Following soaring bird migration from the ground, motorized glider and a radar at a junction of three continents

(Y. Leshem, Israel)

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FOLLOWING SOARING BIRD MIGRATION FROM THE GROUND, MOTORIZED GLIDER AND RADAR AT A JUNCTION OF THREE CONTINENTS

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ABSTRACT

The geographical position of Israel at the junction of three continents is responsible for its importance as a focal point for the largest concentrations of soaring birds (raptors, storks and pelicans) during spring and autumn migrations.

The purpose of the research work conducted in Israel was to map the migration routes of a number of species, to learn about the flight altitudes and velocities and to study and analyze the extent to which the above variables, as well as the routes themselves, are influenced by weather conditions, time of day and time of year.

Three data-gathering systems were employed in conjunction: a network for ground observation crews, a motorized glider and two radar systems - one at Ben Gurion International Airport and the second a meteorological radar system. The data thus gathered produced a clear picture of the geographical positions of the migration routes, the altitudes, velocities and daily progress of the migration, and its relation to changes in weather conditions.

The Israel Air Force sustained heavy damage to its aircraft as a result of collisions with migration soaring birds. Recognizing this, it provided the financing for this research. The data collected and analyzed were submitted to the IAF, which ceased flying at the times, routes and heights at which migration occurs. Consequently, no planes have been destroyed or seriously damaged over the past five years (1983-1987).

INTRODUCTION

The location of Israel at the junction of three continents – Europe, Asia and Africa – has made it part of a migration route of international importance in spring and autumn.

For most soaring birds, large water bodies, such as the Mediterranean, the Caspian or Black Seas, are barriers which must be circumvented on their way from Asia or Europe to Africa. The population of Western Europe concentrates in the area of the Gibraltar Straits; a small part of the central European population crosses the Mediterranean at its narrowest points, such as Italy and Sicily; the major part of the [illegible] Central and Eastern European populations as well as large parts of the Western Asia [illegible] populations [illegible] route, around the [illegible] in the [illegible], Israel and Egypt on their way to Africa.

During the last decade there has been significant progress in studying the phenomenon of soaring bird migration over Israel. From the various surveys held it is now clear that Israel is one of the best places in the world, if not the best, to watch migrating soaring birds.

During the spring of 1985 [illegible] soaring birds were counted [illegible] Eilat [illegible], 1986). In autumn 1985 [illegible] raptors were counted [illegible]. The data of Shirihai (1987), Leshem (1984), [illegible] et al (1981), [illegible] (1982), [illegible] et al. (1983) and [illegible] (1983, 1984) confirm the information on the [illegible] numbers of soaring birds which pass over the area in spring and autumn.

After working for several years with ground crews surveying migration it had become clear to us that the system was incomplete due to the limitations of the system used. Ground crews are not able to estimate exactly the altitude of migration and cannot see above a certain height.

As a result we decided to approach the Israel Air Force and suggest a joint program where we will pass on to the IAF all migration data gathered up to now, to warn them of impending damage by migrating birds. The Air Force in turn would provide a light aircraft to be used in locating major migration routes, altitudes and behavior of the birds, which would complement the limited information from ground crews. When we first contacted IAF officers, at the end of the 1980 spring migration, it became clear, to our astonishment, that the conflict between IAF fighter planes and migrating birds was far beyond what we had imagined. Every year there were dozens of collisions between aircraft and migrating soaring birds. When the number of these collisions between the years 1972-1982 was totaled, it reached into the hundreds, with cases in which fighter planes crashed and pilots where killed. The financial loss was tens of millions of dollars.

Table 1

It is clear from this data that most of the collisions occur during the spring (March-May) and autumn (September-October) migration seasons. The concentration of millions of migrating birds along with hundreds of military aircraft in the limited airspace over Israel would inevitably cause a large number of collisions. To understand the enormity of the danger it is enough to know that an airplane flying at a speed of 800 kilometer per hour colliding with a kite weighing 900 grams is hit with a force of 12.5 tons, a Griffon Vulture with a force of about 40 tons and a Pelican weighing more than 7 kilograms will hit an aircraft with a force of about 100 tons.

In order to reduce the number of aircraft - bird collisions a study was started to define migration routes, altitudes and times of the major species and their relation to changes in weather. This data would then be used to prevent flying at certain times and in certain locations.

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METHODS

1. Ground crew surveys to achieve maximum area coverage: a network of ground crews following migration at major passage points in Israel. The network was based on several volunteer birdwatchers (up to 150 in autumn, Kfar Qasem Survey), who were spread over 14 observation point covering the country from Tel-Aviv to the Mediterranean coast in the west to the Jordan Valley in the east (see map 1). The observers had radio transmitters for communicating to prevent overlapping in counting. In some cases mobile observation points were set up with vehicles to keep up with the changing migration axis during the day.

Map 1

2. Following migration with a motorized glider: after 19 flight days with a military light aircraft (Cessna) we realized that although these flights helped locate several major routes, the flight speed was too great to permit tracking of single flocks. The aircraft was sufficient for days with migration "floods", but was not appropriate for days with less migration. We then started looking for a smaller, slower aircraft which would help us complete our data. Hang gliders were checked, but they were good only for localized tracking and not for longer flights. The "Ultra-Light" a motorized hang glider, was better, but limited to two hour flights and unstable over mountainous areas where most migration passes. We finally found a motorized glider, the PSAB, produced by PZL, Poland, which has a 65 h.p. engine and a wing spread of 18 meters. Thanks to its motor it can take off and land independently, fly about 8 hours on its engine, and by gliding part of the time, double its time in the air. (A spare fuel tank was attached to the glider, which could be refueled in flight and therefore spend this much time in the air.) The motorized glider has 2 seats, both in front. The propellor is behind the canopy and so the observers have a much wider field of vision than in light aircraft. The flocks are located in the evening at their roosting spots by mobile IRIC crews. In the morning the glider arrives at this spot about 15 minutes before the estimated time of departure. It waits at the site until the flock is in the air and then joins it directed by radio transmitters with the ground crews. The gliders instruments enabled us to track the exact migration altitude of the birds, their speed, take off and landing time as well as counting the times the migrating birds use thermals along the way. All this while

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Picture 1

2. Radar: The Airport Authority at Ben Gurion Airport allowed us to use a sensitive radar screen of the ASR-4 type to track bird migration. The IAF had women soldiers manning the radar during bird migration seasons and they drew the exact situation as seen on the screen every 20 minutes. At the same time the screen was photographed with Polaroid cameras. The radar at Ben Gurion Airport was directed very efficiently towards the clocks and a [illegible] could continue to allow a migrating flock [illegible] to be tracked after every hours of flight. An additional military meteorological radar [illegible] migrating flocks [illegible] time in the night.

RESULTS AND DISCUSSION

The observer ground crews were active each autumn migration season between August 20 - October 31, a total of 72 observation days, and in the spring between February 15 - May 20, a total of 95 days. In the almost every year migration was followed for more than 5 consecutive days the period 1980-1984. The ground crew network enabled us to collect important data on several [illegible] dates of [illegible] species are usually quite constant. Some species, [illegible] for example pass over each autumn in two waves between the 10 September and 10 October, the main wave between 2-17 May. The [illegible] known, [illegible] Levipes, begins [illegible] in large numbers concentrations between the end of February to the first week of March. By using this date from the ground crews we could provide the IAF with advance warning in real time on expected large migration waves. They in turn, could then stop low altitude flights during this time.

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The widespread observer network, which was equipped with radio transmitters to prevent overlap in counting, enabled us to perceive clearly (though not completely the number of raptors overflying Israel. In spring 1980 for example, 36,000 Black Kites were counted, in spring 1985 850,000 Honey Buzzards and 75,000 Steppe Eagles and in spring 1986 465,000 Steppe Buzzards. During the 1983 Kfar Gasea autumn migration survey 141,000 Lesser Spotted Eagles were counted and in autumn 1986 44,000 Levant Sparrowhawks. These counts are of value in estimating the size of certain European and Asian populations about whom only partial information exists at present.

Picture 1.

We first started tracking migrating soaring birds with the motorized glider in spring 1986. This sort of tracking had already been done by Pennycuick (1972,1979). However the location of Israel at the junction of three continents and the basic information on migration routes which already existed enabled us to make 14 tracking flights already in the first year (spring 1986). In the autumn of 1986 there were 27 additional flights, a total of 41 flight days in which we followed flocks of Lesser Spotted Eagles, Honey Buzzards, Levant Sparrowhawks, Storks and Pelicans.

The flights in the glider enabled us, for the first time, to obtain real, three dimensional data on the altitude of the migrating flocks. Data on the altitude of flight in relation to the utilization of thermals was recorded, while continuously tracking the flock from the base to the top of the thermal, and gliding altitude till the next thermal was reached. In this way movements were followed from the moment the flock took off in the morning until it landed at the end of the day or reached the border, while mapping exactly all thermals utilized along the way.

Graph 2 exemplifies a typical flight with a flock of Honey Buzzards in a three dimensional flight altitude relation. We can see that the flight was made on a day with 4/8 cumulus clouds at a cloud base altitude of 800 m.a.s.l. and moved most of the time between altitudes of 500 m.a.s.l. and 900 m.a.s.l.

Graph 2

In addition to the migration altitude sections we were able to systematically track the raptor flock's route while flying alongside it for 4-11 hours a day, along the length of Israel, for distances between 38 to 311 kilometers with the same flock. This method enabled us to located important migration routes which we had not formerly known from the data provided by the ground observer crews. This information was the basis for declaring certain areas off-limits for IAF aircraft.

Map 2

The flight speed of the flocks while gliding between thermals and the final speed per hour of migration was computed. Maximum gliding speed reached 85 k.m.h. and the average velocity was 17-46 k.m.h. according to weather conditions (see p.). The average velocity of the flock is very important to the air force, as it enabled us to estimate the rate of progress of the flock, and with the help of the radar warn IAF bases in advance on the time of approach of a flock.

The glider was also useful in checking the data provided by the various radars used. We were able to check the discovery threshold of the radar, our ablility to estimate the size of a flock with it and the reliability of its coverage at different ranges.

In addition to the systematical tracking with the motorized glider, in 1985 we decided to track autumn and spring migration with the MSF-8 arrival radar at Ben Gurion Airport. By using the data from the ground, the motorized glider and the IAF light aircraft we found that the radar could spot migrating flocks of raptors at ranges of 30-40 miles. In spring 1986 about 40 flights were made in which the glider was directed to the migrating flocks by the radar. We found that the radar spotted flocks of 10 or more birds of prey. Air force equipment operated by two senior air control officers drew situation maps of the flocks every 20 minutes and simultaneously photographed the radar screen with a polaroid camera.

With the help of the radar at Ben Gurion Airport we were able to map major migration routes on a horizontal plane (it does not provide altitude data), and receive a rough estimate on the number of flocks and their size on a daily and seasonal basis. We learned that the migration axis has dynamics of its own: in the morning it moves 7-11 kilometers east of the Mediterranean coastline and towards noon it drifts 18-36 kilmeters further east to the slopes and summits of the mountain ridge which lies along the length of the country. On record migration days flocks of 20-60,000 were observed along 70-80 kilometers in one continuous mass (see photos 3,4).

The relation between climate factors and migration

From a preliminary analysis of climate data during migration it seems that meteorological factors play a major role in determining the characteristics of migration. On days when there is atmospheric instability and good thermals develop the raptors manage to "climb" higher and glide for longer distances, thereby reaching an average velocity of up to 65 k.m.h. On warm, windless days gliding conditions are bad, and there are even inversions, the raptors cannot reach high altitudes with the thermals and they migrate closer to the ground, at lower speeds between 17-30 k.m.h., with only short-distance glides between climbs. According to this data, a flock of raptors migrating on days with optimal gliding conditions, may cover a distance of 500-600 kilometers in an average of 10 hours. On days with imperfect gliding conditions it can cover only 170-300 kilometers a day.

Changes in dates of passage

On days with barometric depressions, when good gliding conditions cannot develop and rain falls, migration seems to stop almost completely or is significantly delayed. When this occurs on the way from Europe to Israel, migration waves may come several days late, and enable the IAF to add a few more flight days. One such case was the unusual depression which reached Israel this last year at the end of September.

The Number of Lesser Spotted Eagles (Aquila pomarina) that migrated over Israel during the peak week

(according to Dovrat, The TORGOS 12 and preliminary summaries)

Date/ /Season	27/9	28/9	29/9	30/9	1/10	2/10	3/10
autumn '85	7006	11133	4716	8301	2877	7373	24767
autumn '86	17859	15584	26933	12559	107	160	3407

The week between the end of September to the beginning of October is the peak week for Lesser Spotted Eagle migration. From comparisons of data from the past two years (not in absolute numbers) we see that during the first 7 days in October 1986 there was a sharp decrease in the number of migrating Eagles as compared to the previous year. A satellite map from 29/9/86 (see photo 5) shows a large barometric depression encroaching on the area from Russia, but central Turkey and southwards, Lebanon and Israel are clear of clouds. On the other hand, a satellite photo from 2/10/86 (photo 6), shows a large depression over the Middle East, which caused large amounts of rain to fall over Israel.

In these bad thermal conditions, compared to the previous year, the Lesser Spotted Eagles were detained until the depression passed. And so, finally, between 4-8 October 1986, when the depression had passed, another 22,191 Lesser Spotted Eagles passed over, compared to 11,151 in the same period the previous year.

Pictures 5 & 6

The solution for the Israel Air Force

After the data from all the different sources - ground crews, motorized glider, radar - and the relation between changes in migratory patterns to meteorological factors had been analyzed, the IFA introduced BPZ (Bird Plagued Zone) regulations. These regulations forbid fighter planes to fly during the migratory seasons at the altitudes and along

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Since these regulations were issued in 1971 there was not even one more serious collision and no aircraft or pilot were hurt or damaged. The results of this study which were implemented by the IAF have saved it millions of dollars. By financing the study the air force enabled us to carry out a widespread project to learn about one of the most impressive phenomena in nature.

Acknowledgments

Thanks to Colonel G., Lt. Colonel O. and 7 air force pilots without whose cooperation this project would never have become reality. I would also like to thank Eli Peretz, Michael Lindey, Nor. Lusid, Reuven Ayalon and all the other motorized glider pilots. Pini Nagar and Asher Friedman air force radar operators and Ilana Agai from the Israel Nature Reserves Authority manned the arrival radar at Ben Gurion Airport expertly. And of course, thanks to the Airport Authority who authorized us to use the radar. Special thanks are due to Ehud Dovrat and the hundreds of volunteer birdwatchers who helped gather data from the ground. Finally, the staff of the IAF and the SPNI who provided the framework for the study. To Esther Lachman for helping in the translation. Special gratitude to Prof. Amots Dafni of Haifa University, the scientific mentor of the project, to Dr. Ian Newton and Mark Elkins for their guidance and to the Minerva Center for Bioenergetics, the Israel Science Foundation and the Ministry of Science for their help in funding the project.

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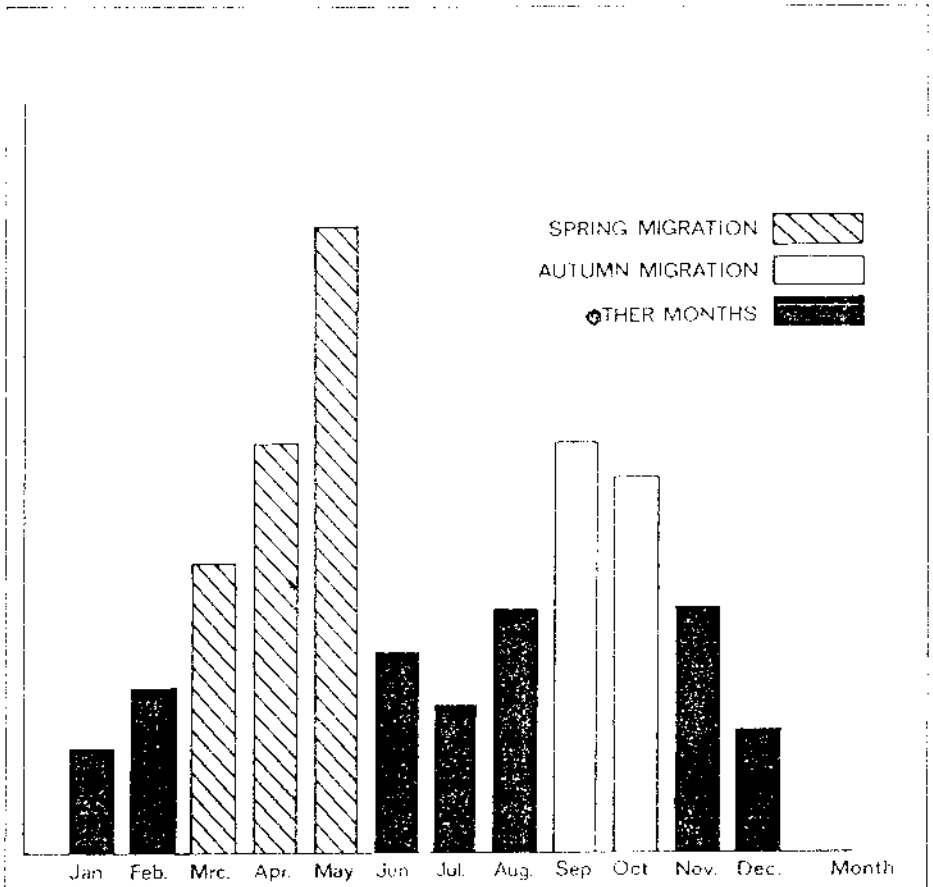
Table 1

Damage to IAF aircraft from birds 1973-1982.
Exact numbers have been censored for security reasons, however the large numbers of collisions during the months of spring (March, April, May) and autumn (September, October) migration is evident.



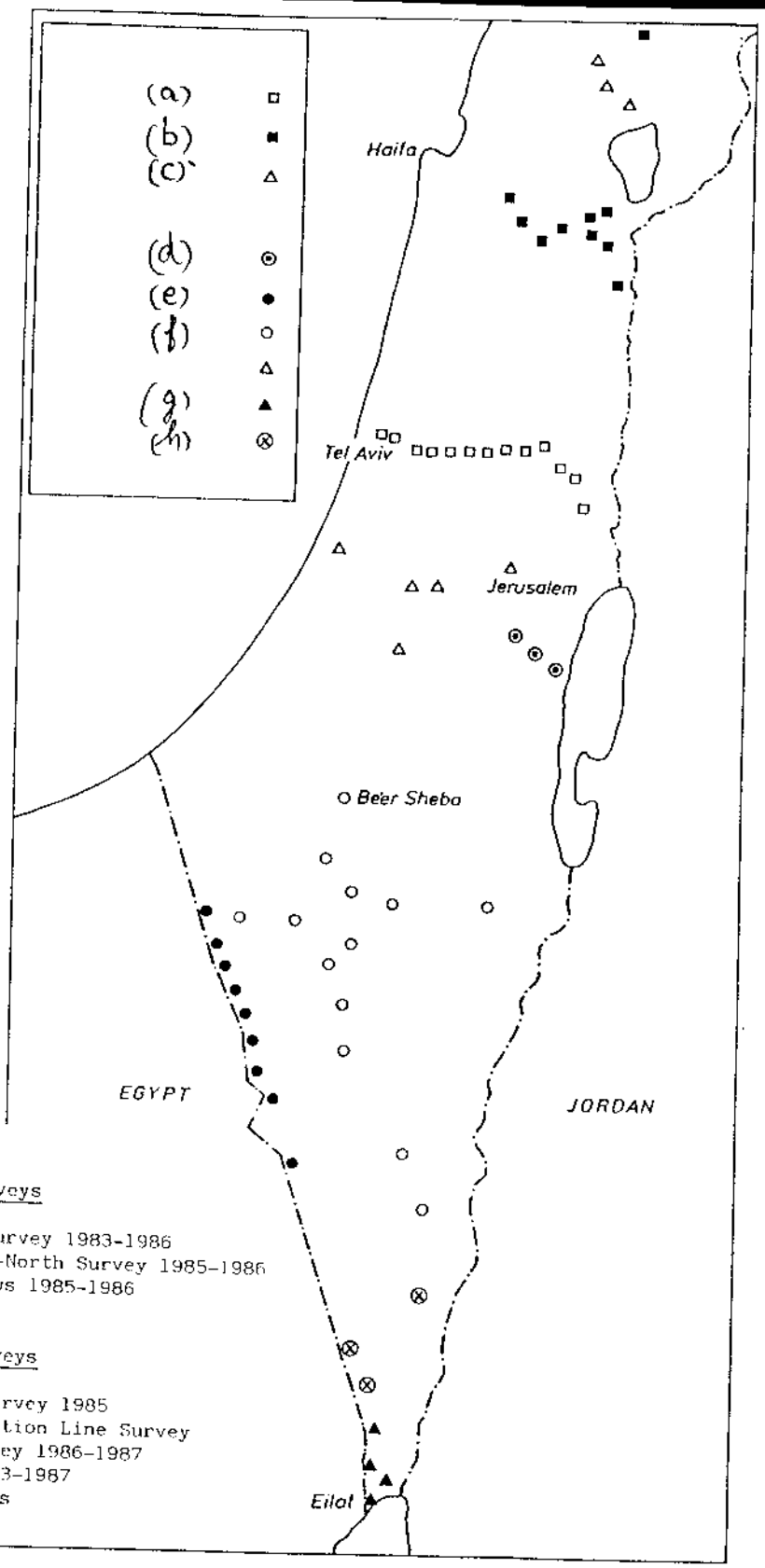
Map 1

Autumn Migration Surve

(a) Cross-Samaria Su
(b) Jezre'el Valley-
(c) Independent crews

Spring Migration Surve

(d) Judean Desert Su
(e) Egyptian Demarcat
(f) Har Hanegev Surve
(g) Eilat Survey 1983
(h) Independent crews



Map 1

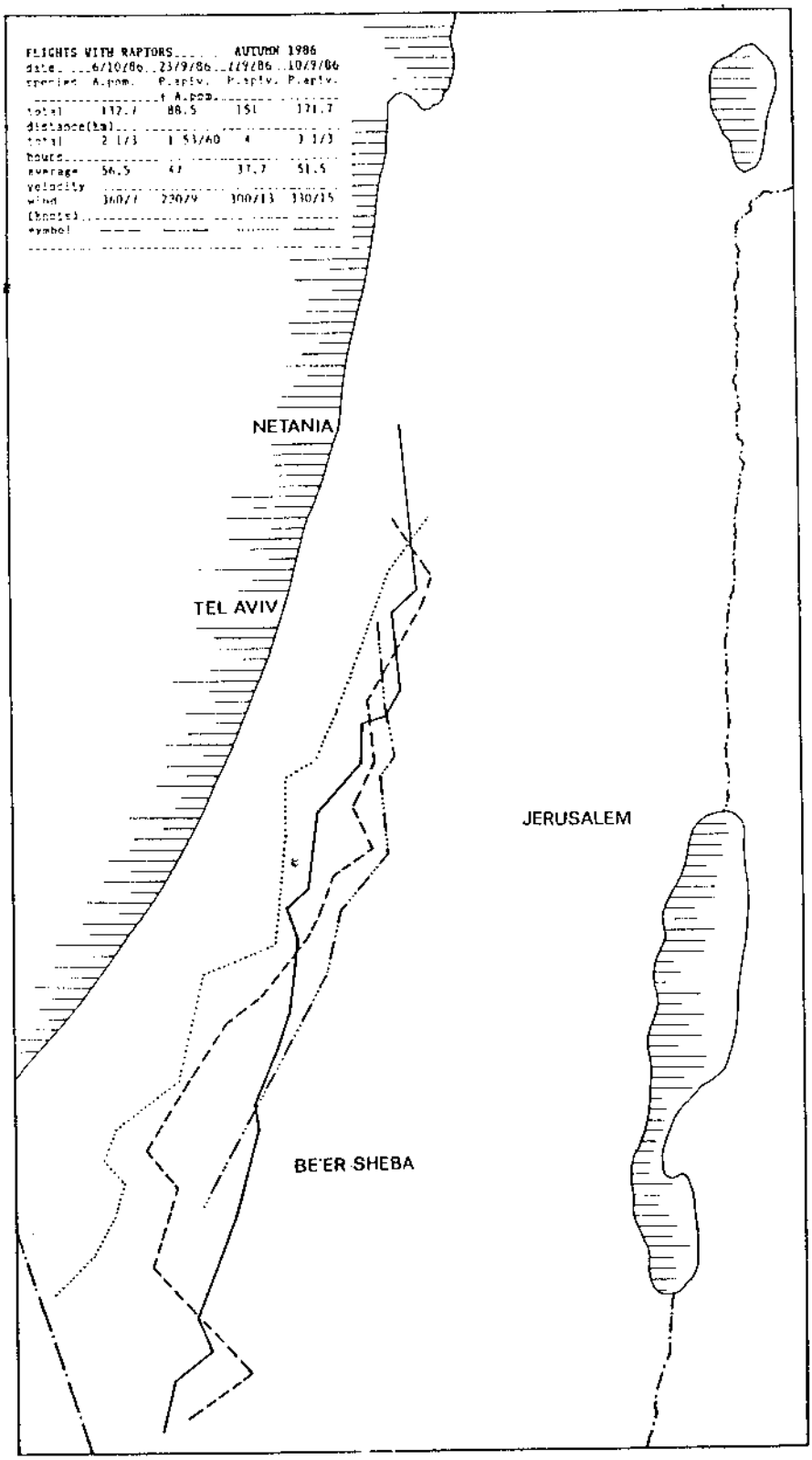
Autumn Migration Surveys

(a) Cross-Samaria Survey 1983-1986
(b) Jezre'el Valley-North Survey 1985-1986
(c) Independent crews 1985-1986

Spring Migration Surveys

(d) Judean Desert Survey 1985
(e) Egyptian Demarcation Line Survey
(f) Har Hanegev Survey 1986-1987
(g) Eilat Survey 1983-1987
(h) Independent crews

Map 2



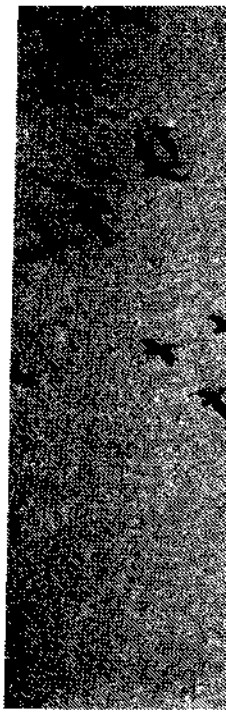
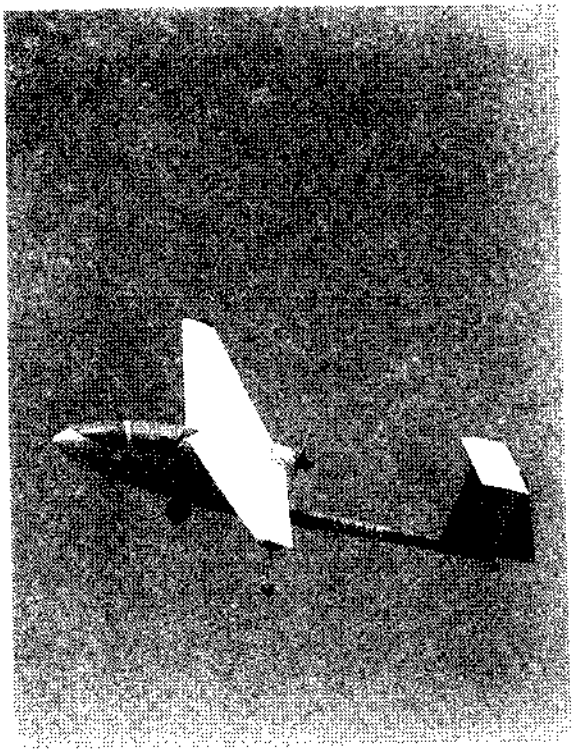


Photo 1

The motorized-gli

Photo 1

The motorized-glider with pelicans (Photo Ofer Bahat)



Graph 2.-

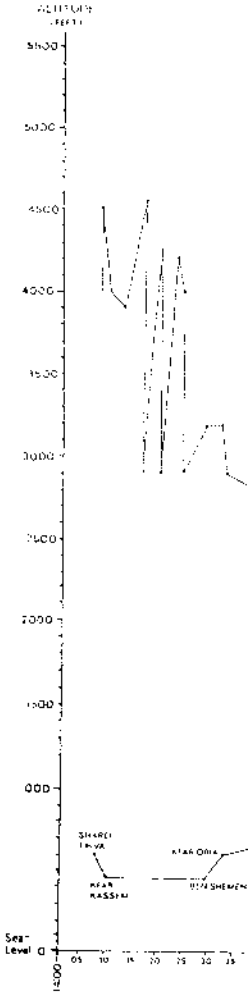
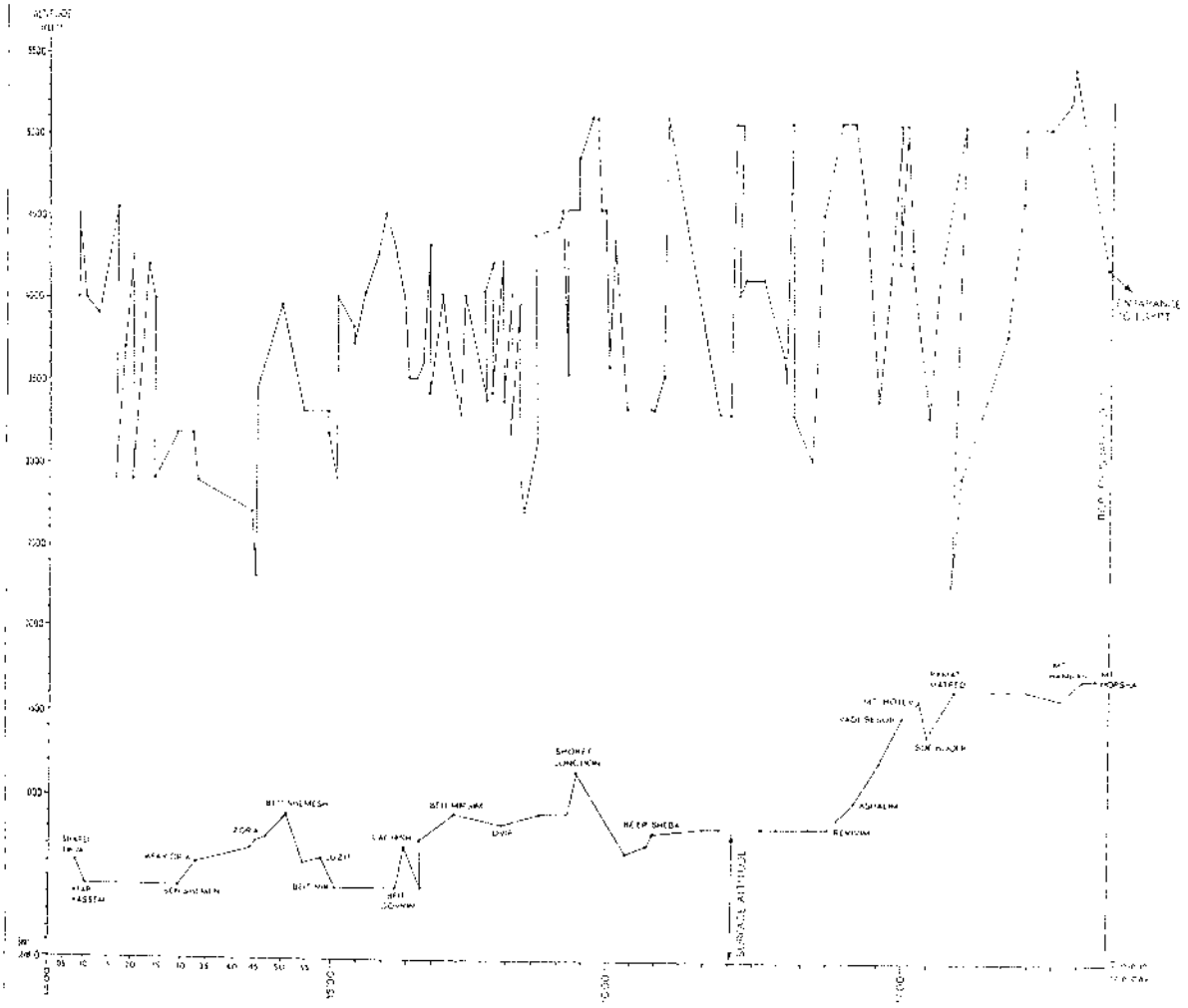


Photo 2

Above: The "OAF" motorized research glider, made in Poland
Below: One of several posters produced by the IAF in cooperation with IRIC, to further pilots' awareness to the problem.

Graph 2.- A typical section representing raptor migration (Honey buzzard, Pernis apivorus) as it was made with the motorized glider in autumn 1986 (3 September). The flight starts at Shefaram (32° km east of the Mediterranean coast from Tel-Aviv) and ends at Mt. Hurshe at the Egyptian border, a total of 185 km. At the bottom of the graph is the altitude above ground along the way, and the first altitude of the raptors soaring with one thermal and gliding on to the next one.

Wind: azimuth 300°, velocity 20-25 knots, cloud 4/8, altitude of cloud base 5500 feet.



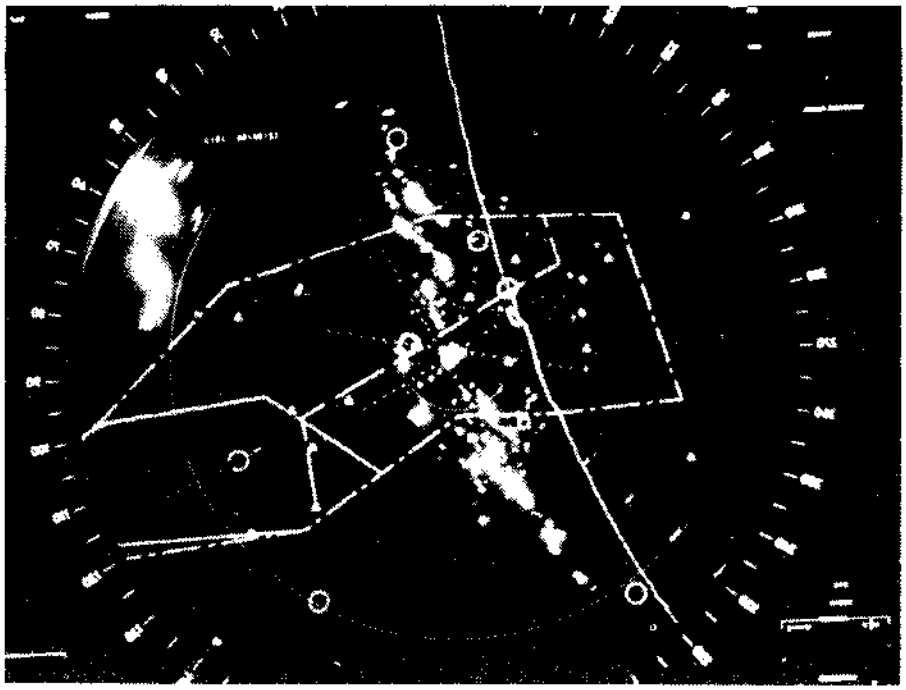


Photo 3 28.9.1986 (11:30) - Ben Gurion Airport radar (ASR-8) shows huge flocks (+/- 15,000) of Lesser-spotted Eagles (Aquila pomarina). Line is 82 km long (narrow line extending from due north to southwest in Mediterranean coastline).

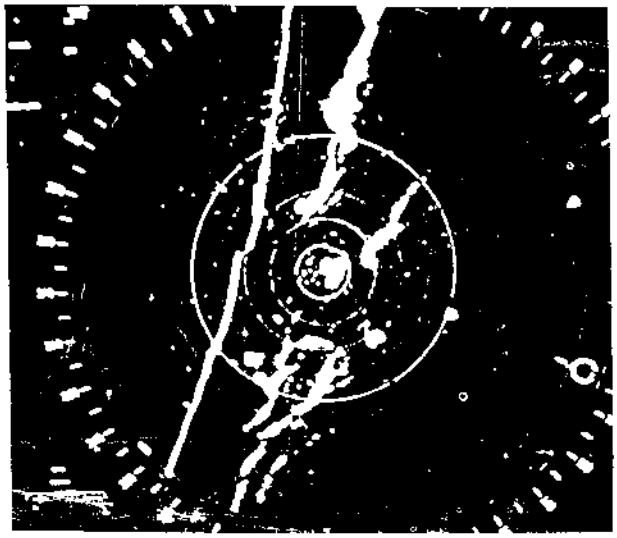


Photo 4 Hugh flocks of Honey Bazzards (Pecnis apivorus) 11.9.86, 10 47 Ben Gurion Radar Lenghth of Lines 75 km. between 30,000 - 40,000 raptors, counted frech glider

Photo 5, above: 29/9/86, 9:30, satellite photo showing the barometric depression over Russia, Italy, Greece and Northern Turkey approaching our area - In Israel Lesser Spotted Eagle migration is at a peak.

COMPARISON OF TWO SATELLITE PHOTOS:

Photo 6, below: 2/10/86, 12:30, the barometric depression is over our area - migration has stopped almost completely.

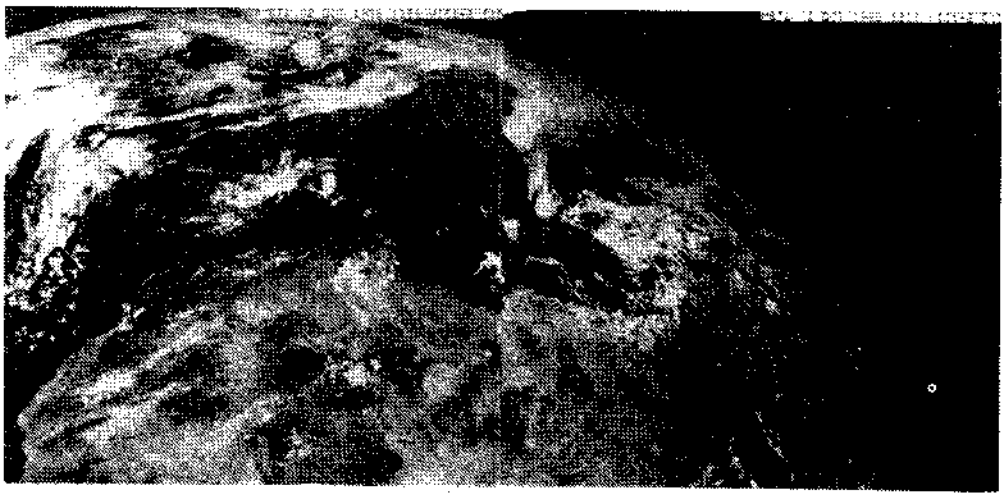


Photo 7, above: An Israeli Air Force Skyhawk with broken windshield – caused by white stork on spring migration.

Photo 8, below: The pilot of an IAF Skyhawk after the air collision

Recogniz
weather

(Ronald P. La