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NOCTURNAL MIGRATION OF BIRDS OVER ISRAEL - CHANGES IN DIRECTION AND RATE OF MIGRATION ACCORDING TO THE TIME OF NIGHT

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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.

Night migration over Israel was first examined in 1989, with an ASR-8 scanning radar. Migration rates and directions through the night, in spring and autumn, were studied. The rate of nocturnal migration in autumn was found to be double that in spring.

Direction of migration was found to be closely related to the time of night. Overland north-south migration characteristically occurs throughout the night, and stops almost completely in the morning. Migration from northwest of the Mediterranean Sea to the Israeli coast, however, commences only at midnight, and continues until 09:00 in the morning.

There is a distinct correlation between nocturnal migration and bird-aircraft collisions in the Israel Air Force (IAF). At the present time it should already be possible to set up a real-time warning system for night flights of IAF aircraft. The system would be based on the relation between migration rates during the first three evening hours and rates throughout the night.

1. INTRODUCTION

Israel is a land bridge between three continents and a main migration junction for birds migrating between Europe, Asia and Africa in spring and autumn.

About 280 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 motorized glider (Leshem, 1988,1984). 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 may reach 5000 ft. above sea level.

Nocturnal migration, on the other hand, occurs at altitudes up to 5000 ft. and is far greater, by at least one order of magnitude, than diurnal migration. As a result, the probability of collisions with these birds is far higher. Civilian flights are damaged by nocturnal migrating birds mainly during take-off and landing, since they fly at greater altitudes than the migrating birds. Air force aircraft all over the world, however, fly at lower altitudes and therefore suffer much more damage from night-flying birds.

Due to objective difficulties in tracking nocturnal bird migration the subject has remained in the "dark" in many parts of the world. Passerine migration, for example, occurs mainly at night, when visual means of observation are not applicable, so radar remains the best source of information on nocturnal bird migration.

Despite the importance of this area as the junction of three continents and a region on the coast of a broad sea barrier which separates Europe from Africa, nocturnal bird migration has never been studied in Israel. In spring 1989 nocturnal migration tracking by radar was first initiated and its magnitude and distribution in time and space studied.

As reported in works done up to now in Europe (Bruderer,1981, Buurma, 1988 and Buurma and Bruderer, 1989), here too, nocturnal migration appears on the radar screen as a broad front of individuals or small groups migrating independently. Continuous tracking during all hours of the night and throughout the migration season showed that the distribution pattern of nocturnal migration direction changes with the time of night. Significant differences in the magnitude of migration were found as well, between spring and autumn (Hunt, 1975).

The migration seasons coincide with the rise in the rate of night collisions in the IAF. The establishment of a real-time warning system, based on the significant correlation between the rate of migration during the early night hours to the rest of the night can allow night flights and bring about a significant reduction in the number of collisions with migrating birds.

2. METHODS

The radar used in the study was the ASR-8 surveillance radar, beam width 35°/4.8°, 10(cm), used as the air traffic control radar at the Ben Gurion 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.

Degrees of migration were determined by the rate of flashes received from migrating birds on the radar screen photographs. A scale of 5 migration levels was established and according to it the rate of migration was determined during each hour of the night during the season. The direction of migration was determined by the flight route appearing on the radar screen photographs, which was possible due to the long exposure (10 minutes) time.

Nocturnal migration velocity was measured directly from the radar screen by tracking several flocks each hour and recording them concurrently with the photographs.

3. RESULTS AND DISCUSSION

A large amount of information on times, routes and rates of nocturnal migration has accumulated from the radar data. The data, however, did not provide information on migration altitude or on the species migrating. Nevertheless, on the basis of direct moonlight observations and listening to birds migrating at night, it seems that passerines and water birds overfly Israel at night. Different species of swifts, Sylvia warblers, pipits, waders and ducks have been definitely identified.

As opposed to diurnal migration which is seen on the radar screen along definite, clear routes, nocturnal migration is characterized by movement along a broad front, which covers a large part of the radar screen (plate 1). This is probably a result of scattered migration of individuals or small groups of birds.

Times of migration at night - nocturnal migration commences at sundown and continues to 0900. At sunrise there is a significant reduction in the migration rate and overland migration stops almost completely (figure 1). Most of the migration during these morning hours is of birds arriving at the Israeli coast from the Mediterranean.

These differences in the rate of migration may be the result of the fact that a large number of juveniles leave Europe in the fall but do not return in spring; or possibly some of the birds which migrate south in the fall return in the spring via a different route. It should, however, be borne in mind that the data are from 1989 only.

Rates of migration at night - relative migration rates were calculated as the average migration rate during all hours of a given night (figure 2). Migration rates in spring are about 50% lower than migration rates in autumn. In spring nocturnal migration starts in March and ends in May, in autumn it starts during the last ten days of August and ends in mid-November (Fig. 2).

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PLATE 1: Nocturnal migration on a broad front from the north, autumn 1989.
At the center -- Ben Gurion International Airport; the solid line on the left side of the screen is the Israel coastline. Migration on a broad front can be seen from 16 miles north of the Ben-Gurion Airport to 14 miles south of it. Radius lines are at a distance of 2 miles from each other. On the circumference are compass directions relative to Ben-Gurion.

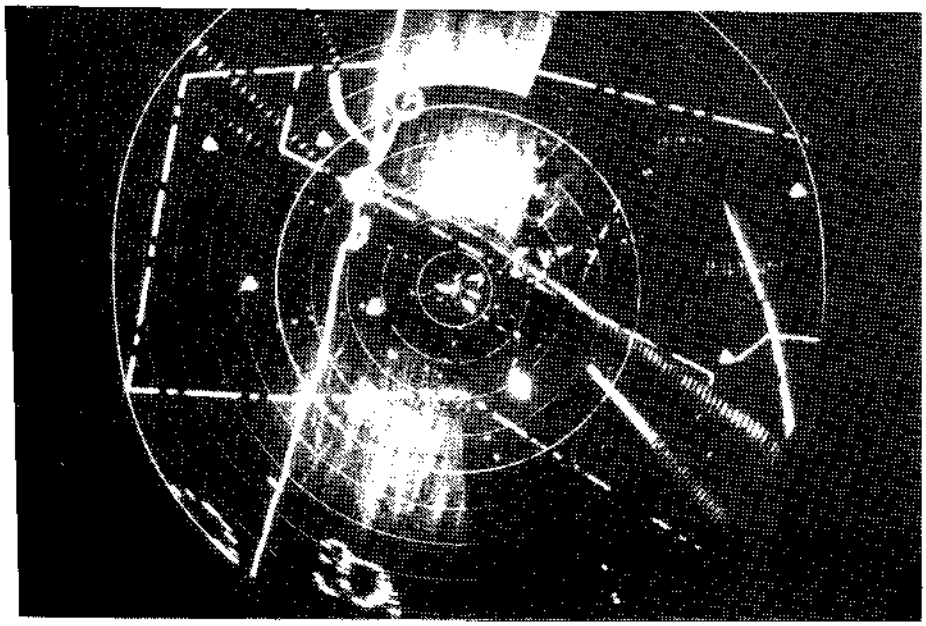

FIGURE 1 - Distribution of nocturnal migration direction in relation to the time of night. The change in frequency of migration appearance from the direction of the sea or from over land throughout the night in August 1989. Until midnight all migration is overland and from midnight there is a significant amount of migration from the sea.

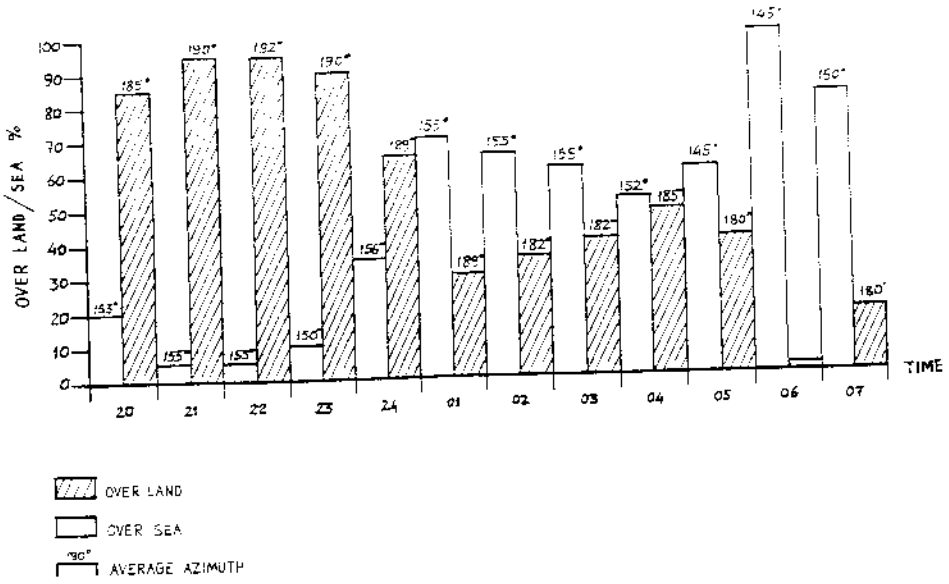

FIGURE 2 - Ave
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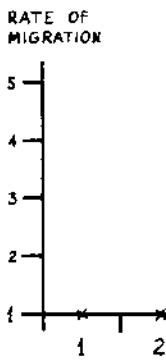
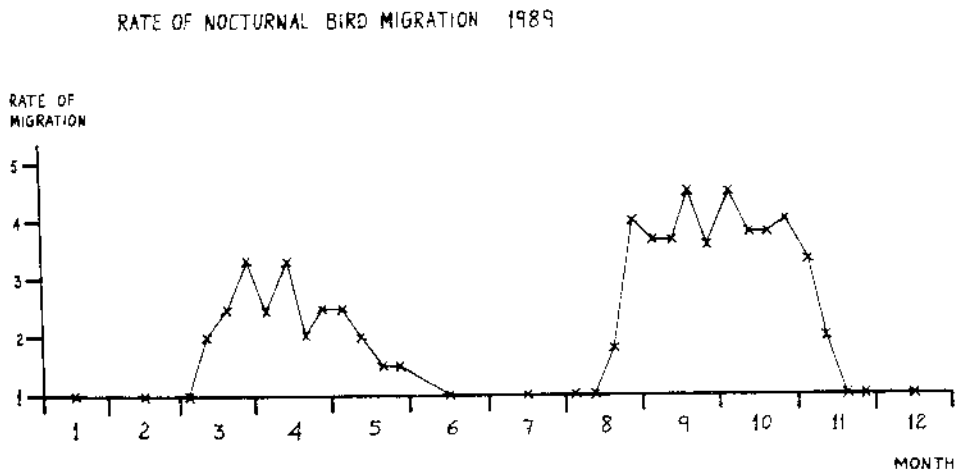


FIGURE 2 - Average monthly migration rates in spring and autumn.
Each point on the graph represents the average migration rate checked during that time.



3.1 Distribution of nocturnal migration directions

During the fall of 1989, 2 main directions of migration were observed - one from north to south over land; the other from northwest to southeast, from the Mediterranean to the shores of Israel. Some of the birds which leave Europe for Africa in the fall migrate in a straight line, across the Mediterranean, traversing a distance of 500 km or more without stopping. Others cross over land, taking a longer route, circumventing the Mediterranean. Some of these shorten their route by flying over the northeastern part of the Mediterranean, landing on Israel's shores, and later continuing southward. By doing this they reduce the time spent over the Mediterranean and make their first stop as close as 250 km from their departure point.

Radar data provide evidence that both the latter routes in fact occur. In August 1989, when the frequency of migration directions during the various hours of the evening or night was examined, a clear connection was seen between the time of night and the frequency of each of the two above-mentioned directions of migration.

Until midnight, the radar shows migration from north to south over land only. From midnight on, migration from the sea begins to appear on the screen. This trend continues until 0500 hours. At sunrise, migration from north to south ceases almost completely. Traces of migration from the direction of the Mediterranean continue into the morning hours, sometimes until 0900 hours.

Examination of the direction from which nocturnal migrants arrived from the Mediterranean (azimuth 320, 330 degrees) may indicate the estimated location from which they began their migration -- Cyprus and the coasts of southern Turkey.

If we assume average flight speed of 50-60 k.m.h., the first birds to arrive in Israel at midnight would have left the Cyprus coast (azimuth 330 degrees) 6 hours previously.

There seems to be a clear connection between the rate of night bird strike and the seasons when nocturnal migration takes place. During the migration months -- spring and fall -- the number of such collisions doubles, a significant increase compared to the rest of the year (α = 0.009, F=10.3, Tdf=11 -- ONE-WAY ANOVA). 70 % of night collisions take place up to an altitude of 2000 f. At this point no quantification of radar data has been made, but there is no doubt that millions of birds are involved. In the light of these facts, the grave danger to night flights below this altitude is clear.

In an attempt to establish a real-time warning system for the Israel Air Force on the rates of nocturnal migration, the correlation coefficient between the rate of migration during the first three hours of night and the rate of migration during the remaining night hours was calculated. A significant correlation was found between the two (regression coefficient r=0.85, α<0.001, Tdf=44). This connection will make it possible to predict the expected degree of nocturnal migration from the first three hours after sunset with a very high degree of accuracy, thus enabling night flights and ensuring flight safety at the same time.

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