

The ecology of the Short-toed Eagle (*Circaetus gallicus*)
in the Judean Slopes
Israel

Graduate Thesis Research report to R.S.G with Additional Aspects of
Conservation and Education between Three Continents

Submitted by

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Abstract

The Short-toed Eagle (*Circaetus gallicus*) is a medium size eagle, preying mostly on reptiles and known to live solitary or in small groups. It is a passing migrant and a summer breeder in Israel. Recently we observed unusual aggregation events, sometimes comprising of more than fifty eagles at a time, mainly preying on rodents. These aggregation events seem to be strongly related to agricultural activities, and appear to be expanding from year to year.

The main goal of this study is to investigate the effect of human agricultural activities on the phenomenon of aggregation of the Short-toed Eagle and its relation to migration, dispersal and feeding habits in central Israel. Understanding these aspects would give us a new perspective on the behavior of the Short-toed Eagle, including its potential for biological pest-control, and would enable us to evaluate/ develop conservation plans for this species.

Background

Raptor research has focused mainly on the breeding aspects (e.g., pair formation, breeding behavior and success, food content at the breeding site (see Newton 1979; Meyburg & Meyburg 2002), while other aspects connected with other parts of the raptor life cycle, and particularly movement dynamics, have been poorly addressed. This can be attributed to the great mobility of these birds (i.e., large home range, breeding and natal dispersal, cross-countries migration) and the lack of adequate monitoring techniques (Meyburg & Meyburg 2002). So far, studies of movement dynamics relied mainly on simple visual observations, ringing recoveries, body markers, and counting of migrating raptors at bottle necks. Radio-telemetry was utilized mainly for studies on home range and gave answers on dynamics near the nest (Kenward 2000). Satellite transmitters appeared later, and in the last few years are being developed to give more answers related to bird migration and other behavioural aspects. However, due to their high cost, their use has been limited to adult birds with higher survival rate (Meyburg & Meyburg 2002). Given their large-scale perception on the one hand and their high spatial accuracy on the other hand, increased accessibility to satellite transmitters has the potential to tackle a variety of questions that remain poorly understood. These include questions regarding post-breeding dispersal, natal dispersal, movements between breeding grounds, roosting or refuelling sites and wintering grounds, emigration and immigration, weather effects on migration patterns, site fidelity, post breeding family interactions, differences in movement dynamics between adults and juveniles and between breeders and non breeders, mortality rates, etc.

One of the interesting phenomena in birds, and in raptors in particular, is the phenomenon of aggregation. It occurs within certain species, which feed on food resources that are patchy – scarce, unevenly distributed and unpredictable. Birds would be more solitary when food is more evenly distributed, such as raptors feeding on live prey (Newton 1979). Aggregation behavior is related to the species biology as well, such as colonial or solitary breeding, but, basically, any organism has the potential of showing aggregative behavior, according to the food availability and the optimal foraging cost (Smith 1968; Horn 1968; Newton 1979; Davies & Houston 1984). Aggregation is not necessarily confined to the breeding season, e.g., Lesser Spotted Eagles, *Aquila pomarina* and Steppe Eagles, *Aquila rapax*, wintering in South Africa and feeding on termite colonies (Styen 1973). Post-disturbance colonization, such as after fire, or following other anthropogenic interference is one of the factors shaping bird dispersal and aggregation (Brotons et al. 2005).

Non raptorial species display similar change of behavior, in being sometimes territorial and solitary and sometimes aggregative, e.g., cranes wintering in Spain (Alonso et al. 2004) and wagtails, that are territorial breeding birds, but flock when food is scarce (Davies 1976) or is scattered over large areas (Zahavi 1971). Most studies that have been done on aggregation were mainly in the context of social influences on foraging (e.g., Giraldeau & Beauchamp 1999; Dubois & Giraldeau 2003) or focusing on prey behavior (Lima 2002; Nelson et al. 2004), but almost no study has

focused on the movement dynamics in relation to aggregation, migration, food abundance and long-term and short-term habitat disturbance together. A systematic study is therefore required, which would address the spatio-temporal movement dynamics of aggregation. The present study should provide us with a better understanding not only of movement patterns, but also on behavior flexibility and decision-making processes.

In this study I have addressed these questions using a non social migratory bird, which exhibits spatio-temporal aggregation dynamics, the Short-toed Eagle (*Circaetus gallicus*). I have investigated the response of the Short-toed Eagle to its prey, whose content and availability is affected not only by its behavior but also by human-mediated immediate and non-immediate disturbances, in relation to migration and aggregation.

The Short-toed Eagle is a medium size eagle of the Accipitridae family. It is a summer breeder and passage migrant through Israel – on its southern breeding range and the east Mediterranean migration route. Noticeable migration parties of two to four, but mostly of three individuals – probably adults and juveniles – and especially in autumn, have raised the possibility of juveniles joining parents through their first migration (Dementiev & Gladrov 1951; Cramp & Simmons 1980; Agostini 2002; and personal observations). Additionally, migration of larger flocks has been observed (Shirihai 1996; and personal observations). Some Short-toed Eagles have been reported summering in Africa (Campora & Cattaneo 2005), but attention should be paid to the problematic separation and identification of the Short-toed Eagle from other related Snake-Eagles (Clark et al. 2005).

The migration of the Short-toed Eagle was not well studied, and comparatively less so than other eagles, particularly with permanently operating transmitters. Studies using this technique on the Short-toed Eagle are recommended. Such studies would give more understanding of the migration strategies of these raptors on both eastern and western migration routes of the Mediterranean (Meyburg et al. 1998). Stable populations have been reported in some countries (e.g., Meir 1986; Rocamora 1994), while a decreasing population size was reported in others (Rocamora 1994; see also a review in Cramp & Simmons 1980).

Food: Mostly reptiles, comprising more than 80 percent of its food, and snakes in particular (Cramp & Simmons 1980; Gil et al. 2000). Other prey items may be taken, such as birds, rodents, mollusks and insects (see a review in Cramp & Simmons 1980; Meir 1986).

The Short-toed Eagle maintains a breeding territory, and is never colonial, but has some tendency to be close to other neighboring breeding pairs (in Cramp & Simmons 1980). Records of three individuals (two adults and the third of a non-breeding age) feeding one chick or staying near a single nest, have been reported (Cramp & Simmons 1980; Meir 1986).

During the summer of 2005, I observed Short-toed Eagles aggregating in Israel, forming groups of over fifty individuals in agricultural fields during plowing, but also during harvesting or other agricultural activities. During that time I found that they fed mainly on rodents. Hunting under these circumstances was preferred by hovering, perching and ground hunting.

Very scarce aggregation events have already been reported in Israel by Meir (1986), but these were limited to a few Short-toed Eagles at a time – a maximum of eleven individuals aggregating over grazing hills on fires, and six individuals over one field being plowed. Similar numbers are also mentioned in Cramp & Simmons (1980). Aggregations of 50-70 Lesser Spotted Eagles have been observed in Welsebruch on freshly mown silage, in which ground and perch hunting was preferred (in Meyburg et al. 2004).

Through the years, the aggregation phenomenon seems to be expanding in Israel, and its timing, believed to begin around mid July – early August, suggests it is correlated with the dispersal of non-breeding, or even with early migrating individuals: Although most studies associate migration with late September – early October (Cramp & Simmons 1980; Meyburg et al. 1998), immature eagles and non-breeding adults already migrate in early September (Boudoint 1984); dispersal away from the natal area begins in early August, or even in late July (Cramp & Simmons 1980).

Research Objectives

The aim of the present research was to study four main factors within the life cycle of the Short-toed Eagle in Israel: Migration, dispersal (referred to as large-scale and small-scale movement dynamics, respectively), breeding and food availability in agricultural fields, and the connection between them.

Within the main objectives of the research, I have addressed the following questions:

1. Is agricultural activity the cause for the aggregation and what monitors flock size?
2. What are the food items taken in fields when aggregating?
3. Where do Short-toed Eagles find their food items in the different parts of the field (i.e., in the part that is being managed, already managed, or yet not managed)?
4. Does aggregation occur also in natural areas?
5. Is the aggregation pattern related to age, sex, breeding status, body condition and time?
6. Where do aggregative birds come from, and where do they go thereafter, in different time scales?
7. Details on migration regarding:
 - a. Timing:
 - b. Distance
 - c. Routes
 - d. Wintering and summering areas
8. Is Short-toed Eagle, being a specialist in reptiles, immune to snake venom?

Description of the Research

Circaetus gallicus is a medium size eagle of the Accipitridae family. This genus (the snake-eagles) numbers six species (*C. beaudouini*, *C. cinerascens*, *C. cinereus*, *C. fasciolatus*, *C. gallicus*, and *C. pectoralis*), five of them restricted to Africa. Only the Short-toed Eagle extends outside this continent, and breeds in southern Europe and Asia, and also in northwest Africa. Individuals have been observed in Kenya, but were misidentified as *C. beaudouini* (Clark et al. 2005).

The Short-toed Eagle prefers relatively open habitats for foraging (making it easy to observe its behavior and to follow individual birds). It nests mostly on trees, but also on cliffs. The Short-toed Eagle has one breeding clutch each year and lays a single egg. It reaches maturity after four years. No obvious sexual dimorphism exists.

Status in Israel: Common summer breeder in northern and central Israel, especially in open dry areas of Mediterranean and semi desert habitats. It is also a common passing migrant through Israel (Shirihai 1996).

The Short-toed Eagle is almost the only species unaffected by the vast poisoning of raptors that occurred in Israel during the 1960's, mainly because of its diet content (mostly reptiles) and the use of pesticides mostly during winter (Meir 1986).

Study area

The study area is about 350 square kms; it is characterized by a heterogeneous, complex matrix of many agricultural-oriented settlements (the fields are either family-owned small fields or collectively-owned large fields), natural chaparral regions, afforested areas and natural pastures – some of which are heavily grazed by livestock.

This area, which is on the main western migration route in Israel, contains one of the largest Short-toed Eagle concentrations in this country (estimated as 80 breeding pairs), and is known for large aggregation incidence, occurrences of different numbers of individuals together.

Field season

Field work was begun in the year 2005, continuing in the years 2006 and 2007.

Trapping and marking methodologies

1. Trapping of individuals was performed by using Bal-chatri traps (B-c).
2. Wing markers: in order to identify Short-toed Eagles at flight we used human hair dyes to mark the under wing. This marker vanishes in a few months.
3. Ringing the Short-toed Eagles with specific metal and color rings.
4. Satellite transmitting: The fact that the survival rate of the non-adults is lower and less rewarding, was taken into consideration and only adult birds were fitted with satellite transmitters. Total of 4 individuals were fitted with such transmitters.

5. Biometrics: Each bird was measured and parameters recorded for the purpose of documentation, comparison between individuals and analyses of relations between body condition, behavior and survivorship. The measures taken were: age –according to Forsman (1998), wing chord, tail length, weight, hallux size, tarsus size and culmen size. To enable comparison between birds, each bird was photographed as well from different angles.

Monitoring

In order to answer the above questions, I tracked the movement of the Short-toed Eagles using satellite telemetry and also identified the birds by colour rings and wing markers.

Locating agricultural activities

In order to have the exact information on agricultural activities, with respect to aggregation events, I collected information on the timing of agricultural activity from farmers in the settlements within the study area. With that schedule, I was able to arrive at the site at the very beginning of the agricultural activity, and record the aggregation process from its inception.

Surveys

Surveys for estimating the numbers and dynamics of the Short-toed Eagle were carried out from the beginning of the Short-toed Eagle's arrival, in spring, through different stages, ending up with the disappearance of the Short-toed Eagle in autumn.

After disappearance of the Short-toed Eagles, continued research was based on satellite data. From these data I was able to monitor the movement of the eagles I fitted with satellite transmitters and study the migration patterns along the eagle's route to its wintering quarters.

Quantifying food in fields

In order to quantify the quantity of rodents in fields, I sampled active burrow density within fields planned to be cultivated. Two by fifty meter quadrants were taken and sampled. Active burrows were identified by their entrances being neat, clean and edges smooth.

Observations gathered from birders

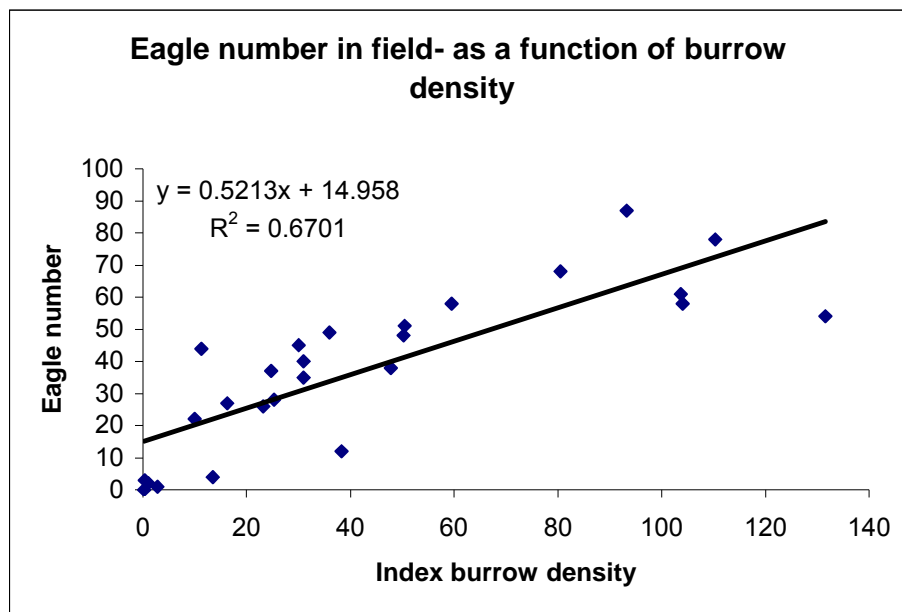
In order to have a better understanding of the phenomenon and its expansion, birders were requested to report any aggregation event they noticed

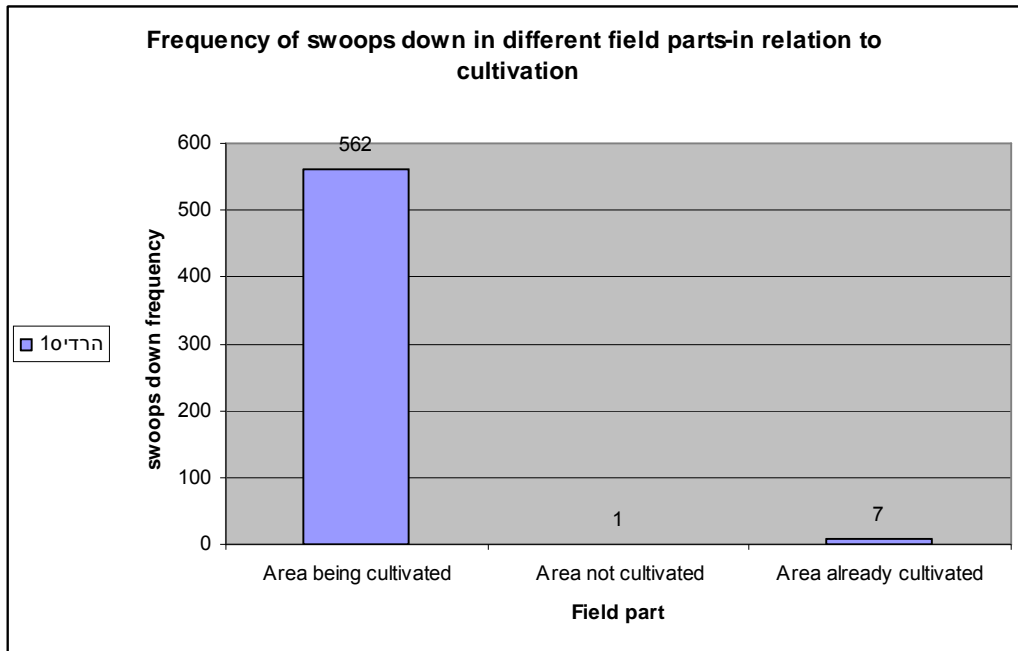
anywhere in Israel and to provide all possible details could be given about their observation, especially whether it was in an agricultural field or other areas.

Semi- final Results- and Discussion

Correlation between the aggregation and burrows density:

We have found a highly significant and positive correlation between rodent burrow density in agricultural fields being cultivated and Short-toed Eagle group size in that field (graph 1, $P < 0.0001$ $r^2 = 0.67$). We have yet to analyze the correlation between group size and cultivation type, time of year, and similar analyses.





Graph 2

swoops-down

Extreme majority of swoops down are in the part being actively cultivated.



Short-toed Eagle swooping down into its prey during aggregation

Diet content of Short-toed Eagles in cultivated fields: Diet content of Short-toed Eagles, also known as Snake-Eagles, is composed of 96% rodents, and only 4% reptiles (data based on 127 prey items identified).

Hunting success: $60.4\% \pm 4.0\%$. Hunting success is considered to be of the highest in the raptor world-indicating the efficiency of aggregation and hunting in those fields.

Breeding territories:

All 4 Birds had breeding territories in the Judean Slopes\hills.

Interaction with other species:

One important interaction was between Short-toed Eagles and White Storks. White Storks were looking for prey on foot, while Short-toed Eagles searched their prey from air. Often, White storks ejected the Short-toed Eagles from the position on which they landed and forced them to abandon. Short-toed Eagle seems to be the losing side of this interaction.

In 2006 there was a great presence of White Storks, sometimes reaching over a hundred individuals in one field along with the Short-toed Eagles. The year, 2007, found very modest White Stork numbers and comparatively little disturbance to Short-toed Eagle was observed. Other interactions observed were between Long legged Buzzards and Short-toed Eagles, where also fledglings of Long legged Buzzards were as aggressive as White Storks; they took advantage of the Short-toed Eagle to locate prey and then they mobbed the prey or expelled the Short-toed Eagle from the point on which it landed. Another interaction with Short-toed Eagle was related to breeding-the Long Legged Buzzard uses old nests of Short-toed Eagles. It is even possible that the Long legged Buzzard takes control over old nests of the Short-toed Eagle and starts breeding in them when the Short-toed Eagle is still in its wintering ground in Africa and has not yet reached the breeding grounds.

Change in time allocation and hunting techniques between natural areas as compared with agricultural fields:

Short-toed Eagles naturally hunt reptiles in the cold hours of the day, and that is mainly in natural areas; they less hunt in the hot hours as a result of the reptiles' hiding or of their increased speed and manoeuvrability.

In agricultural fields, we notice that aggregation is in its peak in the hot hours of the days, and the prey is mainly rodents, and this contrasts with the situation in natural areas. In hot hours, it is energetically easier for Short-toed Eagles to soar and hover above agricultural fields that are being cultivated, and to search for rodents. In contrast, in natural areas, search for prey is done many times from a perching spot or by screening wide areas using thermal vertical or horizontal wind currents.

The combination between hunting in natural areas and agricultural areas, when each is carried out a different hours, with different techniques and behaviour patterns, is actually a combination that does not come one on the count of the other. On the contrary, it is a complementary behaviour, enabling the Short-toed Eagles to better utilize their breeding period to obtain more food. That seems to be one of the main reasons for the high breeding success of Short-toed Eagles and their high breeding density in the study area.

Educational theme

The educational outreach concerning Short-toed Eagles in the last two years proved to be tremendously successful, and revealed an educational opportunity of high potential for ecological tourism. The phenomenon of a cultivated field with a spectacular flock of tens of Short-toed Eagles above, impressing the viewer with their size and beauty and their outstanding acrobatics when swooping down on prey, and observing them catching tens of prey items in one field this amazing sight creates much enthusiasm among viewers.

We began with 2 guided tours to the eagle fields in year 2006, and increased the number to 5 tours in 2007, while our ambition is to further increase this number in year 2008. We are also developing the subject of guided tours to observe Short-toed Eagles, as well as birding in general, in a number of ways and with a number of parties and agencies. We are attempting to build a solid foundation coordinated with the different parties involved, with the intention of publicizing the importance of this area –as a candidate to become a biosphere zone with the Short-toed Eagle as the flag species. We are attempting to pattern this after the Hula Valley model.



Observing the great phenomena of aggregation

Observation of Birders

From accounts of birders, it emerges that this aggregation phenomenon of Short-toed Eagles is wide-spread throughout Israel; we have gotten reports of aggregations in fields from different parts of Israel, with different populations of Short-toed Eagles, extending from northern Israel, south to the study area.

Concerning the age and sex of the Short-toed Eagles present in the aggregations, trapping efforts found all categories are present, with adult females present later in the season and, after hatching, indicating that males are the ones who hunt at the beginning of the nesting period while females are mainly those who incubate the eggs.

Concerning the distance of daily travel of Short-toed Eagles, we found individuals marked in one spot in the morning, and found again later the same day in an aggregation eleven Kms. Other Eagles marked in one site, were found 25 Km away after a few days.

The high numbers of Short-toed Eagles that could be in an aggregation in one field indicates that the eagles concentrate from different areas nearby or from a distance. Worth mentioning is that those individuals seen at a distance of more than 10 km are non-breeders sub-adults without a commitment to any area or nest.

Biological pest control

There is no doubt, after finding the high rodent percent taken in fields aggregation (~96%), that there is a biological pest-control effect due to field cultivation and to the response of the Short-toed Eagles to that by aggregation.

Given the fact that field cultivation show great flexibility and variety between different farming systems, and that different methods attract different numbers of Short-toed Eagles, promotes the idea of maximizing the effective use of the eagles by using the best farming method.

Some factors that could easily be controlled and tuned to bring the best pest control effect are:

- a. Timing of cultivation through the day: Best cultivation should be around noon hours, where peak numbers of Short-toed Eagles are present, and far from cold hours of the morning and night.
- b. Timing of cultivation in the season: Best done in overlapping the time when the Short-toed Eagles are summering here, rather than after they migrate to Africa.
- c. Coordination between the farmers of the area to work in continuation throughout the summer season and not in parallel in a short time-that would give the Short-toed Eagle population the opportunity of utilizing all the fields for a longer period rather than having rich patches of food in more than one place at a time for a short duration.

Another factor seen to bring about is fire. In fires, Short-toed Eagles aggregate similarly to those in fields being cultivated, catching prey that escapes, revealed or injured. Due to our limitations, and since events of fires are something that is hard to predict and a rare event, it was not possible to monitor behaviour of Short-toed Eagles in fires.

Cooperation between three continents:

This research has brought a fruitful cooperation between different countries:

- a) The cooperation with Hawk Watch-USA has been based on the Satellite telemetry project, where Hawk Watch has been the provider of the Transmitters and the professional guide for all stages of the transmit process. To much of our surprise, we managed to have all four transmitters work properly even more than the time needed, hence having data of one full bi-directional migration route, and continuing signalling for one more season-providing us an autumn migration route for the second year. During this period, no transmitter fell down, no transmitter stopped signalling and no bird died. More than that, we managed to find the breeding territories of the four Eagles and even find one of the nests!
- b) Cooperation with Palestinians also turned to be fruitful, in spite of all the political situation and tension in the area. Cooperation was established with the Palestine Wildlife Society, where they were engaged in the project and funded? helpers and apprentices during the study. We hope to have a second stage, where the presence of aggregations is checked in the Palestinian territories and a comparative study between the two entities is initiated.

Discussion and future perspective:

From surveys conducted by us and other birders it was discovered that the Judean slopes have one of the highest breeding densities (if not the highest) in the world. Moreover, it appears that there has been an increase in the breeding density over last decades.

This study gave us the partial understanding of the Short-toed Eagle behaviour in the study area for the first time and revealed to us new aspects of that behaviour. Despite that, and as a result of that, other aspects related to the Short-toed Eagle in the Judean slopes remain unsolved and worth studying, part of which are mentioned here:

- 1) Relation between food items brought to nests comparing days with active cultivation and days without cultivation in agricultural fields.
- 2) Short-toed Eagle utilization of natural land vs. agricultural fields and their home range in relation to field cultivation. (It is expected that Short-toed Eagles would invest relatively less time in natural areas in days where a relevant agricultural activity being held-whereas eagles would invest more time in fields being cultivated. Home range is expected to grow when Short-toed Eagles hunt in agricultural fields).
- 3) Differences in hunting strategies between breeders and non-breeders and relation to age.
- 4) Effect of habitat mosaic intensity on breeding success, group size and breeding density of the Short-toed Eagle, and the development of KK”L forests on its ecology.

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