The change in the phenology of spring migrating passerines at Blåvand Bird Observatory in Denmark 1984 – 2021

Blåvand Fuglestation 2022

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Change in spring passage of passerine migrants at Blåvand, Denmark

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Cover photo: Red-breasted flycatcher, *Ficedula parva*, caught in the nets of the stationshaven. Photo by Mikkel Bello.

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Summary

Climate change has accelerated phenological changes in both plants, insects, and birds, leading to ecological mismatches between insects and birds in the artic regions and in regions at lower latitudes. Birds change their phenology of migration to prevent being mismatched. This leads to changing arrival dates of multiple migrant species. Besides the earlier arrival, many birds have advanced the start of egg-laying. However, not only climate change influences the phenology of migratory birds in North-Western Europe. The North Atlantic Oscillation (NAO) can do so as well.

This research is focussed on the possible relationship between climate change and the arrival date of migratory passerines, and whether the variation in arrival dates can be explained by the NAO. This will be tested for long distance migrants and short distance migrants. Comparable studies have been done at other European bird observatories (e.g., Helgoland, Ottenby, Falsterbo, Hanko and Capri).

Due to the many years of standardised ringing, this data can be used to make an analysis of the phenology of bird migration.

Of the 36 years of data, four years have not been used in the analysis. In the rest of all the years there was a comparable ringing effort. The data of in total eighteen species could be analysed; eleven species are short distance migrants (SDM) and seven are long distance migrants (LDM). The species have been tested in three different phases of migration, at a cumulative 5%, 50% and 95% of the species totals.

Five out of the seven analysed long distance migrant species showed a trend towards an earlier arrival of the first phase and mean spring passage, but Pied flycatcher was the only species where also the last phase of migration advanced. For long distance migrants, the effect of the NAO did not have a significant impact on the passage in any phase of migration.

Five out of the eleven analysed short distance migrant species showed a trend towards earlier passage through Blåvand in all phases of migration. Another five species showed a trend towards earlier passage, but only in the first and mean passage. Linnet is the only species where the migration delayed in all phases, significant in the first phase and mean spring arrival. Four short distance migrants the NAO index correlated negatively with their first phase of migration. Goldcrest is the only species where the NAO significantly correlated both the first phase and their mean spring passage.

1. Introduction

Climate change is a process that is caused by the emission of greenhouse gasses (Parry, 2007). Between 1880 and 2012, temperatures rose by 0,2 °C every ten years globally and the predictions is that temperatures will keep rising in the future (Anon, 2001; Parry, 2007; Stocker et al., 2013). In the artic regions temperatures have risen more than twice as fast as the global average: this phenomenon is known as the Artic amplification (Serreze, 2009; Stocker et al., 2013; Cohen et al., 2014). Climate change has accelerated phenological changes in plants and insects (Myneni et al., 1997; Roy & Sparks, 2000; McCarty, 2001; Fitter & Fitter, 2002; Root et al., 2003; Menzel et al., 2006), leading to ecological mismatches between insects and birds in the artic regions and regions at lower latitudes (Visser et al., 1998; Both & Visser, 2001; Tulp & Schekkerman, 2007; Post, 2009; Both, et al., 2010).

To prevent being mismatched, birds are changing their phenology of migration (Berhold et al., 1998; Hüppop & Hüppop, 2003). This leads to changing arrival dates of multiple migrant species (Cotton, 2003; Strode, 2003; Lehikoinen et al., 2004; Rubolini et al., 2007; Miller-Rushing et al., 2008; Saino, et al., 2010; Kullberg et al., 2015). Next to the earlier arrival, many birds have advanced the start of egg-laying (Crick et al., 1997; Bairlein & Winkel, 2001), but not all species have been studied (Visser et al., 1998; Both & Visser, 2001).

However, not only climate change can influence the phenology of migratory birds in North-western Europe. The North Atlantic Oscillation (NAO) can do so as well (Forchhammer et al., 1998; 2002; Hüppop & Hüppop, 2003; Boyd, 2003; Vähätalo et al., 2004). The NAO index describes the annual fluctuation of atmospheric pressure at sea-level between the subtropical centre of high surface pressure and the subarctic centre of low surface pressure over the long term (Hurrell, 1995). High values of this index are associated with mild and moist winters and low values are associated with cold and dry winters (Hurrell, 1995). Earlier spring arrival is associated with high NAO values, and later spring arrival with low NAO values (Forchhammer, Post & Stenseth, 2002)

Some Palearctic birds that winter north of the Sahara, try to arrive at breeding grounds as early as possible. To do so, wintering ranges of birds that winter north of the Sahara (Short distance migrant; further referred as SDM) have shifted northwards (Thomas & Lennon, 1999; Austin & Rehfisch, 2005; Maclean et al., 2008). This gives benefits for the individuals that arrive early like the best breeding territories, increased chances to find a mate, better quality of mates, increased changes for extra clutches and a higher survival rate for their offspring (Møller, 1994; Kokko, 1999; Forstmeier, 2002; Dunn, 2004; Bearhop et al., 2005; Newton, 2006). But not all Palearctic migratory birds that are wintering south of the Sahara Desert (Long distance migrants; further named as LDM), migrate north towards temperate breeding grounds during spring and arrive on breeding sites the first half of May. After having completed breeding during late summer, the birds migrate southwards to overwintering sites. There, they will spend the rest of their annual cycle.

Current theories suggest that the spring migration of these birds is triggered by endogenous processes (Hagan et al., 1991; Both & Visser, 2001; Coppack & Both, 2002; Jenni & Kery, 2003). Staunch support for this theory comes from some Palearctic migratory passerines (Berthold & Querner, 1981; Bethold, 1984; Gwinner, 1990; Berthold & Terrill, 1991). Environmental factors in the wintering grounds are also thought to influence departure schedules (Berthold, 1993; Berthold, 1996; Gwinner et al., 1985; Kok, Ee & Nel, 1990; Marra, Hobson & Holmes, 1998). Even less is known about factors that regulate timing and rate of migration (Marra et al., 2005). If the timing and rate of migration are both inflexible, birds might arrive at breeding grounds during early spring when habitats are suboptimal (Both & Visser, 2001; Penuelas & Filella, 2001). Evidence for this could be found in the long-distance migrant: the Pied flycatcher (*Ficedula hypoleuca*) (Both & Visser, 2001).

Although the endogenous triggering of migration in LDM, timing and rate of migration is flexible in LDM. Lindstrom (1991) and Moore & Simons (1997) found that stopover length is dependent on multiple factors such as local stopover habitat (e.g., food abundancy in that area), as well as the energetic condition of individuals (Yong & Moore, 1997). These relationships are, however, complex (Schaub & Jenni, 2001). Relationships such as whether the length of stopover or unfavourable weather conditions can influence the rate of migration. For preservation it is beneficial to know which of these relations are important (Richardson, 1978; Elkins, 1993; Huin & Sparks, 1998; 2000; Marra et al., 2005).

Figuring out how the phenology of bird migration has changed over time requires constant sampling over multiple years. This can be achieved by a standardised migration counts or mist-netting. By using standardised mist-netting, difference in migration timing, but also variation in timing between the years can be studied. In this paper, data of 36 years of standardised mist-netting is used, and because of the many years of standardised ringing, this data can be used to measure the phenology of bird migration. This research is investigating whether there is a relationship between climate change and the arrival date of migratory passerines, or if the variation in arrival dates can be explained by the NAO. This will be tested for LDM and SDM. Comparable studies have been done at other European bird observatories (e.g., Helgoland (Hüppop & Hüppop, 2003), Ottenby, Falsterbo, Hanko and Capri (Jonzén, et al., 2006)).

2. Materials and method

2.1 Study area

The garden at Blåvand Fuglestation and at the garden of the lighthouse are constant effort trapping sites. In appendix I, the setup of the nets is displayed. Both sites are situated west of the village Blåvand in the province of Jutland in Denmark. Blåvandshuk is the westernmost point of Denmark (Figure 1). The village is situated just north of the peninsula Skallingen. Skallingen is part of the globally protected Wadden Sea and this part is considered to be the least influenced part of the Wadden Sea in general.

Since 1984, a standardised method for ringing is used. Therefore, these sites can be used to measure of the phenology of bird migration. At the Blåvand Bird Observatory, one to ten observers are present for trapping birds for ringing and for counting active migrating birds. In this research, only the ringing data is used. Standardised ringing has been taking place between 1 March and 15 June for 5 hours a day, starting a half an hour before sunrise (for more details see (Blåvand Fuglestation, 2017). For this research, only the ringing data will be used. The fixed positions of the mistnets can be found in Appendix I.

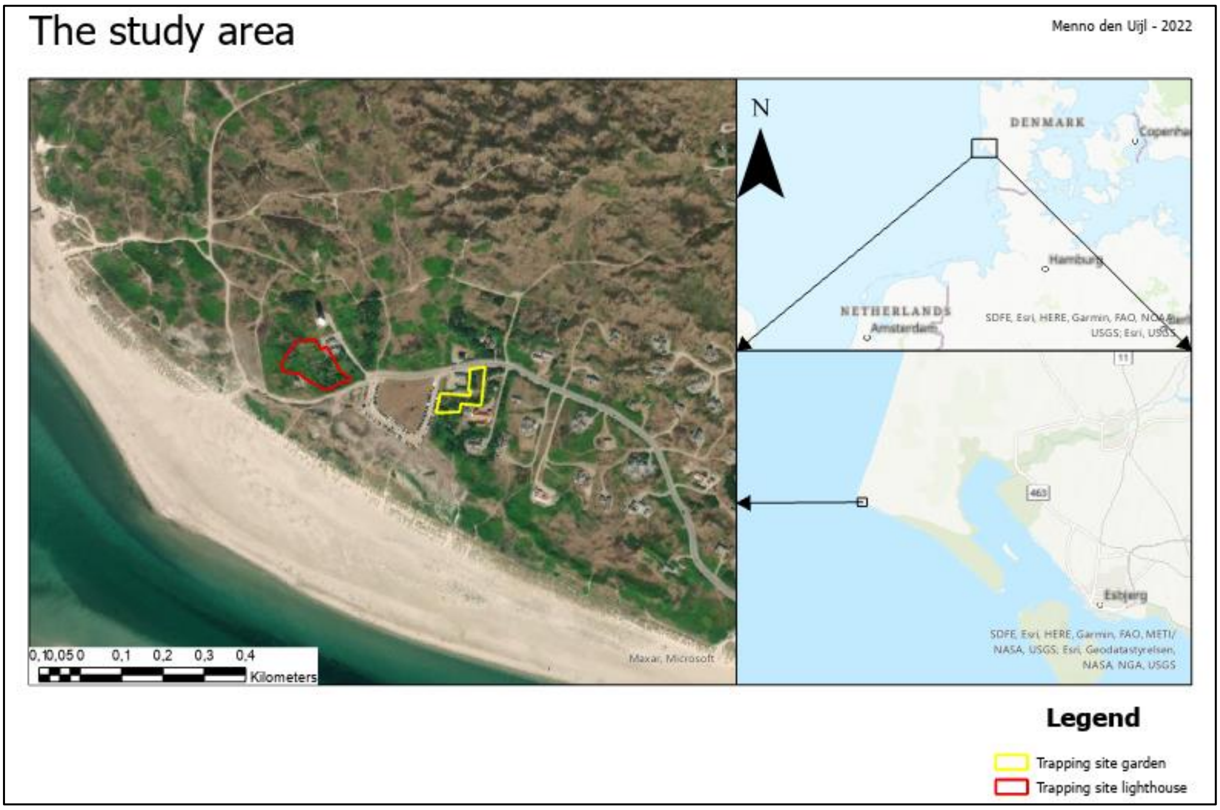

Figure 1 - The places where the trapping and ringing is taking place. For the exact placements of the nets see Appendix I. Source of map: Menno den Uijl (ArcGIS Pro).

2.2 Weather data

The weather data are downloaded from Wunderground.com with the location "Blåvand Oksby" (Weather Underground, 2022). The data of the NAO (North Atlantic Oscillation) is downloaded from National Centre for Environmental Information (2022). To make this study comparable with other studies, the NAO has been averaged over the December-March period. This has also been done in Stervander et al. (2005) and Hüppop & Hüppop (2003).

2.3 Statical analyses

In the analyses all the ringed birds have been splitted into two categories, SDM and LDM. This is based on comparable research done at other bird observatories (see Jonzén, et al., 2006; Appendix II). The dates are displayed as Julian days. The phase of migration was defined as the dates when the season's cumulative bird sum reached 5%, 50% and 95%. Species that were taken into this analysis are the species that have been seen for at least five days. Furthermore, seasonal sums of each species must have exceeded twenty individuals and must have been recorded for more than eight springs.

To test if there was a significant effect of climate change or the NAO index on the migration of birds a linear model has been used. The variables that have been tested are NAO index, year, and the cumulative sum of 5%, 50% and 95% of every species. The analysis has been done in RStudio (R Core Team, 2021), with the help of packages "lme4" (Bates et al., 2015), "stats" (R Core Team, 2021) and "tidyverse" (Wickham, et al., 2019). The full reproducible code is available in Appendix IV.

3. Results

Four years of the data from 36 years have not been used in the analysis. This is because there were missing periods of ringing activity (years '86, '90 and '92). The data of 1993 could not been found and thus analysed. In the rest of all the years there was a comparable ringing effort. The data of in total eighteen species matched the criteria explained in the method section, eleven are short distance migrants (SDM) and seven are long distance migrants (LDM).

3.1 Long distance migrants

Of the seven analysed species, five of them showed a trend towards an earlier arrival of the first phase and mean spring passage, all the seven species showed a delayed last phase of migration. Looking at specific species Common redstart showed a significantly earlier arrival in the earlier phase of migration. Icterine warbler and Garden warbler delayed their migration in all phases, but only the change in mean spring passage is significant. Pied flycatcher was the only long-distance migrant that significantly arrived earlier over the years (Appendix III; Figure 2).

For long distance migrants, the effect of the NAO did not have a significant impact on the passage in any phase of migration (Appendix III; Figure 2).

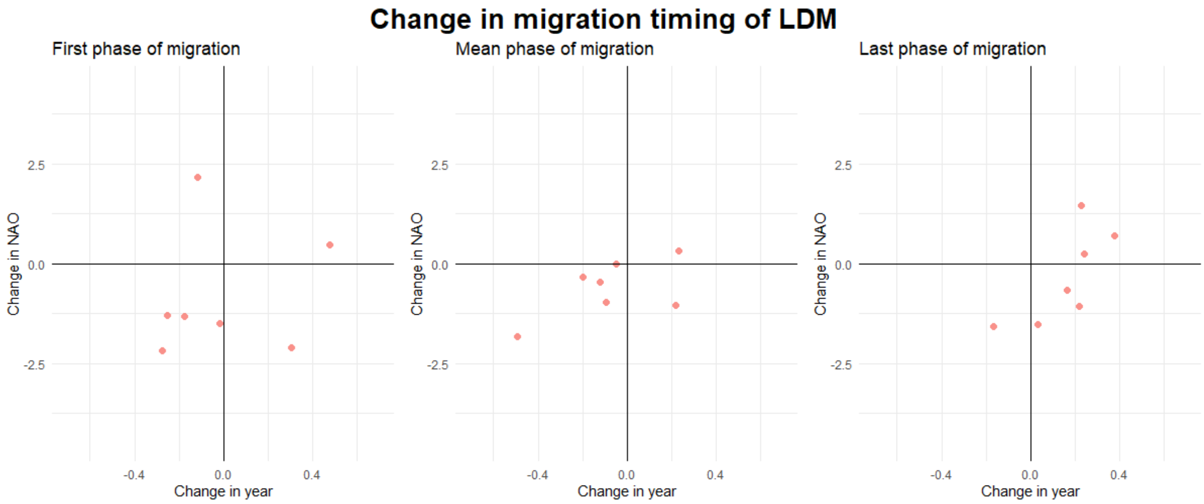

Figure 2 - Changes over the years and with NAO values in all phases of migration.

3.2 Short distance migrants

Of the eleven analysed species, five species showed a trend towards an earlier passage through Blåvand in all phases of migration. Another five species showed a trend towards earlier passage, but only in the first and mean passage. Blackbird, Blackcap, Dunnock, and Song thrush significantly advanced their first phase of migration. Blackbird, Chiffchaff and Song thrush significantly advanced their mean spring passage. Chaffinch significantly advanced their first phase of migration, but also significantly delayed their last phase of migration. Linnet is the only species where the migration delayed in all phases, significant in the first phase and mean spring arrival (Appendix III; Figure 3).

For four short distance migrants the NAO index correlated negatively with their first phase of migration (Appendix III). Dunnock, Chiffchaff and Robin significantly advanced in their first phase of migration. Goldcrest is the only species where the NAO (North Atlantic Oscillation) significantly correlated both the first phase of migration and their mean spring passage (Appendix III; Figure 3).

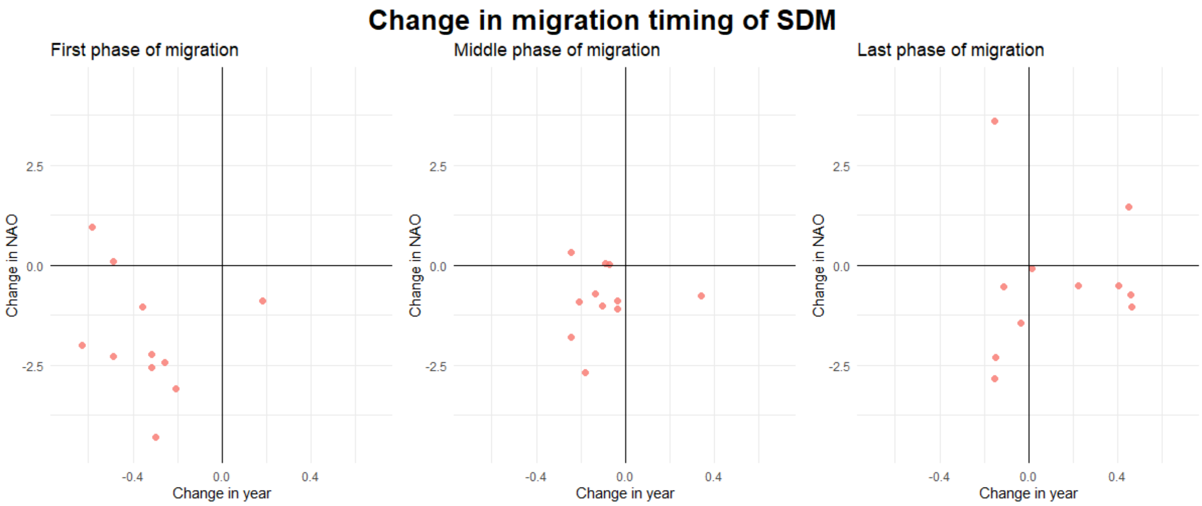

Figure 3 - Changes over the years and with NAO values in all phases of migration.

Discussion

Comparable studies have been executed all over Europe. At Helgoland (Hüppop & Hüppop, 2003; Hüppop & Hüppop, 2011) and Ottenby (Stervander et al., 2005) all long-distance migrants showed earlier mean passage. Jonzén, et al. (2006) found at multiple European ringing sites (Ottenby (Sweden), Hanko (Norway), Capri (Italy), Falsterbo (Sweden) and Jomfruland (Norway)) that long distance migrants arrived earlier in all the different phases of migration over the years, except for Spotted flycatcher, but that species is not included in this study. In this study Garden warbler and Icterine warbler showed delayed arrival in stead of the advanced arrival like the other long-distance migrants. In Icterine warbler this could be explained by the other direction of migration, southeast. Other long-distance migrants have a more southwest orientated migration route (Bønløkke, et al., 2006; Vogeltrekatlas, 2022a; Vogeltrekatlas, 2022b; Migration atlas a, 2022; Migration atlas b, 2022). In other European studies this difference has not been detected (Stervander et al., 2005; Hüppop & Hüppop, 2003; Jonzén et al., 2006).

Just like (Stervander et al., 2005; Hubálek & Čapek, 2008; Gunnarsson & Tomasson, 2011) but contrary to the study by Jonzén, et al. (2006) long distance migrants did not advance their passage through Blåvand more than the short distance migrants. This is also in line with the idea of Lehikoinen et al. (2004), that states that short distance migrants can react better to local weather changes than long distance migrants can. In long distance migrants' migratory activity is under endogenous control (Hagan et al., 1991; Both & Visser, 2001; Coppack & Both, 2002; Jenni & Kery, 2003), but experiments have showed individual variation in response to photoperiodic cues to trigger the mechanisms on the start of migration (Coppack et al., 2003).

All the birds studied here reproduce at one year of age and therefore have a potential for an evolutionary response to environmental changes. Because of the genetic variation in the timing of migration (Moller, 2001; Pulido & Berthold, 2003), and the selection on breeding earlier in Europe (Both & Visser, 2001; Both et al., 2006), a change in earlier arrival, as proven in most species in this study, is expected.

The result found in this study that the NAO (North Atlantic Oscillation) had just an effect on the early phase of migration of the short distance migrants is similar with the results Rainio et al. (2006). There could be some explanations why the migratory birds react more strongly to the NAO in the early phase of migration compared to later phases. It is possible that only individuals that are in good condition can speed up their migration. In milder winters (positive NAO) migrants are likely to have better feeding conditions and are as a result better prepared for migration (Gunnarsson, 2011). Another possible explanation is that the wintering range extend during milder winter (positive NAO) so that the distance between wintering and breeding grounds declines (Root, 1988; Valiela & Bowen, 2003, Austin & Rehfisch, 2004). In Chaffinch it is surprising to see that the first phase of migration is advanced, but that there is a delay in the last phase of migration. An explanation for this phenomenon can be that mainly the males race towards the breeding grounds earlier, as mentioned above. There might even though be ass well a part of the population that is not breeding and thus has no reason to hurry. This explains the advancing of the first and delay of the last phase (Rainio et al., 2006).

The most remarkable result out of this study is that Linnets are caught later each spring. Most of the Danish Linnets winter in Belgium, France, Spain, and some in northern Africa, with most birds wintering in Belgium (Bønløkke, et al., 2006). The expected migration route should be over the Netherlands, but the passage of Linnets did not change in time over the same period (Trektellen, 2022). The delay of the linnets could also be caused by the high numbers of juvenile birds that are caught close to the end of the season. This is indeed true for the data of the last years. Since the data in the early years were only about the numbers per day and without age groups it is impossible to correct for this trend. Linnets need to incubate for 12 to 14 days and after 10 to 17 days (Snow & Perrins, 1998) they can fledge. The pattern of later catches of Linnets could thus be explained by the first fledgelings that now just fall in the period where standardized ringing still takes place, whereas they would fledge after the period with standardized ringing. An advanced breeding season is also could be a reaction of birds on climate change (Halupka & Halupka, 2017)

For future research it would be interesting to investigate the change of migration in autumn at this place as well. Next to that, ringing research in Africa is also very interesting. By ringing there, correlations and or changes in departure dates as well as arrival dates could be detected. Other research conducted at other bird observatories in southern Europe would also be very interesting since most research about phenology is done at observatories at higher altitudes.

References

Anon. (2001). *Climate change 2001. Third Assessment Report of the Intergovernmental Panel on Climate Change IPCC (WG I & II).* Cambridge: Cambridge University Press.

Austin, G. E., & Rehfisch, M. M. (2004). Shifting nonbreeding distributions of migratory fauna in relation to climatic change. *Global Change Biology (11)*, 31-38.

Bairlein, F., & Winkel, W. (2001). Birds and climate change. In J. L. Lozan, H. Grassl, & P. Hupfer, *Climate of the 21st century: changes and risks* (pp. 278- 282). Wissenschaftliche Auswertungen: Hamburg.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models using lme4. *Journal of Statistical Software (55)*, 1-48.

Bearhop, S., Fiedler, W., Furness, R. W., Votier, S. C., Waldron, S., Newton, J., . . . Farnsworth, K. (2005). Assortative mating as a mechanism for rapid evolution of a migratory divide. *Sience (310)*, 502-504.

Berhold, P., Fiedler, W., Schlenker, R., & Querner, U. (1998). 25-Year Study of the Population Development of Central European Songbirds: A General Decline, most Evident in Long-Distance Migrants. *The Science of Nature (85)*, 350-353.

Berthold, P. (1993). *Bird migration. A general survey.* Oxford: Oxford University Press.

Berthold, P. (1996). *Control of brid migration.* Londen: Chapman and Hall.

Berthold, P., & Querner, U. (1981). Genetic basis of migratory behavior in Euopean warblers. *Sience 212*, 77-79.

Berthold, P., & Terrill, S. B. (1991). Recent advances in studies of bird migration. *Annual Review of Ecology and Systematics (22)*, 357-378.

Bethold, P. (1984). The endogenous control of bird migration: a survey of experimental evidence. *Bird Study (31)*, 19-27.

Blåvand fuglestation. (2017). *Blåvand fuglestation handbog.* Blåvand: Blåvand fuglestation.

Bønløkke, J., Madsen, J. J., Thorup, K., Pedersen, K. T., Bjerrum, M., & Rahbek, C. (2006). *The Danish bird migration atlas.* Humlæk: Rhodos.

Both, C., & Visser, M. E. (2001). Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. *Nature (411)*, 296–298.

Both, C., Bouwhuis, S., Lessells, C. M., & Visser, M. E. (2006). Climate change and population declines in a long-distance migratory bird. *Nature (441)*, 81-83.

Both, C., Turnhout, C. v., Bijlsma, R., Siepel, H., Strien, A. v., & Foppen, R. (2010). Avian population consequences of climate change are most severe for long-distance migrants in seasonal habitats. *The Royal Society (277)*, 1259–1266.

Boyd, H. (2003). Spring arrival of passerine migrants in Iceland. *Ringing & Migration (21)*, 193-201.

Cohen, J., Screen, J., Furtado, J., Barlow, M., Whittleston, D., Coumou, D., . . . Jones, J. (2014). Recent Arctic amplification and extreme mid-latitude weather. *Nature Geosciense (7)*, 627-637.

Coppack, T., & Both, C. (2002). Predicting life-cycle adaptation of migratory birds to global climate change. *Ardea (55)*, 369–378.

Coppack, T., Pulido, F., Czisch, M., Auer, D. P., & Berthold, P. (2003). Photoperiodic response may facilitate adaptation to climatic change in long-distance migratory birds. *Proceedings of the Royal Society Biological Sciences (270)*, 43-46.

Cotton, P. A. (2003). Avian migration phenology and global climate change. *School of Biological Sciences (100)*, 12219-12222.

Crick, H. Q., Dudley, C., Gleu, D. E., & Thomson, D. L. (1997). UK birds are laying eggs earlier. *Nature (388)*, 526.

Dunn, P. O. (2004). Breeding dates and reproductive performance . *Advances in Ecological Research (35)*, 69-87.

Elkins, N. (1993). *Weather and bird behaviour.* Calton: Poyser.

Fitter, A. H., & Fitter, R. S. (2002). Rapid changes in flowering time in Britisch plants. *Sience (296)*, 1689-1691.

Forchhammer, M. C., Post, E., & Stenseth, N. (2002). North Atlantic Oscillation timing of long- and short-distance migration. *Journal of Animal Ecologie (71)*, 1002-1014.

Forchhammer, M. C., Post, E., & Stenseth, N. C. (1998). Breeding phenology and climate. *Nature (391)*, 29-30.

Forstmeier, W. (2002). Benefits of early arrival at breeding grounds vary between males. *Journal of Animal Ecology (71)*, 1-9.

Gunnarsson, T. G., & Tomasson, G. (2011). Flexibility in spring arrival of migratory birds at northern latitudes under rapid temperature changes. *Bird Study (58)*, 1-12.

Gwinner, E. (1990). Circannual rhythms in bird migration: control of temporal patterns and interactions with photoperiod. In E. Gwinner, *Bird migration* (pp. 257–268). Berlin: Springer-Verlag.

Gwinner, E., Biebach, H., & Kries, I. v. (1985). Food availability affects migratory restlessness in caged Garden Warblers (Sylvia borin). *Naturwissenschaften (72)*, 51-52.

Hagan, J. M., Lloyd-Evans, T. L., & Atwood, J. L. (1991). The relationship between latitude and the timing of spring migration of North American landbirds. *Ornis Scand (22)*, 129-136.

Halupka, L., & Halupka, K. (2017). The effect of climate change on the duration of avian breeding seasons: a meta-analysis. *Proceedings of the Royal Society Biological Sciences (284)*, 1-10.

Hubálek, Z., & Čapek, M. (2008). Migration distance and the effect of North Atlantic Oscillation on the spring arrival of birds in Central Europe. *Folia Zoologica (57)*, 212–220.

Huin, N., & Sparks, T. H. (1998). Arrival and progression of the swallow Hirundo rustica through Britain. *Bird Study (45)*, 361-370.

Huin, N., & Sparks, T. H. (2000). Spring arrival patterns of the Cuckoo Cuculus canorus, Nightingale Luscina megarhynchos, and Spotted Flycatcher Musciapa striata in Britain. *Bird Study (47)*, 22-31.

Hüppop, O., & Hüppop, K. (2003). North Atlantic Oscillation and timing of spring migration in birds. *The Royal Society (270)*, 233-240.

Hüppop, O., & Hüppop, K. (2011). Bird migration on Helgoland: The yield from 100 years of research. *Journal of Ornithology (152)*, 25-40.

Hurrell, J. W. (1995). Decadal trends in the North Atlantic Oscillation: regional temperatures and precipitation. *Sience (296)*, 676-679.

Jenni, L., & Kery, M. (2003). Timing of autumn bird migration under climate. *The Royal Society (270)*, 1467-1471.

Jonzén, N., Lindén, A., Ergon, T., Knudsen, E., Vik, J. O., Rubolini, D., . . . Stenseth, R. (2006). Rapid adadvance of spring arrival dates in long-distance migratory birds. *Science (312)*, 1959–1961.

Kok, O. B., Ee, C. A., & Nel, D. G. (1990). Daylenght determines departure date of the spotted flycatcher (Muscicapa striata) from its wintering quarters. *Ardea (79)*, 63-66.

Kokko, H. (1999). Competition for early arrival in migratory birds. *Jounal of Animal Ecology (68)*, 940-950.

Kullberg, C., Fransson, T., Hedlund, J., Jonzén, N., Langvall, O., Nilsson, J., & Bolmgren, K. (2015). Change in spring arrival of migratory birds under an era of climate change, Swedish data from the last 140 years. *Ambio (44)*, 69–77.

Lehikoinen, E., Sparks, T., & Zalakevicius, M. (2004). Arrival and departure dates. *Advances in Ecological Research (35)*, 1–31.

Lindstrom, L. (1991). Maximum fat deposition rates in migrating birds. *Ornis Scandinavica (22)*, 12-19.

Maclean, I., Austin, G., Rehfisch, M., Blew, J., Crowe, O., Delany, S., . . . Wahl, J. (2008). Climate change causes rapid changes in the distribution and site abundance of birds in winter. *Global Change Biology (14)*, 2489-2500.

Marra, P. P., Francis, C. M., Mulvihill, R. S., & Moore, F. R. (2005). The influence of climate on the timing and rate of spring bird migration. *Oecologia (142)*, 307-315.

Marra, P. P., Hobson, K. A., & Holmes, R. T. (1998). Linking winter and summer events in migratory bird by using stable-carbon isotopes. *Sience (282)*, 1884-1886.

McCarty, J. P. (2001). Ecological consequences of recent climate change. *Conservation Biology (15)*, 320- 331.

Menzel, A., Sparks, T. H., Estrella, N., Koch, E., Aasa, A., Ahas, R., . . . Zust, A. (2006). European phenological response to climate change matches the warming pattern. *Global Change Biology (12)*, 1969-1976.

Migration atlas a. (2022, 06 22). *Icterine warbler*. Retrieved from Migration atlas:

https://migrationatlas.org/node/1682

Migration atlas b. (2022, 06 22). *Garden warbler*. Retrieved from Migration atlas:

https://migrationatlas.org/node/1817

Miller-Rushing, A., Lloyd-Evans, T., Primack, R., & Satzinger, P. (2008). Bird migration times, climate change, and changing population sizes. *Global Change Biology (14)*, 1959–1972.

Moller, A. (2001). Heritability of arrival date in a migratory bird. *The Royal Society Biological Sciences (268)*, 203–206.

Møller, P. (1994). Phenotype-dependant arrival time and its consequences in a migratory bird. *Behavioral Ecology and Sociobiology (35)*, 115-122.

Moore, F. R., & Simons, T. R. (1992). Habitat suitability and stopover ecology of neotropical landbird migrants. In J. M. Hagan, & D. W. Johnston, *Ecology, and conservation of neotropical migrant landbirds* (pp. 345-355). Washington: Smithsonian Institution Press.

Myneni, R. B., Keeling, C. D., Tucker, C. J., Asrar, G., & Nemani, R. R. (1997). Increased plant growth in the northern high latitudes from 1981 to 1991. *Nature (386)*, 698–702.

National Centre for Environmental Information. (2022, 02 28). *Observation of Seasonal (JFM) mean North Atlantic Oscillation*. Retrieved from Climate Prediction Centre: https://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/JFM_season_nao_index.shtml

Newton, I. (2006). Can conditions experienced during migration limit the population levels of birds? . *Journal of Ornithology (147)*, 146-166.

Parry, M. L. (2007). *Climate change 2007: impacts, adaptation andvulnerability. Contribution of working group II to the fourth assessmentreport of the intergovernmental panel on climate change.* Geneve: IPCC.

Penuelas, J., & Filella, I. (2001). Responses to a changing world. *Sience (294)*, 793-795.

Post, E. F.-H. (2009). Ecological dynamics across the Arctic associated with recent climate change. *Science (325)*, 1355-1358.

Pulido, F., & Berthold, P. (2003). Quantitative Genetic Analysis of Migratory Behaviour. In P. Berthold, E. Gwinner, & E. Sonnenschein, *Avian Migration* (pp. 53-78). Berlin: Springer.

Rainio, K., Laaksonen, T., Ahola, M., Vähätalo, A. V., & Lehikoinen, E. (2006). Climatic responses in spring migration of boreal and arctic birds in relation to wintering area and taxonomy. *Journal of Avian Biology (37)*, 507-515.

Richardson, W. J. (1978). Timing and the amount of bird migration in relation to we ather: a review. *Oikos (30)*, 224-272.

Root, T. (1988). Environmental Factors Associated with Avian Distributional Boundaries. *Journal of Biogeography (15)*, 489-505.

Root, T. L., Price, J. T., Hall, K. R., Schneider, S. H., Rosenzweig, C., & Pounds, J. (2003). Fingerprints of global warming on wild animals and plants. *Nature (412)*, 57-60.

Roy, D. B., & Sparks, T. H. (2000). Phenology of britisch butterflies and climate change. *Global change biology (6)*, 407-416.

Rubolini, D., Moller, A., Rainio, K., & Lehikoinen, E. (2007). Assessing intraspecific consistency and geographic variability in temporal trends of spring migration phenology among European bird species. *Climate Research (35)*, 135–146.

Saino, N., Ambrosini, R., Rubolini, D., Hardenberg, J. v., Provenzale, A., Hüppop, K., . . . Sokolov, L. (2010). Climate warming, ecological mismatch at arrival and population decline in migratory birds. *The Royal Society (278)*, 835-842.

Schaub, M., & Jenni, L. (2001). Variation of fuelling rates among sites, days, and individuals in migrating passerine birds. *Functional Ecology (15)*, 584-594.

Serreze, M. C. (2009). The emergence of surface-based Arctic amplification. *The Cryosphere Discussions (2)* , 11-19.

Snow, D. W., & Perrins, C. M. (1998). Linnet. In D. W. Snow, & C. M. Perrins, *The Birds of the Western Palearctic, Concise edition* (pp. 1568-1571). Oxford: Oxford University Press.

Stervander, M., Lindström, Å., Jonzén, N., & Andersson, A. (2005). Timing of spring migration in birds: long-term trends, North Atlantic Oscillation, and the significance of different migration routes. *Journal of Avian Biology (36)*, 210-221.

Stocker, T., Qin, D., Plattner, G., Tignor, M., Allen, S., & Boschung, J. (2013). *climate change 2013: thephysical science basis. Contribution of working group I to the fifthassessment report of the intergovernmental panel on climate change.* Geneve: IPCC.

Strode, P. K. (2003). Implications of climate change for NorthAmerican wood warblers (Parulidae). *Global Change Biology (9)*, 1137 – 1144.

Telleria, J. L., Blázquez, M., De La Hera, I., & Pérez-Tris, J. (2013). Migratory and resident Blackcaps Sylvia atricapilla wintering in southern Spain show no resource partitioning. *IBIS (155)*, 750-761.

Thomas, C. D., & Lennon, J. J. (1999). Birds extend their ranges northwards. *Nature (399)*, 213.

Trektellen.org (2022, 05 24). *Linnet*. Retrieved from Trektellen: https://trektellen.org

Tulp, I., & Schekkerman, H. (2007). Has Prey Availability for Arctic Birds Advanced with Climate Change? Hindcasting the Abundance of Tundra Arthropods Using Weather and Seasonal Variations. *Artic (61)*, 48-60.

Vähätalo, A. V., Raino, K., Lehikoinen, A., & Lehikoinen, E. (2004). Spring arrival of birds depends on the North Arlantic Oscillation. *Journal of Avian Biology (35)*, 210-216.

Valiela, I., & Bowen, J. L. (2003). Shifts in Winter Distribution in Birds: Effects of Global Warming and Local Habitat Change. *AMBIO: A Journal of the Human Environment (32)*, 476-480.

Visser, M. (2008). Keeping up with a warming world; assessing the rate of adaptation to climate change. *The Royal Society (275)*, 649-659.

Visser, M. E., Noordwijk, A. J., Tinbergen, J. M., & Lessells, C. M. (1998). Warmer springs lead to mistimed reproduction in great tits (Parus major). *The Royal Society (265)*, 1867- 1870.

Visser, M., Perdeck, A., Balen, J. v., & Both, C. (2009). Climate change leads to decreasing bird migration distances. *Global Change Biology (15)*, 1859-1865.

Vogeltrekatlas a. (2022, 05 18). *Spotvogel*. Retrieved from Vogeltrekatlas: https://www.vogeltrekatlas.nl/soortzoek2.html?-0-Spotvogel-Totaal

Vogeltrekatlas b. (2022, 05 18). *Tuinfluiter*. Retrieved from Vogeltrekatlas: https://www.vogeltrekatlas.nl/soortzoek2.html?-0-Tuinfluiter-Totaal

Weather Underground. (2022, 02 28). *IBLVAN4*. Retrieved from Wunderground: https://www.wunderground.com/weather/IBLVAN4

Wickham, H., Averick, M., Bryan, J., Chang, W., DÁgostino McGowan, L., Francois, R., . . . Yutani, H. (2019). Welcome to the Tidyverse. *Journal of Open Source Software (4)*, 1-6.

Yong, W., & Moore, F. R. (1997). Spring stopover of intercontinental migratory trushes along the northern coast of the Gulf of Mexico. *Auk (114)*, 263-278.

Appendix I

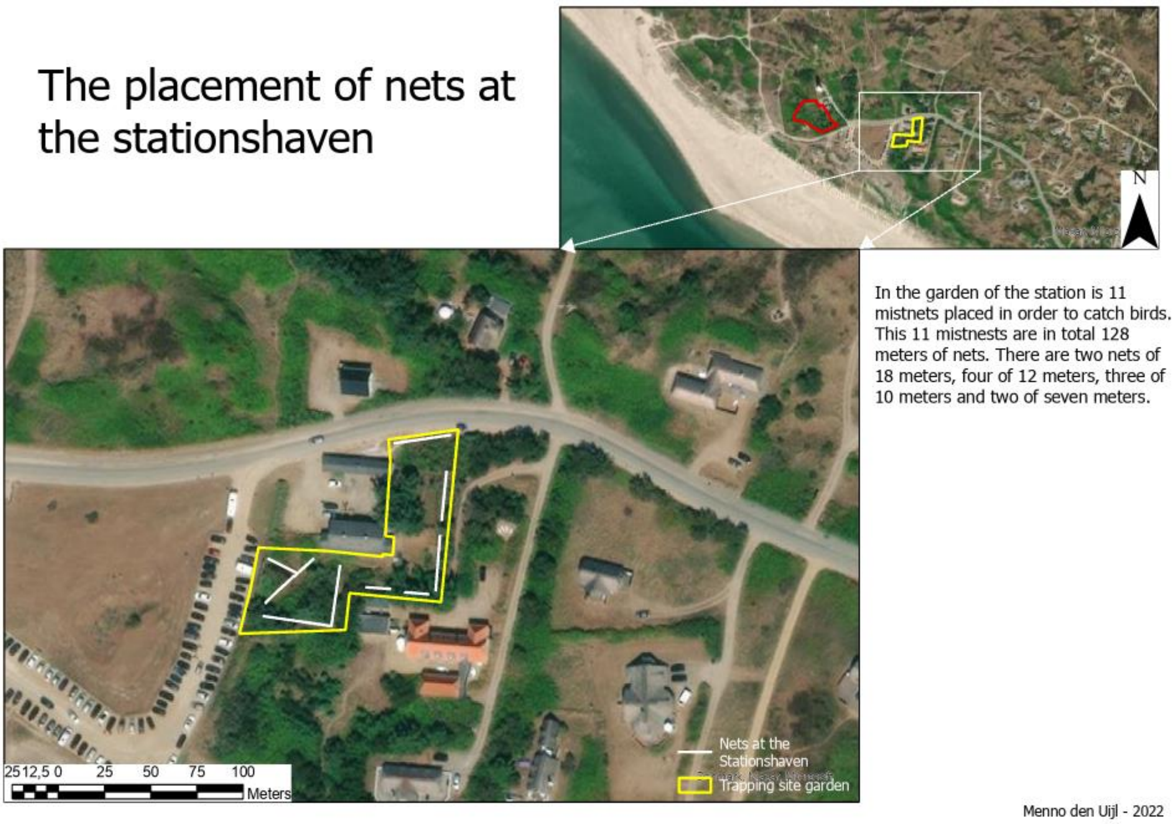

Figure 1 - The placements of the nets at the Stationshaven.

Figure 4 - The placements of the nets at the lighthouse garden.

Appendix II

Table 1 - The grouping of short-distance migrants (SDM) and long-distance migrants (LDM).

Common name	Scientific name	SDM or LDM
White wagtail	*Motacilla alba*	SDM
Winter wren	*Troglodytes troglodytes*	SDM
Hedge accentor	*Prunella modularis*	SDM
European Robin	*Erithacus rubecula*	SDM
Common Blackbird	*Turdus merula*	SDM
Song thrush	*Turdus philomelos*	SDM
Redwing	*Turdus iliacus*	SDM
Chiffchaff	*Phylloscopus collybita*	SDM
Goldcrest	*Regulus regulus*	SDM
Blue tit	*Parus caeruleus*	SDM
Great tit	*Parus major*	SDM
Chaffinch	*Fringilla coelebs*	SDM
Brambling	*Fringilla montifringilla*	SDM
European greenfinch	*Carduelis chloris*	SDM
Common linnet	*Carduelis cannabina*	SDM
Yellowhammer	*Emberiza citrinella*	SDM
Reed bunting	*Emberiza schoeniclus*	SDM
Blackcap	*Sylvia atricapilla*	SDM
Meadow pipit	*Anthus pratensis*	SDM
Barn swallow	*Hirundo rustica*	LDM
Tree pipit	*Anthus trivialis*	LDM
Nightingale	*Luscinia megarhynchos*	LDM
Bluethroat	*Luscinia svecica*	LDM
Common redstart	*Phoenicurus phoenicurus*	LDM
Whinchat	*Saxicola rubetra*	LDM
Marsh warbler	*Acrocephalus palustris*	LDM
Eurasian reed warbler	*Acrocephalus scirpaceus*	LDM
Icterine warbler	*Hippolais icterina*	LDM
Lesser whitethroat	*Sylvia curruca*	LDM
Common whitethroat	*Sylvia communis*	LDM
Garden warbler	*Sylvia borin*	LDM
Willow warbler	*Phylloscopus trochilus*	LDM
Spotted flycatcher	*Muscicapa striata*	LDM
Pied flycatcher	*Ficedula hypoleuca*	LDM
Red-backed Shrike	*Lanius collurio*	LDM

Blackcap, *Sylvia atricapiila,* has been changed to SDM since this species is wintering north of Sahara (Telleria et al., 2013). This has been the only change made from Jonzén, 2016.

Appendix III

Table 2 - Regression of the first phase of migration on year and winter North Atlantic Oscillation (NAO) index, for eleven short distance migrants and seven long distance migrants (<0,05; **<0,01;***<0,001).*

Species	Number of analyzed years	Total amount of birds	First 5% on year			First 5% on winter NAO		
			B	R^2	P	B	R^2	P
Short distance migrants								
Blackbird	33	3792	-0.4874	0.2988	0.0009971 **	-2.279	0.1056	0.06496
Blackcap	29	1347	-0.3588	0.268	0.00402 **	-1.041	0.03704	0.3172
Chaffinch	33	1828	-0.6280	0.3933	0,00009396 ***	-1.989	0.06386	0.156
Chiffchaff	33	3711	-0.2074	0.05548	0.187	-3.075	0.1972	0.009635 **
Dunnock	33	2915	-0.3183	0.1482	0.0269 *	-2.546	0.1534	0.0242 *
Goldcrest	24	1743	-0.2958	0.1319	0.08107	-4.300	0.4074	0.0007903 ***
Linnet	27	908	0.1836	0.06537	0.198	-0.8846	0.02434	0.4371
Redpoll	32	3196	-0.3175	0.06901	0.1397	-2.217	0.05444	0.1913
Robin	33	4269	-0.2582	0.1019	0.07489	-2.418	0.1437	0.03239 *
Song Thrush	23	749	-0.4874	0.2988	0.000997 **	0.09441	0.0002023	0.9486
Wren	19	582	-0.5831	0.1469	0.1053	0.9486	0.1574	0.09258
Long distance migrants								
Common redstart	28	1384	-0.252	0.1901	0.02039 *	-1.296	0.07066	0.1716
Common whitethroat	26	980	-0.1753	0.02016	0.489	-1.304	0.02441	0.446
Garden warbler	18	611	0.3054	0.1712	0.08781	-2.087	0.1375	0.1298
Icterine warbler	9	271	0.4778	0.2453	0.1752	0.4798	0.006756	0.8335
Lesser whitethroat	32	1728	-0.1175	0.007676	0.6335	2.164	0.04628	0.237
Pied flycatcher	9	274	-0.2769	0.05241	0.5535	-2.164	0.05036	0.5616
Willow warbler	33	6118	-0.01754	0.0002521	0.930	-1.484	0.02919	0.3418

Significant codes: <0,05 "*", <0,005 "**", <0,0005 "***".

Table 3 - Regression of the mean phase of migration on year and winter North Atlantic Oscillation (NAO) index, for eleven short distance migrants and seven long distance migrants (<0,05; **<0,01;***<0,001).*

Species	Number of analyzed years	Total amount of birds	MSP on year			MSP on winter NAO		
			B	R^2	P	B	R^2	P
Short distance migrants								
Blackbird	33	3792	-0.2424	0.1208	0.04749 *	-1.807	0.1086	0.06116
Blackcap	29	1347	-0.13452	0.06775	0.1727	-0.7031	0.03041	0.3656
Chaffinch	33	1828	-0.1042	0.02094	0.4217	-1.014	0.03202	0.3191
Chiffchaff	33	3711	-0.20815	0.1242	0.04424 *	-0.9152	0.03885	0.2716
Dunnock	33	2915	-0.03684	0.00481	0.7014	-1.097	0.06903	0.1396
Goldcrest	24	1743	-0.1784	0.07509	0.1951	-2.686	0.2488	0.01311 *
Linnet	27	908	0.3439	0.2708	0.005391 *	-0.7534	0.02084	0.4725
Redpoll	32	3196	-0.07249	0.007982	0.621	0.01136	3,17E-06	0.9922
Robin	33	4269	-0.08753	0.03391	0.313	0.05804	0.0002396	0.933
Song Thrush	23	749	-0.2424	0.1208	0.04749 *	0.3345	0.004205	0.7688
Wren	19	582	-0.03373	0.002438	0.8409	-0.8810	0.04659	0.3748
Long distance migrants								
Common redstart	28	1384	-0.04973	0.01283	0.566	0,006807	3,38E-06	0.9926
Common whitethroat	26	980	-0.09383	0.03213	0.381	-0.9531	0.07255	0.1833
Garden warbler	18	611	0.2193	0.2213	0.04879 *	-1.047	0.08668	0.2357
Icterine warbler	9	271	0.23391	0.7859	0.001448 **	0.3267	0.04188	0.5974
Lesser whitethroat	32	1728	-0.19906	0.16	0.0233 *	-0.3238	0.007532	0.6367
Pied flycatcher	9	274	-0.4923	0.5637	0.01973 *	-1.810	0.1199	0.3613
Willow warbler	33	6118	-0.12129	0.07062	0.135	-0.4624	0.01661	0.4748

Significant codes: <0,05 "*", <0,005 "**", <0,0005 "***".

Table 4 - Regression of the last phase of migration on year and winter North Atlantic Oscillation (NAO) index, for eleven short distance migrants and seven long distance migrants (<0,05; **<0,01;***<0,001).*

Species	Number of analyzed years	Total amount of birds	Last 5% on year			Last 5% on winter NAO		
			B	R^2	P	B	R^2	P
Short distance migrants								
Blackbird	33	3792	-0.1527	0.01143	0.5538	-2.827	0.06335	0.1577
Blackcap	29	1347	0.4529	0.1989	0.01531	1.458	0.03388	0.3392
Chaffinch	33	1828	0.4650	0.2372	0.004046 **	-1.041	0.01924	0.4414
Chiffchaff	33	3711	-0.033	0.001499	0.8306	-1.432	0.04565	0.2325
Dunnock	33	2915	0.4071	0.06604	0.1488	-0.5004	0.001614	0.8243
Goldcrest	24	1743	-0.1462	0.01296	0.5964	-2.306	0.04709	0.3084
Linnet	27	908	0.46083	0.4664	0.0000867 ***	-0.7269	0.0186	0.4975
Redpoll	32	3196	0.2235	0.105	0.06588	-0.5024	0.008577	0.6082
Robin	33	4269	0.01587	0.0006346	0.8911	-0.08505	0.0002929	0.9259
Song Thrush	23	749	-0.1527	0.3583	0.5538	3.607	0.08804	0.1692
Wren	19	582	-0.1095	0.006064	0.7513	-0.5399	0.004132	0.7938
Long distance migrants								
Common redstart	28	1384	0.2268	0.08665	0.1284	1.448	0.04964	0.2545
Common whitethroat	26	980	0.2197	0.1135	0.09238	-1.062	0.05806	0.2357
Garden warbler	18	611	0.1648	0.1004	0.2001	-0.653	0.0271	0.5139
Icterine warbler	9	271	0.3765	0.7375	0.003029 **	0.7126	0.07215	0.4846
Lesser whitethroat	32	1728	0.2432	0.09226	0.09101	0.2517	0.001757	0.8198
Pied flycatcher	9	274	-0.1643	0.06126	0.5208	-1.576	0.0887	0.4363
Willow warbler	33	6118	0.03525	0.00196	0.8067	-1.527	0.0595	0.1713

Significant codes: <0,05 "*", <0,005 "**", <0,0005 "***".

Appendix IV

```
Overview = read.csv("C:/Users/menno/Downloads/OverzichtXLSX.csv",

            sep = ";",

            dec = ",")

attach(Overview)

head(Overview)

view(Overview)

install.packages("lme4")

install.packages("stats")

install.packages("tidyverse")

library("Tidyverse")

library("lme4")

library("stats")

options(scripen = 999)

as.numeric(Overview$Year)

as.numeric(Overview$Amount)

as.numeric(Overview$X5th)

as.numeric(Overview$X50th)

as.numeric(Overview$X95th)

Blackcap <- select(filter(Overview, Species== "Blackcap"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Blackbird <- select(filter(Overview, Species== "Blackbird"),c("Year", "X5th", "X50th", "X95th",
"NAO"))

Chaffinch <- select(filter(Overview, Species== "Chaffinch"),c("Year", "X5th", "X50th", "X95th",
"NAO"))

Chiffchaff <- select(filter(Overview, Species== "Chiffchaff"),c("Year", "X5th", "X50th", "X95th",
"NAO"))

Common_Redstart <- select(filter(Overview, Species== "Common redstart"),c("Year", "X5th",
"X50th", "X95th", "NAO"))

Common_Whitethroat <- select(filter(Overview, Species== "Common whitethroat"),c("Year", "X5th",
"X50th", "X95th", "NAO"))

Dunnock <- select(filter(Overview, Species== "Dunnock"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Garden_Warbler <- select(filter(Overview, Species== "Garden warbler"),c("Year", "X5th", "X50th",
"X95th", "NAO"))
```

```
Goldcrest <- select(filter(Overview, Species== "Goldcrest"),c("Year", "X5th", "X50th", "X95th",
"NAO"))

Icterine_Warbler <- select(filter(Overview, Species== "Icterine warbler"),c("Year", "X5th", "X50th",
"X95th", "NAO"))

Lesser_Whitethroat <- select(filter(Overview, Species== "Lesser whitethroat"),c("Year", "X5th",
"X50th", "X95th", "NAO"))

Linnet <- select(filter(Overview, Species== "Linnet"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Pied_Flycatcher <- select(filter(Overview, Species== "Pied flycatcher"),c("Year", "X5th", "X50th",
"X95th", "NAO"))

Redpoll <- select(filter(Overview, Species== "Redpoll"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Robin <- select(filter(Overview, Species== "Robin"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Willow_Warbler <- select(filter(Overview, Species== "Willow warbler"),c("Year", "X5th", "X50th",
"X95th", "NAO"))

Wren <- select(filter(Overview, Species== "Wren"),c("Year", "X5th", "X50th", "X95th", "NAO"))

Song_Thrush <- select(filter(Overview, Species== "Song thrush"),c("Year", "X5th", "X50th", "X95th",
"NAO"))

#On year

#5th_SDM

Blackbird_5th = lm(formula = X5th ~ Year, data = Blackbird)

summary(Blackbird_5th)

Blackcap_5th = lm(formula = X5th ~ Year, data = Blackcap)

summary(Blackcap_5th)

Chaffinch_5th = lm(formula = X5th ~ Year, data = Chaffinch)

summary(Chaffinch_5th)

Chiffchaff_5th = lm(formula = X5th ~ Year, data = Chiffchaff)

summary(Chiffchaff_5th)

Dunnock_5th = lm(formula = X5th ~ Year, data = Dunnock)

summary(Dunnock_5th)

Goldcrest_5th = lm(formula = X5th ~ Year, data = Goldcrest)

summary(Goldcrest_5th)

Linnet_5th = lm(formula = X5th ~ Year, data = Linnet)

summary(Linnet_5th)

Redpoll_5th = lm(formula = X5th ~ Year, data = Redpoll)
```

```
summary(Redpoll_5th)
Robin_5th = lm(formula = X5th ~ Year, data = Robin)
summary(Robin_5th)
Song_Thrush_5th = lm(formula = X5th ~ Year, data = Song_Thrush)
summary(Blackbird_5th)
Wren_5th = lm(formula = X5th ~ Year, data = Wren)
summary(Wren_5th)
#5th_LDM
Common_Redstart_5th = lm(formula = X5th ~ Year, data = Common_Redstart)
summary(Common_Redstart_5th)
Common_Whitethroat_5th = lm(formula = X5th ~ Year, data = Common_Whitethroat)
summary(Common_Whitethroat_5th)
Garden_Warbler_5th = lm(formula = X5th ~ Year, data = Garden_Warbler)
summary(Garden_Warbler_5th)
Icterine_Warbler_5th = lm(formula = X5th ~ Year, data = Icterine_Warbler)
summary(Icterine_Warbler_5th)
Lesser_Whitethroat_5th = lm(formula = X5th ~ Year, data = Lesser_Whitethroat)
summary(Lesser_Whitethroat_5th)
Pied_Flycatcher_5th = lm(formula = X5th ~ Year, data = Pied_Flycatcher)
summary(Pied_Flycatcher_5th)
Willow_Warbler_5th = lm(formula = X5th ~ Year, data = Willow_Warbler)
summary(Willow_Warbler_5th)
#50th_SDM
Blackbird_50th = lm(formula = X50th ~ Year, data = Blackbird)
summary(Blackbird_50th)
Blackcap_50th = lm(formula = X50th ~ Year, data = Blackcap)
summary(Blackcap_50th)
Chaffinch_50th = lm(formula = X50th ~ Year, data = Chaffinch)
summary(Chaffinch_50th)
Chiffchaff_50th = lm(formula = X50th ~ Year, data = Chiffchaff)
summary(Chiffchaff_50th)
```

```
Dunnock_50th = lm(formula = X50th ~ Year, data = Dunnock)
summary(Dunnock_50th)
Goldcrest_50th = lm(formula = X50th ~ Year, data = Goldcrest)
summary(Goldcrest_50th)
Linnet_50th = lm(formula = X50th ~ Year, data = Linnet)
summary(Linnet_50th)
Redpoll_50th = lm(formula = X50th ~ Year, data = Redpoll)
summary(Redpoll_50th)
Robin_50th = lm(formula = X50th ~ Year, data = Robin)
summary(Robin_50th)
Song_Thrush_50th = lm(formula = X50th ~ Year, data = Song_Thrush)
summary(Blackbird_50th)
Wren_50th = lm(formula = X50th ~ Year, data = Wren)
summary(Wren_50th)
#50th_LDM
Common_Redstart_50th = lm(formula = X50th ~ Year, data = Common_Redstart)
summary(Common_Redstart_50th)
Common_Whitethroat_50th = lm(formula = X50th ~ Year, data = Common_Whitethroat)
summary(Common_Whitethroat_50th)
Garden_Warbler_50th = lm(formula = X50th ~ Year, data = Garden_Warbler)
summary(Garden_Warbler_50th)
Icterine_Warbler_50th = lm(formula = X50th ~ Year, data = Icterine_Warbler)
summary(Icterine_Warbler_50th)
Lesser_Whitethroat_50th = lm(formula = X50th ~ Year, data = Lesser_Whitethroat)
summary(Lesser_Whitethroat_50th)
Pied_Flycatcher_50th = lm(formula = X50th ~ Year, data = Pied_Flycatcher)
summary(Pied_Flycatcher_50th)
Willow_Warbler_50th = lm(formula = X50th ~ Year, data = Willow_Warbler)
summary(Willow_Warbler_50th)
#95th_SDM
Blackbird_95th = lm(formula = X95th ~ Year, data = Blackbird)
```

```
summary(Blackbird_95th)
Blackcap_95th = lm(formula = X95th ~ Year, data = Blackcap)
summary(Blackcap_95th)
Chaffinch_95th = lm(formula = X95th ~ Year, data = Chaffinch)
summary(Chaffinch_95th)
Chiffchaff_95th = lm(formula = X95th ~ Year, data = Chiffchaff)
summary(Chiffchaff_95th)
Dunnock_95th = lm(formula = X95th ~ Year, data = Dunnock)
summary(Dunnock_95th)
Goldcrest_95th = lm(formula = X95th ~ Year, data = Goldcrest)
summary(Goldcrest_95th)
Linnet_95th = lm(formula = X95th ~ Year, data = Linnet)
summary(Linnet_95th)
Redpoll_95th = lm(formula = X95th ~ Year, data = Redpoll)
summary(Redpoll_95th)
Robin_95th = lm(formula = X95th ~ Year, data = Robin)
summary(Robin_95th)
Song_Thrush_95th = lm(formula = X95th ~ Year, data = Song_Thrush)
summary(Blackbird_95th)
Wren_95th = lm(formula = X95th ~ Year, data = Wren)
summary(Wren_95th)
#95th_LDM
Common_Redstart_95th = lm(formula = X95th ~ Year, data = Common_Redstart)
summary(Common_Redstart_95th)
Common_Whitethroat_95th = lm(formula = X95th ~ Year, data = Common_Whitethroat)
summary(Common_Whitethroat_95th)
Garden_Warbler_95th = lm(formula = X95th ~ Year, data = Garden_Warbler)
summary(Garden_Warbler_95th)
Icterine_Warbler_95th = lm(formula = X95th ~ Year, data = Icterine_Warbler)
summary(Icterine_Warbler_95th)
Lesser_Whitethroat_95th = lm(formula = X95th ~ Year, data = Lesser_Whitethroat)
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```
summary(Lesser_Whitethroat_95th)
Pied_Flycatcher_95th = lm(formula = X95th ~ Year, data = Pied_Flycatcher)
summary(Pied_Flycatcher_95th)
Willow_Warbler_95th = lm(formula = X95th ~ Year, data = Willow_Warbler)
summary(Willow_Warbler_95th)
#On NAO
#5th_NAO_SDM
Blackbird_5th_NAO = lm(formula = X5th ~ NAO, data = Blackbird)
summary(Blackbird_5th_NAO)
Blackcap_5th_NAO = lm(formula = X5th ~ NAO, data = Blackcap)
summary(Blackcap_5th_NAO)
Chaffinch_5th_NAO = lm(formula = X5th ~ NAO, data = Chaffinch)
summary(Chaffinch_5th_NAO)
Chiffchaff_5th_NAO = lm(formula = X5th ~ NAO, data = Chiffchaff)
summary(Chiffchaff_5th_NAO)
Dunnock_5th_NAO = lm(formula = X5th ~ NAO, data = Dunnock)
summary(Dunnock_5th_NAO)
Goldcrest_5th_NAO = lm(formula = X5th ~ NAO, data = Goldcrest)
summary(Goldcrest_5th_NAO)
Linnet_5th_NAO = lm(formula = X5th ~ NAO, data = Linnet)
summary(Linnet_5th_NAO)
Redpoll_5th_NAO = lm(formula = X5th ~ NAO, data = Redpoll)
summary(Redpoll_5th_NAO)
Robin_5th_NAO = lm(formula = X5th ~ NAO, data = Robin)
summary(Robin_5th_NAO)
Song_Thrush_5th_NAO = lm(formula = X5th ~ NAO, data = Song_Thrush)
summary(Song_Thrush_5th_NAO)
Wren_5th_NAO = lm(formula = X5th ~ NAO, data = Wren)
summary(Wren_5th_NAO)
#5th_NAO_LDM
Common_Redstart_5th_NAO = lm(formula = X5th ~ NAO, data = Common_Redstart)
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summary(Common_Redstart_5th_NAO)
Common_Whitethroat_5th_NAO = lm(formula = X5th ~ NAO, data = Common_Whitethroat)
summary(Common_Whitethroat_5th_NAO)
Garden_Warbler_5th_NAO = lm(formula = X5th ~ NAO, data = Garden_Warbler)
summary(Garden_Warbler_5th_NAO)
Icterine_Warbler_5th_NAO = lm(formula = X5th ~ NAO, data = Icterine_Warbler)
summary(Icterine_Warbler_5th_NAO)
Lesser_Whitethroat_5th_NAO = lm(formula = X5th ~ NAO, data = Lesser_Whitethroat)
summary(Lesser_Whitethroat_5th_NAO)
Pied_Flycatcher_5th_NAO = lm(formula = X5th ~ NAO, data = Pied_Flycatcher)
summary(Pied_Flycatcher_5th_NAO)
Willow_Warbler_5th_NAO = lm(formula = X5th ~ NAO, data = Willow_Warbler)
summary(Willow_Warbler_5th_NA
#50th_NAO_SDM
Blackbird_50th_NAO = lm(formula = X50th ~ NAO, data = Blackbird)
summary(Blackbird_50th_NAO)
Blackcap_50th_NAO = lm(formula = X50th ~ NAO, data = Blackcap)
summary(Blackcap_50th_NAO)
Chaffinch_50th_NAO = lm(formula = X50th ~ NAO, data = Chaffinch)
summary(Chaffinch_50th_NAO)
Chiffchaff_50th_NAO = lm(formula = X50th ~ NAO, data = Chiffchaff)
summary(Chiffchaff_50th_NAO)
Dunnock_50th_NAO = lm(formula = X50th ~ NAO, data = Dunnock)
summary(Dunnock_50th_NAO)
Goldcrest_50th_NAO = lm(formula = X50th ~ NAO, data = Goldcrest)
summary(Goldcrest_50th_NAO)
Linnet_50th_NAO = lm(formula = X50th ~ NAO, data = Linnet)
summary(Linnet_50th_NAO)
Redpoll_50th_NAO = lm(formula = X50th ~ NAO, data = Redpoll)
summary(Redpoll_50th_NAO)
Robin_50th_NAO = lm(formula = X50th ~ NAO, data = Robin)
```

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summary(Robin_50th_NAO)
Song_Thrush_50th_NAO = lm(formula = X50th ~ NAO, data = Song_Thrush)
summary(Song_Thrush_50th_NAO)
Wren_50th_NAO = lm(formula = X50th ~ NAO, data = Wren)
summary(Wren_50th_NAO)
#50th_NAO_LDM
Common_Redstart_50th_NAO = lm(formula = X50th ~ NAO, data = Common_Redstart)
summary(Common_Redstart_50th_NAO)
Common_Whitethroat_50th_NAO = lm(formula = X50th ~ NAO, data = Common_Whitethroat)
summary(Common_Whitethroat_50th_NAO)
Garden_Warbler_50th_NAO = lm(formula = X50th ~ NAO, data = Garden_Warbler)
summary(Garden_Warbler_50th_NAO)
Icterine_Warbler_50th_NAO = lm(formula = X50th ~ NAO, data = Icterine_Warbler)
summary(Icterine_Warbler_50th_NAO)
Lesser_Whitethroat_50th_NAO = lm(formula = X50th ~ NAO, data = Lesser_Whitethroat)
summary(Lesser_Whitethroat_50th_NAO)
Pied_Flycatcher_50th_NAO = lm(formula = X50th ~ NAO, data = Pied_Flycatcher)
summary(Pied_Flycatcher_50th_NAO)
Willow_Warbler_50th_NAO = lm(formula = X50th ~ NAO, data = Willow_Warbler)
summary(Willow_Warbler_50th_NAO)
#95th_NAO_SDM
Blackbird_95th_NAO = lm(formula = X95th ~ NAO, data = Blackbird)
summary(Blackbird_95th_NAO)
Blackcap_95th_NAO = lm(formula = X95th ~ NAO, data = Blackcap)
summary(Blackcap_95th_NAO)
Chaffinch_95th_NAO = lm(formula = X95th ~ NAO, data = Chaffinch)
summary(Chaffinch_95th_NAO)
Chiffchaff_95th_NAO = lm(formula = X95th ~ NAO, data = Chiffchaff)
summary(Chiffchaff_95th_NAO)
Dunnock_95th_NAO = lm(formula = X95th ~ NAO, data = Dunnock)
summary(Dunnock_95th_NAO)
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Goldcrest_95th_NAO = lm(formula = X95th ~ NAO, data = Goldcrest)
summary(Goldcrest_95th_NAO)
Linnet_95th_NAO = lm(formula = X95th ~ NAO, data = Linnet)
summary(Linnet_95th_NAO)
Redpoll_95th_NAO = lm(formula = X95th ~ NAO, data = Redpoll)
summary(Redpoll_95th_NAO)
Robin_95th_NAO = lm(formula = X95th ~ NAO, data = Robin)
summary(Robin_95th_NAO)
Song_Thrush_95th_NAO = lm(formula = X95th ~ NAO, data = Song_Thrush)
summary(Song_Thrush_95th_NAO)
Wren_95th_NAO = lm(formula = X95th ~ NAO, data = Wren)
summary(Wren_95th_NAO)
#95th_NAO_LDM
Common_Redstart_95th_NAO = lm(formula = X95th ~ NAO, data = Common_Redstart)
summary(Common_Redstart_95th_NAO)
Common_Whitethroat_95th_NAO = lm(formula = X95th ~ NAO, data = Common_Whitethroat)
summary(Common_Whitethroat_95th_NAO)
Garden_Warbler_95th_NAO = lm(formula = X95th ~ NAO, data = Garden_Warbler)
summary(Garden_Warbler_95th_NAO)
Icterine_Warbler_95th_NAO = lm(formula = X95th ~ NAO, data = Icterine_Warbler)
summary(Icterine_Warbler_95th_NAO)
Lesser_Whitethroat_95th_NAO = lm(formula = X95th ~ NAO, data = Lesser_Whitethroat)
summary(Lesser_Whitethroat_95th_NAO)
Pied_Flycatcher_95th_NAO = lm(formula = X95th ~ NAO, data = Pied_Flycatcher)
summary(Pied_Flycatcher_95th_NAO)
Willow_Warbler_95th_NAO = lm(formula = X95th ~ NAO, data = Willow_Warbler)
summary(Willow_Warbler_95th_NAO)
```