

Pest bird damage in agriculture is a significant and long-standing problem globally especially for high value field crops such as wheat, rice and corn. The present study aims to control the pest birds in the field crops by using sonic waves. The study treatments were sonic waves frequency under four levels of 1, 3, 5, and 7 kHz; exposure time intervals of 1, 5, and 1 0 minutes; field measuring distances of 0, 30 and 50 m and the daily measuring period sunshine and sunset. The obtained results revealed that the sound pressure level (dBA) of sonic waves repeller was negatively affected with levels of device frequency (kHz), exposure time intervals (min) and measuring distance in the field. However, the bird's departure time (min) was positively affected with levels of device frequency and with exposure time. While, the similar effect was obtained for bird's departure time at measuring distance in the field. Finely the results indicated strongly that the most important factors were the frequency and the exposure time which consider effective in pest birds deterrent for the target species mentioned in this study. Low frequency (1; 3 kHz) which increase scaring influence to the pest birds was greater than the high frequency and caused high levels of sound pressure levels (SPL). Also, in the birds departure time Dove, Pigeon and Sparrow flock never returned to the initial position to attack the field crops after only 5 min, but Crow after only 10 min.

Keywords: bird repeller control, frequency range, environmentally friendly, decibel.

INTRODUCTION

Birds were taken into account as one of the most interesting animals to retain it out of agricultural fields. Farmers attempt few methods to frighten them, containing visual, auditory and physical resources. While some of these procedures work some of the time, none provide stand-alone security all the time. Lately there has been attention in developing technology-based results for example sonic and ultrasonic waves for bird deterred control in agricultural field (Rivadeneira *et al.* 2018; Baral *et al.* 2019). Bird kinds cannot be classified as good or bad. A particular bird may be helpful or harmful to man's concerns depending upon its actions at a specific time and place. The expression "pest bird" talks about a single, group, or population causing economic destruction or making a health or safety risk by its actions at a given time and place (Vincent and Roy 1980).

Inhabitants of some birds, which are fit, modified to live on agricultural crops, have enlarged extremely in number and turn into pests. Such bird species as doves, pigeons, sparrows, parakeets, weaver birds etc. These birds are frequently considered as pests and if their influence on agriculture is sufficient to impose severe harm, their inhabitants becomes the objective of huge management or control works. A survey of the NewZealand farmers by the nation's Plant Protection Society, exposed that great percentage of them had come upon crop harm from birds (Coleman and Spurr, 2001).

The most familiar national birds are pigeons (*Columba liviadomestica*), sparrows *(Passer domesticus*), starlings *(Sturnus vulgaris*), Common myna (*Acridotheres tristis*), Jungle myna (*Acridotheres fuscus*), crows (*Corvus splendens*) and blackbirds (*Turdus merula*) in India as well as in several countries in the earth (Pandiyan *et al.* 2019; Saglam and Onemli, 2005; Avery *et al.*, 2005). Pesticides are materials or a mix of materials consumed for terminating, avoiding, deterring or justifying pests. To solve the beyond trouble ecofriendly tool can be used for deterring pest and insects, the use of an electronic device which can apply sonic or ultrasonic sound waves to deter pest. The mechanical method of controlling pest includes generating sounds mechanically to fright pests left. It also includes setting of tricks, the use of weapons and other mechanical ways to destroy pests. Any pest can be controlled by sound. Fireworks, balls horns and other noise fabricators have been used in bird control (Ezeonu *et al.* 2012; Khapare *et al.* 2015; Simeon *et al.* 2013, Tiwari and Ansari 2016).

Sonic bird control system is fitting familiar in the bird control division. It makes a diversity of electronically-generated sounds normally releasing noise amounts up to 120 dB (A) and is designed to scare birds with forceful and horrible noises. Sonic noise is sound that is easy to hear to the human ear. Alarm sounds are made when the bird identifies itself to be in threat, distress calls are prepared when the bird is in hurt or has been attacked by a hunter and hunter calls are hollers made by a destructive bird. Distress calls, alarm calls and predator calls are audible to the human ear. Most sonic systems are drove by mains electricity (AC current) for improve of use and in an work to decrease the need for human interface, but a common of systems also present a battery-powered possibility (DC current) and in some cases a solar panel option. Thus, the sound waves that frightened the birds were significantly under ultrasonic frequency (Griffiths, 1987 and Erickson *et al.* 1992)

The internal ear of birds assists two purposes: equilibrium and hearing. Hearing takes location in the

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cochlea. Contrasting the twisting mammalian cochlea, the avian cochlea is a straight or slightly curved tube whose length varies as well as species. In pigeons (Columba livia) it is about 5 mm lengthy but over 1 cm in the owl *(Tyto* alba) (Smith 1985). The variances in length, both among avian species and among birds and mammals, probably reveal changes in the frequencies that the species can identify. Longer cochlea let for more auditory receptors and better feeling to either a larger range of frequencies or better resolution between frequencies. The auditory sensory are the hair cells, which are alike in formula and purpose to those of other vertebrates. These cells are outfitted with cilia that are moved by the vibrations in the fluid of the cochlea. As the changes in cilia lengths and the locations of the cells along the basilar membrane, single cells are most precise to specific frequencies; i.e., they are changed to a limited band of frequencies. Thus, the information forwarded to the brain includes encoded frequency information. Another species of birds have the most sensitivity to sounds within a quite narrow range. For most avian species this is around 1 - 4 kHz, but some species are sensitive to minor or senior frequencies (Hienz *et al.* 1977; Robert 2004). Pigeons are greatest sensitive to sound among 1 – 2 kHz, with a certain upper boundary of about 10 kHz (Goerdel-Leich and Schwartzkopff 1984). No one of the avian species that have been inspected has revealed sensitivity to frequencies above 20 kHz (ultrasound) and mostly the upper limit is about 10 kHz (Hamershock 1992 and Necker 2000). Sensitivity to sound (less than 20 Hz) has been perceived in the pigeon and in some other species but not in all species experimented (Yodlowski *et al.* 1977; Kreithen and Quine 1979 and Theurich *et* al. 1984). Optimum hearing act for extremely bird species is attained between 1,000 and 4000 Hz. Upper limit hearing sensitivity be able to approximate 30,000 Hz in several species. Greatest bird species do not display significant hearing abilities within the ultrasonic range in most cases; birds have larger hearing capacity than humans. Birds can categorize sonic frequency changes 10 times faster than man and some (song birds) can create and detect two modulated sounds or "notes" simultaneously. To the human ear these modulations sound like one note (Meyer 1986; Vikrant 2015).

Sound has been used in tries to retain birds out of man's field crops ever since they and man have differed to whom the crops fitted. It is a physical disturbance in a medium that is capable of actuality perceived by the human ear. The medium of sound waves transportable included mass and elasticity. Sound waves will not travel through a vacuum. The protection of the environment (POE) Turn likewise contains noise in the description of environmental contamination, which includes the starter to an environmental medium, Noise has been expressed as any sound which has the ability to cause disturbance, discomfort or psychological stress to a subject subjected to it (EPA. 2006).

Anthropogenic noise is one of the major contributors to environmental contamination around urban areas (WHO 1999). Recognition threshold changes can result from revealing to very great noise levels, noise persuaded hearing loss happens when disruption by noise set off internal and external hair cell loss and auditory nerve collapse. Destruction to the hair cells can be a cause of revelation to a single impulse noise of a very great level, or as a result of regular exposure to lower noise levels. Birds display threshold shifts after exposure to amplitudes of 75 dB (A) (Gannouni *et al.* 2015; Smith *et al.* 2004; Dooling and Popper 2007). Noise also disturbs interaction and animals that depend on acoustic signaling, for example birds, can be mainly sensitive to rises in environmental noise (Slabbekoorn and Ripmeester 2008).

The sensitivity to sound intensity is affected by the frequency of the sound. This represents that if a human can hear a weak sound, birds at the same location might not be able to hear it. Overall, birds hear well over a limited frequency range, but not as well as humans. Large, nightly owls are the exception in that they can hear well over a wide frequency range (Smith 1985). Noise (and sound) is usually calculated on the decibel scale, which is a logarithmic scale, based on a ratio to a reference level (20 micropascals). The sound pressure level (L*p*) in decibels dBA, corresponding to a sound pressure, *p* is defined by:

$$\mathbf{L}\boldsymbol{p} = \mathbf{10\ log\ 10}\left(\frac{\boldsymbol{p}}{\boldsymbol{p0}}\right)^{\mathbf{2}} = \ = \mathbf{20\ log\ 10}\left(\frac{\boldsymbol{p}}{\boldsymbol{p0}}\right)$$

Where:

***p* is the sound pressure level, p_0 is the reference sound pressure level of 20 micropascals (µPa) (Duncan *et al.* 1994; FMO. 1974; Pater *et al.* 2009). The objective of this research is to study the pest bird's control in field crops by using sonic waves as a bio friendly way in deterring birds from areas.**

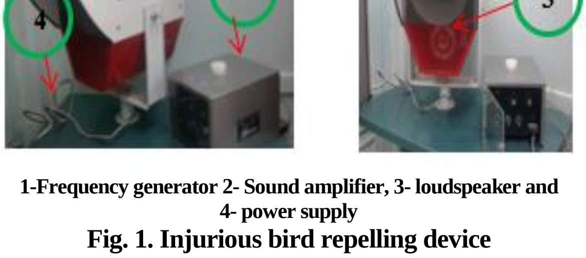
MATERIALS AND METHODS

Sonic waves bird control

The sonic waves bird control is used for spreading the pest birds by sound waves that creates them painful and uncomfortable, this device usually employed by the farmer to stay pest birds away from treated areas to protect these areas against bird damage and save it in a good condition. The farmers may be use this device alone or with any of a number devices in the field according to its effect covering radius and field area.

The main components of the sonic waves bird device used in this experiment are frequency generator, sound amplifier, loudspeaker and power supply as shown in Fig. (1). However, The main specifications are summarized as follows:-

Dimensions : 25 x 30 x 45 cm
Covered area: up to 70 m radius
Weight : 4 Kg
Power requirements: 110 or 220vAC or 12vDC (110vAC adapter included)
Sound pressure: 110 dB @ 1 meter.
Frequency : 50 Hz - 10 kHz



1-Frequency generator 2- Sound amplifier, 3- loudspeaker and 4- power supply

Fig. 1. Injurious bird repelling device

Experimental procedure and study variables

The field experiments were conducted in the Rice Mechanization Center, Meet Eldeyba, Kafr El-Sheikh, AENRI, ARC, during the spring, summer and autumn of 2019 after corn crop planting in the field and during harvesting both of wheat and rice crops.

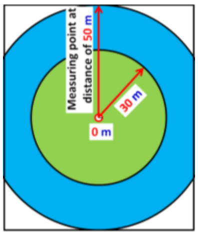
The experiments of the sonic waves bird control was performed on four selected birds which were familiar to be seen such as Dove *(Spilopelia senegalensis),* Crow *(Corvus cornix),* Pigeon (*Columba livia*) and Sparrow *(Passer domesticus).* The response of these pest birds was checked under different sonic waves frequency levels and exposure time intervals.

Two periods were used to repel the pest birds in the morning (sunshine from 5-8 a.m.) and in the afternoon (sunset from 5 to 6 p.m.) where birds were most active during those hours. The study was conducted in an area (about two feddans) where covered with the crops and plenty of tens of intensively used by domestic birds for their roosts in it. The measuring readings of device sound were located at 3 points. Firstly at the center of the field, (0 m), then by increased the distance up to 30 m and at the field head (50 m distance) as shown in Table (1).

Therefore, the study treatments were arranged from the study variable combinations of the device sonic waves frequency levels, the exposure time interval and the distance from the center of the field up to the field head, by using four blocks (replicates) for sunshine and sunset two blocks for each (measuring periods) as shown in Table (1).

Table 1. The study variables and their levels

Variable	levels	values
1- Sonic waves frequency levels	4	1 ; 3 ; 5 and 7 kHz
2- Exposure time intervals	3	1 ; 5 and 10 minutes
3- Decided measuring distance from field center to field head	3	Zero; 30 and 50 m
4- Daily measuring period	2	Sunshine, sunset (replicates)



Field measuring distances

During applying sonic wave using bird control in this experiment we used the data of sound limits for different pest birds which might be expected, species differ in their sensitivities and range of sensitivities to frequencies of sound as shown in Table (2).

Table 2. Species-specific sensitivities to frequencies, peak sensitivity, and range of sensitivities

Species	Lower Limit (HZ)	Most Sensitive (kHz)	Upper Limit (kHz)
Dove *(Spilopelia senegalensis)*	50	1.8 – 2.4	11.5
Crow *(Corvus cornix)*	300	1-2	8
Pigeon (*Columba livia*)	20	1-2	10
House Sparrow *(Passer domesticus)*	675		11.5

Study measurements and measuring instrumentation

Sound pressure level

Sound level meter model SL-4023SD was shown in Fig. (2). While the main specifications were summarized as follows**:**

Circuit: Custom one-chip of microprocessor LSI circuit.

Display: LCD size: 52 mm x 38 mm, LCD with green backlight (ON/OFF).

Measurement Range: 30 - 130 dB.

Resolution: 0.1 dB.

Function: dB (A & C frequency weighting), Time weighting (Fast, Slow), Peak hold, Data hold, Record (Max., Min.).

Accuracy (23 ± 5 ℃): Characteristics of "A" frequency weighting network meet IEC 61672, class 2. Under 94 dB input signal, the accuracy (31.5Hz ± 3.5 dB, 63 Hz ± 2.5 dB, 4 kHz ± 3.6 dB, 8 kHz ± 5.6 dB)

Frequency Weighting Network: Characteristics of A & C.

Data hold: To freeze the measurement value.

Time weighting (Fast & Slow): Fast - t= 200 ms, Slow - t = 500 ms

Range selector: Auto range: 30 to 130 dB.

Frequency: 31.5 to 8 kHz.

Power Supply: Alkaline or heavy duty DC 1.5 V battery (UM3, AA) x 6 PCs.

Weight: 489 g.

Dimension: 245 x 68 x 45 mm.

Fig. 2. Sound level meter

Bird's departure time

It is defined as the time needed for pest bird to completely leave the treated area by using stopwatch and digital camera.

Stopwatch

To record the time consumed during bird's departure time from the initial location to come back again to the field during experiments

Digital camera (Infinity IDC 5068)

To record the pictures of bird's departure time from the initial location to come back again to the field during experiments

Data analysis

A factorial experiment according to randomized complete blocks design RCBD of field layout design was taken. The sunshine and sunset were taken as replications (blocks). The data were processed for frequencies procedure and analysis of variance using statistical package for social science, SPSS version 20 software and a probability value of $p \leq 0.05$ was considered to show a statistical significant difference among mean values of the study treatments (Gardner and Tremblay, 2006).

RESULTS AND DISCUSSION

Effect of sonic waves frequency levels on the sound pressure levels

The experimental observations showed that the bird's activity would be extreme early in the morning and regularly decrease as the day continues. This agreed with the outcomes of (Schmutterer 1978) that birds feed early in the mornings and late afternoon, but relaxes and drink in-between. Therefore, the field testing was conducted four times between 5-8 am and 5-6 pm. The test was carried out after corn crop planting in the field and during harvesting both of wheat and rice crops. The aimed bird species were Dove *(Spilopelia senegalensis)*, Crow *(Corvus cornix)*, Pigeon (*Columba livia*) and Sparrow *(Passer domesticus)* flocks were on the average of plenty of tens of intensively birds

Results presented in Fig. (3) showed the relationship between the frequency levels of the sonic waves repeller (kHz) and its sound pressure levels (SPL) at sunshine and sunset times. From this figure it could be clear that there is a negative correlation between sound pressure levels (SPL) and the frequency levels (kHz) of the sonic waves repeller for both sunshine and sunset times. In sunshine time the measuring values of the SPL were ranged from 67 to 100; 51 to 68; 39 to 58 and 30 to 52 dBA at repeller frequency levels of 1; 3; 5 and 7 kHz**,** respectively. But, on the other hand, the values of SPL were ranged from 73 to 98; 46 to 73; 33 to 52 and 30 to 40 dBA at repeller frequency levels of 1; 3; 5 and 7 kHz**,** respectively during sunset measuring time. It was clear that the SPL ranges obtained during sunshine time was higher than it on sunset time, this results may be due to the fast travelling waves for decided field measuring distances in moist air in the morning (sunshine time) compared to dry air in the afternoon (sunset time).

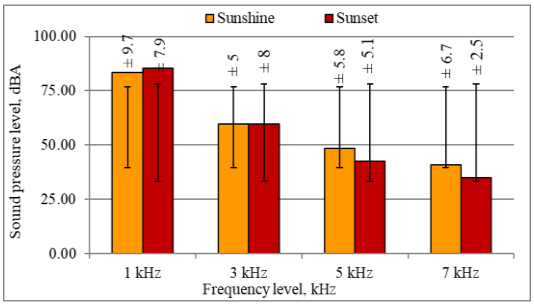


Fig. 3. The relationship between the device frequency level, kHz and sound pressure level, dBA

Effect of the exposure time intervals on the sound pressure levels

Results in Fig. (4) showed the relationship between exposure time intervals, min of the sonic waves repeller and its sound pressure levels (SPL). From this Figure it could be concluded that there is a negative correlation between sound pressure levels and exposure time intervals of the sonic waves repeller in case of sunshine and sunset times. At sunshine time, the SPL were ranged from 40 to 100; 33 to 88 and 30 to 79 dBA under exposure time intervals of 1; 5 and 10 min, respectively. But, on the other measuring time of sunset, the SPL were ranged from 30 to 98; 33 to 91 and 31 to 82 dBA under exposure time intervals of 1; 5 and 10 min., respectively.

One can say, the obtained results of SPL values at exposure time interval of 10 minutes were acceptable and safely for the investigators under this experiment conditions, according to the Egyptian environmental law (LEE) number 4/1994, which modified in 2012 for the (SPL) as shown in Table (3).

Table 3. Sound pressure levels (SPL) with daily permissible exposure times

Sound pressure levels, SPL (dBA)	90	95	100	105	110	115	EEL 4/2012
Permissible exposure time, (h/day)	8	4	2	1	0.5	0.25	

Source, (Egela, M. E. and A. R. Hamed, 2017).

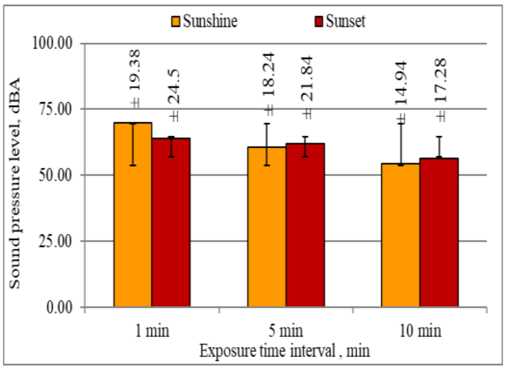


Fig. 4. The relationship between exposure time interval, min and sound pressure level, dBA

Effect of decided measuring distances on sound pressure levels

Results in Fig. (5) showed the sound pressure levels, SPL (dBA) of the sonic waves repeller at the decided measuring points in the experimental field at distances of zero m (at the field center); 30 m (from the field center with 30 m distance) and 50 m (from the field center up to field head with 50 m distance). The obtained values of SPL in sunshine time were ranged from 31 to 100 ; 32 to 94 and 30 to 91 dBA at 0; 30 and 50 m measuring distances, respectively. However, these values were ranged from 33 to 98; 31 to 97 and 30 to 94 dBA. during sunset time at 0; 30 and 50 m measuring distances, respectively. The obtained variance in SPL readings between sunshine and sunset times may be due to the change in climate conditions between two times, like air velocity, humidity, temperature, sunny or rainy…ect. which very affected on waves travelling at morning or evening according to (Ezeonu *et al.* 2012; Tiwari and Ansari 2016).

Also, during carrying out these experiments, it could be mentioned that the crow birds *(Corvus cornix)* represent more resistance for sonic sound waves than other pest birds under study, because they were leave the experimental place for a few meter (less than 50 m) from the sound source then go back again and leave the place for 2-3 times up to feel pained and tired by sound waves they leave and stay away for long time up to they feel good (Pandiyan *et al.* 2019).

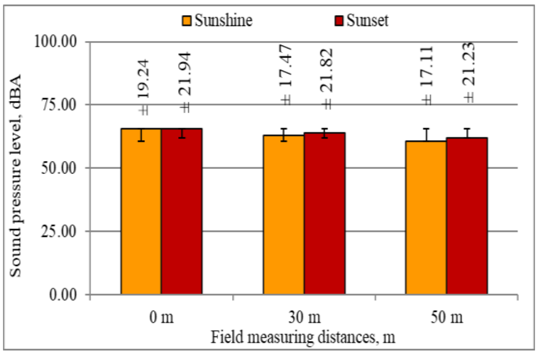


Fig. 5. The relationship between field measuring distances, min and sound pressure level, dBA

Effect of frequency levels of the sonic waves repeller on bird's departure time

The results of bird's departure time, min due to change the frequency levels of the sonic waves repeller were plotted in Fig. (6). These results cleared that, there is a positive correlation between sonic waves frequency and bird's departure time for its place in both measuring times sunshine and sunset. In sunshine time, the bird's departure time, min was ranged from 1 to 6; 1 to 7; 1 to 9 and 1 to 10 min at 1; 3; 5 and 7 kHz, respectively. But on the other sunset time, the bird's departure time, min were ranged from 1 to 5; 1 to 7; 1 to 8 and 1 to 9 min at frequency level of 1; 3; 5 and 7 kHz**.,** respectively**.** This is due to that the birds insist in the morning to eat, so it takes more time to leave the area in spite of the higher values of sound pressure levels in this time. This watching was very clear especially for crows more than other pest birds in this study**.**

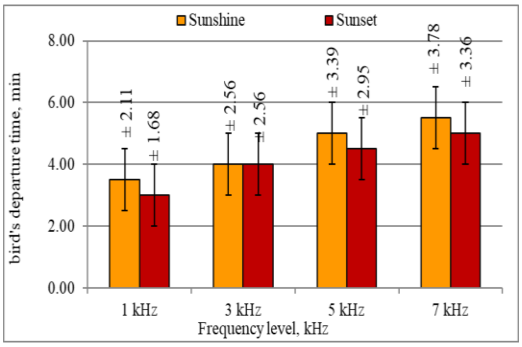


Fig. 6. The relationship between the frequency levels, kHz and bird's departure time, min

Effect of exposure time intervals of the sonic repeller on the bird's departure time

The obtained results of bird's departure time, min due to change the exposure time interval levels of the sonic waves repeller were represented in Fig. (7). These results showed that the bird's departure time, min was ranged from 1 to 1; 3 to 5 and 6 to 10 min. at exposure time intervals of 1; 5 and 10 min, respectively during sunshine time. However, during sunset time, the bird's departure time, min was ranged from 1 to 1; 3 to 5 and 5 to 9 min**.,** at exposure time interval levels of 1 ; 5 and 10 min., respectively. The pest birds were usually seen hide from view in big trees near the field and they were also seen falling into the field in the initial location, quickly locating and eating upon the target crops after which they flew back into the trees. The entire method usually takes not more than 5 minutes from the initial time for Dove *(Spilopelia senegalensis)*, Pigeon (*Columba livia*) and Sparrow *(Passer domesticus)* flocks but for Crow *(Corvus cornix)* flocks it was taken up to 10 minutes according to the emission of frequency pulses. It was also noted that the resting and lazing birds are simply dispersed than the feeding birds since it is always hard to break the habit once they are feeding as reported by (Bishop *et al.* 2003; Pandiyan *et al.* 2019). A break in the signals broadcast was ensured when the birds have given their maximum response to the stimulus so as to avoid the birds' habituation to the device wave.

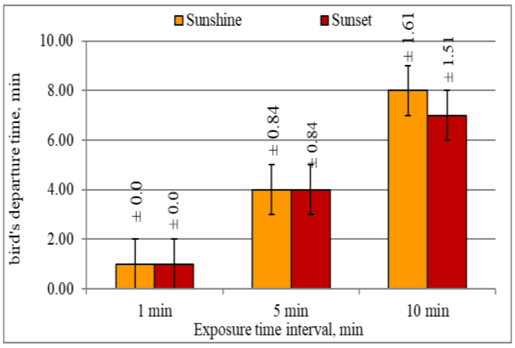


Fig. 7. The relationship between exposure time intervals, min and bird's departure time, min

Effect of field measuring distances on the bird's departure time

Effect of measuring points at different distances from the center of the experimental field up to the field head on bird's departure time, min are shown in Fig. (8). These results concluded that, in case of sunshine time, the bird's departure time, min were ranged from 1 to 10, 1 to 10 and 1 to 10 min under distances of zero; 30; and 50 m, respectively. However, during sunset time the bird's departure time, min were ranged from 1 to 9; 1 to 9 and 1 to 9 min for the same pervious measuring distances. respectively. Also, these results clear that, in the morning (sunshine time) the pest bird under study need more time to leave its feeding field because they have high activity to eat, but it was different in the afternoon (sunset time) they need to relax and sleep.

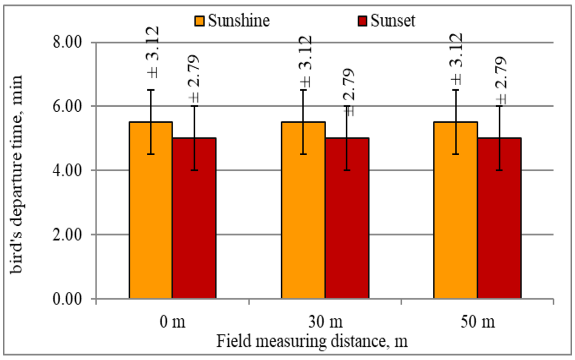


Fig. 8. The relationship between field measuring distances, min and bird's departure time, min

Data analysis for the effect of wave's frequency levels, exposure time intervals and field measuring distances on sound pressure levels

Table (4) presents the results of the statistical analysis of ANOVA for treatments conducted under sonic waves frequency levels, exposure time intervals and distances from the center of the field up to the field head (the three factors under study), using four blocks (replicates) for sunshine and sunset times on the sound pressure level (SPL).

The statistical analysis of sound pressure level (SPL) data showed a highly significant differences ($p < 0.05$) between sonic waves frequency levels (f = 791.448), exposure time intervals (f = 53.55) and measuring distances in the experimental field (f = 14.522) including the interaction effect between Frequency levels * Exposure time intervals (f = 14.869). However, the interactions effect for frequency levels * measuring distances in the field (F = 0.420), exposure time intervals * measuring distances (F = 0.506) and frequency levels * exposure time intervals * measuring distances (F = 0.102). was not significant ($p < 0.05$) differences on the sound pressure level (SPL) for sunshine and sunset times,

Table 4. Statistical analysis of ANOVA for the effect of frequency levels, the exposure time intervals and the measuring distances in the field on sound pressure levels (SPL).

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	53377.556[a]	38	1404.673	69.101	0.00
Intercept	455850.028	1	455850.028	22424.981	0.00
Frequency levels	48265.139	3	16088.380	791.448	0.00
Exposure time interval	2177.097	2	1088.549	53.550	0.00
Distance from the field center	590.389	2	295.194	14.522	0.00
Frequency levels * Exposure time interval	1813.569	6	302.262	14.869	0.00
Frequency levels * Distance from the field center	51.278	6	8.546	0.420	0.864
Exposure time interval * Distance from the field center	41.111	4	10.278	0.506	0.732
Frequency levels * Exposure time interval * Distance from the field center	24.889	12	2.074	0.102	1.000
Blocks	414.083	3	138.028	6.790	0.00
Error	2134.417	105	20.328		
Total	511362	144			
Corrected Total	55511.972	143			

a. R Squared = 0.962 (Adjusted R Squared = 0.948)

Also, the statistical analysis of multiple comparisons of ANOVA for the three above mentioned factors under study on sound pressure level (SPL) using four blocks (replicates) for sunshine and sunset times was done. The obtained results cleared that all levels of sonic waves frequency (1, 3, 5 and 7 kHz), all levels of exposure time interval (1, 5 and 10 min) and all levels of measuring distance in the field (0, 30 and 50 m) had a highly significant effect on sound pressure level (SPL) for sunshine and sunset times .

Data analysis for the effect of waves frequency levels, exposure time intervals and field measuring distances on bird's departure time

Table (5) presents the results of the statistical analysis of ANOVA for the three factors under study of sonic waves frequency levels, exposure time intervals and measuring distances in the experimental field, using four blocks (replicates) for sunshine and sunset times on bird's departure time.

The obtained results from this figure cleared, that the sonic waves frequency levels (f = 439.444) and exposure time intervals (f = 8271.667) including the interaction effect between frequency levels * exposure time interval (f = 151.667) had a highly significant effect ($p < 0.05$) on the bird's departure time at sunshine and sunset times. However, the measuring distances in the field (f = 0.00), and the interactions effect for frequency levels * measuring distances (F = 0.00), exposure time intervals * measuring distances (F = 0.00) and frequency levels * exposure time intervals * measuring distances (F = 0.00) were not significant effect ($p < 0.05$) on the bird's departure time for sunshine and sunset times.

Table 5. Statistical analysis of ANOVA for the effect of frequency levels, the exposure time intervals and the measuring distances in the field on bird's departure time

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1209.000[a]	38	31.816	494.912	0.00
Intercept	2450.250	1	2450.250	38115.000	0.00
Frequency levels	84.750	3	28.250	439.444	0.00
Exposure time interval	1063.500	2	531.750	8271.667	0.00
Distance from the field center	0.000	2	0.000	0.000	1.000
Frequency levels * Exposure time interval	58.500	6	9.750	151.667	0.00
Frequency levels * Distance from the field center	0.000	6	0.00	0.00	1.000
Exposure time interval * Distance from the field center	0.000	4	0.00	0.00	1.000
Frequency levels * Exposure time interval * Distance from the field center	0.000	12	0.00	0.00	1.000
Blocks	2.250	3	.750	11.667	0.00
Error	6.750	105	.064		
Total	3666.000	144			
Corrected Total	1215.750	143			

a. R Squared = 0.994 (Adjusted R Squared = 0.992)

Also, the statistical analysis of multiple comparisons of ANOVA for the three factors under study on the bird's departure time showed that there was highly significant ($p < 0.05$) effect on the bird's departure time of all the levels of sonic waves frequency (1, 3, 5 and 7 kHz), all the levels of exposure time interval (1, 5 and 10 min). While, all measuring distances in the field (0, 30 and 50 m) was not significant effect on the bird's departure time for sunshine and sunset times.

In order to find out the relationship between sound pressure level (SPL), bird's departure time, frequency levels, exposure time interval and field measuring distance, a stepwise multiple linear regression models was used in which frequency levels, exposure time interval and field measuring distance were considered as explanatory variables and (SPL) and bird's departure time as dependent variables. The results of the regression model demonstrated that there was a significant relationship between SPL, bird's departure time and the explanatory variables. This can be inferred from the t value and its associated p value. The explanatory variables explain 88%, 93% of variations in SPL and bird's departure time, respectively showing that the strength of relationship between SPL and bird's departure time and the explanatory variables are high. By referring the F value and its p value, it may be concluded that the model is valid and there is a correlation between SPL and bird's departure time and the explanatory variables. To verify the existence of the mentioned relationship, a multi collinearity test was carried out. The results revealed that the variance inflation factor (VIF) of the model was (1 < 3) indicating the nonexistence of multi collinearity problem as shown in (Tables 6, 7). Thus the results indicate the following equations:

- SPL = 110.6 – 16.0 (frequency levels) – 4.7 (time exposure interval) – 2.5 (field measuring distance) + error
- Bird's departure time = – 4.21 + 0.68 (frequency levels) + 3.31(time exposure interval) + error

Table 6. Step wise regression results for the parameters effects on the SPL

Model	Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	F	Sig.	Model Summary				Collinearity Statistics
		B	Std. Error	Beta					R	R Square	Adjusted R Square	Std. Error of the Estimate	VIF
1	(Constant)	96.3	1.65		58.1	0.0	699	0.0	0.91	0.83	0.83	8.12	1
	Frequency	-16.0	0.60	-0.912	-26.4	0.0							
2	(Constant)	105.6	2.07		51.0	0.0	468	0.0	0.93	0.87	0.87	7.18	1
	Frequency	-16.0	0.53	-0.912	-29.9	0.0							
	Time exposure	-4.7	0.73	-0.194	-6.4	0.0							
3	(Constant)	110.6	2.44		45.3	0.0	341	0.0	0.94	0.88	0.88	6.91	1
	Frequency	-16.0	0.51	-0.912	-31.1	0.0							
	Time exposure	-4.7	0.70	-0.194	-6.6	0.0							
	Distance	-2.5	0.70	-0.103	-3.5	0.0							

Table 7. Step wise regression results for the parameters effects on the bird's departure time.

Model	parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	F	Sig.	Model Summary				Collinearity Statistics
		B	Std. Error	Beta					R	R Square	Adjusted R Square	Std. Error of the Estimate	VIF
1	(Constant)	-2.50	0.23		-10.6	0.0	921	0.0	0.93	0.86	0.86	1.00	1
	Time exposure	3.31	0.10	0.931	30.4	0.0							
2	(Constant)	-4.21	0.21		-19.6	0.0	1023	0.0	0.96	0.93	0.93	0.74	1
	Time exposure	3.31	0.07	0.931	43.5	0.0							
	Frequency	0.68	0.05	0.263	12.3	0.0							

From the tables above the results indicated strongly that the most important factors were the frequency and the exposure time which consider effective in pest birds deterrent for the target species mentioned in this study. Low frequency (1 kHz, 3 kHz) which increase scaring influence to the pest birds was greater than the high frequency and caused high levels of sound pressure levels (SPL). Also, in the birds departure time Dove *(Spilopelia senegalensis)*, Pigeon (*Columba livia*) and Sparrow *(Passer domesticus)* flock never returned to the initial position to attack the field crops after only 5 min, but Crow *(Corvus cornix)* after only 10 min. Avian hearing covers a narrower range of frequencies than human hearing; within that range, avian hearing is less sensitive than human hearing. Birds cannot hear ultrasound (>20,000 Hz), but some can hear infrasound (<20 Hz). By themselves, audio devices are very effective at dispersing birds. To be useful, acoustic devices must be combined with other control techniques in an integrated management program to increase the efficiency. The most effective use of acoustic signals is when they are covered with activities that produce death or a painful experience to some members of the population. Such support will prevent birds from habituating to the auditory stimulus; this was agreed with (Robert 2004).

CONCLUSION

The obtained results concluded that the sound pressure level (dBA) of sonic waves repeller was negatively affected with levels of device frequency (kHz), exposure time intervals (min) and measuring distance in the field and SPL during sunshine time was higher than it on sunset time at any given frequency level under study. At sunshine time, the SPL were ranged from 40 to 100; 33 to 88 and 30 to 79 dBA under exposure time intervals of 1; 5 and 10 min, respectively. But, on the other measuring time of sunset, the SPL were ranged from 30 to 98; 33 to 91 and 31 to 82 dBA under exposure time intervals of 1; 5 and 10 min., respectively. It could be mentioned that the crow birds (Corvus cornix) represent more resistance for sonic sound waves than other pest birds under study during carrying out these experiments. The statistical analysis of sound pressure level (SPL) data showed a highly significant differences between sonic waves frequency levels, exposure time intervals and measuring distances in the experimental field including the interaction effect between frequency levels * exposure time intervals. However, the other interactions effect was not significant differences on the sound pressure level (SPL) for sunshine and sunset times, the bird's departure time (min) was positively affected with levels of device frequency and with exposure time. While, the similar affect was obtained for bird's departure time at measuring distance in the field. The bird's departure time, min was ranged from 1 to 10, 1 to 10 and 1 to 10 min under distances of zero; 30; and 50 m, respectively in sunshine time. However, during sunset time the bird's departure time, min was ranged from 1 to 9; 1 to 9 and 1 to 9 min for the same pervious measuring distances, respectively. The sonic waves frequency levels and exposure time intervals including the interaction effect between frequency levels * exposure time interval had a highly significant effect ($p < 0.05$) on the bird's departure time at sunshine and sunset times. However, the measuring distances in the field (f = 0.00), and the all interactions effect were not significant effect ($p < 0.05$) on the bird's departure time for sunshine and sunset times. Finely the results indicated strongly that the most important factors were the frequency and the exposure time which consider effective in pest birds deterrent for the target species mentioned in this study. Low frequency (1; 3 kHz) which increase scaring influence to the pest birds was greater than the high frequency and caused high levels of sound pressure levels (SPL). Also, in the birds departure time Dove, Pigeon and Sparrow flock never returned to the initial position to attack the field crops after only 5 min, but Crow after only 10 min.

RECOMMENDATION

- Low frequency should be used in deterrent pest birds by sonic wave's devices.
- Sonic wave's devices should emit high sound pressure levels as an ecofriendly method.

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استخدام الموجات الصوتية لمكافحة الطيور في حقول المحاصيل

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يعد التلف الحادث بواسطة الطيور في الزراعة مشكلة كبيرة وطويلة الأمد على مستوى العالم خاصة بالنسبة للمحاصيل الحقلية عالية القيمة مثل الأرز ،القمح والذرة. وتهدف الدراسة الحالية إلى مكافحة آفات الطيور في المحاصيل الحقلية باستخدام الموجات الصوتية باستخدام جهاز يولد موجات صوتية يستخدم لطرد الطيور ، و كانت معاملات الدراسة هى استخدام تردد الموجات الصوتية الصادرة من الجهاز المستخدم فى التجربة بأربعة مستويات هى ١ و ٣ و ٥ و ٧ كيلو هرتز. ؛ وفترات التشغيل فصل و وصل الجهاز ١ و ٥ و١٠ دقيقة والتى تمثل أوقات التعرض بالنسبة للطيور؛ المسافة المقررة للقياس هى صفر و ٣٠ و ٥٠ مترًا من مكان وضع الجهاز(فى منتصف الحقل) ؛ وقت القياس اليومية لشروق الشمس وغروبها. وقد كانت اهم النتائج المتحصل عليها كما يلى تأثر مستوى ضغط الصوت (ديسيبل) لجهاز طرد الطيور بالموجات الصوتية سلبًا بمستويات تردد الجهاز (ك هرتز) وفترات التعرض (دقيقة) وعند مسافات القياس في الحقل التجريبي. كانت القيم التي المتحصل عليها لمستوى ضغط الصوت أثناء وقت الشروق أعلى منها في وقت غروب الشمس لأي مستوى تردد للجهاز تحت الدراسة. تراوحت قيم مستوى ضغط الصوت أثناء الشروق من ٤٠ إلى ١٠٠ ؛ ٣٣ إلى ٨٨ ومن ٣٠ إلى ٧٩ ديسيبل عند فترات تعرض زمنية قدرها ١ ؛ ٥ و ١٠ دقائق على التوالي. مقارنة بمدى من ٣٠ إلى ٩٨ ؛ من ٣٣ إلى ٩١ ومن ٣١ إلى ٨٢ ديسيبل عند فترات التعرض من ١ ؛ ٥ و ١٠ دقائق على التوالي أثناء الغروب. أظهرت طيور الغربان مقاومة أكثر للموجات الصوتية أثناء إجراء هذه التجارب مقارنة بالطيور الضارة الأخرى تحت الدراسة . تبين من التحليل الإحصائي لبيانات مستوى ضغط الصوت وجود فروق معنوية عالية بين مستويات تردد الموجات الصوتية وفترات التعرض ومسافات القياس في الحقل التجريبي بما في ذلك تأثير التفاعل بين مستويات التردد * فترات التعرض. بينما لم يكن لتأثير التفاعلات الأخرى أي فروق معنوية على مستوى ضغط الصوت عند الشروق والغروب. تأثر وقت مغادرة الطائر (بالدقائق) بشكل إيجابي بمستويات تردد الجهاز ووقت التعرض. بينما تم الحصول على نفس التأثير لوقت مغادرة الطائر عند مسافات القياس المختلفة في حقل التجارب. تراوح وقت مغادرة الطائر من ١ إلى ١٠ ، ومن ١ إلى ١٠ ومن ١ إلى ١٠ دقائق عند مسافات القياس صفر. ٣٠ ؛ و ٥٠ م ، على التوالي وقت الشروق. بينما فى وقت الغروب الشمس ، تراوحت قيم وقت مغادرة الطائر من ١ إلى ٩ ؛ من ١ إلى ٩ ومن ١ إلى ٩ دقائق لنفس مسافات القياس السابقة ، على التوالي.أظهرت مستويات تردد جهاز طرد الطيور بالموجات الصوتية وفترات التعرض وكذلك التفاعل بين مستويات التردد * فترات التعرض تأثير عالى المعنوية على وقت مغادرة الطائر عند الشروق والغروب. بينما لم يكن لمسافات القياس في الحقل وجميع التفاعلات أي تأثير معنوي على وقت مغادرة الطائر عند الشروق والغروب. أوضحت النتائج المتحصل عليها بهذه الدراسة أن أهم العوامل تأثيرا هي تردد جهاز طرد الطيور ووقت التعرض له والتي تعتبر أكثر فاعلية في طرد الطيور الضارة للأنواع المستهدفة في هذه الدراسة حيث كان التردد المنخفض (١ ؛ ٣ كيلو هرتز) الذي يزيد من تأثير التخويف على الطيور الضارة كان أكبر من التردد العالي ويسبب مستويات عالية من ضغط الصوت (SPL).أيضًا ، بالنسبة لوقت رحيل الطيور نهائيا دون العودة ثانية كان بعد ٥ دقائق من التعرض فقط ، لقطعان اليمام والحمام والعصافير حيث لم تعد إلى موقعها الأول فى الحقل المستهدف بينما كانت لقطيع الغربان بعد ١٠ دقائق.