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FIVE METHODS FOR STUDYING NOCTURNAL BIRD MIGRATION OVER ISRAEL

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Israel is a land bridge between three continents and a major crossroads for birds migrating from Europe and Asia, to Africa and back twice yearly, during spring and autumn. Most birds migrating over Israel (280 species) do so mainly at night.

Nocturnal migration rates and times over Israel were first studied in 1989, with an ASR-8 scanning radar. Since then, five different methods for tracking migration have been tried: direct observations, listening to calls, radar, night flights and indirect data from aircraft bird strikes. Radar tracking has been found to be the most efficient method.

Three years of research have shown that there is a regular pattern in times and rates of nocturnal migration. Radar data has shown that on peak migration nights a million birds fly over Israel in one night.

During these three years it was found that the correlation between the migration rate during the first three hours of the night and the total rate for that night makes statistically significant predictions of the expected migration rate possible.

1. INTRODUCTION

About 280 bird species migrate over Israel, mainly at night. Diurnal migration of soaring birds over Israel -- raptors, storks and pelicans -- has been thoroughly studied with radar, ground observers and motorised glider (Leshem, 1984, 1988, 1991). Most of the damage done to Israel Air Force aircraft is attributed to these birds. This is due mainly to their large size and their flight altitude, which can reach 5000 ft. above sea level.

Nocturnal migration, on the other hand, occurs mainly at altitudes up to 4000 ft. and is far greater, by at least one order of magnitude. The probability of collisions with these birds is thus much higher.

The importance of fighter plane night flights has been emphasized by the Gulf War. Most Air Forces in the world will probably increase the number of nocturnal training hours in the future. With improved technology solving problems of night vision, nocturnal aerial skirmishes will practically become "day skirmishes". The flight altitude at night has decreased, so that aircraft are now exposed to significantly greater masses of migrating birds. In order to prevent the heavy damage which may occur during these night flights the distribution of nocturnal migration in time and space must be studied.

As a result of objective difficulties in tracking nocturnal bird migration the subject has remained in the "dark" in many parts of the world. Several studies using different methods on the subject have been carried out (Bruderer, 1981; Buurma, 1988; Buurma and Bruderer, 1989).

In Israel, a combination of five different methods were used to follow nocturnal migration, with varying amounts of success: direct observations, bird call tracking, night flights with light aircraft to count and identify individual species, radar and indirect data gleaned from the number of bird–aircraft collisions at night. Radar tracking was found to be the most efficient method, but the five methods complement each other, and none can be of use by itself.

Radar tracking has enabled study of nocturnal migration distribution in time and space. Comparison of results from the years 1989–1991 indicates a regular pattern of migration times and rates in different seasons. Light aircraft equipped with a projector has provided estimates of the numbers of birds migrating at night over Israel, and made quantification of radar data possible.

A statistically significant correlation between the rate of migration during the first three hours of the night and the total rate for that night has been found. This has allowed predictions on the total rate of migration each night to be made. More that 20 different species have been definitely identified by calls and direct observations in the moonlight.

2. METHODS

Surveillance radar – The radar used in this study was an ASR–8 surveillance radar, beam width 35°/4.8°, 10 (cm), used for air traffic control at Ben–Gurion International Airport, Tel–Aviv. Nocturnal migration for a radius of 20 miles can be seen on the radar screen.

The radar screen was photographed with a Nikon reflex camera, diaphragm opening 4.5, continuous exposure of 10 minutes for each still photograph. Photographs were taken once every 1/2 hour during the night in spring and autumn. Control photographs were taken during the day at 0900, 1200 and 1500 hours, using the same method (Alfiya, 1990).

Magnitude of migration was determined by the rate of flashes received from migrating birds on the radar screen photographs. A scale of 5 migration magnitude levels was established and the rate of migration during each hour of the night determined accordingly. The levels were: 1 – no migration, 2 – weak migration, 3 – medium migration, 4 – heavy migration, 5 – very heavy migration.

This radar makes it possible to study migration speed and direction over a relatively large range. Its drawbacks are the inability to measure migration altitude, determine bird species or exact numbers of migrating birds. The data received is limited to the area covered by the radar, and when conditions are cloudy, the birds cannot be seen since the screen is covered with clouds.

Light aircraft – A Cessna airplane, equipped with a projector and with lit landing lights, flew at a right angle to the migrating birds, across Israel from east to west, along 10 km. During each flight 1 million cubic meters of air were scanned for 5 minutes. The flights took place when radar showed migration magnitudes of 5. Flights were held at altitudes of 1000, 1500, 2000, 2500 and 3500 feet, and the number of birds seen recorded. This method made it possible to estimate the number of birds migrating over Israel in magnitudes 1-5, and to receive quantitative estimates of the radar data. Its main disadvantages are the high cost of flight hours and the inability to identify the bird species because of the short time in which it passes through the light beam (about 1/10 second).

Direct observations – An observer using a Kowa telescope with 45x magnification watched the moon. Birds passing between the observer and the moon can be seen for a short period of 1/10 second. Identification is made from the silhouette or flight style. A thermal image camera (Mini Flare, Israel) was used similarly. These methods require many observation hours and very experienced personnel, and even so up to 50% of the birds can remain unidentified. The principal advantage of this method is that in many cases it makes identification of the bird species or genus possible.

Bird call tracking – This included direct listening with no instruments and tracking with amplifiying instruments, making it possible to identify some of the migrating species. This method is effective only for those birds which use calls while migrating, requires many hours and great experience and expertise. Its main advantage lies in the positive identification of the bird genus or species.

Bird–aircraft collisions – This method can provide indirect data on the location of birds in time and space. In many cases it is also possible to identify the bird species from feather remains. Its drawback lies in the fact that it reflects mainly the activity of the sampling instrument – the aircraft involved in the collision.

3. RESULTS AND DISCUSSION

Times of night migration in Israel – The results of three years of following nocturnal migration show that migration times follow a regular pattern. Table A presents data on migration times in spring and autumn. The beginning of the season was determined according to the first night with magnitude 2 migration. In the same manner, the end of the season was determined by the last night with migration magnitude ≥ 2.

Table A – Nocturnal migration times in spring and autumn 1989–1991*.

Season	Start of migration	End of migration	Remarks
Spring '89	-	21/5	Partial data
Autumn '89	17/8	-	Partial data
Spring '90	8/3	16/5	
Autumn '90	15/8	21/11	
Spring '91	19/3	20/5	
Autumn '91	19/8	21/11	

*End of season determined according to the last night with average migration magnitude 2.
*Beginning of season determined according to first night with average migration magnitude 2.

Cloudiness sometime prevented documentation of migration, which might mean that the real first or last night was missed. The magnitude of migration also followed a regular pattern, with average migration magnitude 2 during the first month, and 3.5 and 2.5 for the second and third month in autumn and spring respectively. In the final month of migration the average magnitude was 2.

Migration rate in the years 1989–1991 – The distribution of migration magnitude (levels 1–5) was examined during all the tracking hours (radar data). In table B we can clearly see that migration rate in autumn is higher on the average by 50% than in spring. This ratio was constant during the three years of this study. The same is true for the average migration rates each season.

Table B – Distribution of tracking hours according to migration magnitude
Comparison of nocturnal migration hours (%) according to migration magnitude levels (1989-1991).

Level / Season	1	2	3	4	5	Average migration magnitude degree - per hour of night in the season
Spring 1989 Partial data 13/4-30/5	35	33	23	7	2	2.08
Autumn 1989 Partial data 1/8-30/10	16	7	10	28	39	3.67
Spring 1990 Complete data 1/3/-30/5	30	25	21	17	7	2.46
Autumn 1990 Complete data 1/8-30/11	27	13	12	20	28	3.09
Spring 1991 Complete data 1/3-30/5	42	22	20	10	6	2.16
Autumn 1991 Complete data 18-30/11	29	10	15	21	26	3.08

Quantification of radar data – Night flights with light aircraft showed that during a 10–hour night, with average migration magnitude 5, approximately a million birds pass over the skies of Israel. According to this standard, the significance of the radar photographs from Ben–Gurion is as follows: during a night with an average migration magnitude of 4, 0.75 million birds pass over in 10 hours, 0.5 million when the average migration magnitude is 3, 0.25 million when it is 2 and no birds at all when it is 1.

Prediction of migration magnitude degrees – One of the most valuable indicators for predicting the rate of migration during one night, is the correlation found between the migration rate during the first three hours of the night to the rate for the entire night. The coefficient of correlation is high and statistically significant (table C), providing a success rate of 80% in predicting the magnitude of migration at the beginning of the night for the rest of it.

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Table C – Correlation between migration magnitude during the first three hours of the night to that during the rest of the night, 1989-1991.

Year	1989	1990		1991	
Season	spring	autumn	spring	autumn	spring
r	0.85	0.80	0.80	0.75	0.85
$\alpha <$	0.001	0.0001	0.0001	0.0001	0.0001

Direct observations and tracking of night migrant calls – Despite the low effectiveness of these methods 22 different species/genera were definitely identified migrating at night.

One of the objectives of this study is to compose a map of bird strike danger areas for Israel Air Force aircraft. This map will be based, among other factors, on the masses of birds found in the air at any given moment. In order to attain this objective it is necessary to know which species migrate at night and when they pass over. Ringing information could possibly be a source of reliable information which would complement the data from direct observations and bird call tracking.

The information we possess at present provides quite a clear picture of migration rates in time. Putting together the "puzzle" of the bird strike danger map necessitates data on the rate of migration in time (which we have), the weight of the migrating birds and the times they migrate (exists partially) and the distribution of migration in space – horizontally and vertically. The last component of this "puzzle" has been studied so far only from indirect data from bird–aircraft collisions, a method whose drawbacks have been discussed. In order to complete this information a pair of Furuno mobile radars have been recently purchased. These are marine radars which have been modified for bird tracking. The FR–1411 scanning radar and the FR–8100 altitude radar have been mounted on a vehicle and will perform as mobile laboratories to study migration, thus completing the picture on migration in space.

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