

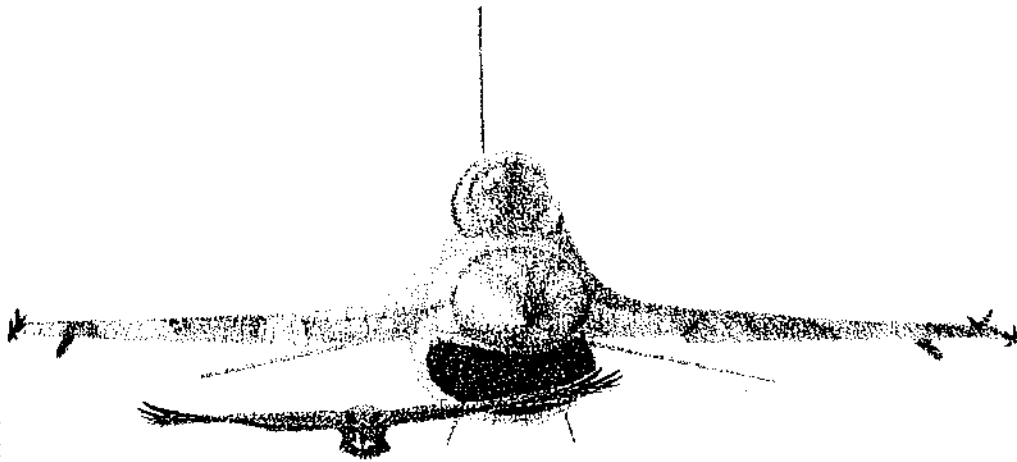
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THE DEVELOPMENT OF A BIRD MIGRATION REAL-TIME WARNING SYSTEM FOR THE
ISRAELI AIR FORCE UTILIZING GROUND OBSERVERS, RADAR, MOTORIZED GLIDER
AND DRONES; AND A PRELIMINARY REPORT ON THE USE OF TRANSMITTERS
RECEIVED BY SATELLITE AS A NEW WARNING METHOD

Yossi Leshem
Israel Raptor Information Center (IRIC)
Har Gilo, Doar Na Zifon Yehuda 90907 Israel



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USE OF SATELLITE TRANSMISSIONS AS A NEW WARNING METHOD

Yossi Leshem, IRIC Har Gilo, DN Zfon Yehuda 90907, Israel

ABSTRACT

In 1985-88 a joint research project was carried out by the Israel Air Force (IAF), the the Israel Raptor Information Center (IRIC), Tel Aviv University and the Ministry of Science and Technology, with the purpose of precisely identifying the central migration routes of birds soaring over Israel, their flight elevation, dates of their arrival, and the effect of climatic changes on the character of the migrations.

The study was conducted in the wake of very severe damage to the IAF, mainly during the migration seasons; preliminary results were published in the Proceedings of the Madrid BSCE Conference (1988). This article contains a detailed presentation of the applicable methods developed in the course of our research. During the spring (March 1-May 30) and fall (August 1-November 20) migrations, for a total of about seven months per year, the IAF activates a real-time warning system based on the data we collected. A procedure regulating flights in Bird-Plagued Zones (BPZ) was developed. Detailed maps were prepared and are now distributed to all aerial units, obligatorily limiting the elevation, location and time of flights.

A "Birdwatching Center" was established at the approach radar of Ben-Gurion International Airport. All information about birds throughout Israel is channeled to the Center -- from flights towers in IAF bases and from control units in the IAF. Manned 24 hours daily, the Center produces real-time warnings based on all the information anished from IAF radar units, from a network of birdwatchers across the country, and from drones and a glider. With the data collected, IAF flights are able to fly at low altitudes when bird migration is low.

Following the study and the development of the real-time warn- ing system, damage to IAF aircraft was significantly reduced, compared to the ten years preceding the study. In 1990, the civil aviation system began to utilize the military system.

A preliminary report explains how satellites may receive trans- missions from storks fitted with transmitters, eventually provi- ding a real-time warning system for the approach of flocks.

INTRODUCTION

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INTRODUCTION

The location of Israel at the junction of three continents has made it part of a migration route of international importance in spring and autumn. Because of the large concentration of birds in the extremely limited air space of Israel, the Israeli Air Force (IAF) sustained severe damage resulting from collisions with birds, mainly migrating soaring birds (Leshem, 1988a).

From 1985-1988, a joint research project was carried out by the IAF, the Israel Raptor Information Center (IRIC), Tel Aviv University and the Ministry of Science and Technology. Our research addressed several questions:

1. Do migration routes on the horizontal plane conform to specific patterns?
2. Do migration altitudes (the vertical plane) conform to specific patterns?
3. Do the birds' dates of passage conform to specific migratory patterns?
4. How do climatic factors influence the variables in the migratory system?
5. Is it possible to predict changes in the characteristic migratory patterns and apply them to the IAF's activities?

Our research methods and findings are described in the proceedings of the BSCE's meeting in Madrid (1988a), as well as in the cited literature (1,2,4,5,6,7). As we were carrying out the above research, we simultaneously activated five parallel sources of information. Each of these sources complemented the other, providing information which was lacking in the others and thus making it possible to verify the authenticity of the data collected via these sources: 230 motorized glider flights, on which we accompanied migrating flocks of storks, pelicans, and birds of prey; 29 flight days with drones; 19 flight days with a Cessna; thousands of Polaroid photos of the radar screens at Ben-Gurion Airport, of IAF radars, and of meteorological radars; and ten years' data collected by ground crews of birdwatchers.

RESULTS

1. PRODUCING A MAP OF THE BIRD-PLAGUED ZONES.

From the reservoir of data which were collected and analyzed, we were able to draw a map of the Bird-Plagued Zones (BPZ) delineating the routes taken by the major concentrations of birds. Fighter planes have been forbidden to use these routes at low altitudes, except for take-offs and landings (see Map #1). Research data revealed that the masses of soaring birds are concentrated, on most days, at altitudes up to 3000 ft. AGL, and the permitted altitude for fighter planes was regulated accordingly. It was recommended that carrier planes fly at lower speeds within the limited areas.

Predicted times for the start and end of the migratory season are printed on the map. Various colors are used to show the areas where different varieties of birds appear on different dates, for instance: Large masses of storks migrate south along the Afro-Syrian Rift as early as the middle of August, while the great wave of birds of prey arrives only at the start of September, flying primarily along the parallel route to the west. The map also carries detailed instructions for planning flights during the migration season and for dealing with any sort of collision with the birds.

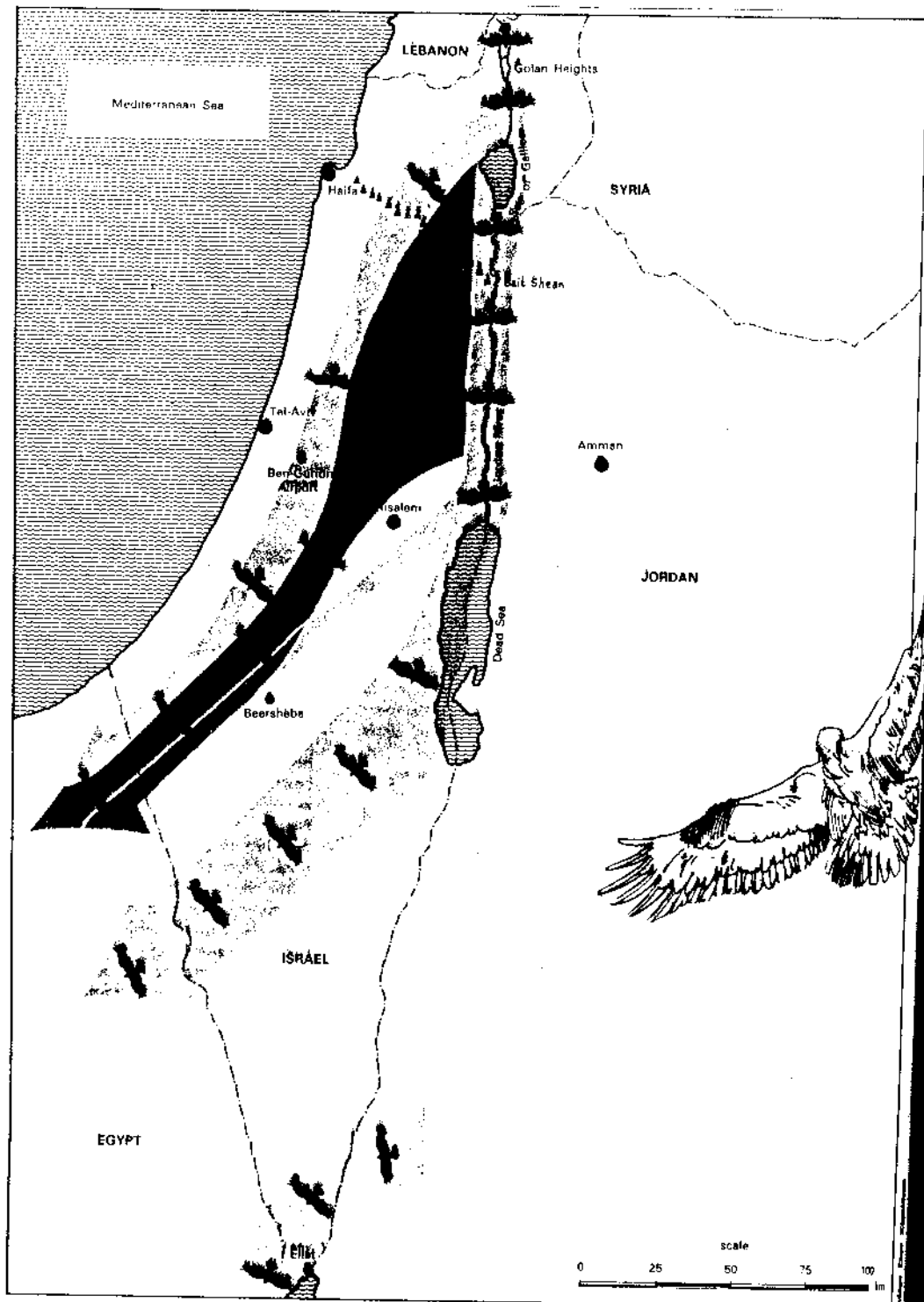
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Schematic drawing of the Bird-Plagued Zones (BPZ), produced by the Israel Air Force, depicts areas where flights are forbidden during migration seasons. Also noted is the Autumn Real-Time Warning System, comprised of a network of 17 observation points. ▲



Two separate maps and the written procedures. The maps show the cycle of every pilot's air squadron.

2. "MARKETING" IAF.

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3. DEVELOPING

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Ground crew observation spread across the entire Galilee - Lake Kinneret. 60 volunteers (see Map) head of the system. The in local kibbutzim, systems transmitters for their communication were able to obtain information throughout the country

The network of ground crew was later completed by The IAF was then able to obtain information regarding the later than usual, the Air

The research made it clear that migrating flocks dwindle even in the middle of the days with poor migration. We developed a procedure permitted to make low-altitude either by birdwatcher crew

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Two separate maps were published, one for the spring migration season and one for the autumn; and the written procedures, known as the BPZ Regulations, became part of the IAF's official codes. The maps are distinguished by high-quality color printing meant to stand out and attract the eye of every pilot when they are hung, according to orders, in the briefing rooms of every air squadron.

2. "MARKETING" THE BIRD ISSUE AND THE BPZ, AND "SELLING" THEM TO THE IAF.

During the course of our research, an elaborate program was introduced into the IAF to raise pilot' consciousness about birds and the IAF's conflicts with them. A course of lectures accompanied by films and slides was delivered to all air squad- rons and other IAF personnel, such as radar units, who are involved in flight systems. The IAF also produced, in cooperation with IRIC, a series of color posters on the subject along with calendars, stickers, explanatory pamphlets, and a video-cassette series which was distributed to all flight squadrons during every migratory season. Thanks to this "marketing" program and the new army regulations, the bird issue had a significant impact on the largest part of the Air Force, becoming part of the IAF's consciousness within an unexpectedly short time.

3. DEVELOPING THE REAL-TIME WARNING SYSTEM.

During the first phase of the research, when the first BPZ map was produced, it became clear to the IAF that due to Israel's special location, 50% of the country's air space would have to be closed to low-altitude flights for half the year (see Map #1). This could seriously damage the level of the Air Force's training program. Hence the Real Time Warning System was developed, based on several sources of data:

Ground crew observers. During the autumn migration season, a network of ground crews was spread across the entire country, from Haifa to Beit She'an (located 20 km. south of the Sea of Galilee - Lake Kinneret). These 17 ground observation posts were manned by a total of some 60 volunteers (see Map #1). Three vehicles which served as mobile observation posts were at the head of the system. The volunteers, who largely came from abroad, were lodged free of charge in local kibbutzim, systematically followed the migration. The Air Force provided radio transmitters for their communications, one mobile transmitter for each post. Thus the observers were able to obtain information within "real time" on the shifting movement of the migration throughout the country.

The network of ground observers made it possible to obtain a relatively accurate picture (which was later completed by radar reports from Ben-Gurion Airport) of the large flocks of birds. The IAF was then able to begin adjusting and correcting the regulations according to real-time information regarding the birds' actual appearance. In years when the migrating birds arrived later than usual, the Air Force could sometimes add a few more flight days to its schedule.

The research made it clear that, during about 30% of the migra- tory season, the strength of the migrating flocks dwindles to almost nothing, and on such days low-altitude flights can be allowed even in the middle of the migration season. The obser- ver network provided early warning on days with poor migration. When few birds were seen at dusk, and radar confirmed the report, we developed a procedure for informing the IAF. The following morning aircraft would be permitted to make low-altitude flights; however, if large flocks were sighted in the morning -- either by birdwatcher crews or on radar -- permission was withdrawn immediately.

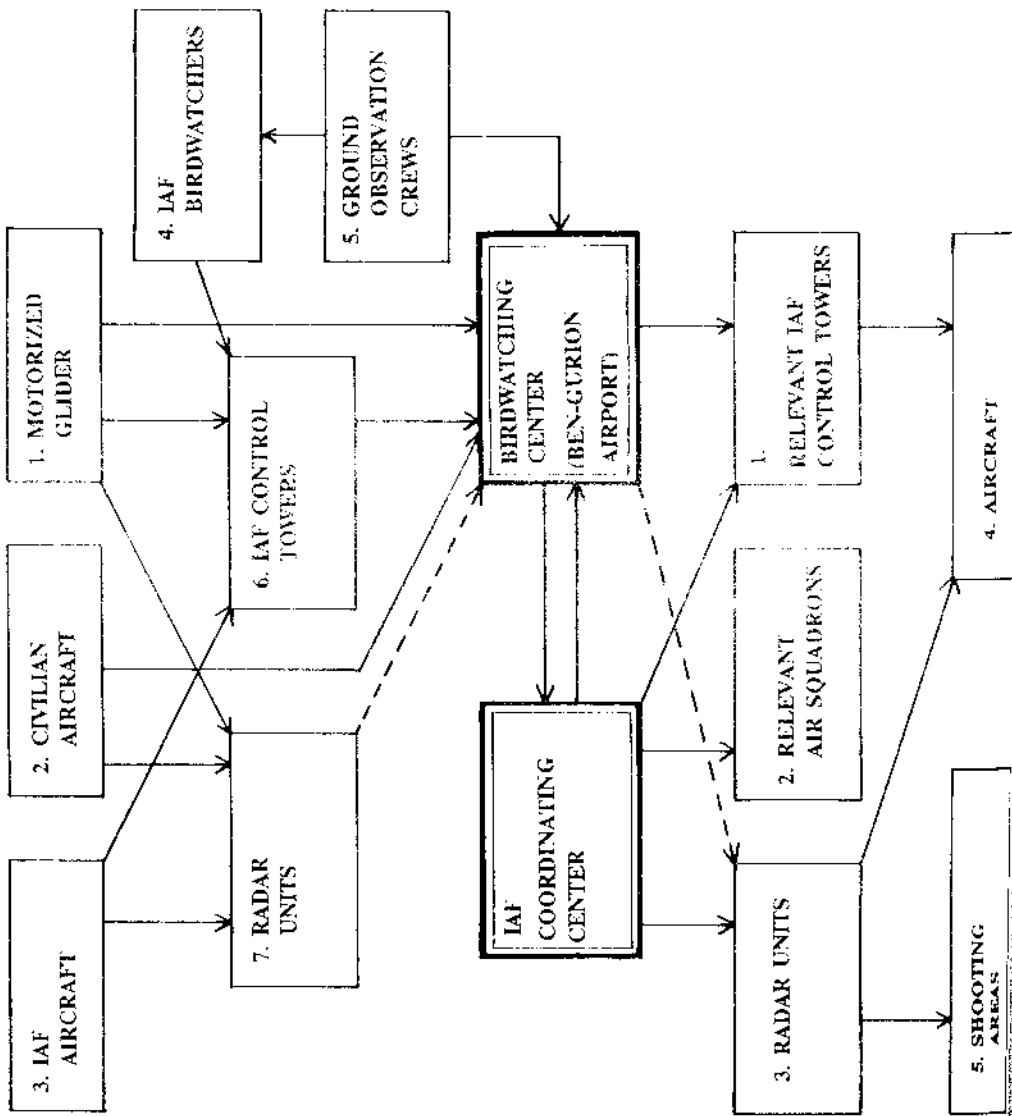


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The following graph data from Ben-Gurion (the IAF is not in these times).

Degree of Migration

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- Degree III
- Degree IV
- Degree V

As shown on the graph

Operation of the Birdwatching with dramatic changes southerly or SE, push reports to warn the

3. ESTABLISHING THE BIRDWATCHING CENTER AT BEN-GURION AIRPORT. In order to establish a single center which could collect all relevant data regarding movement of birds from all the sources of information, and to distribute this information in real time to all parties in the IAF who might need it, we established the Birdwatching Center in the control tower of Ben-Gurion Airport. It is currently run 24 hours a day by a retired radar officer of the IAF and by four female IAF radar specialists. A direct, private telephone line near the radar screen ensures that the information is relayed smoothly and quickly. Input comes from the network of ground observers, aircraft (motorized glider and civilian and military planes), control towers of IAF bases, and radar control units.

The Birdwatching Center provided ongoing information about flocks of birds located by radar which were flying in close proximity to IAF air bases or the approaches to them. In

Cooperation with the NRA, a woman soldier trained in birdwatching was positioned in each IAF control tower to help locate particular flocks which had been sighted on radar.

We also developed a procedure to calculate the speed of the migrating flocks so that it was possible to deliver real-time warnings even to those Air Force bases which are out the range of Ben-Gurion's radar system.

When huge flocks flew over shooting training areas, a real-time warning was given to the IAF control center to close the area in real time until the birds had completely passed by.

On days of heavy migration, warnings were also delivered to IAF radar control units to call off flights even outside the BPZ. Since some of the Air Force's largest bases are located in the center of the BPZ, with a high number of landings and take-offs, this real-time information was highly effective. Officers in the control towers thus had the opportunity to change the direction of landings and take-offs according to information about the birds' routes which was provided by the Birdwatching Center. On days with low migration, we permitted low-altitude flights in the BPZ, depending on the high reliability of radar to immediately signal any new flocks approaching.

The following graph shows the movement of flocks from March 5 - May 31, 1989, according to data from Ben-Gurion Airport's approaching radar. Data was collected on a total of 73 days (the IAF is not in training on Saturdays and holidays, and therefore the radar is not manned at these times).

<u>Degree of Migration</u>	<u>Birds per Day</u>	<u>Total days</u>
Degree I	1-1000	24
Degree II	1000-5000	25
Degree III	5000-10,000	9
Degree IV	10,000-20,000	5
Degree V	20,000-200,000	9
		—
		Total: 73

As shown on the graph, there is a low migration rate on 32.8% of the days.

Operation of the Birdwatching Center is critical because, during each season, there are a few days with dramatic changes in wind direction and speed. These changes, such as NW winds becoming southerly or SE, push the flocks out of the BPZ. In such cases the Center provides immediate reports to warn the whole system of the changes in real time.

The Birdwatching Center's autumn migration and migration is expected to be the heavy migrations of the year. This procedure allows for significant numbers, and which do not necessarily fit the Center's season give the BPZ, with the understanding that which are still present.

Motorized glider and ground observers can provide a motorized glider, flying in the warnings of the birds' addition to its radio, the main flocks and the

Due to a shortage of funds of the Birdwatching Center, limitations (primarily due to in response to real-time every other day throughout the whole country, potentially cancelling even the BPZ took off in the north of around the glider and the

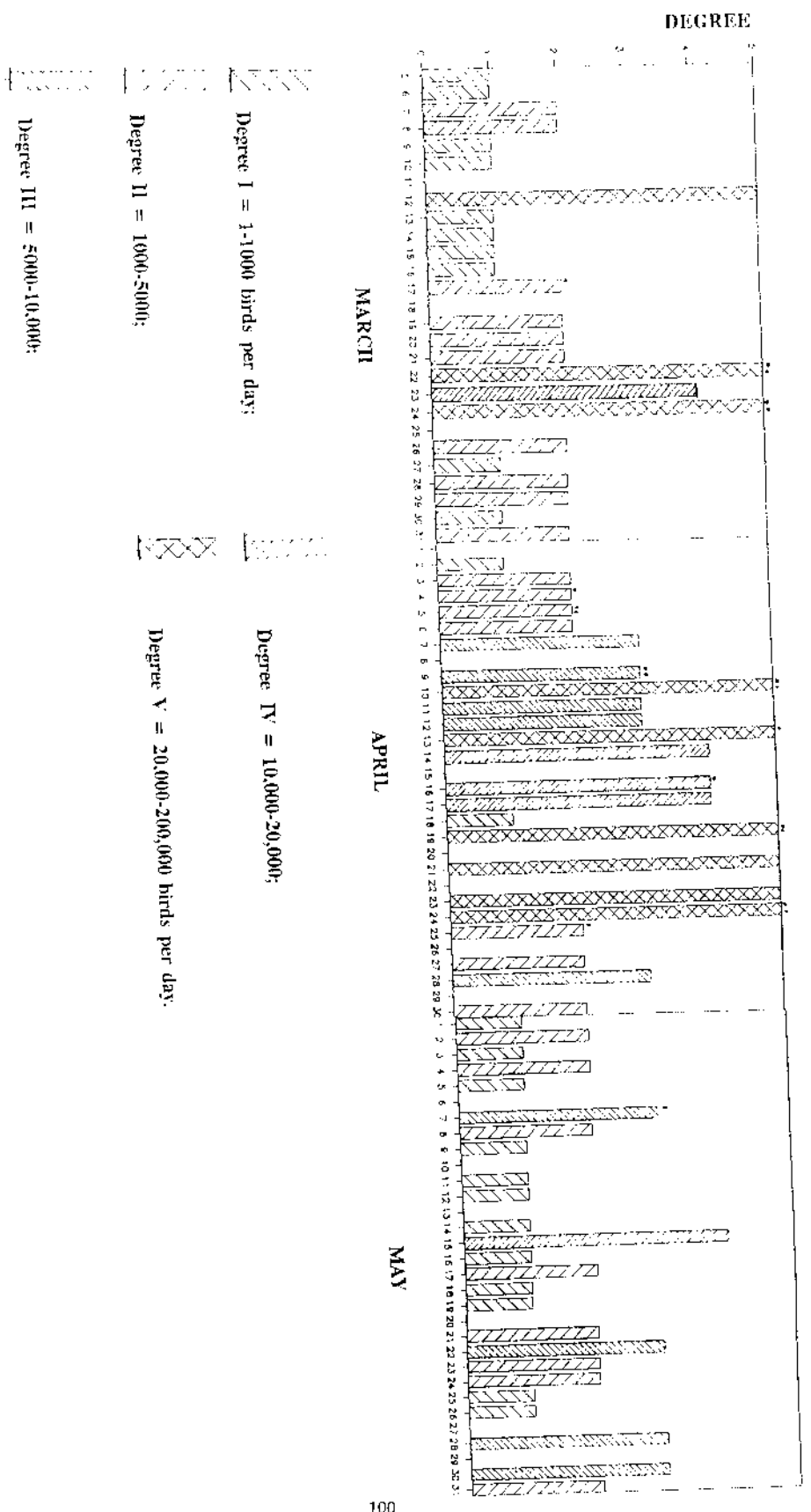
Instead of the glider, or four-five hours, from the tool, mapping out the main the drones filmed the camera; as far as we anywhere in the world.

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FINAL RESULTS

Since the BPZ regulatory air collisions with migration operation, the IAF lost a single instance of its success. In 1983 the IAF suffered a major achievement.

Total of 1989 spring migration as tracked by Ben-Gurion approach radar (ASR-8), March 5 - May 31, 1989. Data is based on photos of radar screen.



The Birdwatching Center begins its Real-Time Warning System activity on August 1 for the autumn migration and on March 1 for the spring season (in each case, two weeks before heavy migration is expected to begin). The activity ends on November 30 and May 30, two weeks after the heavy migrations cease.

This procedure allows us to follow the migration from the moment it starts to build up in significant numbers, and to provide warnings about the presence of smaller flocks flying through which do not necessitate putting the BPZ regulations into effect. The final two weeks of the Center's season give the IAF the opportunity to fly at low altitudes, with no limitations in the BPZ, with the understanding that the Center will provide real-time warnings about small flocks which are still present and might cause problems.

Motorized glider and drones. Neither Ben-Gurion's approaching radar nor the network of ground observers can provide accurate information about the altitudes of migrating flocks. The motorized glider, flying along the migration route, is the perfect tool to provide real-time warnings of the birds' altitudes, and is crucial to the success of the Birdwatching Center. In addition to its radio, the glider is equipped with a cellular phone, and from the air it can locate the main flocks and their flying heights and report back to the Center instantaneously.

Due to a shortage of funds, we were not able to fly the glider daily. Nevertheless, the net work of the Birdwatching Center, as described above, made it possible to significantly shorten the BPZ limitations (primarily during the heaviest migration season), closing and re-opening it as needed in response to real-time warnings. During the fall, the BPZ was closed about October 10, but every other day through the end of November, one-four large flocks of pelicans flew across the whole country, potentially causing severe problems. We thus developed another procedure for cancelling even the BPZ regulations. The glider accompanied the flock from the moment they took off in the north of the country till they flew over the Egyptian border. A two-mile zone around the glider and the pelicans was declared a "moving BPZ" and closed to all flights.

Instead of the glider, on some days we used drones for the same purpose, escorting the birds for four-five hours, from the time they took off in the morning. The drones were also an ideal tool, mapping out the migration routes for our research. Flying some 4000-5000 feet above them, the drones filmed the birds along the whole length of their flight with a sophisticated video camera; as far as we know, this is the first time drones have been used for this purpose anywhere in the world.

Real-Time Warning System for Civilian Flights. We spent two years developing the IAF's Real-Time Warning System, and seeing it through till it was accepted and integrated into the Air Force's operations systems, with data flowing smoothly between the Birdwatching Center and all IAF units. Although the warning system was developed for the IAF, we began providing data regularly to civilian systems as well in 1989. They too had well absorbed the significance of the BPZs, and we received a great deal of information from them.

FINAL RESULTS

Since the BPZ regulations and Real-Time Warning System were put into effect, the number of air collisions with migrating birds has fallen dramatically. In the six years since we began the operation, the IAF lost no aircraft due to accidents with migrating birds, and there was not a single instance of its sustaining severe damage in such a collision. Considering that, from 1972-1983 the IAF suffered from tens of serious collisions with birds, this is clearly our greatest achievement.

REAL-TIME WARNING SYSTEM VIA SATELLITE

Professor U. Renner and A. Ginati, of the Technical University of Berlin, West Germany, are developing the TUSBAT project -- following the migration of 12 white storks fitted with radio transmitters which will be tracked by satellites in 1991.

In April 1990, Renner, Ginati, and Leshem equipped three white storks in Israel with transmitters and followed them with the motorized glider to check the operation of the system and whether or not the storks can fly freely carrying the transmitters. The results were promising (see cited literature, 8), and it is planned to launch the satellite in 1991. We believe that, in the coming decade, we will be able to attach tens or even hundreds of transmitters to migrating pelicans, storks and raptors, and these will provide a superb new real time warning system for the IAF when flocks approach Israel from abroad.

ACKNOWLEDGEMENTS

Thanks are due to senior officers D., Z., H., A., G., O., B., and R. of the IAF for their close cooperation at all stages of the project; to E. Peretz, M. Pinkus, and the other glider pilots for many magnificent hours and days with the birds; to

A. Gilad, E. Satat, and Z. Frank of the Israel Airport Authority; P. Magor, A. > Firedman and the women operators of IAF radar equipment, for professional work; I. Agat, for assistance at Ben Gurion International Airport; E. Dovrat, D. Alon, S. Blitzblau and R. Yosef, and all the 300 birdwatching volunteers from 27 countries, who helped collect the data in the field; to SPNI and NRA staff who also helped in the field.

Special thanks to Y. Yom-Tov, Scientific Supervisor of my PhD. thesis, the Israel Ministry of Science and Development, and the Ecology Foundation for providing funds for the study. And finally, to Prof. U. Renner and A. Ginati for launching the exciting new satellite project.

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