

Migration of the Lesser Spotted Eagle *Clanga pomarina* Brehm, 1831 (Aves: Accipitridae) in Bulgaria

Petar Iankov¹, Irina Mateeva¹ & Henk Sierdsema²

¹ Bulgarian Society for the Protection of Birds – BirdLife Bulgaria, POB 50, 1111 Sofia, Bulgaria;
E-mail: bspb_hq@bspb.org, www.bspb.org

² Sovon Dutch Centre for Field Ornithology, POB 6521, 6503 GA, Nijmegen, The Netherlands;
E-mail: henk.sierdsema@sovon.nl, www.sovon.nl

Abstract: An overall picture of the autumn and spring migration of the Lesser Spotted Eagle in Bulgaria is presented. This includes the spatial distribution of the migrants, terms and timing of the passage, numbers and abundance and some other main characteristics of the migration. The Lesser Spotted Eagle migrates over the entire territory of Bulgaria but predominantly over the eastern part of the country along the *Via Pontica* flyway, streamed by the Black Sea coastline. The spring migration takes about 80 days between the second decade of March and the end of May, with peaks around 2-10 April. The autumn passage (for about 87 days) takes time between the beginning of August and the end of October, with peaks around 25–27 September (second peak may occur around 1 October). Most of the birds fly between 9 h and 17 h in the altitudinal range from 20 m up to 2200 m above ground level. Up to 52000 individuals cross the country during autumn migration, which is about 86% of the world population of the species. “Mass concentrated passages” of Lesser Spotted Eagles, reaching at some points up to 10000 birds in an hour, have been observed during the autumn migration around the Burgas bottle-neck area. During spring migration most of the birds cross the country in 2 days (44.8%), followed by those passing for 3 days (31%), 1 day with no stops for roosting (20.7%), and only 3.5% – for more than 3 days. During autumn migration, most of the birds cross Bulgaria for 2 days (48.5%), followed by those for 1 day (28.6%), more than 3 days (11.5%) and for 3 days (11.4%). Most of the stopover and roosting sites are in forested areas near open terrains, mainly in Eastern Bulgaria. The electricity power lines of 20 kV voltages are identified as threatening factor for the Lesser Spotted Eagle during migration.

Key words: migration, Lesser Spotted Eagle, spatial distribution, numbers, dynamics, Bulgaria

Introduction

About 73% of the breeding range of the Lesser Spotted Eagle *Clanga pomarina* Brehm, 1831 is in Europe, with a population of 16,400–22,100 pairs (BIRDLIFE INTERNATIONAL 2015, 2017). It is a long-distance migrant, wintering in Africa to the South of the Equator (CHRISTENSEN & SORENSEN 1989, MEYBURG et al. 1997, 2000, 2015). The larger part of the world population of the species passes over Bulgaria during migration, where at the westernmost point of the Black Sea near Burgas is one of the most prominent bottle-neck site along its entire migratory flyway together with the Bosporus, where the

highest concentration of Lesser Spotted Eagles was reported (MEYBURG et al. 1997, ZALLES & BILDSTEIN 2000, HARRIS 2013).

With population of more than 600 breeding pairs Bulgaria is a stronghold in the southern periphery of the species distribution range (DEMERDZHIEV et al. 2019 a). In spite of the numerous data spread in various technical reports and public datasets and even in some publications about the birds of prey’s passage at certain migration hotspots (LAINE 1978, MICHEV & SIMEONOV 1981, IANKOV et al. 1994, MICHEV et al. 2011), there is no summarising publication about

the Lesser Spotted Eagle migration in Bulgaria, thus the overall picture of the passage of the species in the country remains poorly known. Besides fulfilling this information gap, the present study can put light on some unclear aspects, especially concerning the numbers of the global population. Inconsistent data about the total number of the migrants at key bottle neck sites as Burgas (RUSKOV 1998, MICHEV et al. 2011), Bosphorus (BEAMAN 1975) and Kefar Kassem in Israel (DOVRAT 1991) do not help in revealing the real situation of the world population of the species. The aim of the present paper is to present an as complete as possible picture of the migration of the Lesser Spotted Eagle in Bulgaria on the base of all the existing data, including these from a recent extensive study of the migration of the soaring birds over the entire territory of the country. This information should give also a scientific basis for more effective conservation action for the species.

Materials and Methods

Field surveys

The study is based on the unpublished data collected by the authors and the Bulgarian Society for the Protection of Birds – BirdLife Bulgaria (BSPB) during the period 1988–2017, obtained from in total 80 vantage points with raptor counts during the entire autumn migration period (5 August – 31 October) during in total 7040 observation days and from 36 vantage points with raptor counts during the entire spring migration period (15 March – 15 May) during in total 2232 observation days. In each observation day migrants were counted from 7:00 till 18:00 h. Additional data were collected throughout the country during partial surveys of the autumn migration of raptors from 55 vantage points (during in total 2310 observation days) and of the spring migration of raptors from 26 vantage points (during 546 observation days) (ANONYMOUS 2005, GERDZHNIKOV & ILIEV 2010, 2011, GERDZHNIKOV et al. 2010, PETKOV 2010, 2011, MATEEVA et al. 2011, MATEEVA & IANKOV 2013). Most complete information was collected during the research in 2011–2012 simultaneously and across the entire day from 13–16 vantage points for the entire spring and autumn periods (dates as above). In 2011 the points were situated in Northern Bulgaria between the border with Serbia and the Black Sea, and in 2012 they were in South-Eastern Bulgaria on the line Burgas – Madzharovo (no vantage points in the high mountains of the south-west). This was the first Bulgarian research on bird migration with such intensity and scope. Mobile Furuno radar was used for certain periods at all vantage points.

Prior to the study the surveyors were trained in all necessary skills for proper collecting and filling in the data and for minimizing the bias (including determining the flight altitude, for which the radar was used for calibrating their estimation skills in the field as well). Special field forms were used to obtain standard data, together with topographic maps where flight trajectories of all birds were drawn for further transferring them in GIS environment. All the details about the methodology, including the number of observation days, number of observation hours per day, number of observers per point, the type of the GPS devices used etc., are described in the report on the survey (MATEEVA & IANKOV 2013).

All the above mentioned surveys have been carried out according to the standard methodology (MICHEV 1984, MICHEV & PROFIROV 2010, VERHELST et al. 2011) officially accepted for the country. Although this methodology does not include expressly the Minimum Repeatable Field Protocol (MRFP) proposed by BILDSTEIN et al. (2007), it has the MRFP basic elements – use of fixed watch points, continuous observation across the season and the day, two observes at the point, filling the data in standard forms. Thus it corresponds with the worldwide standards and to a large extent with the latest recommendations for such surveys (PANUCCIO et al. 2018).

Autumn migration surveys at the most prominent bottle-neck site in Bulgaria – the Burgas area during the years after 2011 have been carried out by different observers and from different vantage points at the same time, which produced different daily totals for the migrating Lesser Spotted Eagles from these given by MICHEV et al. (2011) for the same area during the period 1979–2003. Following PANUCCIO et al. (2018) we did not use these data to compare the totals for the period after 2011, but only as reference for the totals of the migrating Lesser Spotted Eagles for Bulgaria as a whole.

To complete the picture all available fragmentary data (from the period 1977–2017) were used from published (LAINE 1978, DONCHEV 1980, MICHEV & SIMEONOV 1981, IANKOV et al. 1994, MICHEV et al. 2011, KARAIVANOV & KARAIVANOV 2015) and unpublished sources, from authors own observations, from other researchers kindly provided their unpublished data, public datasets and other public sources. We also visually checked the available in the web tracks from satellite-tagged birds crossing Bulgaria (64 crossings of 18 individuals from Estonia, Germany, Hungary, Romania and Slovakia (<http://milvus.ro/pomarina>; <http://birdmap.5dvision.ee> ; <https://maps.birdlife.org/MSBtool/> ; [92](http://www.satellitetracking.</p></div><div data-bbox=)

eu/inds/showtable; <https://satellite-telemetry.jimdo.com/english/>; <https://www.movebank.org>). In general the present paper is based on about 402000 single records of the species (374 000 about the autumn, and 28 000 about the spring migration).

Data analyses

The systematic research of the migration covers a relatively small part of the territory of Bulgaria. However, it is known (including from the satellite data) that part of the migrants pass over the rest of the country. This was the reason that a model of the distribution of the species and the intensity (abundance) of its passage over the territory of Bulgaria was developed. We tested a combination of regression tree statistics (boosted regression trees, ELITH et al. 2008) and statistical interpolation (SIERDSEMA & VAN LOON 2008, HENGL et al. 2009) on the base of all available data. The model was developed on the base of the total numbers of Lesser Spotted Eagles passed through a polygon with radius of 5 km around each vantage point for a season, expressed by the numbers of observation hours. Uniform data clusters were gathered with covariant information about the studied sites and were exported as txt-files for further processing with the program TRIM maps for spatial modelling (KAMPICHLER et al. 2016). The spatial model thus was developed on the basis of summarized and standardised data. For the final maps of the migration only spatial interpolation of the observations (number of observed bird per hour) was used because the inclusion of environmental data did not

improve the maps. In order to account for the general directionality of migration (north/south) anisotropic kriging (BIVAND et al. 2008) was used. This results better in migration pathway interpolation.

Results

Spatial distribution and abundance of migrants

The relative numbers of the migrating Lesser Spotted Eagles through Bulgaria is presented on Fig. 1.

The direct visual observations show that the Lesser Spotted Eagle migrates with varying intensity over the entire territory of Bulgaria. The passage is concentrated in the eastern part of the country while single or small numbers of birds which fly over the rest of the territory. The main part of the migrants pass between the line General Toshevo – Balchik to the east and the line Ruse – Targovishte – Straldzha – Bolyarovo to the west with biggest concentration at the westernmost point of the Black Sea near Burgas.

The generalised spatial distribution of the passing Lesser Spotted Eagles during both spring and autumn migration through Bulgaria on the base of all data is presented in Fig. 2.

Seasonality

During both migration seasons in Southern Bulgaria the general picture of the species' migration is similar. During the autumn of 2012 almost the whole flow (97% of the eagles) passed through the Burgas region – between the coastline and Suhodol, with main concentration at Atanasovsko Lake – Vetren,

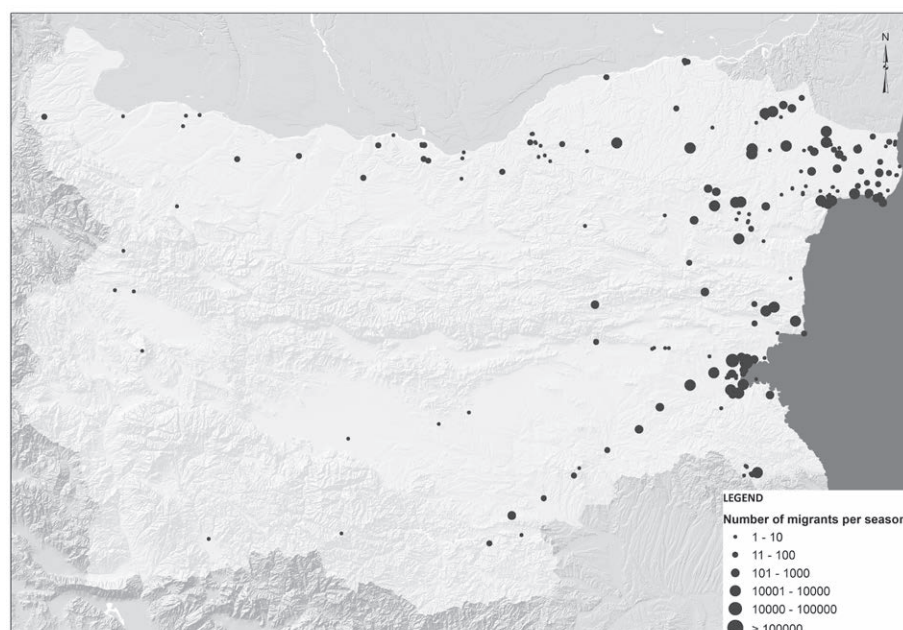


Fig. 1. Relative numbers of the migrating Lesser Spotted Eagles on the territory of Bulgaria

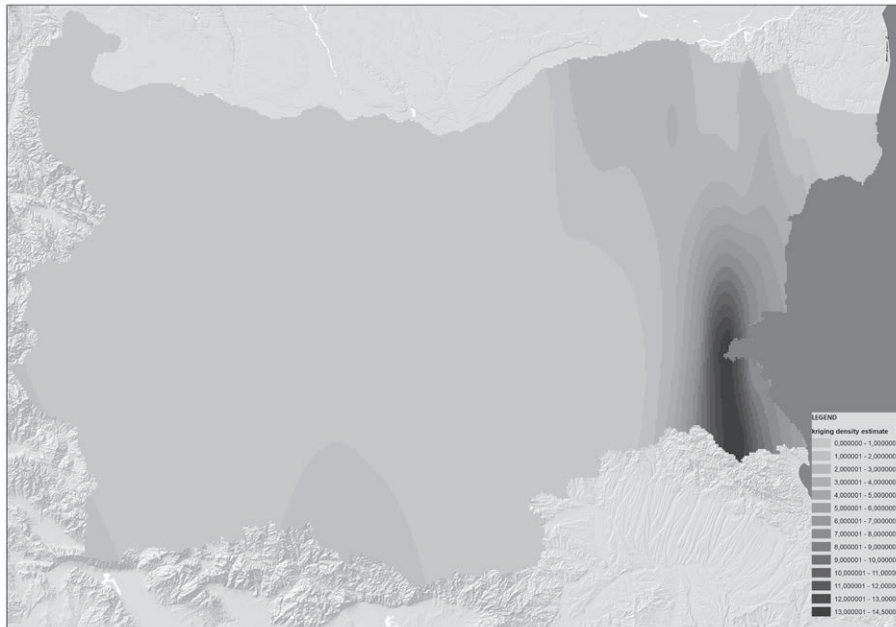


Fig. 2. Model of the abundance of the Lesser Spotted Eagle in Bulgaria during migration

where between 14000 and 15000 eagles passed over each of the two points. Toward the west the numbers decrease with slightly over 8000 eagles at Ravnets and 3000 at Suhodol.

To the west of the line Vrushka Chuka – Ivaylovgrad the Lesser Spotted Eagle migrates with very low intensity. Migration is slightly more active in Central Southern Bulgaria, probably due to the passage of the eagles breeding to the north of it (IANKOV 2007) or of individuals deviated from the main migratory flyway.

Data from the satellite-tagged Lesser Spotted Eagles passing over Bulgaria show a similar picture as the one from visual observations. During both spring and autumn migration the satellite-tagged eagles from Estonia passed mainly through the eastern part of Bulgaria, in Southern Bulgaria – through the Burgas region, some individuals crossing the Burgas Bay and even further east over the Black Sea (Fig. 3).

Lesser Spotted Eagles from Romania also pass through the eastern part of Bulgaria during both spring and autumn migration, but in general their flight paths are slightly more to the west than the Estonian ones (Fig. 3). During the autumn migration (Fig. 4) most of the Lesser Spotted Eagles enter Bulgaria in its north-eastern part on a front of about 130 km. The satellite-tagged birds from Hungary however, enter Bulgaria in the north-west. Most of the eagles from all countries leave Bulgaria however chiefly in Strandzha on a front of about 70 km only. Some Lesser Spotted Eagles can fly out of

Bulgaria as westernmost as Svilengrad. The wider front of migration during the autumn can be result of the bigger number of satellite tagged birds during this season. The main direction of the migrating Lesser Spotted Eagles during the autumn in the eastern part of the country (to the east of Ruse) is from north-northwest to south-southeast during the autumn, and this direction is maintained almost to the region of Burgas. More to the east the direction of the flying eagles changes to north – south. During the spring migration the main direction of the eagles in both Northern and Eastern Bulgaria is south – north.

The satellite tagged birds from Estonia and Romania show quite a strong fidelity to one and the same route during both spring and autumn migration including clear conservativeness concerning even the locations of entering and leaving the country.

It should be noted, that the above mentioned is based on a sample of restricted and not equally dispersed satellite-tagged birds and can be different from the real situation which can be revealed better by further investigations.

Timing, Numbers and Migration Characteristics – Spring

The first Lesser Spotted Eagles during spring migration have been recorded on 11 March (2009). In the past as beginning of the spring migration was considered the middle of February (DONCHEV 1980), which probably concerns very early single migrants or confusion with Greater Spotted Eagles (*Clanga*

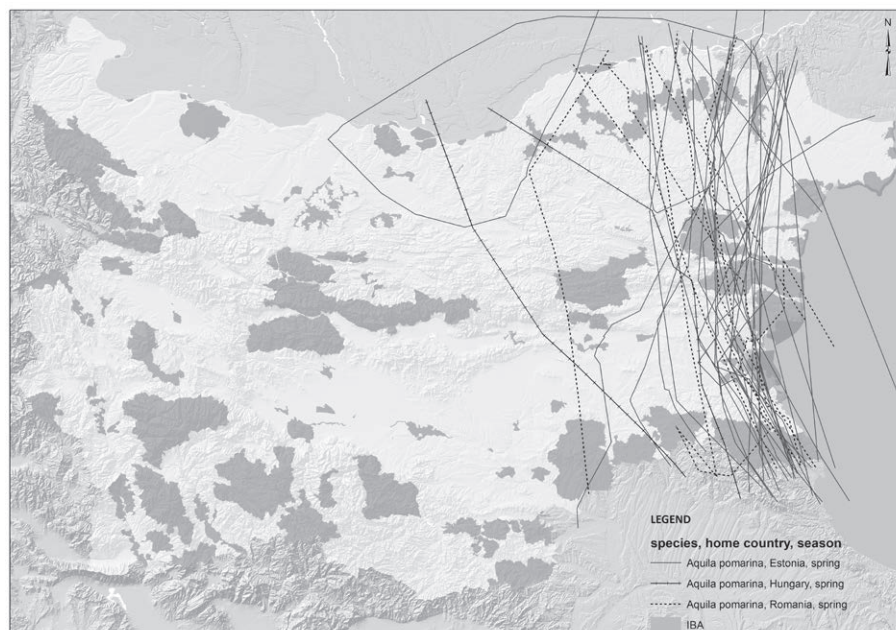


Fig. 3. Tracks of 15 Lesser Spotted Eagles passing through Bulgaria during spring migration in 2011–2017

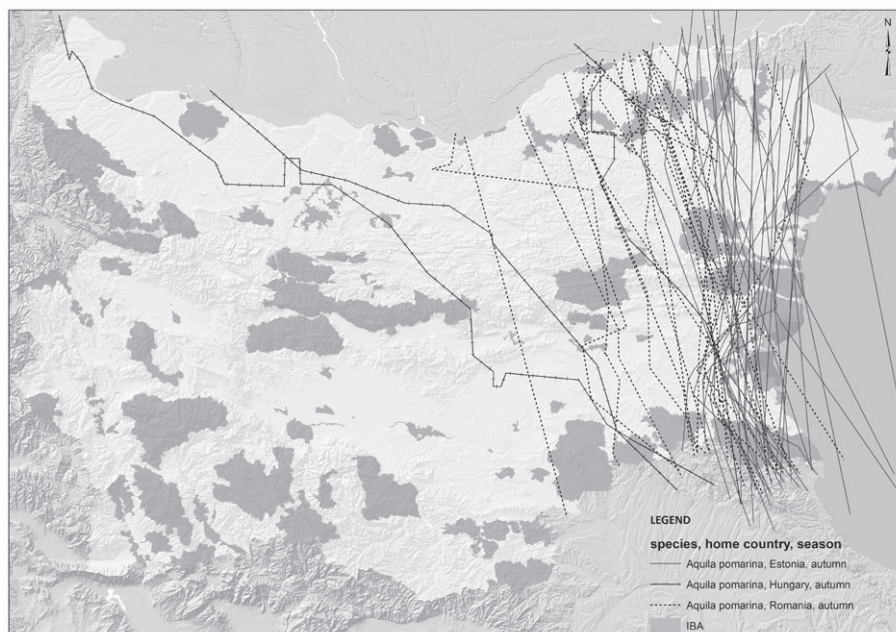


Fig. 4. Tracks of 25 Lesser Spotted Eagles passing through Bulgaria during autumn migration in 2011–2017

clanga Pallas, 1811). Passage continues until the last week of May, though about the time before 1980 the above mentioned author states that the migration ends at the beginning of April. The spring migration as a whole covers about 80 days.

The spring migration begins with single birds, followed by an increase of the numbers of the eagles between the beginning of the third decade of March and the beginning of the second decade of April, having peaks around 2nd April for Southern and around 10th April for Northern Bulgaria, followed by a rapid

decrease of the numbers of the migrants. During the period in question 88% and 93% of the Lesser Spotted Eagles for the season passed. The generalised timing of the migration of the species for the both parts of the country is presented in Fig. 5.

These are general pictures of the migration for a period of about 15 years. During each of the years the phenology of the migration is different. During the spring of 2012 two peaks were observed. The first one for Southern Bulgaria was on 2nd April and for Northern Bulgaria – on 4th April. The second, less

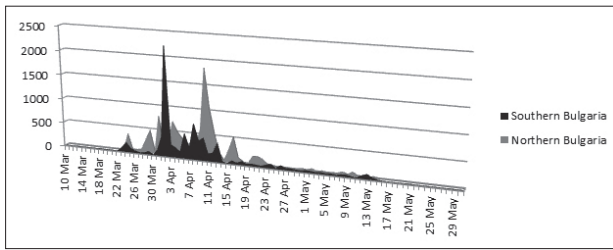


Fig. 5. Timing of the passage of the Lesser Spotted Eagle during the spring migration in Bulgaria, 1999–2012 (n=19342)

prominent peak was observed around 12–13th April for the both parts of the country (Fig. 6). In total during the period in question in Northern Bulgaria passed 79% of all the eagles for the season, and 92% in Southern Bulgaria.

Data from the satellite-tagged eagles crossing Bulgaria during spring migration (29 crossings) show that 20.7% (6 cases) passed through the country in one day with no stops, 44.8% (13 cases) in two days, 31% (9 cases) in three days, and 3.5% (1 case) in four days.

Timing, Numbers and Migration Characteristics – Autumn

The autumn migration starts with single birds at the beginning of August (earliest date 05.08.2012) and ends at the end of October (latest date 30.10.2009), but the passage is intensive during the second half of September and first days of October only. In general for the country it continues about 87 days (about 7 days longer than the spring passage). Some of the birds in August and the beginning of September are still wandering individuals; they often change the flight direction and stop for feeding for short periods at different places, roosting there. Since the beginning of September the passage of the eagles is in the main direction towards south and most of the eagles fly directly, stopping for roosting only.

Gradual increase of the numbers of migrants speeds between the middle and the end of September, reaching peaks around 25 September in Northern and around 27 September in Southern Bulgaria, where a second peak may occur around 1 October. During the period in question around 96% and 86% respectively of the Lesser Spotted Eagles pass over each part of the country. Further the numbers of the migrants rapidly decreases (Fig. 7).

From among 35 crossings of Lesser Spotted Eagles with satellite transmitters during autumn migration 28.6% (10 cases) passed through the country for 1 day with no stops, 48.5% (17 cases) – for 2 days, 11.4% (4 cases) – for 3 days, 2.9% (1 case)

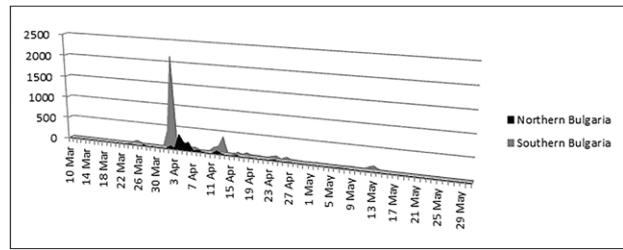


Fig. 6. Comparative timing of the passage of the Lesser Spotted Eagle during the spring migration in Northern and Southern Bulgaria in 2012 (n = 6326)

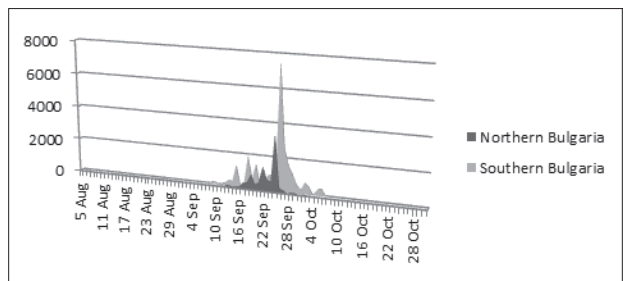


Fig. 7. Daily maximum counts of migrant Lesser Spotted Eagles in Northern and Southern Bulgaria in 2011–2012 (n=35995)

– for 6 days, 5.7% (2 cases) – for 7 days, and 2.9% (1 case) – for 14 days. Autumn migration in these cases is 10 days longer than the spring one.

At the most prominent migration bottle-neck site in Bulgaria, Burgas area, the migration of the Lesser Spotted Eagle within our survey was followed systematically during the entire period of the autumn migration in 2005 and 2012 only. In the same time, every year between 2004 and 2017 (with exception of 2010) systematic counts of the Lesser spotted Eagles have been done during the period between 13 September and 1 October, when according to the data from 2005 and 2012 about 91% of all Lesser Spotted Eagles for the autumn season migrate. The autumn migration phenology of the species in the Burgas area is presented on Fig. 8.

The number of the migrants increases gradually and peaks on 24, 25 and 28 September, when record daily totals for Bulgaria have been registered – 21300 (24.09.2014), 16505 (28.09.2008), and 13863 (25.09.2013).

Daily Timing of the Migration

In general the Lesser Spotted Eagle migrates between 9 h and 17 h but in some cases migrants have been observed also between 17 h and 18 h. In the day preceding a period with intensive rainfall – 06.10.2017, in the Burgas area 126 Lesser Spotted Eagles, gliding to the south were counted between 17.00 and 17.30 h, moreover, at about 1300 m above

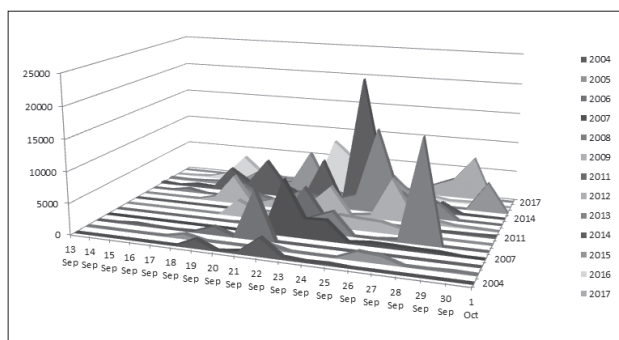


Fig. 8. Daily maximum counts of migrant Lesser Spotted Eagles in Burgas area in 2004–2017 (n = 273630)

the ground level. The most intensive migration, however, at the Burgas bottle-neck area in the autumn is observed during the hours before noon and in the noon hours, while in Northern Bulgaria the active passage is registered in the afternoon hours, even in the late afternoon. During the spring migration active passage in Southern Bulgaria was registered in the morning time, and in Dobrudzha – in the afternoon (Fig. 9–11).

Flight Altitude

As not all the information about the altitude of the flying migrants over the ground level was collected by radar or other precise equipment, only the data about the altitudinal belts are presented here. During the autumn migration the Lesser Spotted Eagle has been observed to migrate in a wide altitudinal range – from 20 m up to 2200 m above ground level, while most of the birds have been registered to fly between 200 and 1000 m above the ground (Fig. 12).

During the spring migration the Lesser Spotted Eagle fly considerably lower, with maximum birds observed at height below 300 m in both Southern Bulgaria and in Dobrudzha (Fig. 13).

During the different parts of the day the eagles fly in all altitudinal belts, while between 11 h and 16 h most of the birds have been recorded higher than 200 m and even higher than 500 m. In Northern Bulgaria most of the Lesser Spotted Eagles have been observed higher than 500 m during almost the entire day, while in Burgas area even in the noon time big numbers of the birds were seen to fly at less than 200 m altitude. The daily timing of the flight altitude during the spring migration is shown in Fig. 14.

The correlation between the flight altitude and the air temperature is shown in Fig. 15.

The timing of flight altitude of the Lesser Spotted Eagles during the day in the autumn migration (Fig. 16) shows a prominent peak at noon time and smaller ones at around 14–15 h and around 9 h.

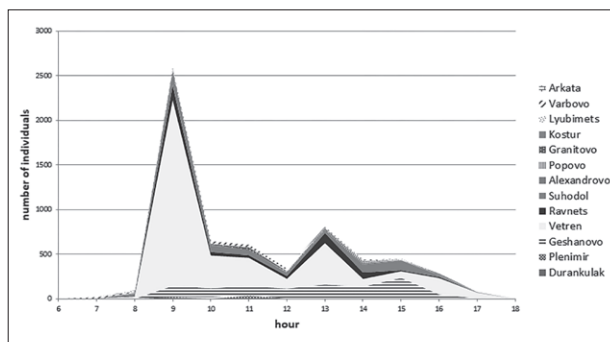


Fig. 9. Daily timing of the Lesser Spotted Eagle migration in Bulgaria during the spring of 2012 (n = 6326).

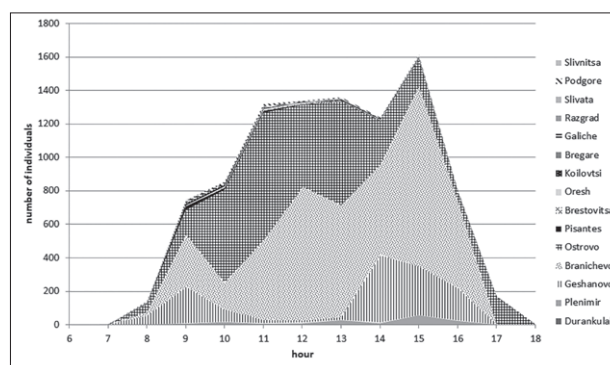


Fig. 10. Daily timing of the Lesser Spotted Eagle migration in Northern and Western Bulgaria during the autumn of 2011 (n = 9555).

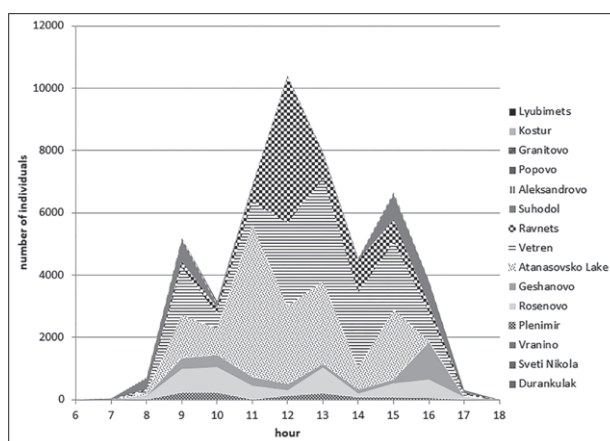


Fig. 11. Daily timing of the Lesser Spotted Eagle migration in Bulgaria during the autumn of 2012 (n = 49771).

Such peaking of migration intensity of large obligate-soaring species during the core period of thermal activity at mid-day is reported at other thermal convergence zones, including at the eastern coast of the Black Sea (VANSTEELANT et al. 2014).

The relation between the flight altitude and the air temperature during the autumn migration is shown in Fig. 17.

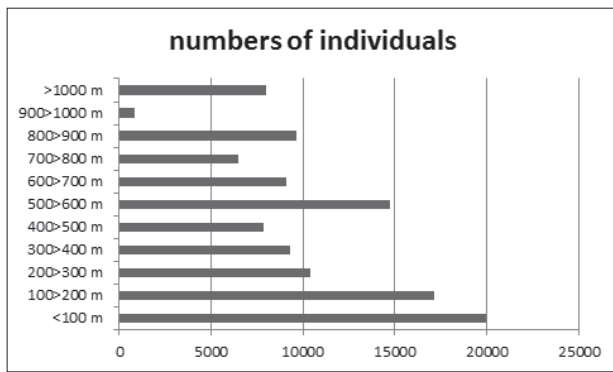


Fig. 12. Flight altitude of the Lesser Spotted Eagles in Bulgaria during autumn migration (n = 113542)

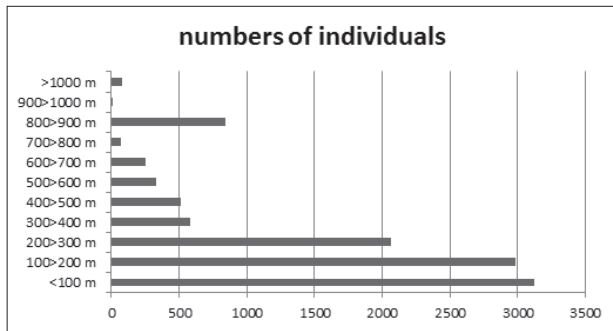


Fig. 13. Flight altitude of the Lesser Spotted Eagles in Bulgaria during spring migration (n = 10850)

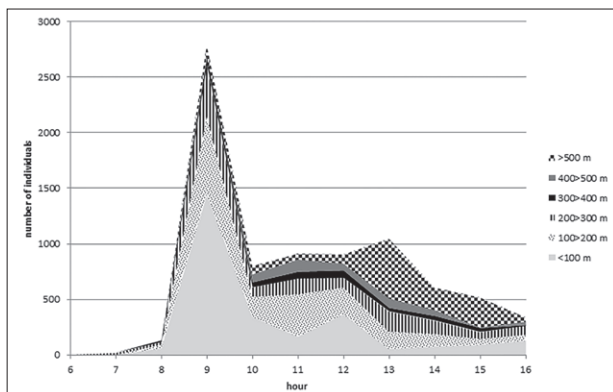


Fig. 14. Daily timing of the flight altitude of the Lesser Spotted Eagle during spring migration in Bulgaria

Total number of migrants

As shown in Fig. 2, the highest concentration of the Lesser Spotted Eagle is at the migration bottle-neck area around Burgas. The autumn migration there was studied during 33 seasons since 1979, which provides the best opportunities to assess the total numbers of migrants in Bulgaria. The record total is in the autumn of 2014, when in the period 13–30 September only (18 days) 51850 individuals were counted (<http://www.trektellen.org>, F. Ennemark, G. Guldvang, pers. comm., authors own data).

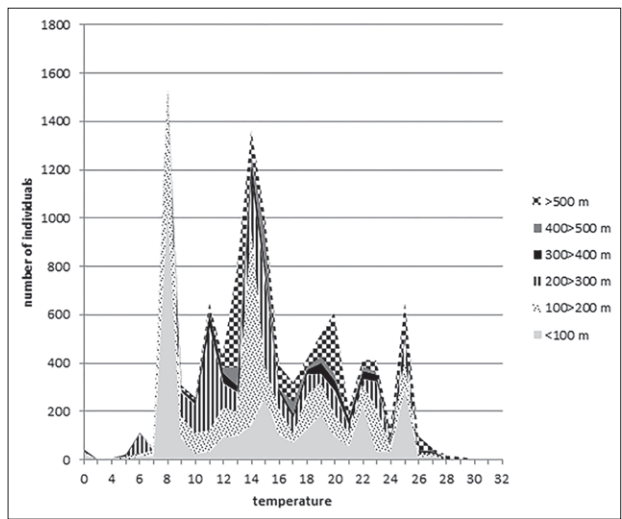


Fig. 15. Flight altitude of the Lesser Spotted Eagles in relation to the air temperature during spring migration in Bulgaria

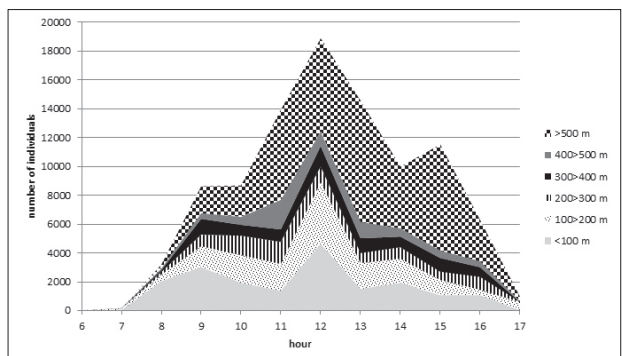


Fig. 16. Daily timing of the flight altitude of the Lesser Spotted Eagle during autumn migration in Bulgaria

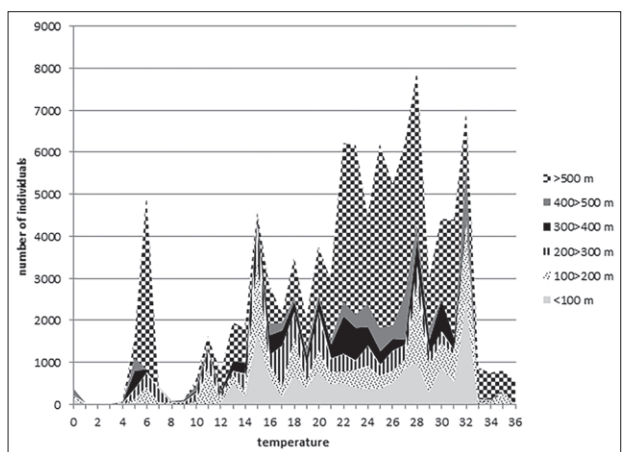


Fig. 17. Flight altitude of the Lesser Spotted Eagles in relation to the air temperature during autumn migration in Bulgaria

Stopover Sites

Both direct observations and data from the satellite-tagged birds show that part of the Lesser Spotted Eagles during migration stop for roosting and feeding at various places in Bulgaria. There are multiple

observations of eagles, especially during autumn migration, landing for roosting or taking off in the morning from tree belts and forested dry valleys in Dobrudzha, woodlands of the Ludogorie, Eastern Balkan, forests of Strandzha Mnt. and other sites.

During autumn migration some eagles spent days or longer periods in sites with abundant food, roosting on trees or electricity pylons. Such cases exist in Pleven area (satellite-tagged Lesser Spotted Eagle from Hungary), around Burgas, Sliven and other sites, where during the migration period single or small groups of eagles forage and make local movements for a certain time before continuing their flight south. It is possible that some of these cases are related to post-breeding roaming. There are no observations however, of Lesser Spotted Eagles stopping and foraging for days during the spring migration.

A recent study of the Lesser Spotted Eagle stopover sites during migration shows that the eagles spend the night predominantly in forest massifs (mainly of oak, *Quercus* sp.) near open terrains. The predominant part of the core and secondary zones of the stop over sites are arable lands and broad-leaf forests. The most important stop over sites, where the Lesser Spotted Eagles spend the night, rest and forage, are in Eastern Bulgaria (D. Demerdzhiev, personal communication).

Lesser Spotted Eagle Migration and SPAs

The Lesser Spotted Eagle migrates through in total 38 Special Protection Areas (SPAs). Out of them 17 SPAs are of particular importance for the migration of the species mainly as roosting and stop over sites (Fig. 3, 4). The most significant with this respect are those situated in Eastern Bulgaria and especially along the Black Sea coast.

Most of them, i.e. SPAs Kaliakra, Belte Skali, Suha Reka, Hursovska Reka, Ludogorie, Provadiisko-Royaksko Plato, Kamchiiska Mountain, Emine, Kotlenska Mountain, Bakarluka, Complex Mandra-Poda, Burgas Lake, Atanasovsko Lake and Strandzha, cover the criteria for bottle-neck sites for the migratory raptors and it is obvious that the Lesser Spotted Eagle should be a priority species for conservation there.

Discussion

The migration of the Lesser Spotted Eagle takes place almost entirely in Eastern Bulgaria over the Eastern Balkan migratory flyway, known as *Via Pontica* (ZALLES & BILDSTEIN 2000), which is the shortest way of the birds to the Bosphorus. Two

main factors predetermine most of the world population of the species to cross the country during its spring and autumn migration. First is the fact that most of the Lesser Spotted Eagle's breeding range is situated to the north and north-west of Bulgaria (BIRDLIFE INTERNATIONAL 2017, DEMERDZHIEV et al. 2019a). And the second is the presence to the east of Bulgaria the largest in Europe inland water body – the Black Sea, creating one of the most considerable barriers for the migrating soaring birds in this part of the continent and funnelling the migrants along the coastline being also a typical convergence zones with one of the strongest and most stable thermals which are of critical importance for the migration of such a large obligate-soaring species as the Lesser Spotted Eagle. The same migration pattern was reported in Romania, on the eastern coast of the Black Sea in Georgia, in Turkey, as well as in several Mediterranean areas (LESHEM & YOMTOV 1998, MEYER et al. 2000, MEYBURG et al. 2002, VANSTEELANT et al. 2014, PANUCCIO et al. 2018, FÜLÖP et al. 2018). The satellite telemetry (<http://www.satellitetracking.eu/inds/showtable>; <https://www.movebank.org>) shows that some of the Lesser Spotted Eagles migrate along the Bulgarian coast over the open sea, which proves that migration occurs also over the large water areas (Fig. 6). This can be one of the reasons for the differences in the numbers of the recorded eagles at the northern and southern vantage points along the migration flyway.

The highest abundance of the migrants in Bulgaria is at the area of Burgas and to the south of it. At this most prominent bottle-neck site in Bulgaria the autumn migration of the Lesser Spotted Eagle has been followed during 20 seasons in 1979–2003. During this period the species passes there between 26 August and 21 October with peaks numbers between 23 September and 2 October, when on average about 61% of all migrants for the season pass through. The peak dates are 24 and 25 September and around 1 October (MICHEV et al. 2011). Species migration in the area starts with single individuals at the middle of August, slightly accelerating at the end of the same month and remains such until 7–8 September. Gradual increase follows before the numbers reach their maximum around 24–27 September, with exception of 1989, when the peak was on 2 October (RUSKOV 1998). This corresponds to a large extend with the dates established in the present investigation. Two of the peak dates (24 and 25 September) fully coincide during both periods. Additional research is needed to explain the difference in the third peaks (28 September for 2005–2017 and around 1 October for 1979–2003 period), but a possible reason

can be the higher in the past instability of the weather conditions at the end of September – beginning of October. The phenology of the Lesser Spotted Eagle autumn migration at the Burgas bottle-neck site for the period 2005–2017 to large extent corresponds not only with those obtained by MICHEV et al. (2011) for the period 1979–2003, but also with those at the Bosphorus (FÜLÖP et al. 2014, PANUCCIO et al. 2017) considering the difference in the locations. The above mentioned can be an indication about stability in the phenology of the passage of the species.

According to the present study the total numbers of the Lesser Spotted Eagles, passing over Bulgaria during the autumn season is 51850 individuals (in 2014). The totals and some data from countries along the Lesser Spotted Eagle migratory flyway to the south of Bulgaria (58327 individuals in 2008 at Bosphorus, FÜLÖP et al. 2014) raise the question about the reason for the difference in the number of the eagles crossing Bulgaria and those counted at Bosphorus. One possibility is part of the Lesser Spotted Eagles over Bulgaria to be omitted. It seems that the figures obtained for the country reflect the minimal number of migrants, as these figures in the present study reflect the really seen individuals. It is obvious that it is impossible to cover the entire flight corridor of the *Via Pontica* flyway in both territorial and altitudinal aspect. The eagles flying higher than 1000 m above ground level are very difficult to be spotted, especially on a blue cloudless sky, which was clearly shown by the use of the radar in 2011–2012. A more precise estimation, however, can be obtained by parallel counts from vantage points situated on an optimal distance from one another, covering the entire flyway in combination with use of radar or of infrared devices for spotting flying objects. Satellite tracking of bigger numbers of Lesser Spotted Eagles can also provide very important information, especially concerning the migration over the sea. However, the breeding population of the Lesser Spotted Eagle in Bulgaria, estimated at more than 600 pairs, is concentrated mainly in the eastern and the south-eastern parts of the country (DEMERDZHIEV et al. 2019a, b). Therefore, during migration at least 1000 individuals, including offspring, will not migrate through the area of Bourgas and will not be counted, but they will be recorded at the Bosphorus. It seems that more precise estimation of the global population of the Lesser Spotted Eagle can be obtained at the Bosphorus or in Israel, where the eagles from the Eastern part of the Black Sea (up to 6011 individuals in 2011, <https://www.batimiraptorcount.org/migration-count-data#annual-totals>) will be counted as well.

As mentioned above, the survey of the autumn migration of the soaring birds in Burgas area started in 1979 and was carried out during 20 seasons to 2003 (MICHEV et al. 2011) and 13 seasons afterwards to 2017 (this study). Due to the different survey effort and counting strategy between years however, a comparison between the two periods is impossible. The visible increase of the numbers of the Lesser Spotted Eagles for both periods (1979–2003, MICHEV et al. 2011, and 2004–2017, this study) is seemingly, as during the first period there were gradually increasing level of the effort, the training of the observers and the quality of the optics, and during the second period special efforts (by changing vantage points) were paid to cover maximum of the flight corridors, as it was known that under particular conditions (especially the wind direction) some of the flows of migrating raptors remain outside of the range of visual detection (RUSKOV 1998).

There are cases, however, when at the “standard” vantage point of Atanasovsko Lake (used during all the years with counts) sudden high numbers of Lesser Spotted Eagles have been recorded. RUSKOV (1998) mentions “unusually high peak numbers” of 9066 Lesser Spotted Eagles on 25.09.1984. On 24.09.2014 (the day with the absolute maximal daily total for the species of 21300 eagles), during western wind over this vantage point 12450 Lesser Spotted Eagles passed between 15.00 h and 17.00 h, almost 10000 of which crossing within 1 hour between 15.30 h and 16.30 h (F. ENNEMARK, personal communication, authors’ unpublished data).

These and other similar records allow assuming another reason for such high values in some cases in both periods. Intensive migration flows of the Lesser Spotted Eagle may pass to the west of Burgas at 45–50 km front. The most distant ones are far outside the visual range of the “standard” vantage point at Atanasovsko Lake. During appearance of strong western wind however the flows got moved towards the vantage point at the coastline, resulting in a sharp increase in the numbers of registered migrants. Such reasons for rerouting migration of raptors are described also by EISAGUIRRE et al. (2018).

In general the migration of the Lesser Spotted Eagle can be characterised in clear terms. It is quite typical for the species that in just 2–3 days more than half of the entire season numbers of eagles for the season can pass by. The possible reason for this (besides the change of the wind direction) can be periods with more intensive rainfalls, when eagles wait the period of limited thermal convection to pass perched and often concentrated in woodlands, especially in the Eastern Balkan, Strandzha and Ludogorie.

Such aggregations are reported by DEMERDZHIEV & POPGEORGIEV (2017) and are observed during the present study as well. Similar behaviour of the large obligate-soaring species has been reported by other authors for the eastern Black Sea coast (VANSTEELANT et al. 2014). In the first day without rain the eagles continue their migration in big numbers at the same time and over the areas immediately after the roosting sites along the main migration direction resulting in the passage of thousands of Lesser Spotted Eagles in just an hour. The phenomenon was described as “mass concentrated passages” (DOVRAT 1991) and in Bulgaria can be observed virtually every year during the autumn migration near the southern slopes of the Eastern Balkan, including at Burgas area. In combination with stronger western winds in this particular area large numbers of eagles can get deviated from inland and concentrate along the coastline.

The threatening factors for the Lesser Spotted Eagle during migration through Bulgaria are not sufficiently known. It is a matter of fact that illegal hunting on birds of prey in the country is very limited and in the last several decades there are no documented cases of shot Lesser Spotted Eagles. It seems that a more significant threat is the dangerous power-line grid, especially the 20 kV lines (DEMERDZHIEV et al. 2009, DEMERDZHEV 2014). On 10.10.2017 an electrocuted individual was found under such a powerline close to the Petrol Refinery near Burgas. Little is known of the impact of forestry activities in the key forested stop over sites, but potentially it has an important role during species migration.

Conclusions

The migration of the Lesser Spotted Eagle takes place over most of the territory of Bulgaria with highest abundance of migrants in its eastern part and especially along the *Via Pontica* flyway along the Black Sea coast (except its northernmost parts) with a gradient of decrease westwards. Some of the Lesser Spotted Eagles fly over the Black Sea as well. The most intensive migration take place at the Burgas bottle-neck area, where the predominant part of the eagles pass at 45–50 km front.

During spring migration the Lesser Spotted Eagle passes through Bulgaria for about 80 days between the second decade of March and the end of May, with peaks around 2nd April for Southern and around 10th April for Northern Bulgaria. During autumn passage the species crosses the country for about 87 days between the beginning of August and the end of October, with peaks around 25 September in Northern and around 27 September in Southern

Bulgaria, where a second peak may occur around 1 October.

The Lesser Spotted Eagle migrates in general between 9 h and 17 h, though in some cases passage can continue later in the day. During the spring migration active passage in Southern Bulgaria is observed in the morning time, and in Dobrudzha – in the afternoon. The most intensive autumn migration at the bottle-neck area near Burgas is registered during the hours before noon and in the noon, while in Northern Bulgaria the active passage is registered in the afternoon hours, including the late afternoon.

The Lesser Spotted Eagle migrates in a wide altitudinal range – from 20 m up to 2200 m above ground level. During the autumn migration most of the birds fly at altitudes between 200 and 1000 m. During spring migration the altitude is considerably lower, with most of the birds observed at heights below 300 m. Flight altitude in Southern Bulgaria is in general below 800 m, with most of the eagles flying at about 200 m altitude, while in Northern Bulgaria the Lesser Spotted Eagles fly much higher, between 400 and 1400 m, with most of the eagles passing at around 800 m.

The Lesser Spotted Eagle is one of the most numerous soaring migrants on passage in Bulgaria. Up to 52000 individuals cross the country during autumn migration, which is about 86% of the world population of the species.

“Mass concentrated passages” of Lesser Spotted Eagles, reaching at some points up to 10000 birds in an hour occur annually in Bulgaria during the autumn migration.

As stopover and roosting sites the Lesser Spotted Eagle uses forested areas (mainly of Oak species) near open terrains. Most of them are in Eastern Bulgaria, to a large extend within existing SPAs.

Electricity grids and particularly the 20 kV power lines are a threatening factor for the Lesser Spotted Eagle during migration.

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