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# First Results of the Tracking of Eastern Imperial Eagles (*Aquila heliaca*) Tagged with Radio-Transmitters in Bulgaria

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**Abstract:** This paper presents the results of the first radio tagging of juvenile Eastern Imperial Eagles (*Aquila heliaca* Savigny 1809) in Bulgaria. The study was carried out in the period between July 2007 – June 2009. Two juvenile birds from the same clutch were radio-tagged in the nest before fledging, at the age of 54 and 60 days. In 2008, another juvenile individual was tagged with a radio transmitter. Useful information was gathered through the radio telemetry. A total of 141 positions of the three radio-tagged birds were located within the study period in the territories of three countries – Bulgaria, Turkey, and Israel, and two continents – Europe and Asia, providing data about the wandering period of juvenile individuals – movements, temporary settlement areas, etc. Four areas harboring concentrations or regular presence of 3 to 8 Eastern Imperial Eagles were confirmed or newly-found within this study. The gathered data reveals that juvenile Eastern Imperial Eagles from the Bulgarian population of the species winter in the country. The present study also presents the first data about the prey and the hunting territories of juvenile Eastern Imperial Eagles in Bulgaria after fledging. Having left the territory where it was hatched, one of the radio tracked birds migrated to Israel.

**Key words:** radio telemetry, temporary settlement area, Eastern Imperial Eagle

## Introduction

Since 1989, when Green Balkans found the first pair of Eastern Imperial Eagles in the Sakar Mountains, the team has focused their efforts mainly on protecting breeding pairs and their habitats. Conservation activities, in general, are focused on adult individuals, and only few of the actions are directly related to the studying of the juvenile, non-breeding Eastern Imperial Eagles. Regarding the juvenile individuals of the "Bulgarian" population of the species, there is no comprehensive and confirmed data about the survival rates of successfully fledged individuals. Other unknown facts that have not been studied yet include: the period when juveniles leave the nesting area; the dispersal, migration, and wintering areas; and the occupation of new breeding areas and the formation of pairs by juvenile individuals. In general, the wintering of the Eastern Imperial Eagle in Bulgaria is insufficiently studied (Petrov, Stoychev 2002). In the recent past there were only two reported observations of wintering Eastern Imperial Eagles (Michev, Petrov 1979) and the species is extremely rare in winter (Simeonov *et al.* 1990). For the past few years, the authors of this paper have regularly observed adult individuals from the breeding pairs wintering in the nesting area; however, there are no such observations of juvenile individuals. Therefore, before this study it was presumed that juvenile birds hatched in Bulgaria go to Turkey or further south, and winter beyond the borders of Bulgaria.

To find the answers to these and many other

questions, in 2007 Green Balkans' team, in partnership with CBD–Habitat and the Spanish and the Bulgarian Environmental Ministries, tagged juvenile Eastern Imperial Eagles with radio transmitters for the first time in Bulgaria.

Telemetric study of the Eastern Imperial Eagle is recommended by the INTERNATIONAL ACTION PLAN FOR IMPERIAL EAGLE (*Aquila heliaca*) (Heredia 1996). Similar studies of the Eastern Imperial Eagle have been carried out by MME–BirdLife Hungary (www.imperialeagle.hu) and Raptor Protection of Slovakia (www.ec.europa.eu)

This paper summarizes the results of the first radio tagging and tracking of juvenile Eastern Imperial Eagles in Bulgaria.

## Material and Methods

The study was carried out in southern Bulgaria, along the Bulgarian-Turkish border, in the area of the Sakar Mountains, Dervent Heights, Western Strandja, and the adjacent territories. The altitude of this region varies between 50-300 m, as the relief peculiarities include round heights furrowed by small river valleys and plain areas. The land cover is varied, as the predominating types include: bushes and/or grass communities, orchards and vineyards, arable lands, pastures, forests (CORINE Land Cover classification). Today, this region holds most of the Eastern Imperial Eagle population in Bulgaria (Stoychev *et al*. 2004, Demerdzhiev *et al*. 2011).

In 2007, two juvenile birds hatched in the same nest were tagged with VHF radio transmitters. This was the easternmost nest of all known nests in southern Bulgaria. The nest was built on a Poplar tree (*Populus* sp. L.). In 2007, this pair hatched two chicks, which, after being radio-tagged, fledged successfully. These two juvenile individuals are hereafter referred to as Eagle 1 and Eagle 2, respectively. The birds were tagged on June 27th, 2007 (at an approximate age of 54-60 days). In 2008, the only chick (at a similar age) of a pair situated in the Sakar Mountains, occupying the westernmost part of the population, along the Bulgarian-Turkish border, was also tagged with a radio transmitter. The bird is hereafter referred to as Eagle 3. Both pairs, whose chicks were tagged for the purposes of this study, had raised successfully their offspring in the previous years. This was the underlying consideration in the selection of juvenile individuals to be tagged. Moreover, these were pairs from different parts of the species' population (easternmost and westernmost).

All three eagles were tagged with VHF Radiotransmitter – Biotrack TW 3 – 69 g, by attaching the transmitter to the back of the bird, using the Garcelon system, with a central breaking point (Garcelón 1985). The transmitters used frequencies within the range of about 150,092 mHz. The birds were additionally marked with standard and color PVC rings.

Antennae TVP Y-4FL, 150-152 mHz, and a receiver – Communications Specialists Inc. R-1000 Telemetry Receiver, provided by WWF Greece, Dadia Project, were used for the follow-up tracking and telemetry. Tracking of radio-tagged birds was done at least once a month in winter and twice a month for the rest of the year. The last position of each bird was used as a starting point for the next tracking. In cases when there was no signal, other suitable positions were sought – high hills and elevations (dominant heights). Thus, various dominant heights in the regions of the Sakar Mountains, Dervent Heights, Eastern Rhodopes, parts of Strandzha, and the adjacent areas, were used when searching for signals. In order to locate the current position of the bird tracked, the signal direction had to be caught from two different positions at the same time, i.e. by two teams positioned on elevated places in the region. This simultaneous location of the signal is called biangulation. To communicate to each other, the teams used radio communication and mobile phones. The position of each team was located through the geographic coordinate system WGS 84 and target coordinates X and Y. GARMIN GPS 72 and GARMIN GPSmap 60CSx were used to determine the geographical location of the teams. The data gathered through the telemetry was filled in a specific field data form. Then, calculations were made based on the location of each team and the angle of the direction from which the signal was received, in order to locate the position of the bird. These calculations and the location of the bird's position were done through the specialized LOAS V 4 software. In order to visualize the results, the territory was presented in the 3rd class nomenclature of CORINE Land Cover. When a signal was caught, the tracking was done repeatedly from different positions, in order to reduce the

perimeter of the current location of the eagle and to obtain visual contact.

Tracking radio-tagged birds and receiving signals from their transmitters started while the birds were still in their nests. This, on one hand, contributed to the training of the team, and, on the other hand, tested the transmitters and the receivers.

This paper presents the results of a study carried out in the period between June 2007 – June 2009, involving more than 35 experts and volunteers of Green Balkans, who contributed more than 250 man-days of tracking efforts.

## Results and Discussion

During the follow-up telemetry of the radio-tagged birds there were more than 1,500 radio locations. As a result, 141 different positions of the three eagles were located; hence more than 20 visual observations of the juveniles, also including observations of non-tagged juvenile birds in the same area were recorded. Transmitters sent information from two continents – Europe and Asia, and three countries – Bulgaria and Turkey (radio telemetry), and Israel (visual observation).

The results and success of the telemetry of each of the tagged birds differ; therefore the data is presented individually:

**Eagle 1**

79 positions were located using telemetry system with this bird – 78 of them in Bulgaria and one in Turkey (Fig. 1). The juvenile eagle fledged successfully at the age of about 80 days, being the second successfully fledged chick of this pair, most probably a female. At first the bird stayed near the nest, but 40 days after leaving the nest, at the age of about 120 days (03.9.2007), it started moving away from the breeding territory and visiting nearby areas, then returning to the nest site. It was discovered that at the age of about 150 days (03.10.2007), or 70 days after fledging, the juvenile eagle abandoned the breeding territory. While moving around the area the bird crossed the breeding territories of all neighboring breeding pairs of Eastern Imperial Eagles – 4 in total. These neighboring breeding territories are presented in Fig. 1, 2, and 3 as circles with a radius of 5 km. In 2008 the bird was located in the territories of two other Eastern Imperial Eagle pairs. As a result of the regular tracking of this bird, a temporary settlement area to the north of the Dervent Heights was found in early winter 2007. Maximum concentration of 8 juvenile Eastern Imperial Eagles was reported for this region (Zhelev *et al.* 2009). Eagle 1 spent the winter 2007/2008 in the area of the Dervent Heights and the adjacent territories. During that period the bird was located 8 times, twice in November, twice in December and 4 times in February. In spring, at the beginning of the breeding season, the bird was lost. The last positions of Eagle 1 located during this period dated back to February 25th and 27th, 2008, as the bird was moving southwards. The position recorded on February 27th was 55 km further south than that of February 25th.

Again, signals sent by Eagle 1 were caught at the end of August 2008. The bird's position was located in the north-eastern part of the Sakar Mountains. In the winter of 2008–2009 the bird wintered in Bulgaria. Another temporary settlement area was located in the Dervent Heights. Five Eastern Imperial Eagles – first to fourth plumage, were reported in this area. Two or three of these birds (including Eagle 1) remained in the area.

**Eagle 2**

This bird was from the same brood as Eagle 1. Eagle 2 was the first hatchling, a proven male individual (later observed mating). During the telemetry, 55 positions of this bird were located, all of them in the territory of Bulgaria. (Fig. 3 – Map of the movements of Eagle 2 in relation to the neighboring occupied breeding territories). The juvenile individual finally fledged at the age of about 80 days. When Eagle 2 fledged, signals from its transmitter were caught on August 21st, 2007 sent from a distance of 117 km. At that date, the signals from the transmitter were caught from the Eastern Rhodope region, while at the same time the bird was observed near the nest in the Dervent Heights. Like the other tagged bird, Eagle 2 first stayed in the breeding area, as both birds used to spend the night in the nest. Eagle 2 was recorded abandoning the breeding territory and moving away to adjacent areas on September 3rd, 2007. At that time the bird was about 125 days old, and had fledged 45 days earlier. During this period, after visiting the neighboring regions, the bird would return to the breeding territory. On October 3rd, 2007, when the eagle

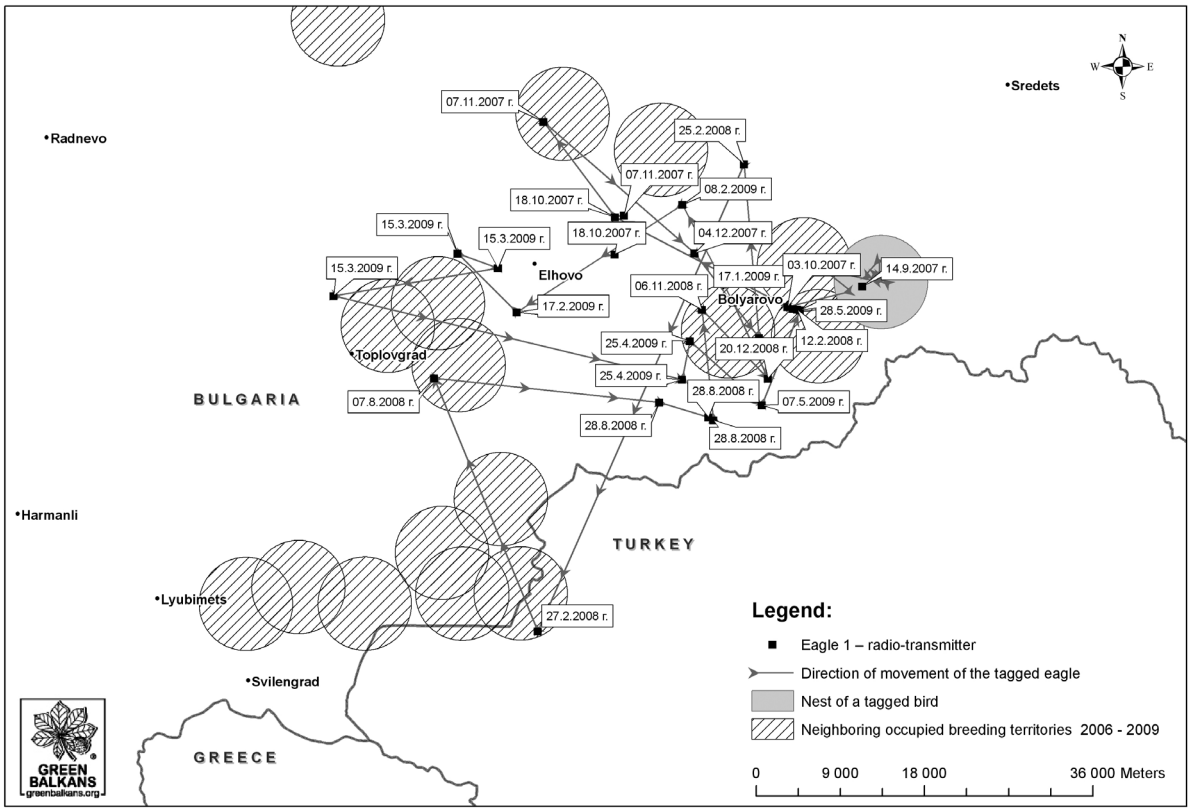


**Fig. 1.** Map of the movements of Eagle 1 in relation to the neighboring occupied breeding territories

was approximately 155 days old, the team recorded that the juvenile had finally abandoned the breeding area, i.e. 75 days after leaving the nest. While moving around the nearby regions, Eagle 2 was located in only two breeding territories occupied by other Eastern Imperial Eagle pairs. In November, the bird was located together with Eagle 1 and other juvenile Eastern Imperial Eagles in a territory holding a concentration of juvenile individuals to the north of the Dervent Heights (Zhelev *et al*. 2009). Although signals from Eagle 2 were recurrently caught, the exact position of the bird was not located. The exact location of the juvenile eagle was recorded late in March 2008, as the bird was observed in the immediate proximity of the native territory. At the beginning of the breeding season this bird was lost, too, as there was no signal until midsummer. At the end of June 2008, Eagle 2 was located in the Eastern Rhodopes. Every autumn, other juvenile Eastern Imperial Eagles could also be found there. This was the third identified territory harboring juvenile individuals. In August, Eagle 2 was located in the area of the Monastery Hills, to the north of the Sakar Mountains. Those were the last located positions of the bird.

**Eagle 3**

This was the pair's only chick in 2008. The juvenile fledged successfully at about 80 days. Seven positions in total were located, six in Bulgaria and one in Israel. In the period between August-September 2008, four different positions of the juvenile individual were identified within the pair's breeding territory. On October 3rd, 2008, at the age of about 155 days, or 70 days after fledging, the radio-tagged eagle was located beyond the breeding territory, near the Bulgarian-Turkish border, some 15 km away from the nest; the bird was observed spending that night in the nest from which it was hatched. This was the last contact with the juvenile eagle in the territory of Bulgaria in 2008 (Fig. 4 – Map of the movements of Eagle 3 in relation to the neighboring occupied breeding territories). On November 4th, the bird was observed by Ohad Hadzofe's team (Israel Nature & Parks Authority) in northern Israel. The eagle was identified by the color ring and the transmitter attached to it. At that time another juvenile Eastern Imperial Eagle tagged in Bulgaria with a satellite transmitter was

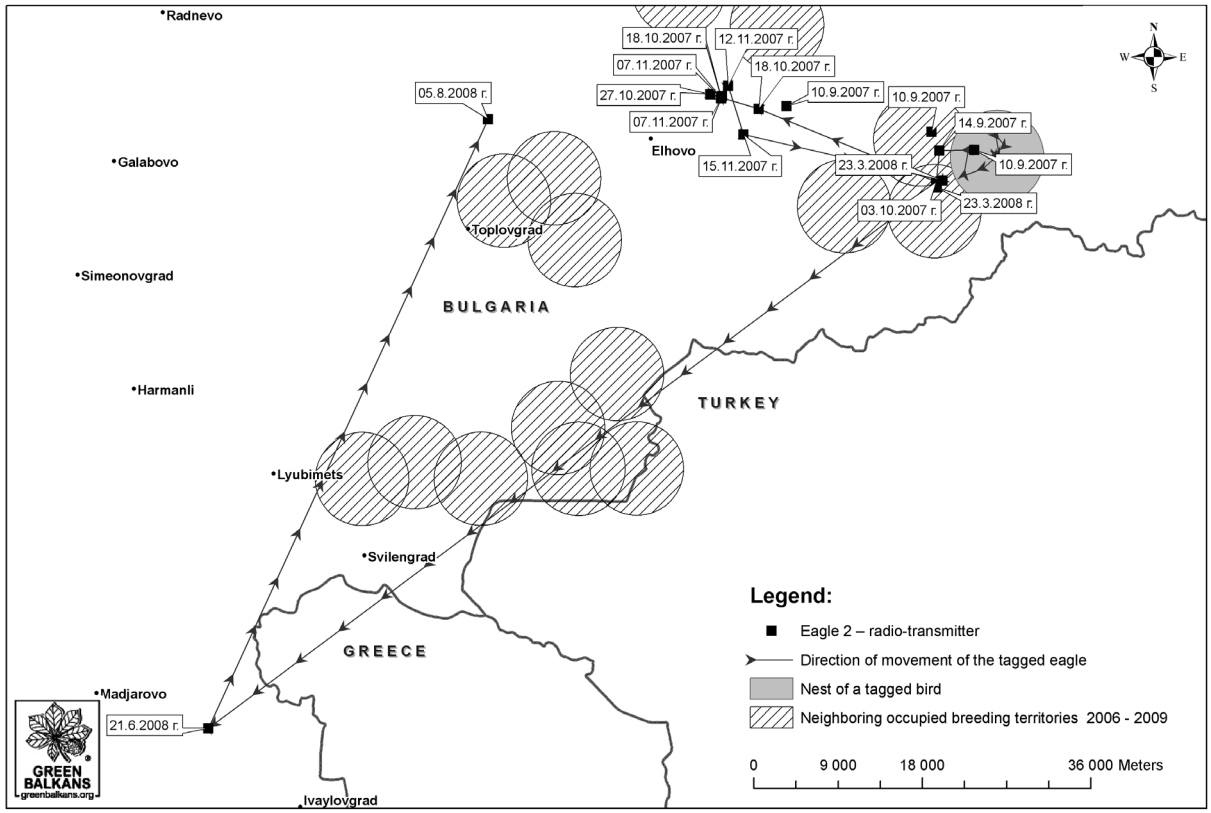


**Fig. 2.** Map of the movements of Eagle 2 in relation to the neighboring occupied breeding territories

reported in Israel (Stoycho Stoychev, pers. comm.), also. The comparison of the data from the satellite transmitter and the position of the eagle observed by Ohad Hadzofe's team revealed that the two birds were located in different regions.

The return of the bird to Bulgaria after the wintering period was recorded in the spring of 2009 (April 28th). Initially, signals from the transmitter were located in the Dervent Heights, as the bird was moving actively northwards. The next day a position was located in the Upper Thracian lowland in the area of Sveti Iliysky Hills and Sredna Gora Mountains.

During the telemetry of the three radio-tagged eagles and the movement of the team in the study area, another territory with juvenile birds was identified. In May-June 2008, two juvenile Eastern Imperial Eagles were observed feeding at a dump site near the town of Simeonovgrad, in the Maritsa river valley. This was the fourth territory holding concentrations or constant presence of juvenile Eastern Imperial Eagles, identified as a result of the radio tracking of the three tagged birds.

The located positions of all the three birds recorded before they started leaving the breeding territory, during the periodical abandonment of and return to the breeding territory, as well as in the period of final abandonment of the area, differ in number and intensity. The results are presented in Fig.4.

Besides the positions located through signal bi-angulation, the presence of any of the radio-tagged birds was suggested by isolated signal locations. In 953 cases one of the teams caught signals from a tagged bird without bi-angulation. These isolated signals cannot identify the exact position of the bird, but they indicate the direction of the individual's location. Based on the functioning of the radio transmitters and the experience gained in telemetric tracking of radio-tagged birds, these isolated signals could imply the presence of an individual – in the specific area or in neighboring territories. The number of isolated signals located for the three radio-tagged birds at different stages of the study is presented in Fig. 5.

According to the distribution of land cover (CORINE Land Cover, class 3), the three eagles visited 10 habitats of the following types and codes: .112 – Discontinuous urban fabric, 211 – Non-irrigated arable lands, 221 – Vineyards, 231 – Pastures, 242 –

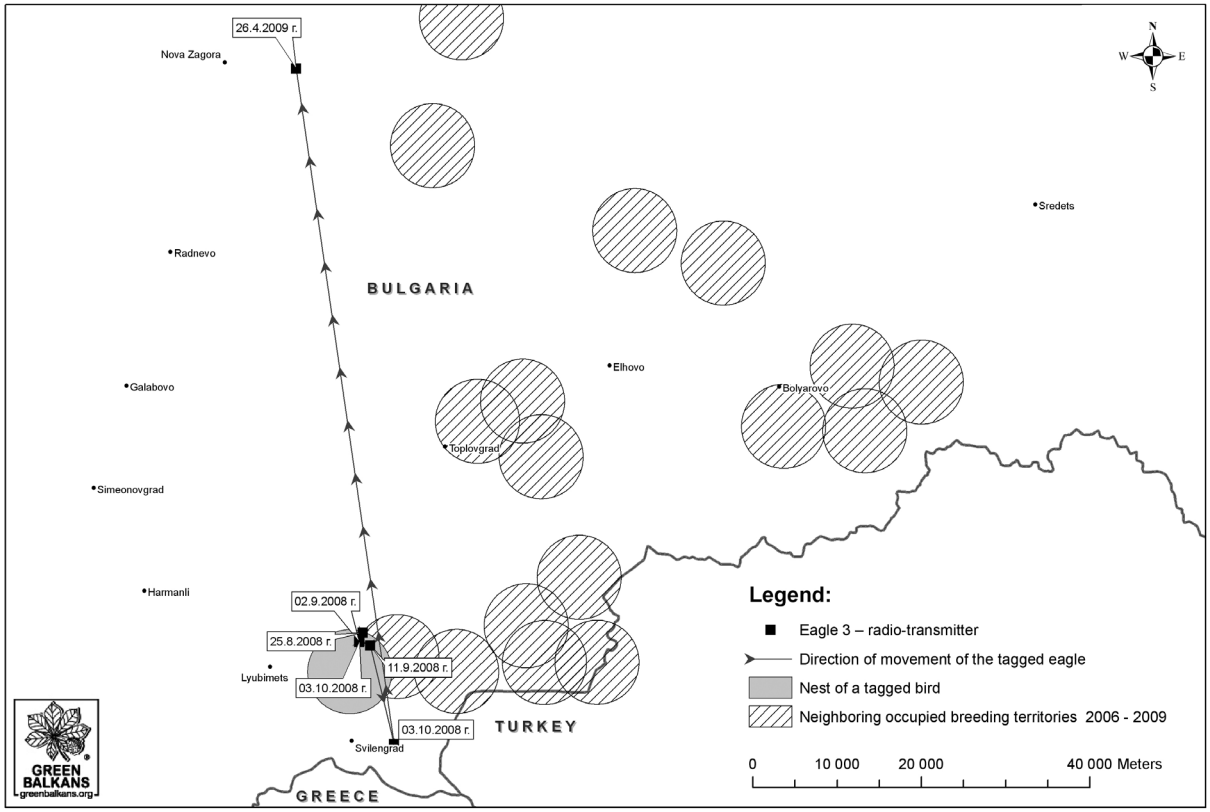


**Fig. 3.** Map of the movements of Eagle 3 in relation to the neighboring occupied breeding territories

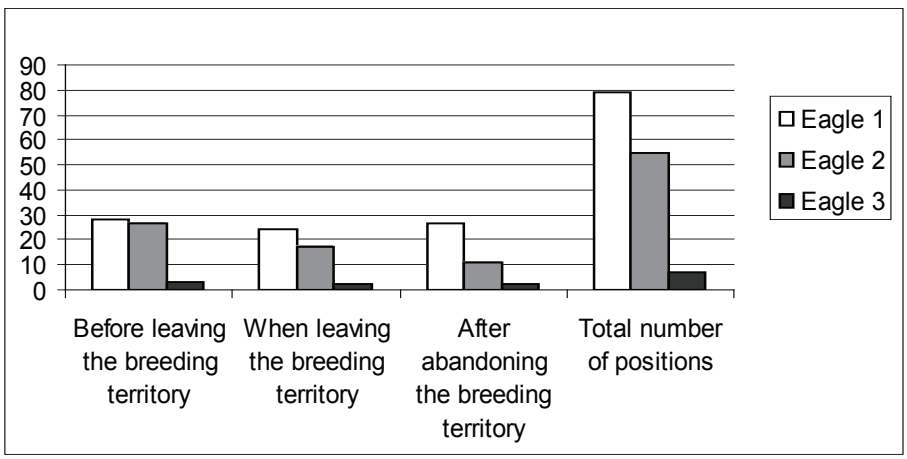


**Fig. 4.** Ratio of positions located at different stages of breeding territory abandonment

Complex cultivation patterns, 243 – Land principally occupied by agriculture, with significant areas of natural vegetation, 311 – Broad leaved forest, 313 – Mixed forest, 321 – Natural grassland and 324 – Transitional woodland/ shrub.

The number of the birds' positions in different land cover types was 139 of all 141 locations, since two of the positions (one of Eagle 1 and one of Eagle 3) were located beyond Bulgaria's territory. There is no land cover distribution available for Turkey and Israel.

# Conclusions

The first tagging of juvenile Eastern Imperial Eagles in Bulgaria revealed previously unknown aspects of

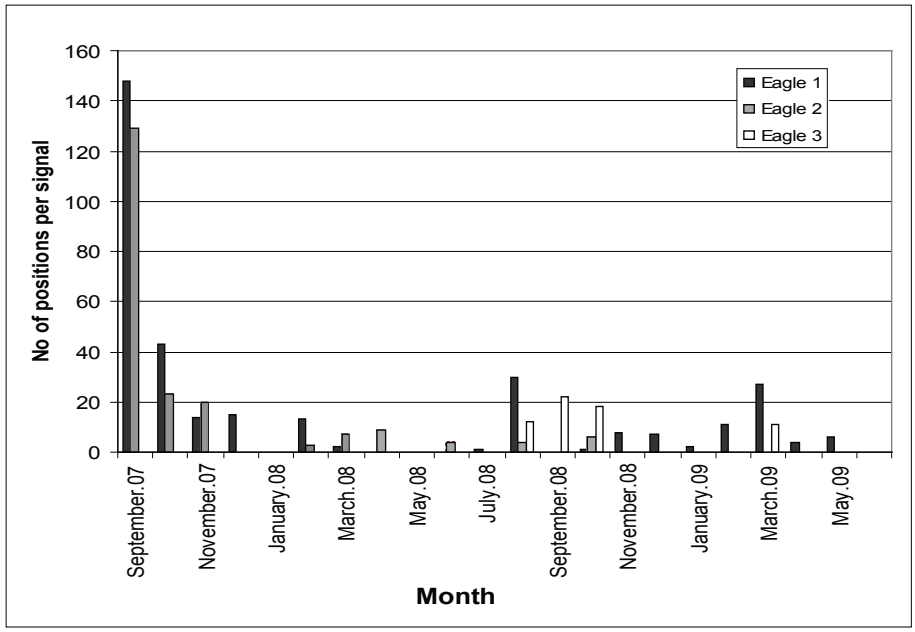


**Fig. 5.** Distribution by months and number of isolated signal locations

the biology and ecology of the juvenile individuals from the Bulgarian population of this species.

Radio-tagged birds left the nests at the age of about 80 days; at the age of 120-125 days the eagles started moving beyond the borders of the breeding territories, i.e. some 40 days after their first flights. During this period, having visited adjacent regions, the tagged eagles used to return to their breeding territories.

Some 70 days after fledging, at an approximate age of 150–155 days, the juvenile eagles finally abandoned the breeding territory.

After the abandonment of the breeding territory, two of the radio-tagged birds (Eagles 1 and 2) moved to the neighboring areas in Bulgaria and Turkey.

The third eagle (Eagle 3) migrated across Israel. The bird returned to Bulgaria after the wintering period.

Eagle 1 was located a total of 28 times in the winter of 2007/2008 (November – 11 times, 2 biangulations; December – 9 times, 2 biangulations; February – 18 times, 4 biangulations) and 20 times in the following winter of 2008/2009 (December – 7 times; January – twice and February – 11 times; a total of 2 successful biangulations).

Eagle 2 was located a total of 5 times in the winter of 2007/2008 (December – once and January – 4 times, no successful biangulations). There is no evidence of Eagle 2 being in Bulgaria in the following winter 2008/2009.

Thus, juvenile Eastern Imperial Eagles from the Bulgarian population of the species might either winter in Bulgaria (Eagles 1 and 2), or follow the traditional migration route to Asia (Ferguson-Lees, Christie 2006).

Despite previous suppositions, this study reveals that part of the population might be established in dispersal areas in Bulgaria throughout the year. In a very similar species, the Spanish Imperial Eagle (*Aquila adalberti* Brehm, 1861), mortality is concentrated particularly in the dispersal areas (González *et al*. 2007), so the availability of data on their location is basic for the implementation of adequate conservation activities.

The two eagles that remained in Bulgaria moved mainly westwards and southwards.

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# Първи резултати от проследяването на Източни Царски орли (*Aquila heliaca*), маркирани с радио-предаватели в България

***Гр. Градев, В. Матаранз, Е. Добрева, Д. Попов, С. Марин, И. Иванов, П. Желев***

## (Резюме)

Статията представя резултатите от първото за страната маркиране на млади Източни Царски орли (*Aquila heliaca* Savigny 1809) с радио предаватели. Проучването е извършено през периода юни 2007 – юни 2009 г от експерти и доброволци на Федерация Зелени Балкани. През 2007 г две млади птици от едно люпило са маркирани преди излитането им, в гнездото, на възраст съответно 54 и 60 дни. През следващата 2008 г на още един млад царски орел от друго гнездо е поставен радиопредавател. Локализирани са общо 141 позиции от трите маркирани птици, от териториите на три държави – България, Турция и Израел, както и от територията на два континента – Европа и Азия. Получени са данни за скитническия период на младите птици – придвижвания, райони на концентрация и трайно присъствие на индивиди. В рамките на проучването са потвърдени или новооткрити общо 4 места за концентрация или редовно присъствие на царски орли, с численост от 3 до 8 птици. Събраните данни за първи път доказват зимуване в България на млади царски орли от българската популация на вида. За първи път е събрана информация за плячката и ловните територии на младите царски орли в България, през първата година от живота им. Получена е информация за една от птиците която мигрира в Израел след напускането на гнездовата територия в която е излюпена.