Thesis

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Study of the age composition of the Eurasian Woodcock between 2015-2024 in Hungary

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1. Introduction

The Hunting of Eurasian Woodcock has deep roots in the hunting culture of Europe. For centuries, it has been regarded as one of the most traditional and prestigious forms of small-game hunting, celebrated for the bird's elusive behaviour, challenging flight and the skill required to hunt it. Across much of the continent, from the Atlantic coast of France to the Carpathian Basin, the woodcock has long been a symbol of refined hunting culture and sportsmanship.

Despite the relatively scarce game bag and the overall exclusion from game management plans, the Eurasian woodcock stood, and still stands as a cultural keystone species in the eyes of the Hungarian hunters. Its perceived hunting value derives from the rarity and unpredictability of the presence of the bird (Heltay 2017).

Although the hunters of the woodcock saw restrictions come and go since the 1930's (Szabolcs, 1971) with first the prohibition of driven hunts and by the ban on the use of dogs for flushing, the official hunting, as we know it, came to a halt just around two decades ago.

Following Hungary's accession to the European Union in 2004, the adoption of the principles of the Birds Directive - originally Directive 79/409/EEC, now codified as 2009/147/EC - which regulates the protection hunting of bird species during their breeding season or during their migration was inevitable. From then on, the old tradition of hunting Eurasian Woodcocks (*Scolopax rusticola*) in Hungary was facing international agreements, and thus could no longer be sustained under the new legal framework. Article 7(1) of directive 2009/147/EEC, however, states that species listed in Annex II, where *Scolopax rusticola* is included, may be hunted under national legislation. Member States shall ensure that hunting of the species does not jeopardize conservation efforts in their distribution area and that hunting is carried out in accordance with national measures in force. (https1)

At the initiative of the Hungarian Hunters' National Association (*Országos Magyar Vadászati Védegylet*) a National Woodcock Monitoring Programme was established in 2009 to estimate the size of the Eurasian Woodcock population migrating through Hungary, and to monitor the changes in the population based on synchronous counts and population-biological data as well as sampling (https2). The core objective of this research is to process and analyse the nearly a decade's worth of data collected within the frames of the National Woodcock Monitoring Programme from 2015 till 2024.

The planning of the monitoring, as well as the data and sample collection, is coordinated by the *Institute for Wildlife Management and Nature Conservation*, *Department of Wildlife Biology and Conservation* at the Hungarian University of Agriculture and Life Sciences, through which I also participated in the processing of the collected samples.

My personal motivation for choosing this topic originates from my involvement in bird ringing activities. While assisting in capturing and ringing wild birds, I became increasingly interested in the study of plumage, moult, and age determination. On 15 June 2024, I obtained my official bird ringing licence from the Hungarian Ornithological and Nature Conservation Society (MME), with specific authorisation for the Eurasian woodcock. Since then, I have been actively participating in ringing sessions and data collection. The ringing experiences for me had created a personal connection to the species and had greatly inspired the direction of my research.

My study sets out to quantify the annual proportion of early juveniles relative to all juveniles, describing the mean, standard deviation, minimum and maximum values for each year. In addition, the temporal trend of early juveniles was analysed across the entire study period, with particular focus on testing for a linear trend. A further objective was to determine the annual proportion of fully moulted adults. Finally, the study examined whether the proportion of early juveniles and that of fully moulted adults were correlated with each other, and whether either of these variables showed a relationship with the total hunting bag.

2. Literature review

2.1 Moulting processes

Moulting in birds is a natural process in which birds gradually renew their feathers to keep the plumage in working condition. Because feathers are non-living structures, they wear out over time, losing both their aerodynamic efficiency and insulating capability. To stay fit for flight and protection, birds have evolved several moulting strategies adapted to their life cycle and ecological needs (Scott, 2010).

The pattern and timing of feather replacement can differ widely between species and even between individuals of the same species. In most cases, a complete moult takes place once each year, usually after breeding, when energy demands are lower and food is more abundant. Migratory birds, however, often follow more complex schedules of moulting. They may interrupt or limit feather replacement to stay capable of flight, balancing the need for new plumage with the necessity to travel long distances.

Environmental and physiological factors strongly influence when and how moult occurs. Day length, temperature, hormonal state and food availability can all trigger or delay the process. In many birds, moulting follows reproduction and helps adults regain condition after breeding; in others, it comes just before migration, ensuring that new feathers are ready for the journey ahead. These differences show how closely feather renewal is connected to energy balance and seasonal survival strategies. For the Eurasian woodcock, this connection is particularly strict: the bird completely halts moulting before migration, regardless of its progress, because performing both energy-demanding activities at once is impossible (Fluck, 2019).

Studying moulting also provides valuable clues for ageing birds. Differences between juvenile and adult plumage, especially in the order and extent of feather replacement, can indicate distinct age classes. In the Eurasian woodcock, however, determining age is not straightforward. The species shows substantial variation in its plumage and the pace of moult, which requires observers to be careful. The contrasts between juvenile and adult feathers are often subtle, sometimes overlapping due to local environmental conditions or individual growth rates. Because of this, reliable age classification depends on evaluating several feather traits together, rather than relying on a single diagnostic feature (OMPO 2002; Ferrand & Gossmann, 2008; Scott, 2010).

In some species such as ducks and waders, older individuals tend to moult more efficiently and completely than first-year birds. The degree of moult completion can therefore reflect the physical condition of individuals and, on a larger scale, population-level processes such as breeding success or survival rates. For this reason, moult data are often used in population monitoring and demographic studies, linking individual physiology with broader ecological patterns (Scott, 2010)

2.2 Population age tracking and demographic indicators

Understanding how age groups are distributed within a bird population is one of the key foundations of population ecology. The balance between young and adult individuals determines how survival and recruitment shape overall population trends. By following these age groups through time, researchers can interpret whether a population is stable, increasing, or declining. In practice, ageing birds accurately is not always simple, especially in species where the sexes look similar, and where sexual monomorphism is present (Christensen et al., 2017). Because of this, reliable studies often combine several traits, such as feather wear, wing length, or plumage pattern, while using standardized measurement protocols to make results comparable between years and observers (Silvy, 2012).

In species like the Eurasian woodcock, single traits are rarely decisive. Determining age correctly usually requires examining several feathers together: shape and wear of primaries, patterns of coverts, the thickness of the rachis, and the progression of moult. When only partial samples are available, such as isolated wings collected during the monitoring season, these differences can become subtle. Therefore, applying the same detailed and repeatable criteria every year is essential when tracking population age composition.

2.3 Reproductive success and recruitment monitoring

Reproductive output and recruitment are the key forces that maintain or alter population size from one year to the next. Monitoring breeding success provides essential context to the observed age ratios, as fluctuations in juvenile numbers often reflect differences in productivity rather than survival alone. In practice, estimating reproductive success in wild bird populations is challenging. Therefore, researchers rely on indirect methods such as capture-mark-recapture or radio-tracking to derive recruitment rates and apparent survival.

Valuable information can also be obtained from harvested individuals (Silvy, 2012; Ferrand et al. 2008; Ferrand, 2006). During regulated hunting, systematically collected samples such as wings or feathers offer reliable material for determining age ratios and assessing annual productivity. Such data, gathered under national or local monitoring programs, are often crucial for demographic analyses and long-term trend assessment (Christensen et al., 2017). Comparable studies on the American woodcock (*Scolopax minor*) have applied similar monitoring approaches combining bag statistics and field surveys (Robinson and Bolen, 1989) Consequently, researchers rely on both field observations and harvest-derived samples to evaluate recruitment and population performance. These parameters, together with observed age ratios, allow for a clearer understanding of annual population dynamics.

2.3 The Boidot ageing methodology

Although the official standardized method used for determining the age of the individuals in bird ringing is the one of EURING, this system is not a species-specific ageing method, but rather a standardized categorization framework that ensures that all researchers use the same definitions for age classes (e.g., “first-year,” “juvenile,” “adult”) across different species. The actual determination of age, however, varies from species to species and depends on distinct morphological criteria and plumage characteristics.

The Eurasian Woodcock Monitoring Programme uses the method developed by Dr. J.-P. Boidot. Originally, Boidot adopted this ageing methodology from studies on the wing moult of the American woodcock (*Scolopax minor*) (Fluck 2019). This adapted system uses a so-called suspended moulting rate (*Taux de Mue Suspendue* or *T.M.S*) that helps to achieve a structured framework determining the age of the Eurasian woodcock.

The marking of the moult categories:

- A= adult (birds older than one year)
- J= juvenile (birds in their first calendar year)
- C= category of moult (ranging from 4 to 0, depending on the progress of wing feather replacement
- 0 = point or absence of moult (not completed)

The moult categories (C0 to C4) describe a gradual process of feather renewal:

- C4: initial stage of moult, only a few primaries replaced, Juvenile feathers still dominant.
- C3: intermediate stage, a mixture of juvenile and adult-type feathers with visible contrast.
- C2: advanced stage, the majority of primaries replaced, only minor differences detectable
- C0: moult fully completed, uniform adult-type plumage visible

Thus, a code such as An+1 C2 refers to an adult second calendar year individual at moult category 2, while JC4 designates a juvenile with only the first stages of moult visible (**Figure 1**,**Figure 2**). Similarly, An+X C3 indicates an older adult with an intermediate progress of feather replacement.

Figure 1: Dorsal view of the left wing of an individual in JC4 category.
(Source: own photograph)

Figure 2: Ventral view of the left wing of an individual in JC4 category
(Source: own photograph)

In adult birds, the wing feathers generally provide a clear indication of moult progression. However, in young individuals the situation is less straightforward. The presence of the so-called Fabricius gland remains detectable for roughly four and a half months following the end of the primary moult. In this stage, a study revealed that moulting feathers may not provide a safe basis for age determination given that this organ does not directly correspond to the stage of moult. In fact, a bird showing only slight progress in feather replacement may in fact be older than another whose moult is already complete (Boidot 1999).

Although the practical application of the Boidot method requires experience and careful observation, its widespread use in national and international woodcock monitoring demonstrates its proven value in research. The method provides a unified and comparable system for determining age classes across different study areas and years, allowing researchers to analyse long-term changes in population structure and productivity with a consistent framework.

Because the criteria are standardised and well-documented, results obtained by independent observers remain comparable between regions. This harmonisation has made the Boidot approach an essential reference in monitoring schemes coordinated by organisations such as OMPO and Wetlands International. Its continuous application not only ensures the reliability of demographic analyses but also supports coordinated conservation strategies based on shared data sets and common ageing standards.

Table 1: Moult categories of the Eurasian woodcock in chronological order.

Code	Moult status	Age group	Description
JC4 JC3 JC2 JC1 JC0	Incomplete	Juvenile	Birds in their second calendar year in spring
*AC0	Complete	Adult	Birds in their third calendar year or more
An+1 C4 An+1 C3 An+1 C2 An+1 C1	Incomplete	Adult	Birds exactly in their third calendar year
An+X C4 An+X C3 An+X C2 An+X C1	Incomplete	Adult	Birds in their fourth calendar year or more

* Possible to occur as a Second-year, but due to the full moult we cannot state that the bird is in its second-year.

2.2 The bursa of Fabricius (bursa cloacalis or bursa Fabricii)

The bursa of Fabricius is a lymphoid organ located dorsally to the cloaca of birds, and it plays a key role in the development of the immune system during the early stages of life after hatching. Its primary function is the maturation of B-lymphocytes, which are essential for the adaptive immune response (Glick 1991). In the researches conducted, the presence of the bursa in Eurasian woodcock is also of practical importance for age determination.

The organ is well-developed in juveniles and can usually be detected up to four and a half months after the end of the primary moult. During this period, its presence serves as an auxiliary element to distinguish young individuals from adults. However, its regression begins relatively early, and the organ becomes less pronounced or completely absent in older birds Age-related involution of the bursa has also been described in other waterbirds, such as the green-winged teal (*Anas crecca*) where progressive structural reduction was documented with increasing age (Abdel-Fattah et al. 2025).

As a result, reliance solely on the bursa may lead to uncertainties, since individuals with a still-visible gland can show very different stages of wing moult progression. For example, a juvenile with a persistent bursa may appear less advanced in moult than another of the same age whose bursa has already regressed.

However, in the context of woodcock monitoring, this organ has no practical role in age determination, as only wing samples are collected and examined from harvested individuals. The bursa of Fabricius is an internal organ that cannot be assessed in such material, and it naturally regresses around five months of age (Fluck 2019). Considering that the monitoring period takes place in early spring, long after the breeding and fledging period, the bursa is already fully resorbed and thus provides no applicable information for age classification.

Therefore, while the bursa of Fabricius offers useful additional information in the first months of life, it should be considered only as a complementary characteristic alongside wing feather analysis in the Boidot ageing method.

3. Materials and methods

In 2023 and 2024 three of my course mates and I had the opportunity to participate in the data processing of the Monitoring Programme in the Institute for Wildlife Management and Nature Conservation. In the laboratory of the Institute in Gödöllő, we sorted the envelopes containing wing samples provided by nationwide Programme participants.

Each sample is required to be sent with a data sheet filled with information: the site of the sample collection, date and time of collection, weight of the bird, length of the bird in mm (measured from the tip of the beak to the end of the tail) and sex of the bird. There is also a section for further comments on the sampling, the circumstances or on the bird. The sample collector is obliged to provide his/her name and the identification number of the valid hunting licence along with a signature. Every sample is marked with an individual code for further processing.

The age determination of the wing samples is conducted by experts using the Boidot methodology. Some wings are semi- or unsuitable for this process due to various factors such as previous improper preparation of the samples, damage by insects, too much damage dealt by pellets, or rough recovery of the woodcock. These wings are sorted out of the data processing.

Following the age determination, the data sheets are sorted by county and then the data is transcribed manually from paper sheets into Microsoft Excel. This process is time consuming and requires patience and precision.

During the nine years of the Monitoring Programme between 2015 and 2024 an astonishing number of 24.582 samples were collected. With the help of MS Excel, I was able to extract the number of samples for each age group. My research mainly focuses on three age groups of the Boidot system: AN+X C0, marking fully moulted individuals, JC0, where 15-16 moulted feathers can be observed on the upper greater coverts and three moulted juvenile primaries are visible, and JC1, where 10-14 moulted feathers are present on the upper greater coverts together with two moulted juvenile primaries. These categories form the backbone of the analysis presented in this thesis, as they allow the comparison of different life stages of the woodcock population and provide the basis for understanding demographic trends across the study period.

4. Results

4.1 Annual ratio of early juveniles to total juveniles

Based on the collected samples, the ratio of the Early Juveniles (JC1 and JC0) compared to the total number of Juveniles averaged 57.8% with a standard deviation of +/-5.6%. The minimum value was marked by the year 2023, where the ratio was 49.9%, while the maximum was peaking in 2017 with 61.8%. The analysis shows little fluctuations from year to year, but overall, it can be stated that the ratio is stable.

The deviations are visible on the yearly horizontal bar charts of the ratio of early juveniles (**Figure 3**). The boxplot of the proportion of early juveniles to all juveniles is shown as Figure 4. The median is 59%.

The mean is no different than 57.8% which also suggests that more serious deviations are rare. 2023 stands as the only significant, where the value dropped below 50%. As of now, there is no definitive explanation for this drop. As well as other fluctuations, it might be due to the influence of factors such as weather conditions, breeding success, migration circumstances. This anomaly presents itself as an excellent opportunity for further research, however the inspection of this event is not within the scope of this study.

The trendline shown on the diagram (**Figure 3**) was created with linear regression, which models the relationship between the years (independent variable) and the proportion of early juveniles (dependent variable). The equation of the trendline and the R^2 value (R^2 =0.06) were calculated by the MS Excel program. The 0.0594 as the R^2 value is extremely low, indicating that the fluctuations are not significant.

Figure 3: Ratio of early juveniles to total juveniles (2015-2024).

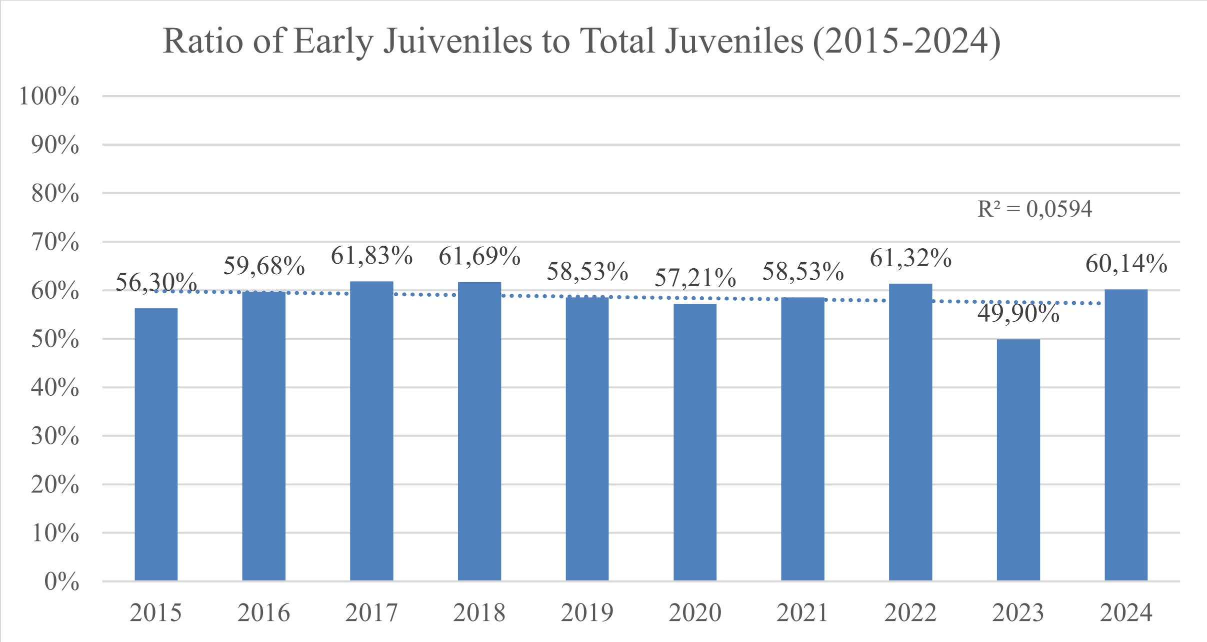
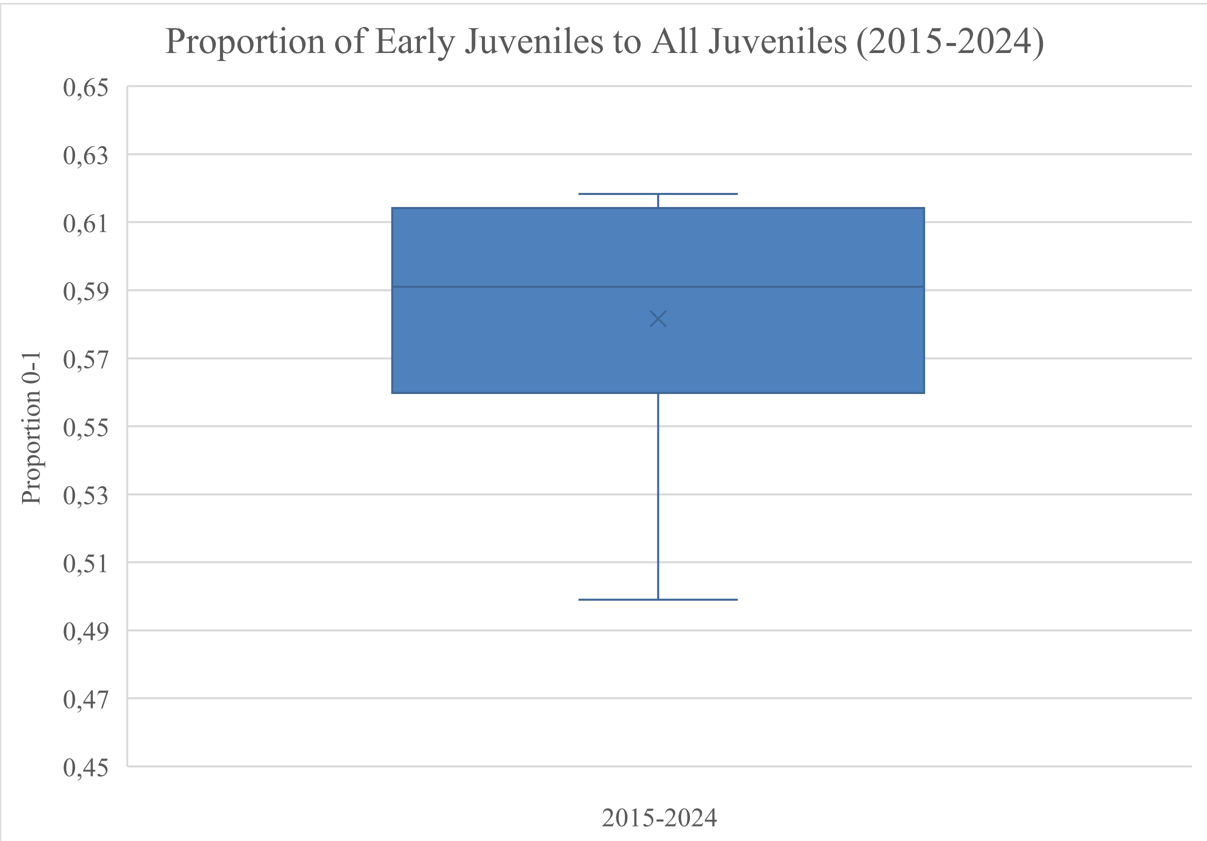


Figure 4: Proportion of early juveniles to all juveniles (2015-2024).



4.2 Trend of Early Juveniles Throughout the Study Period

Beyond the descriptive statistics, the dataset was also examined with a linear regression model in order to test whether the proportion of early juveniles showed a long-term directional change across the study period. In this analysis, the years were treated as the independent variable, while the proportion of early juveniles represented the dependent variable.

The resulting regression line showed almost no slope, and the coefficient of determination ($R^2 = 0.06$) indicated that the model explained only a negligible fraction of the variance in the data. In other words, the observed year-to-year fluctuations cannot be linked to a consistent increase or decrease in the proportion of early juveniles. The differences between years therefore appear to be short-term variations rather than evidence of a continuous demographic shift.

This finding is consistent with the descriptive results presented earlier, which already suggested that the annual rations remained relatively stable, with the exception of a few outlier years. The trend analysis reinforces the view that the 2023 drop, as well as smaller deviations in other years, should be interpreted as temporary events instead of signs of a longer-term transformation.

Overall, the analysis of the linear trend demonstrates that the proportion of early juveniles remained stable throughout the decade under study, and that the temporal pattern of variation does not point towards any significant long-term change.

Since no long-term trend could be detected in the proportion of early juveniles, the next step of the analysis focuses on the adult segment of the population, specifically the annual ratio of fully moulted individuals.

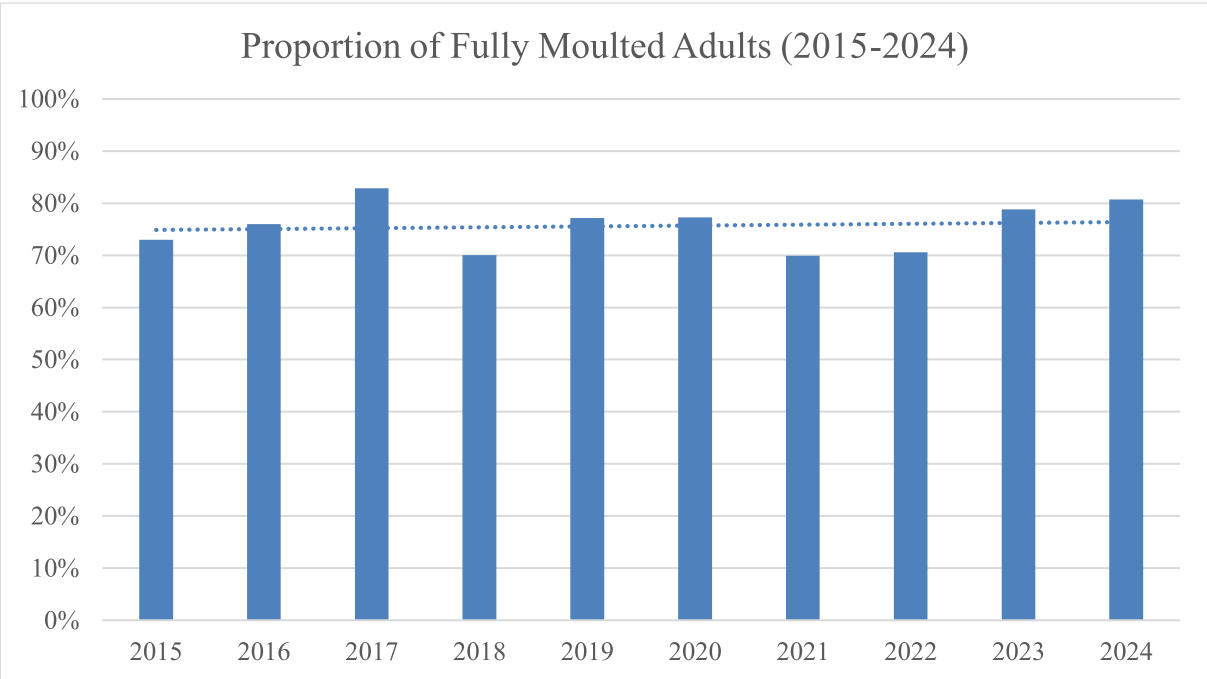
4.3 The proportion of adults with complete moult by year

The annual proportion of fully moulted adults (AN + X C0) (**Figure 5**)showed noticeable fluctuations throughout the study period (*Table 4.*), ranging from a minimum of around 70% to a maximum above 80%. The lowest values were observed in 2018 and 2021, while the peak occurred in 2017, when more than 82% of adults completed their moult.

Despite the variation across years, the fitted linear trendline suggests a slight increase in the proportion of fully moulted individuals over time. This indicates that, on average, a somewhat larger share of the adult population underwent complete moult in the later years of the study compared to the earlier period.

Overall, the results point towards relative stability in the proportion of fully moulted adults, with a weak but positive long-term trend. The annual differences are likely the outcome of previously mentioned short-term environmental or demographic factors, while the general pattern suggests that the population maintained a consistently high rate of complete moult throughout the years.

Figure 5: Proportion of fully molted adults (2015-2024)



4.4 Correlation analyses of Age-Structure indicators and between age groups

The relationship between age-structure indicators and annual bag size was tested by calculating Pearson's correlation coefficients. The proportion of early juveniles and the proportion of fully moulted adults were both compared with the total bag size (**Table *2***).

The analysis revealed a weak negative correlation in both cases. For early juveniles, the correlation with the total bag was $r = -0.354$, while for fully moulted adults it was $r = -0.302$. These values indicate that years with larger harvests were slightly more likely to coincide with lower relative proportions of early juveniles and fully moulted adults. However, the strength of the correlations is low, which suggests that these associations are not robust and should be interpreted with caution

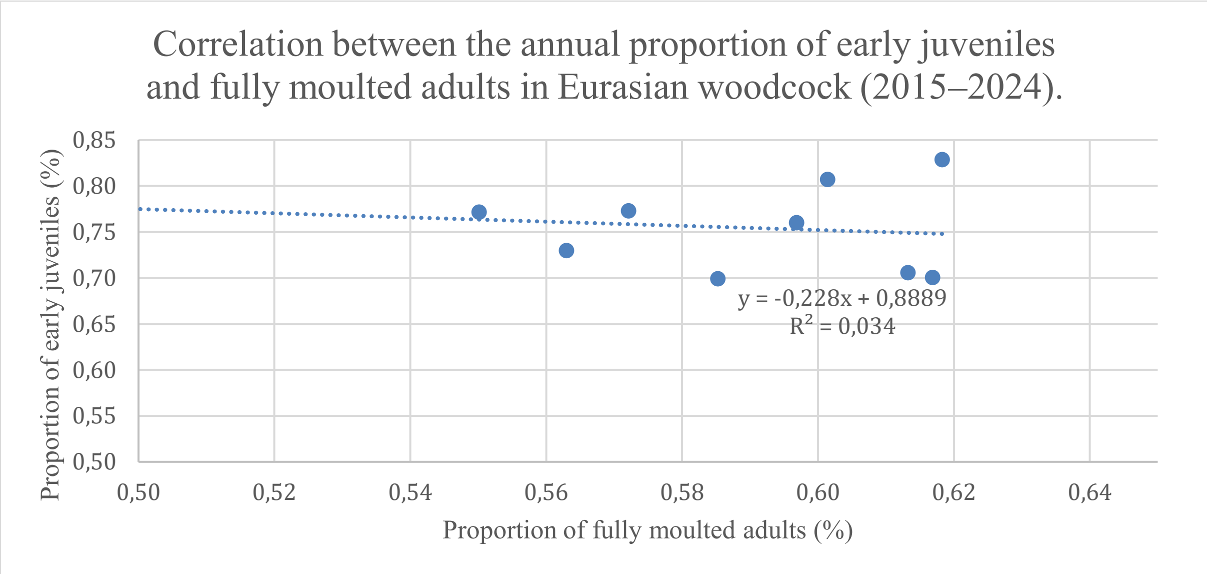
Table 2: Ratio of early juveniles and fully moulted adults compared to total bag size (*Source: own work, extracted from the data of the Woodcock Monitoring Program*)

	Early/total	C0/ad	Juvenile + adult total bag		
	Ratio of Early Juveniles	Ratio of fully Moulted Adults	Juvenile	Adult	Total
2015	0.56	0.73	1858	1306	3164
2016	0.60	0.76	1260	1075	2335
2017	0.62	0.83	951	876	1827
2018	0.62	0.70	1078	1138	2216
2019	0.55	0.77	1067	845	1912
2020	0.57	0.77	1262	969	2231
2021	0.59	0.70	1929	1621	3550
2022	0.61	0.71	786	1067	1853
2023	0.50	0.79	1555	1275	2830
2024	0.60	0.81	1578	1089	2667

Most importantly, no evidence was found for a strong positive or negative linkage between the demographic composition of the harvested population and the total bag size. Instead, the weak correlations imply again that other factors may be at play.

Taken together, the results show that while both early juvenile and fully moulted adult ratios provide valuable information on the biological characteristics of the population, they are not directly predictive of hunting yield. Their utility lies more in long-term monitoring of demographic balance than in explaining short-term variations in bag size.

Figure 6: Correlation between the annual proportion of early juveniles and fully moulted adults in Eurasian woodcock (2015-2024).



A separate correlation analysis was performed to assess the relationship between the annual proportion of early juveniles and that of fully moulted adults. The correlation coefficient between the two variables was r = -0.18 (R^2 =0.034), indicating a weak negative relationship (**Error! Reference source not found.**). The scatter plot shows that the points are widely dispersed, with no apparent linear trend, suggesting that the two ratios vary largely independently from each other.

The weak negative correlation implies that years with higher proportions of early juveniles do not necessarily coincide with years showing a high percentage of fully moulted adults. Although both parameters can be linked to environmental conditions such as food availability, weather, and timing of migration, their relationship appears to be indirect. This supports the assumption that early juvenile ratios mainly reflect breeding success and timing of hatching, while the proportion of fully moulted adults is more influenced by individual condition and moult progression prior to migration. Consequently, the absence of a clear correlation suggests that these two indicators capture different ecological aspects of the population. Both variables should therefore be interpreted with caution when used as proxies for annual feeding or habitat conditions, and are best evaluated jointly with independent environmental and phenological data. These results prompted an additional analysis focusing on the relationship between the two age-structured indicators themselves.

5. Discussion

5.1 Annual ratio of early juveniles to total juveniles

An analysis of nearly a decade of national monitoring data shows that the demographic structure of the harvested Eurasian Woodcock population in Hungary has remarkably stable. The share of early juveniles (JC1 + JC0) varied only slightly between years, averaging 57.8 +- 5.6% (range: 49.9-61.8%), and no clear long-term trend was detected ($R^2 \approx 0.059$). This steady pattern suggests that the overall breeding success and recruitment rate did not undergo notable changes during the 2015 - 2024 period.

The temporary decline in the proportion of early juveniles observed in 2023 likely reflects short-term environmental influences rather than any lasting demographic change. Similar one-year drops have been documented in other European monitoring programs (for example, ONCFS/OMPO 2022), often linked to poor breeding or migration conditions. In the Hungarian population, such fluctuations may result from unfavourable weather during the nesting season, variable food availability, or timing differences during migration. Taken together, the results point to a resilient breeding population that has maintained stable productivity despite occasional annual variation.

5.2 Trend in early juvenile proportions

The absence of a consistent trend across the study period indicates that recruitment level of the species has remained balanced in recent years. This finding contrasts with observation from some northern and western European populations, where gradual declines in juvenile ratios were associated with habitat changes or shifting climatic conditions (e.g. Ferrand et al. 2008, Christensen et al. 2017). In Hungary, the stability of juvenile proportions could reflect relatively constant breeding habitat quality or compensating demographic factors along the migration routes. Continued monitoring is nevertheless important to verify whether this equilibrium persist under future climatic and environmental pressure.

5.3 Fully moulted adults (AN + X C0)

The proportion of fully moulted adults, on the other hand, remained consistently high, typically between 70% and 83%. This stability suggests that the adult segment of the population maintains strong survival and body condition across years. Slight increases in the adult moult ratio observed in the later years of the dataset may indicate favourable moulting conditions or high, post-breeding survival, although the trend was not strong enough to be considered statistically significant. Previous studies (Ferrand et al., 2008) have similarly described the European woodcock as a demographically stable species, with relatively minor interannual variation in age composition, particularly in Central European populations.

5.4 Correlations with total bag size

The correlation analysis between demographic ratios and total bag size provided further insights into the independence of these variables. Both the proportion of early juveniles and the proportion of fully moulted adults showed weak negative correlations with the total harvest ($r = -0.354$ and $r = -0.302$). These results imply that years with higher bag sizes tended to coincide slightly with lower proportions of these age categories, but the relationships were weak and non-significant. The absence of a strong link between age structure and harvest volume suggests that the total bag is primarily driven by factors unrelated to demographic composition- for example, differences in monitoring effort, weather during the monitoring season, or local woodcock abundance and migratory intensity.

Other long-term monitoring programmes (e.g., Hoodless et al. 2008) reached similar conclusions, finding that demographic ratios and annual harvest numbers are only weakly related. These indicators should therefore be viewed as complementary biological measures rather than direct reflections of population size. From a management standpoint, the regular monitoring of age ratios remains and important tool, allowing early detection of demographic changes before they become apparent in population or harvest trends.

5.5 Limitations and future perspectives

Some limitations should also be considered when interpreting these results. A small proportion of the collected wing samples were unsuitable for analysis due to improper preparation, insect damage or pellet impact, which may have slightly influenced annual sample sizes. In addition, the manual data transcription from and to field forms introduces a risk of human error and limits the speed of data processing. Future improvements in data digitalization and perhaps an openly available guide to standardized sample preparation could help reduce these sources of uncertainty.

Despite these limitations, the Monitoring Programme provides a robust dataset that offers valuable insight into the long-term demographic stability of the Hungarian woodcock population. The Boidot method remains a reliable and practical approach for the age determination, particularly when large numbers of samples are processed annually. The combination of this method with modern statistical tools, such as correlation and trend analysis, allows researchers to better understand the underlying demographic balance and to evaluate the population's resilience to environmental changes.

6. Conclusions

This thesis analysed nearly a decade of national monitoring data on the Eurasian woodcock harvested in Hungary (2015 - 2024), based on 24,582 wing samples. Three main conclusions emerge.

6.1 Stable age structure and consistent demographic performance

The proportion of early juveniles (JC1 + JC0) among all juveniles was remarkably stable across years (mean 57.8%, range 49.9–61.8%), and no directional change was detected over time (linear trend: $R^2 = 0.0594$). The share of fully moulted adults (AN + X C0) was likewise consistently high (70 - 83%), with at most a weak, non-significant increase. Taken together, these results indicate stable recruitment and adult condition during the study period.

6.2 Harvest volume is largely decoupled from age composition

Pearson correlations between annual bag size and the two age-structure indicators were weak and negative (early juveniles: $r = –0.354$; fully moulted adults: $r = –0.302$), implying that interannual variation in total harvest is driven more by effort, weather, or migratory intensity than by demographic composition per se. Consequently, age ratios should be interpreted as biological indicators of productivity and survival rather than predictions of harvest magnitude.

6.3 Methodological implications for long-term monitoring

Ageing from wings using the Boidot framework proved practical and repeatable at scale, but it requires consistent criteria and careful sample handling. As only wings are available from harvested birds, internal characters such as the bursa of Fabricius are not applicable and should not be used in age assignments for this material. Improving sample preparation and digitising data capture would further reduce uncertainty and processing time.

6.4 Outlook

Future work should link age-structure indices to environmental covariates (e.g., weather during breeding, habitat conditions, migration phenology) and to standardised effort metrics, and expand international comparisons with other monitoring schemes. Such integration will sharpen inference on the drivers of annual deviations (e.g., the 2023 dip in early juveniles) and strengthen evidence-based management for this culturally and ecologically important species.

6.5 Summary of the main findings

In summary, the objectives defined in the introduction were fully met. The study successfully quantified annual variations in the proportion of early juveniles and fully moulted adults, analysed their temporal trends, and assessed their relationships with total hunting bag size. These findings provide a coherent and statistically supported picture of the recent population dynamics of the Eurasian woodcock in Hungary.

In addition, a separate correlation analysis between the proportions of early juveniles and fully moulted adults revealed no strong relationship, indicating that these parameters describe different ecological aspects of the population rather than a shared environmental response.

7.Summary

This thesis examined age structure and demographic indicators of the Eurasian woodcock (*Scolopax rusticola*) in Hungary, using 24.582 wings collected through national monitoring between 2015 and 2024. The main objectives were to determine the annual proportion of early juveniles with the total juvenile group, to assess the temporal trend of this ratio, to estimate the proportion of fully moulted adults, and to test correlations between these variables and the annual hunting bag.

The proportion of early juveniles showed moderate year-to-year variation but no consistent linear trend, indicating stable recruitment levels over the decade. Fully moulted adults remained dominant across the entire study, suggesting good survival and a balanced age composition within the population. Statistical analyses revealed only weak, negative correlations between harvest volume and both age-structure indicators, implying that annual bag size is more influenced by hunting effort and migration dynamics than by demographic shifts.

Additionally, no correlation was found between the annual proportion of early juveniles and fully moulted adults, suggesting that these indicators should be interpreted independently.

The study demonstrated that the Boidot ageing method, based on wing feather characteristics, provides a reliable and repeatable approach for large-scale monitoring of harvested woodcock

Overall, the results support the conclusion that the Hungarian woodcock population has remained demographically stable during the monitoring period with no signs of recruitment decline or age imbalance.

8. Acknowledgment

I would like to express my sincere gratitude to the Hungarian Hunters' National Association for their work and support of this project. I am also thankful to all those who participated in the fieldwork and contributed to the collection of samples, without whose efforts this research would not have been possible.

My deepest appreciation goes to my supervisor, Dr. Gergely Schally, for his guidance, encouragement, and invaluable advice during preparation of this thesis.

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10.List of tables and figures

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Tables

Study of the age composition of the Eurasian Woodcock between 2015-2024 in Hungary

Márton László

Wildlife Management Engineering BSc, full-time programme

Institute for Wildlife Management and Nature Conservation

Department of Wildlife Biology and Conservation

Insider subject leader: dr. Gergely Tibor Schally, Senior research fellow, Institute for Wildlife Management and Nature Conservation, Department of Wildlife Biology and Conservation

This thesis examined age structure and demographic indicators of the Eurasian woodcock (*Scolopax rusticola*) in Hungary, using 24.582 wings collected through national monitoring between 2015 and 2024. The main objectives were to determine the annual proportion of early juveniles with the total juvenile group, to assess the temporal trend of this ratio, to estimate the proportion of fully moulted adults, and to test correlations between these variables and the annual hunting bag.

The proportion of early juveniles showed moderate year-to-year variation but no consistent linear trend, indicating stable recruitment levels over the decade. Fully moulted adults remained dominant across the entire study, suggesting good survival and a balanced age composition within the population. Statistical analyses revealed only weak, negative correlations between harvest volume and both age-structure indicators, implying that annual bag size is more influenced by hunting effort and migration dynamics than by demographic shifts. Additionally, no correlation was found between the annual proportion of early juveniles and fully moulted adults, suggesting that these indicators should be interpreted independently.

The study demonstrated that the Boidot ageing method, based on wing feather characteristics, provides a reliable and repeatable approach for large-scale monitoring of harvested woodcock

Overall, the results support the conclusion that the Hungarian woodcock population has remained demographically stable during the monitoring period with no sins of recruitment decline or age imbalance.

Appendix 2

Declaration of Students and Doctoral Candidates on the Use of Artificial Intelligence (AI)"

1. general information:

Name of the student:	Márton László
Neptun ID:	OEVTJY
Level of program (mark with X):	☒ BSc/BA ☐ MSc/MA ☐ Doctoral School (PhD) ☐ Other: ....
Name and code of the subject*:	Thesis (BSc)
Title of the work:	**Study of the age composition of the Eurasian Woodcock between 2015-2024 in Hungary**

* Not required to be completed in the case of a doctoral dissertation.

2. Declaration on the Use of AI

I, the undersigned, fully aware of my ethical responsibility, make the following declaration:

(Please choose one of the options below!)

☒ A) I have not used any artificial intelligence system or service.

(If you selected this option, completing the subsequent tables is not required.)

☐ B) I have used an artificial intelligence system or service.

(Please fill in the relevant tables!)

3. Details of Artificial Intelligence Usage

TABLE I: Assistant or Minor Usage (e.g., translation, language proofreading, brainstorming, etc.)

(For these uses, attaching the specific prompts and responses is not required.)

Purpose of Use	**Name and Version of the AI Tool Used**	**Affected Section (if not applicable to the entire text)**

TABLE II: Significant Content Contribution (e.g., generating an entire figure or a longer text section)

(In these cases, documenting the key prompts used and the raw responses provided by the AI, and attaching them as an appendix to the work, is required.)

Purpose of Use	Name, Version, and Access Information of the AI Tool Used	Exact Number of the Affected Chapter / Figure / Table	Entry Number of the Appendix Containing the Prompt Log

3/A. Additional Rules Prescribed by the Lecturer (if any)

If the instructor or supervisor of the course has established specific rules or expectations regarding the use of AI tools, please summarize them in the field below:

For example: prohibition of AI use for certain types of tasks; only specific tools are permitted; different citation requirements; documentation format, etc.

Rules Prescribed by the Lecturer or Supervisor

....

....

....

....

4. Declaration of Doctoral Program Participants[4]

In addition to the above, the following additional rules apply to students participating in the doctoral program:

1. **Mandatory Disclosure:** All circumstances of AI use listed in Table II must be presented in detail in the "Materials and Methods" chapter of the dissertation.
2. **Supervisor's Endorsement:** The declaration must also be approved by the supervisor..

I declare that I have read and understood the specific rules pertaining to the doctoral program detailed above, and I will fully comply with them during the preparation of my dissertation.

5. Declaration Applicable to All Students:

I declare that I have critically reviewed, edited, and incorporated any content potentially generated by AI in all cases. I take full responsibility for every element of the submitted work, including its originality and scientific validity. I acknowledge that the Hungarian University of Agriculture and Life Sciences may check the submitted work with an artificial intelligence detector and may initiate proceedings if my declaration is found to be false or incomplete.

Place and Date: ....Gödöllő................, 2025. ....November....... month 0 3 . day

....

Signature of the Student **Signature of the Advisor/Supervisor**

4This section applies exclusively to doctoral program students; at other educational levels, it can be removed from the document up to the Declaration Applicable to All Students.

MATE Organizational and Operational Regulations
III. Requirements for Students
III.1. Study and Examination Regulations
Appendix 6.13: The MATE Uniform Thesis /thesis / final thesis / portfolio guidelines
Annex 4.2: Declaration of public access and authenticity of the thesis/thesis/dissertation/portfolio

DECLARATION

the public access and authenticity of the thesis

Student's name:	Márton László
Student's Neptun code:	OEVTJY
Title of thesis:	Study of the age composition of the Eurasian Woodcock between 2015-2024 in Hungary
Year of publication:	2025
Name of the consultant's institute:	Institute for Wildlife Management and Nature Conservation
Name of consultant's deparment:	Department of Wildlife Biology and Conservation

I declare that the final thesis submitted by me is an individual, original work of my own intellectual creation. I have clearly indicated the parts of my thesis or dissertation which I have taken from other authors' work and have included them in the bibliography. Furthermore, I declare that the artificial intelligence tools (e.g. text generation, linguistic correction, translation, data analysis) used during the preparation of the thesis did not substitute my own research and creative work; their use was indicated either in the list of sources or in the methodology section, and I acted in accordance with professional and ethical expectations.

If the above statement is untrue, I understand that I will be disqualified from the final examination by the final examination board and that I will have to take the final examination after writing a new thesis.

I do not allow editing of the submitted thesis, but I allow the viewing and printing, which is a PDF document.

I acknowledge that the use and exploitation of my thesis as an intellectual work is governed by the intellectual property management regulations of the Hungarian University of Agricultural and Life Sciences.

I acknowledge that the electronic version of my thesis will be uploaded to the library repository of the Hungarian University of Agricultural and Life Sciences. I acknowledge that the defended and

- not confidential thesis after the defence
- confidential thesis 5 years after the submission

will be available publicly and can be searched in the repository system of the University.

Date: 2025 year 11. month 03. day

Student's signature

DECLARATION

Márton László (student Neptun code: OEVTJY) as a consultant, I declare that I have reviewed the final thesis and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

I recommend / do not recommend[1] the final thesis / dissertation / portfolio to be defended in the final examination.

The thesis contains a state or official secret: yes no

Date: Gödöllő, 2025.11.02.

insider consultant

[1] The appropriate one should be underlined.