Bird Migration

Timing changes in 37 common autumn migrants

School research project

By: Mark van Leeuwen

Mentor: Drs. A. J. van Vught

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Preface

First of all, I want to thank A. de Jong, MA, drs. A. Boele and mr. G. Troost for delivering all the data I needed for analyzing, for helping me with all my questions I had about the topic and for revising and improving my work.

Furthermore, I want to thank mr. G. Holvast for checking my profile paper on mistakes in English.

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Introduction

It is about six years ago that I first became fascinated by birds and in particular by watching them. While I first just wanted to see as many birds as possible, the last few years I am getting more and more interested in knowing more about the backgrounds of birds. I started counting for various counting projects of Sovon, like counting hibernating birds in a park nearby and counting city birds in the town I live.

Last autumn, I also started counting migratory birds together with some other birdwatchers from the area. At the same moment, I had to choose a subject for my school research project. Because I became more and more fascinated by bird migration, it was not difficult to choose a subject. I wanted to examine if there were changes in the timing of bird migration, or something related to this.

And that is what I have done in the past couple of months. To now introduce people in the world of bird migration, I first did some literature reviews to introduce bird migration and to give some general information. Secondly, I focused on clearly visible patterns in bird migration, which is useful to know when it comes to this subject. Before starting the real analysis, I first did some other literature reviews to make people understand how migrating birds are counted.

The real research was based on changes in timing, using certain percentiles to make the changes clear. Concluding, I watched three bird species in which the timing of autumn migration had changed significantly.

Logically, my research question is as following: *Are there timing differences in autumn bird migration between the periods 2000-2006 and 2007-2014*. To answer these questions, I set up the following sub-questions: *1) What is bird migration? 2) What are the most important migration patterns in birds? 3) Which methods are being used by migration counters?*

Chapter 1: What is bird migration?

§1.1: Bird movements

Birds do not stay at the same area during their life. Some will stay near their breeding site, others will travel thousands of kilometers. In general we can distinguish six general types of bird movements[1]:

1) *Everyday routine movements*: These movements occur in all birds. Included are movements like flights from and to the breeding or feeding site, flights between two feeding sites or flights to and from sleeping places. These movements mainly take place within a range of some kilometers.
2) *Dispersal movements*: Usually, when a bird species becomes independent from its parents, the young bird will disperse in any direction from the breeding site. Dispersal movements seem to be quite random, because within a species, there is no specific directional preference. Usually, the young bird will settle within some kilometers from its breeding site, but in a few species, distances may be much greater.
3) *Migration*: Twice a year, many birds are flying either from their wintering ranges to their breeding ranges or the other way around. Compared with the above movements, the distances are much greater, ranging up to thousands of kilometers. This type of movement causes a massive shift of populations from (usually) higher to lower latitudes.
4) *Irruptions*: Irruptions are just like other seasonal migration movements, but the number of migrating birds can vary greatly each year. These movements are generally associated with the food supply in their normal wintering or breeding ranges. An example is the Bohemian Waxwing *Bombycilla garrulus*, which suspend their wintering ranges upon the availability of berries in Scandinavia.
5) *Nomadism*: There are also birds which reside at places with a great food supply. This means they will not be breeding at the same places each year, because they just choose the most comfortable place during breeding time. This means individual birds will not necessarily return to their past breeding areas.
6) *Facultative migration*: This type of migration is almost the same as the one above. The difference is that facultative migrants only migrate when it is needed. Individuals may migrate in some years but not in others, depending on the food supplies or weather conditions. [2]

§1.2: Resident, short-distance and long-distance

In this school research project, migration as in (3) will have the main focus. Among scientists, migration is often defined as 'the seasonal movement, often north and south along a flyway, between wintering and breeding grounds'.[3] This means that birds are flying towards their breeding grounds in spring, and flying back to their wintering grounds during fall. However, not all birds migrate. We can distinguish between three types of birds: resident birds, short-distance migrants and

[1] Newton I., 2008, 3-4

[2] Newton I., 2011

[3] Wikipedia.org, http://www.en.wikipedia.org/wiki/Bird_migration

long-distance migrants. Resident birds are staying in the same area the whole year long. They will not move away, and their breeding ground is in the same place as their hibernating ground. Barn Owl *Tyto alba* and Eurasian Nuthatch *Sitta europaea* are two prominent representatives. These species only show features of (1 *Everyday routine movements)* and (2 *Dispersal movements).* The difference between short-distance migrants and long-distance migrants is less clear. However, in general we could say that European short-distance migrants have their wintering grounds in Europe, while European long-distance migrants hibernate in Africa, south of the Sahara. Lapwings, cranes and finches are examples of short-distance migrants; examples of long-distance migrants are swallows and many species of stilts.

§1.3: Orientation

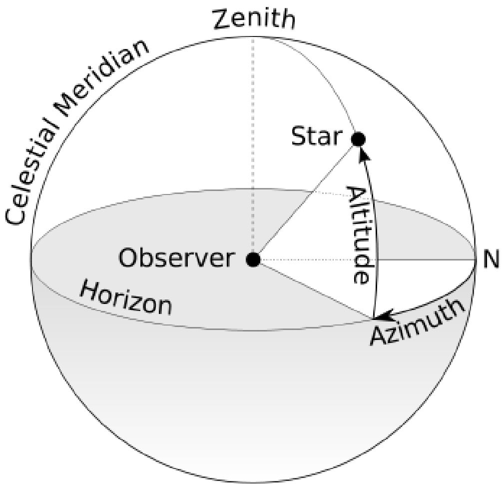

Figure 1. Using the sun's azimuth, birds are able to navigate during their migration.

Until now, research has found out that there are at least four important 'resources' birds use to navigate on their journey. The first are celestial objects, like the sun, moon and stars. Birds which migrate during the day use the position of the sun, using the principle of the azimuth. The azimuth is the angle between the projection of the sun on the horizon and the North, seen from an observer. In this way, it is possible to use the sun as a compass. Various experiments with Common Starlings *Sturnus vulgaris* kept in circular wire cages confirmed this hypothesis. Researchers varied the angle they took to the sun and the starlings were almost always oriented in the same direction as free-living birds. When the view of the sun was changed by using mirrors, the starlings would change their route according to the 'new' sun-azimuth. Birds which migrate during the night mainly use the pole star to navigate during their journey and other star patterns around the pole star.[4]

Another (visible) indicator is by just remembering their journey and/or by following certain lines in the landscape. For example, birds which mainly fly in (family) groups will be lead by their parents for the first time, and from then on, they are able to remember the way back. Other birds, mainly the smaller birds, use landscape features like hill and mountain ridges, rivers, valleys etc. Even clear lines like big roads are followed by some birds.[5]

Birds, however, do not only use visible indicators. Since a number of years now research has shown that many animals, including birds, coordinate on the basis of geomagnetism[6]. It is believed that birds compare the direction of the magnetic field with the gravity vector. In this way, birds could determine their relative location between the pole and the equator. An inclination compass works in the same way, but it is not yet known how birds can perceive magnetic fields. However, it is most likely that birds, just like other animals like sharks, tuna and salamanders, have pieces of magnetite in them. These are particles which register the magnetic field like a compass needle. The last years,

[4] Hoffmann K., 1953
[5] Ritchison G., *Avian Navigation and Orientation*, http://www.people.eku.edu/ritchisong/nav_orient.htm
[6] Wiltschko R. & Wiltschko W., 1995

there has been more and more evidence that birds too have particles like magnetite to perceive magnetic fields.[7]

Another quite surprising orientation method has been found in the Cory's Shearwater *Calonectris borealis*. Research in 2013 has found out that this bird species – and probably other species of shearwaters too – uses olfactory cues, not only to find their food, but also to navigate over large distances in the ocean. Researchers used three groups of shearwaters: One control group, one group (the 'magnetic birds') magnetically treated by some magnets they carried with them, and one group (the 'anosmic birds') deprived of their sense of smell by washing their olfactory mucosa. Of the control group, all the birds were able to fly back to their breeding colony. The same was true for the magnetic birds. For the anosmic birds however, only two out of eight could find their colonies back, which proves olfactory cues are quite important for sea birds.[8]

§1.4: Reasons for bird migration

Whether a bird migrates or not, is genetically determined. When days start to get shorter or longer, birds undergo a number of changes, such as changing hormone levels and an increased fat deposition. These changes are all physiologic of nature. These changes ensure that the willingness of the birds to go on their migration route increases, which is called '*Zugunruhe',* migratory restlessness. Besides, birds don't have the choice whether or not to leave. This is because in the winter, there is less food, while in summer, there's lots of food in the breeding ranges. So, by migrating, birds are ensuring that they always will have enough food, both in winter and in summer time.

Summary

We can distinguish between six types of bird movements: everyday routine movements, dispersal movements, migration, irruptions, nomadism and facultative migration. Migration will have the main focus. However, we distinguish between resident birds, short-distance migratory birds and long-distance migratory birds. The way birds are able to find their way, is pretty amazing. Most diurnal migrants use the azimuth of the sun; nocturnal migrants find their way using the moon and certain star patterns. Also certain lines in landscape are followed by migrants. Other 'devices' which are used are geomagnetism and olfactory cues. Lastly, birds migrate to ensure that they always have plenty of food.

[7] Mulheim R., 2004, 11
[8] Gaglardio A. et al., 2013

Chapter 2: Migration patterns

§2.1: Partial migration

Normally, we refer to a species being a resident bird or a migrant. So, one species either stays the whole year around the same place, or migrates to far-away regions. The latter is the case in bird species like Yellow Wagtail *Motacilla flava* and Common Cuckoo *Cuculus canorus*, which are not seen in winter in their breeding ranges. However, this assumption does not apply to all bird species. There are many species in which some individuals do migrate, and some don't. Just have a look at European Robins *Erithacus rubecula*. It is a species that breeds in The Netherlands and hibernates here as well. When we have a look at robins from North Europe, it is totally different. They breed in Scandinavia, but never hibernate here. In the autumn, they fly to Southern Europe, passing by their congeners in West Europe. However, it can be brought closer. Even robins from our own country migrate, though only partially. So, one part of the Dutch robin population migrates to South Europe; the other part stays hibernating over here. Only from France and further southwards, robins are real resident birds.

But why would some robins like to stay here in winter, while others go to the south of France and Spain? This phenomenon, called partial migration, occurs when there's a balance between the advantages and disadvantages of migrating. The biggest advantage for a (male) robin hibernating in The Netherlands is that he can claim his territory before the migrating robins are back in spring. This means a better breeding site and so better chances for his posterity. However, staying here is only possible during a mild winter. When it is a harsh winter, European Robins will not be able to find food, and so possibly die.
Migrating European Robins are not at this risk, because winters in South Europe are mild with plenty of food. However, when returning, the best breeding sites may be occupied by non-migrating robins, which means worse chances for their posterity.[9]

With today's climate change, we are also seeing changes in such migration patterns. Great examples are Chiffchaffs *Phylloscopus collybita*. A number of decades ago, there were almost no Chiffchaffs hibernating in The Netherlands. They all migrated to the Mediterranean. In recent years, we see a shift: more and more Chiffchaffs aren't migrating anymore, but are staying here in The Netherlands, particularly during warm winters. This means that Chiffchaffs are becoming a partial migrant in The Netherlands, instead of being a 'real' migrant. The last decades, we see this development more and more. [10]

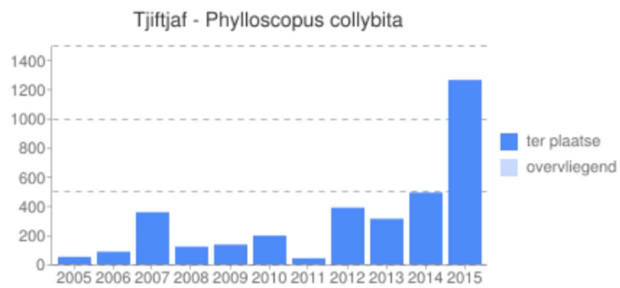

Figure 2. This graphic shows the number of observed Chiffchaffs in January from 2005-2015. It shows clearly that the Chiffchaff is hibernating more frequently in the Netherlands than ten years ago. It should be kept in mind though that the number of observers has increased a lot since 2005. However, this number did not rise as strong as the number of hibernating Chiffchaffs.

[9] Elphick J., 1996, 12-14
[10] Bergkamp P.Y., Boele A., 2005

§2.2: Timing

Timing is everything for birds. When they arrive too early at the arrival location, it is possibly too cold to find any food, so they will die. When they arrive too late, other birds will have taken the best breeding spots, which means a smaller chance on posterity (this is only the case during spring migration). But, how do birds know when it is the right time to depart?

Firstly, the decrease of daylight triggers hormonal changes which stimulate a laying on of subcutaneous fat, just under the skin, and the moulting. Moulting means that a bird replaces its feathers by shedding old feathers while producing new ones. Moulting takes a lot of energy and some bigger-sized bird species can't fly during this period. This is particularly the case in waterfowl. Therefore, it mostly happens in late summer, when less energy is needed. In this way, a bird is well-prepared for the migration. Not all bird species finish moulting before migration starts. Raptors and gulls for example, stop the moulting during their migration.
When the moulting is over, birds are ready to leave. This doesn't mean that birds just depart randomly. Birds will also take the weather conditions into consideration. Most of the time, birds won't leave when the sky is heavily overcast, during strong contrary winds, or in rain. Interestingly, most of the time birds seem to be able to forecast future wind directions. The result is that birds of a certain species can leave at once, after being delayed by unfavorable weather conditions. In general, the week of departure is more or less the same over the years, though day and hour are not, being dependable from the weather.[11]

As mentioned before, it may be risky to depart too early during spring migration. However, it is a well-known phenomenon that early birds, as long as they have enough fat reserves, may fly back a little bit when they migrate too far, and try their luck later on. In some species, there even seem to be early migrants acting as scouts. If they encounter poor weather conditions, they return, being a sign to later migrants of their species that it is not worth trying to go further yet.[12]

§2.3: Day and night migration

The fact that many bird species coordinate on star patterns, suggests they not only migrate by day, but also by night. For many birds, this is completely true. During a bright October night, it is very well possible to hear dozens of Song Thrushes and Redwings calling. These two species are examples of birds which fly both by night as well as by day. Also species like geese, stilts, ducks and swans migrate during the night. Many passerine birds, especially small insect eating birds like Blackcaps, Robins and Whitethroats, even fly only during the night. On the other hand, raptors and storks are only flying during the day.

A lot of research has been done on nocturnal migration, but there is still a lack of information about whether birds would like to fly during day or night. However, in the case of raptors and storks, it is easier to get an answer to this question. Both the big raptors and storks migrate using thermals, columns of warm, rising air. Thanks to these 'lifts', they can easily go up, without spending a lot of

[11] Idem, 26-28
[12] Idem, 28

energy. When they reached the top of the thermal, they will let themselves float in the direction they have to go. When they reach another thermal, the same process will repeat itself. Thermals only occur during the day, because warm air is needed. This is the reason that raptors and storks only migrate during the day and not at night.

Small birds are too small to profit from thermals, which means they have to fly actively. Both migrating by day and by night has advantages. However, according to Thomas Alerstam, it is logical that there are many birds which mainly fly by night. The reason for this is as follows: When a bird flies at night, the bird is able to rest and forage during the day. In this way, foraging time is maximized, and the bird will have more energy left to fly on during the next night. When a bird flies during the day, the bird can only forage around sunrise and sunset, meaning less energy supplies for the rest of the migration. However, the best strategy for birds would be to fly both during the days as well as by night, especially when birds migrate across regions with relatively poor conditions for energy deposition. In this way, birds can fly on when crossing regions without enough food supplies, and rest when there is enough food available.[13] However, this does not apply to all bird species: stilts and widgeons also forage by night, which means it does not make a big difference for these species to fly by day or by night.

§2.4: Migration routes

Most of the migratory birds follow certain (obvious) landmarks like valleys, coastlines or mountain ridges, mainly because those routes, called migration routes, are easy to remember and they know important stopover sites: areas to refuel, like the Wadden Sea in The Netherlands or saltpans in South Europe. Another characteristic of bird migration routes is that they tend to avoid water plains like seas. This means the birds, especially raptors which need thermals, are searching for places where the sea is the least wide. When we zoom in to Europe, Africa and West Asia, we can distinguish three general migration routes: One which goes via Spain, Gibraltar and Morocco, one via Italy, Sicily, Malta and Tunisia or Libya, and the last one via the Bosporus or Georgia, Eilat and the Sinai Peninsula. [14]

Figure 3. The three most common flyways of Europe, West Asia and Africa: One via Gibraltar, the second via Italy/Tunisia, and the third via the Black Sea and Eilat (Israel).

Even within a species, the migration route may vary. A good example is the Honey Buzzard *Pernis apivorus.* A big part of the Western Palearctic population migrates via Germany to Spain and then via Gibraltar to Africa. However, the more eastern breeding population flies the Sicilian flyway, while Honey Buzzards breeding in Eastern Europe or Russia mainly take the Black Sea/Eilat flyway.

[13] Alerstam T., 2009
[14] Elphick J., 1996, 86

Because all the birds have to go via certain routes to avoid dying in the sea or desert, they meet each other at one or other point. Therefore some places, like Gibraltar and Batumi (Georgia), are well-known for 'funneling', the phenomenon that migrating birds are pressed to one certain point in the landscape. In The Netherlands, we also know this aspect of bird migration, especially along the coast. This is because birds which migrate south-west in autumn, meet the sea. Therefore, all the birds have to shift their route a little bit to the south, ultimately resulting in some points where all the birds are funneled through one point. The migration site 'Breskens' is well-known for its very high migration counts in spring, because the Westerschelde is a big hurdle to take, and birds follow the shore inland to avoid crossing the water.

Not all the birds are flying from the north to the south and the other way around like in the examples above. Redwings *Turdus iliacus* for example, have a more east-west flyway. This species breeds in Siberia and North Europe, and has its wintering ranges in West Europe. On the southern hemisphere, south-north migration is even more common. This is because the farther you go north on the southern hemisphere, the warmer it gets. So, a certain 'exotic' species can breed in South Africa, but hibernate relatively close to 'our' Barn Swallows *Hirundo rustica*.

Summary

It is a well-known phenomenon in birds, that one part of the population migrates southwards in autumn, while another part stays near the breeding sites. This is called partial migration. Birds can encounter lots of dangers on their way north or south, so it is crucial to time the departure time very well. Some bird species mainly fly by night, while others fly only by day. A combination of both may be the best. In Europe we can see three different flyways during migration time, though within a species, not the same flyway is being taken by every individual. Funneling may occur when birds try to avoid certain areas like seas or deserts.

Chapter 3: Migration counting methods

§3.1: History of migration counting

Bird migration has been studied since a long time. Records of bird migration were made already 3000 years ago by Ancient Greek writers like Herodotus and Aristotle. Also the Bible mentions migration: in Job 39:26 is said: “Doth the hawk fly by thy wisdom, and stretch her wings toward the south?” and in Jeremiah 8:7 is mentioned: “Yea, the stork in the heaven knoweth her appointed times; and the turtle and the crane and the swallow observe the time of their coming.”
However, there were many ideas about bird migration, which from a modern viewpoint are absolutely untrue. Aristotle for example thought that summering Redstarts transform themselves annually into European Robins in winter, and that Garden Warblers, a summer visitor, changed into Blackcaps in winter. These explanations seemed plausible: Redstarts disappeared migrating to Sub-Saharan Africa, while at the same time European Robins were arriving from the north into Greece.

Aristotle also claimed that swallows had been found hibernating in holes in the ground. This is maybe the most famous myth about bird migration from earlier times. This idea even lasted until the late 19th century. A woodblock print from 1555 shows fishermen pulling up a full net with hibernating swallows from a lake. It was said that they came together in large numbers in fall, and sank down into the mud.[15]

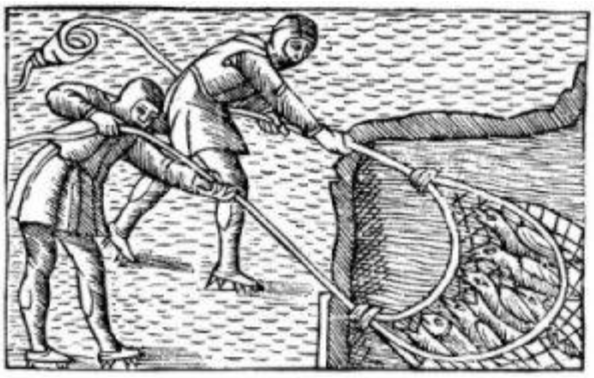

Figure 4. Fishermen pulling up a net-load with hibernating swallows. The belief that swallows hibernated in mud, lasted even until the 19th century.

From the late 19th century, researchers found out that these theories were not true at all. Research showed that birds were actually migrating. From off the 1930s, counting migration for amateur-birders was strongly on the rise in The Netherlands. Stimulated by findings of Tinbergen (1949), the migration counters united in a national network of migration counting sites. From the end of the 1960s, counting migration became less popular, probably due to upcoming radar research to invisible migration. This research showed that most of the migration passed by night. Possibly this was the reason for many counters to stop counting.

In other countries, birders were just counting on, like in Sweden (Falsterbo), Poland and Gibraltar. However, from the mid seventies, migration counting started again in the Achterhoek and Limburg. At the same time, there were some birding groups specializing in for example sea migration or migration of raptors. Something important for the counters was standardization of counting and elaborating. After some years, it became clear that field counting was as interesting as radar research, mainly because it showed some great similarities in both spatial and temporal patterns. Besides, it was an exciting activity for most of the counters.

[15] Lienhard J.H., *ANCIENT EXPLANATIONS OF BIRD MIGRATION,* http://www.uh.edu/engines/epi2228.htm

On March 14, 1981, the Landelijke Werkgroep Vogeltrektellen (LWVT) was founded. From then on, the number of local migration count groups rose explosively until 1993, when the LWVT stopped collecting migration counting data. This meant the number of counters dropped again. However, since 2000, there has been a renewed interest for migration counting, partly due to the founding of the website *www.trektellen.nl*. Today, there are more than 150 active migration counting sites spread over The Netherlands.

The main goal of the LWVT was to stimulate and coordinate the research to visible migration over The Netherlands, and to take care of the processing and publishing of collected data. Initially, the research targeted on the following points:

- In which numbers do birds migrate?
- In which period of the day and of the year is this the case?
- What direction do the birds take?
- Are there regional differences in The Netherlands, concerning the above-mentioned points?
- Are there trends in the changes of the number of migrants?[16]

§3.2: Ways to count visible bird migration

Of course, it is possible to count bird migration with the bare eye. However, there are some devices to make counting lots easier. When counting, it is important to have a notebook and a pen, to write down the species and the number of them. Of course, a tablet or smartphone with the trektellen-app is also a good way to note the migrating species and numbers.

Finding the birds can be done in two ways: By sight or by hearing. It depends on the type of species which method is the most useful. When someone is looking for raptors, storks, herons or seabirds, it will not be useful to pick up the birds by sound, just because they do not make lots of sounds. Also by sight, it can be very difficult to see them, especially on warm days with lots of thermals. On such days, the birds will fly very high, meaning it is sometimes almost impossible to see them with the bare eye. Therefore, binoculars are the first tool you might use during the count. For seabirds, a telescope may be more convenient. This is mainly because most of these species fly very far away, making it very difficult to determine the species even when using binoculars.

Smaller birds, like larks, pipits and finches, stand out more by their sounds than by their appearance, just because they are quite small. Most of the time, these bird species call a lot, making it very important to know all the little migration calls, if only to find them. Besides, it is an easy way to determine the species quickly.

While it is possible to just count with binoculars and/or a telescope, it might be useful to also have a camera and a sound recorder with you. Sometimes, a bird might pass which is not easily determined. When a photo is taken, identification of the bird is in most cases possible afterwards. The same applies for hearing a strange call you don't know. In this case, sound recorders are used to record the

[16] LWVT/SOVON, 2002, 9-11

sound. In this way, it is possible to determine the species later on the basis of the recorded call, which can be compared to online recordings of the same species.

§3.3: Counting methods

To get reliable and manageable data, it is important to standardize counts as much as possible. Therefore, the LWVT wrote instructions for counting visible land migration. At first, only birds within a radius of 100 meters were to be counted, because within this radius, it is almost always possible to determine the bird species correctly. Secondly, only birds found with the bare eye were counted. So, it was not allowed to look for birds with binoculars, telescope or any device a birder might have in use. Thirdly, it was important to note certain details, like the flight direction in one out of sixteen wind directions, flight behavior, the altitude of the birds etc. Lastly, observations were to be recorded by quarters or half hours.

Nowadays, the protocol of LWVT is hardly used anywhere, but some main points are still used on counting sites. In general, collecting data on sites comprises:

- The counter(s) stands always on the same spot
- Birds are picked up by the naked eye, binocular or telescope
- Local movements and long-distance migration are separated. Only the latter is counted.
- Fixed time units
- Secondary data, like the weather, has to be noted
- A spot, which is usable for a long time has to be chosen

It is not mandatory to keep all the above requirements exactly. This is mainly because of the fact that it is not realistic to expect that hundreds of counters will adhere to a tight schedule of requirements. Secondly, the storage of data on www.trektellen.nl has its limitations.

However, this doesn't mean there are no guidelines anymore. New guidelines are described by Bas van Dijk in the *Vernieuwde handleiding voor het tellen van zichtbare landtrek (Renewed manual for counting visible land migration).* In this manual, the most important guidelines have been summarized, ensuring the quality of the data.

According to this manual, it is still important to record the migration by fixed time units. It is up to the counter to choose to count in hours, half hours or quarters. Contrary to the old counting instructions, it is nowadays not mandatory to note the flight direction of all the individual birds. Only deviating flight directions have to be reported. In spring, this means all the flight directions which are not between north and east have to be noted down, and in fall, all the directions not between south and west are deviating.

Furthermore, there are some secondary data, like the weather, counting time, counters and possible details. Concerning the weather, it is important to use objective information. So, temperature has to be noted in degrees Celsius, wind power in the Beaufort scale, cloud cover in eights etc.

Lastly, it is now permitted to count with binoculars, telescope, sound recorder or any other device. Therefore, it is also not longer forbidden to count the birds outside the radius of 100 meters. So, nowadays, a counter can count every far-away flying bird, as long as he is able to determine the bird correctly. [17]

§3.4: Location of the migration site

Figure 5. Migration site De Puinhoop, Katwijk, well-known for very high numbers of birds, due to funneling. Besides, it has an unobstructed view in all directions.

There are some criteria which are important by choosing a migration site. At first, it is important to have an unobstructed view in all directions. Secondly, it is important to choose a location from which you can count during the time of the year you want to count. It is best to count not only one year, but several years from the same site. The data will be of greater value when they concern a longer period of time. This means there has to be looked to future developments. So, areas with young trees, periodic flooding by high water or industrial destination are "risk areas": there is a chance that there won't be the opportunity to count in the future.

Less determining when choosing a site, but still important, are a good accessibility of the site and the noise levels in the area. Quiet areas are especially of interest when counting passerine bird migration, because these types of birds are often determined by their calls.

A migration site can be placed everywhere, because migration takes place over the whole of The Netherlands. However, it might be a good idea to choose strategically. A hill ridge, river or forest edge can cause a change of the route or even a kind of funneling. This means the counter will be able to count more birds. For passerine birds like wheatears, whinchats or redstarts, even a row of stakes in empty farmland can be a route to follow. The same goes for rows of bushes for species like tits and goldcrests.

§3.5: Problems with bird migration counts

Studying bird migration is definitely no hard science. The data provided by counts are all provided by 'citizen science: All data is collected by non-scientists, in order to provide scientists with data to compute it and to give it sense. Therefore, a few side notes are in place.

Firstly, every counter is different. The young counters may hear all the sounds made by birds, while older counters will not hear the higher sounds. The same applies to loss in vision, for the eyes of young men are lots better than the eyes of older counters. This means that one person will hear and see more birds than another person, meaning there will be some differences in counted numbers.

- [17] Van Dijk B., 2008

Secondly, there is a big risk on duplications. For example, the migration sites 'De Puinhoop' (Katwijk), 'De Vulkaan' (The Hague) and 'De Bloedberg' (Monster) are all positioned in a line along the dune strip of South Holland. This means that many birds will pass De Puinhoop, as well as De Vulkaan and De Bloedberg due to funneling. These birds will all be counted thrice. This has to be taken into account, when analyzing the data provided by these sites.

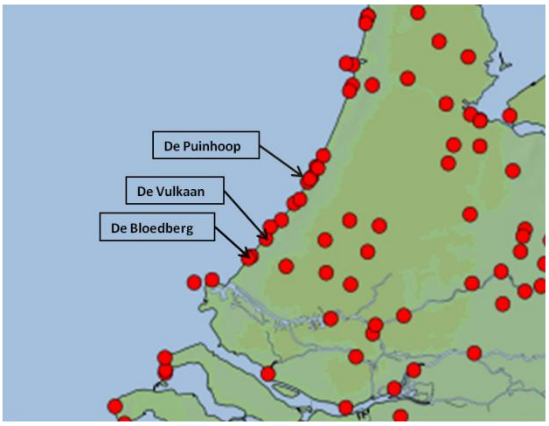

Figure 6. De Puinhoop, De Vulkaan and De Bloedberg are three migration sites positioned on one line. This means that there is the possibility, that certain birds are counted thrice instead of one time.

The opposite can be a problem too. There are regions where there are almost no migration sites, like in Drenthe and Friesland, while birds are also migrating over these regions. This means that it is well possible that too few birds are counted in these regions. This has to be taken into account too when analyzing the data.

Another difficulty is distinguishing local movements and long-distance migration[18]. Species like gulls and geese sleep together. In the mornings and evenings, they will all spread over the area around their roost. These birds can easily be confused with migrating birds. Especially in areas with large roosts, like the Biesbosch and the Oostvaardersplassen, this problem can occur easily. Therefore, it is important to know local movements very well, so the counter is able to distinguish migration movements from local movements.
Most counters are hobbyists with some spare time. This means that many sites are only manned in weekends. In this way, it is difficult to get a real image of migration, because birds are flying during the whole week. A problem closely connected to this, is that there is no standardization in the counts. In the time of the LWVT, each counter counted in the same way, which meant the data delivered by the counts was quite reliable. Nowadays, this is not the case anymore. Some sites are manned the whole week, others only during the weekends. Some counters are counting the whole day long, while others stop counting when the birds stop flying.

§3.6: Other methods to record bird migration

Nowadays, many other methods to study bird migration have been developed in addition to visible bird migration. One of them is radar recording. Development of aircraft for military use which were able to enter an airspace unnoticed, required detection devices operated by radar techniques. These devices work on the basis of beams of electromagnetic waves of short wavelength. After the Second World War, this technique brought great progress in research to nocturnal migration. On the radar screens, it was possible to 'see' birds. Swarms were depicted as clouds; single individuals were depicted as lines. Radar recording can be used to measure migration density, altitude of the migrating birds, directions and the speed of both diurnal and nocturnal migrants. Radar studies also provide insight into other matters, like if there is any link between the weather and the migration, if mixed migration flocks exist, etc. Radar has mainly showed how complex nocturnal migration is, and

[18] See Chapter §1.1

how important it is to get very detailed information in order to analyze and understand migratory movements.

However, it may well be that radar recording is waning. This is mainly because it is almost impossible to determine the species depicted on the screen. Only general information like the flight speed and body size can be given. Still now though, radar recording might be useful: it is still not known how birds are able to cross deserts and high mountains. Radar recording might help solving that problem.

Maybe the biggest development in bird migration studies is due to ringing. This method has uncovered lots of migratory routes, winter and summer quarters, migration times and survival rates. More details than any other method. There are lots of ways to ring birds, for example plumage dyes, wing tags and neck collars. The most used rings though, are metal rings attached around the legs of the birds, due to the special shape of their legs. The rings make it possible to identify an individual bird for his whole life, by using a certain code for every ringing station. When a ring is found, it is possible to calculate the minimum migratory distance and the maximum time a bird needed to cover the migratory distance.

Figure 7. A Robin *Erithacus rubecula* is being ringed. Small birds like this Robin get small rings around their legs. Bigger bird species, like geese, are mainly marked by rings around their necks. Raptors are given wing tags.

Still now, there is lots of criticism on ringing, for it is said that ringing is very damaging to the birds. However, this idea has since long been rejected. Unfortunately, it is quite difficult to recover a ringed bird, especially with passerine birds. The recovery rate in these species is below 1 per cent. For bigger birds, like geese, storks and herons, coloured rings and collars carrying readable inscriptions have been developed, making it possible to identify the ringed bird from quite a big distance. Therefore, the recovery rate is about 15 - 30 per cent in these larger birds.

Besides radar techniques, another technique developed quickly too after the Second World War: Telemetry. This technique uses small transmitters using electromagnetic pulses. During the first years, they only had a range of several kilometers, meaning that one certain bird had to be followed by airplane or by car. However, with the emergence of systems like GPS, it became possible to track birds with a satellite. During the 80s, the transmitters equipped with GPS were so heavy, that they were only to be used at large birds. Nowadays, it is possible to produce transmitters weighing only four grams, making it possible to attach these transmitters also to the smaller birds. Due to telemetry, many details like exact migration routes, stopover locations, fatality circumstance etc. have become known.

A stranger in the row is shooting. Nowadays, it is never used by researchers, but it was hundred years ago. This method was especially useful to identify species which were difficult to determine, like birds of prey, waders and ducks in eclipse plumage. Due to stricter rules around hunting birds, this method is not used for scientific reasons anymore.

The last method which is used to study bird migration is trapping. This means that birds are caught in nets. Most of the time, birds are ringed after being caught. At first, some small successes were achieved by using small fish traps, food lures etc. However, with this method, not many birds were caught. Therefore, the so-called trammel-nets came into vogue. However birds could easily dodge these, because they were made of visible cotton threads. Therefore, mist nets were developed, currently used at a large scale. With these nets, it is possible to catch the smallest birds like Goldcrests up to bigger species like pigeon-sized birds. The nets are mainly used in the birds favourite stop-over sites, in order to catch migrants over the whole migratory period. While previously nets were only used to catch and eat birds, nowadays the nets are mainly used to catch the birds in order to ring them.[19]

Summary

Bird migration has been known for centuries, but the real research began only in the late 19th century. In The Netherlands, the LWVT played a big role in monitoring data. There are multiple ways to count bird migration; binoculars, telescopes, cameras and sound recorders are the most-used devices. During the LWVT-period, there were lots of rules on how to count, but nowadays, counters have more freedom in counting. Some problems which may arise are the age of the counters, duplications and the distinction between local movements and real migration. In the course of time, other methods have been developed as well, like using radar, ringing, telemetry and even shooting.

- [19] Berthold P., 1993, 13-23

Chapter 4: Timing differences between 2000 – 2006 and 2007 – 2014

Hypothesis

1) Trends in 2000 – 2006

There are a number of factors, which influence the timing of migrants, which are:

I. The end of the annual reproductive period;
II. The conditions in the breeding area after the breeding season; and
III. The expected conditions in the passage and wintering grounds.

Recent climate changes may have altered the relative importance of these three factors, resulting in an advance or a delay in autumn migration.[20] Since climate has been changing in the same direction as before 2006 (warmer springs e.g.), I expect a similar development of timing of autumn migration.

2) Timing differences between species which hibernate in NW-EU, in SW-EU and in Africa

Several studies have pointed out that long-distance migrants tend to advance their migration, while short-distance migrants tend to delay their migration, as shown by for example Jenni & Kéry and Mills. Both studies, done on ring roads, showed that long-distance migrants tend to advance their return to their hibernating areas, while short-distance migrants tend to delay their migration.[21] [22] The study to the period of 2000 – 2006 did not show any differences between the three groups though. However, I still think that the further away a bird hibernates, the more it advances its migration.

3) Correlation between the main migratory period and the peak migratory period

I expect that when the main migratory period (p10_90) advances, the peak migration period (p25_75) will advance too, and that when the main migratory period delays, the peak migration period will be delayed too. I think so, because the p10 and p25 mostly follow each other up quickly, meaning that there will not easily be a lot of differences. Besides, I think it is a more or less proportional correlation.

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[20] Jenni L. & Kéry M., 2003
[21] Idem
[22] Mills A.M., 2005

4) *Correlation between the median migrating date (P-50%) and the 10%- and 90%-percentiles*

The study to the period 1980 – 2006 showed that the onset of the migration advanced, while the end of the migration was delayed.[23] I expect these trends to be continued.

Selection of data

The selection of the data was done in exactly the same way as in the research to the period 1980 – 2006. This selection was (and is) done as following:
The autumn was defined as the period between the 24th and the 48th week, which is the period from the 10th of June until the 1st of December. To define the weeks, standard weeks are used. The first standard week covers 1-7 January, the second 8-14, and so on. Counts were only used when starting and finishing times were known. Besides, these counts had to be started in the period until two hours after sunrise, with a minimal counting length of one hour.
Thereafter, the migration sites were selected where there had been more than 20 counts a year (as well in spring as in autumn) during at least three years. The migration sites near the coast were disregarded, because there were not many of them during the LWVT-period (until 1993), but due to the large numbers of migrating birds (funneling), they were able to determine the annual pattern drastically.
Only birds with an average number per hour higher than 0.3 during the period of 1980-2006 were included, which meant only 37 species remained. Lastly, Common Starling *Sturnus vulgaris* and Greylag Goose *Anser anser* have been left out of the selection, due to their clearly visible bimodal migration pattern.

Calculations

The timing of the yearly autumn migration is based on percentiles. This method indicates the day numbers on which 10, 25, 50, 75 and 90% of the autumn total has passed. The period between the 10% and 90% percentiles has been designated as main migratory period; the period between the 25% and 75% as the peak migratory period.
At first, the average number of birds per counting site and per count has been calculated. These numbers have been converted to average values per counting site per standard week, and thereafter to averages per standard week, in which all the counting sites are included. These averages are added together to season sums a year, which is the autumn total.
In this way, it was possible to calculate the dates on which 5, 10, 20, 25, 50, 75, 80, 90 and 95% (P-5%, P-10%, etc.) of the total migrants during autumn has passed. These dates are shown in *Attachment 1*. Thereafter, the dates are converted to day numbers to be able to calculate changes in days. This was done as following:
The average day number of the first period was subtracted from the average number of the second period. The result has been divided by 7, for there are 7 years from 2007-2014. For example: The P-25% of the second period is 192, the P-25% of the first period is 184 (Great Cormorant). 192 – 184

[23] Van Turnhout C., Troost G. et al., 73

gives a result of 8. 8 divided by 7 gives a result of 1,143, which means that the date on which 25% of the total number of migrants in a year has been delayed by 1,143 days a year.

Next, the 37 species have been divided into three groups: A group with species hibernating south of the Sahara, a second group with species hibernating in Northwest Europe and a third group which hibernates in Southwest Europe. For every P-value, the average has been calculated in each group.

For the third hypothesis, I have been looking at the differences between certain P-values. P25-75 means the number of days which are between P-25% and P-75%. For example: During the first period, there were 108 days between the P-25% and the P-75%. During the second period, this has been advanced to 121 days (Great Cormorant). To calculate the differences, 108 has been subtracted from 121. This result was divided by 7, giving a result of 1,857. This means that the period between P-25% and P-75% has been extended by 1,857 days a year. A positive result means a delay in migration, while a negative result means an advance in migration. -1 for example means that the date on which a certain percentage has passed, has been advanced by one day a year.

To examine whether a change is significant or not, I chose the boundaries ≥ 1 or ≤ -1 as being proportional enough, for there are not too many values greater than or equal to 1 or -1. Besides, 1 and -1 are clear numbers and easy in use.

P-5% and P-95% have been included in the tables to also show the very beginning of the migration. The numbers though may not be very representative for a certain species. Tits for example can show invasive-like behavior, which can disturb especially the P-5%, for at this point, not a lot of birds have passed, meaning that a possible change is not very representative for a species.

For the first hypothesis, I have looked to *Table 3* and *Table 4*. If a certain value, for example P-10% of Great Cormorant was negative in *Table 4*, I have been looking if it was negative too in *Table 3.* If so, I counted it as corresponding. If not, I counted it as nonconforming. This has been done for all the 185 values. When, according to *Table 3*, there was no change in timing, I have counted it as ½ corresponding and ½ nonconforming. I have set the boundary for trend/no-trend on 4 points, for this means that 4 out of 5 values stayed the same, which should be enough to distinguish whether it is a trend or it is not a trend.

P-20% and P-80% have been left out from *Table 5, Table 6* and *Table 7,* for they were not useful in analyzing the differences between the three groups of species, as these percentiles show neither the important data about the onset nor about the end of the migration of the selected species.

It would seem plausible to calculate averages for each group of migrants or for each species individually in *Table 5, Table 6* and *Table 7.* This is not possible though, because all the values from P-5% until P-95% are cumulative. It's therefore that I have not calculated averages for these groups or individuals.

For the differences between the three groups of migrants, I have only been looking to the averages of the P-25%, P-50% and P-75%, for these three dates are the most important when looking to differences between certain species.

Results

Table 3 shows the changes of the period 2007 – 2014, while *Table 4* shows the changes of the period 2000 – 2006. In total, I have counted 95.5 corresponding values, and 89.5 nonconforming values. 11 species show ≥ 4 corresponding values, which are: Great Cormorant (4), Sparrowhawk (4), Barn Swallow (4), House Martin (4), Tree Pipit (5), Meadow Pipit (4½), Yellow Wagtail (5), Dunnock (4½), Blue Tit (4), Tree Sparrow (4½) and Goldfinch (4).

These changes are also shown visually in *Figure 8* for the period 2000 – 2006 and *Figure 9* for the period 2007 – 2014.

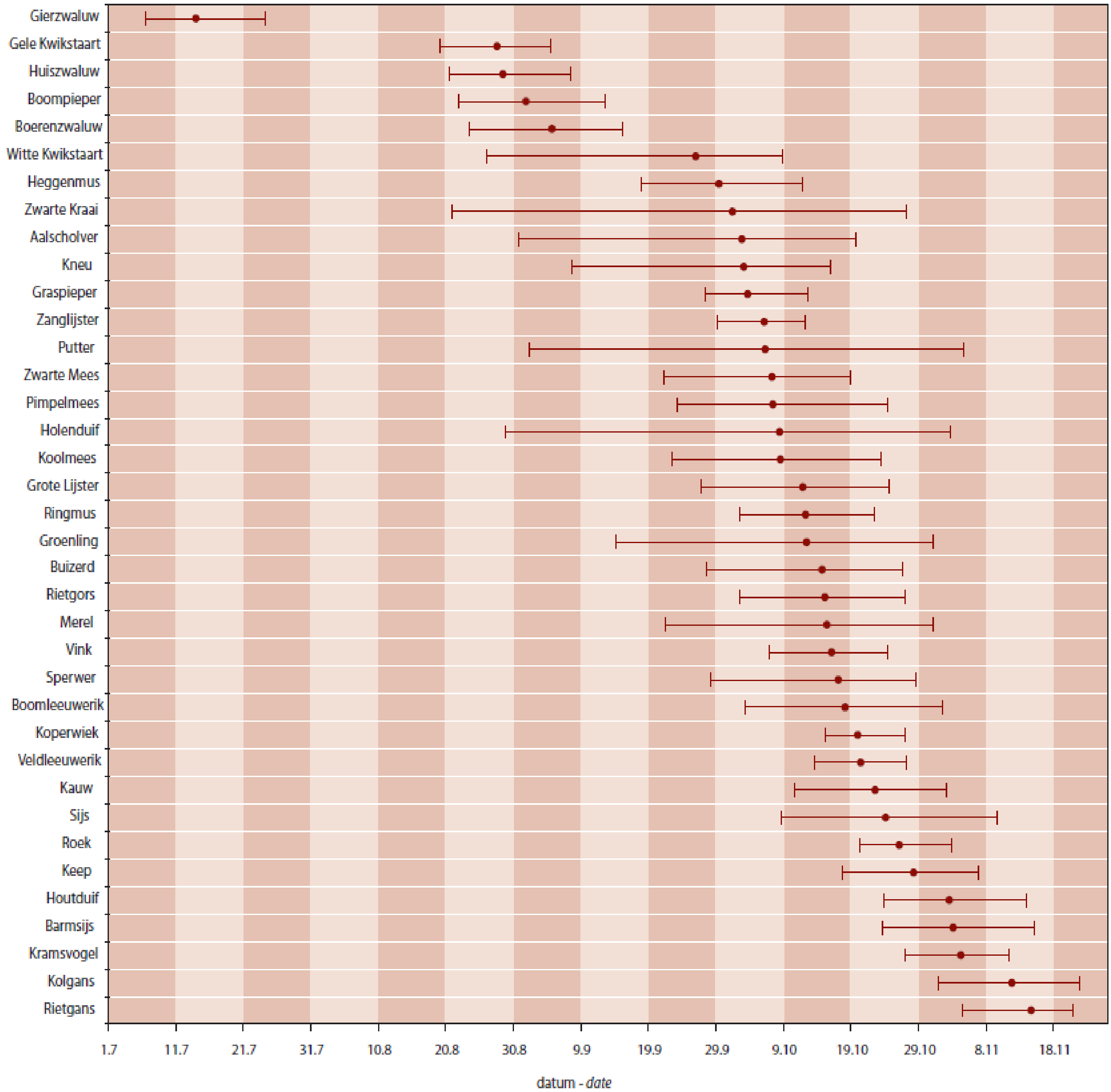


Figure 8. Timing of visible autumn migration in The Netherlands in 37 common migrants in 2000 – 2006. Shown are median dates (the dots in the middle of each beam) and main migratory period (P-25% - P-75%) (P-25% is the beginning of the beam, P-75% is shown as the end of the beam).

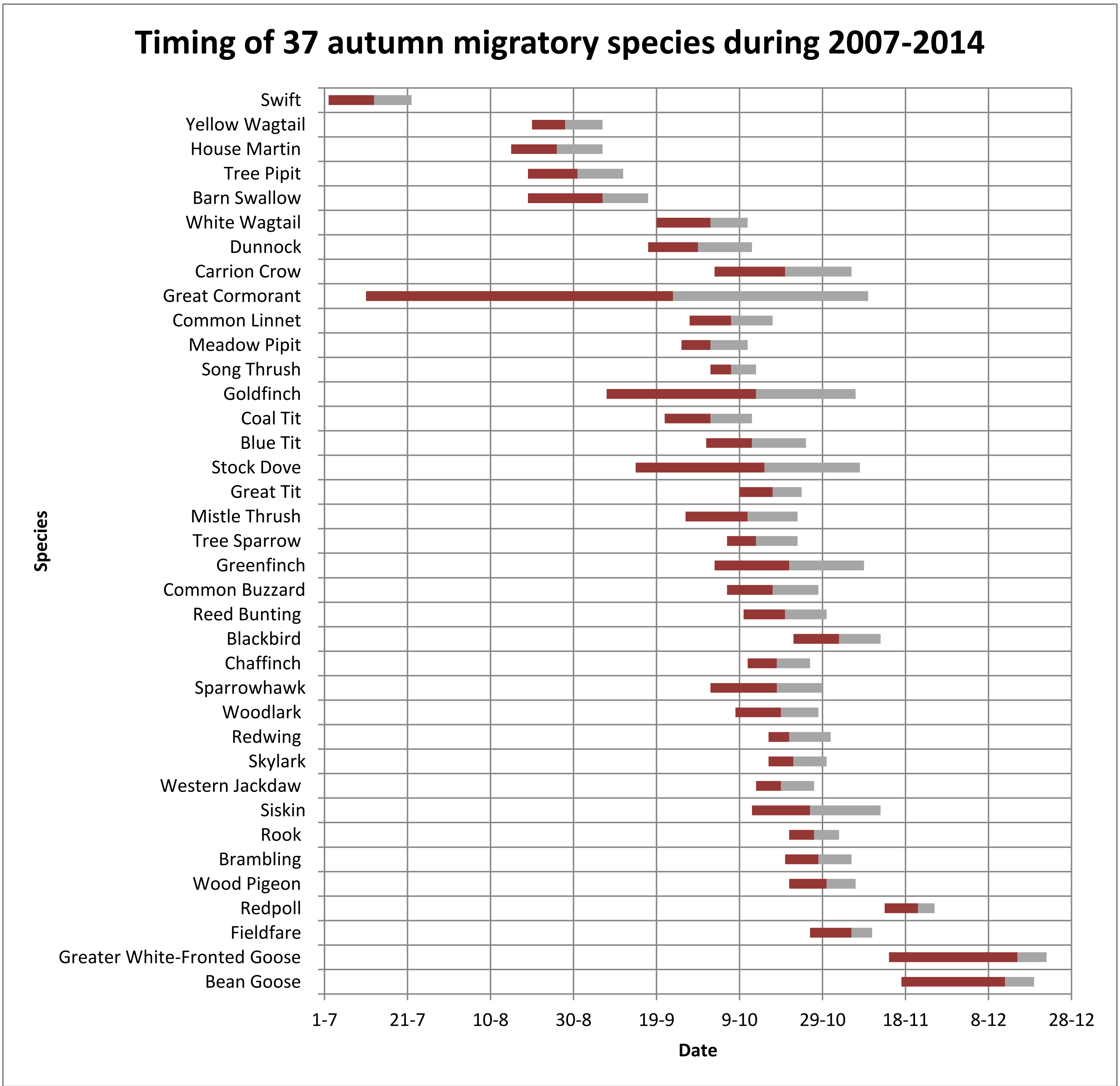


Figure 9. Timing of visible autumn migration in The Netherlands in 37 common migrants in 2007-2014. Shown are median dates (the place of the colour change) and main migratory period (P-25% - P-75%) (P-25% is the beginning of the beam, P-75% is shown as the end of the beam).

In the group with Trans-Saharan migrants (*Table 5; Attachments*), almost all species tend to advance their migration. Only Swift *Apus apus* has a small delay during the start of its migration, though this change is not significant. At the end of its migration, it even has a significant advance. Especially the beginning of the migration has advanced a lot in this group. The P-25%, the P-50% and the P-75% advance, but not as strong as the very first part of the migration. The P-25% advances with 0,400 days a year, the median date only advanced 0,171 day a year on average and the P-75% advanced 0,229 days a year on average in this group. However, the end of the migration (P-90% and P-95%) advances > 0,4 days a year. This causes the main migratory period to extend significantly, with the exception of the Swift.

In the group with bird species migrating to Southwest Europe (*Table 6; Attachments*), numbers are quite different. Most birds are nor delaying their migration, nor advancing it. Exception is the Great Cormorant, which delays especially the second part of its migration very strong. Its P-25% delays with 1,143 days a year, but its median migration date advances with 6,857 days, and its P-75% with 3,000 days a year. Wood Pigeon is one of the only species which has advanced its migration, together with Common Linnet *Linaria cannabina,* which shows at first a significant delay, though the end of the migration has advanced significantly. It is especially the median date which has been delayed strongly in this group with 0,442 days a year. The P-25% and the P-75% have been delayed with respectively 0,169 and 0,091 days a year.

Numbers are again different in bird species migrating to Northwest Europe (*Table 7; Attachments*). This group has by far the most significant changes in it. Lots of species have advanced their migration significantly, both the onset and the end of the migration. The Stock Dove *Columba oenas* shows a very consistent advance through the whole of its migration. Siskin *Spinus spinus* is probably the only species with a real delay in its migration. This species has mainly delayed the end of its migration. Notable is the high number of significant changes during the first part of the migration. Especially Mistle Trush *Turdus viscivorus*, Blue Tit *Cyanistes caeruleus* and Redpoll *Carduelis cabaret/flammea* show a very big advance; Blue Tit even 8,571 days a year. Fieldfare *Turdus pilaris* is the only species in which the end of the migration advances significantly. Especially the P-25% and P-75% have advanced, with respectively 0,293 and 0,327 days a year. The median date has only advanced with 0,082 days a year.

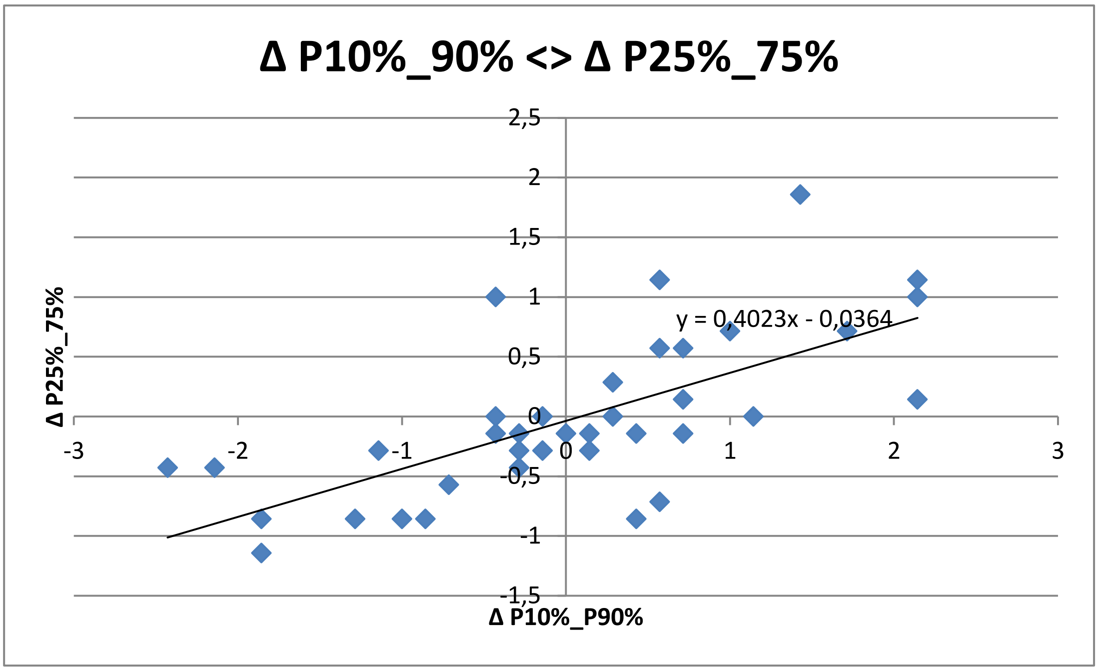
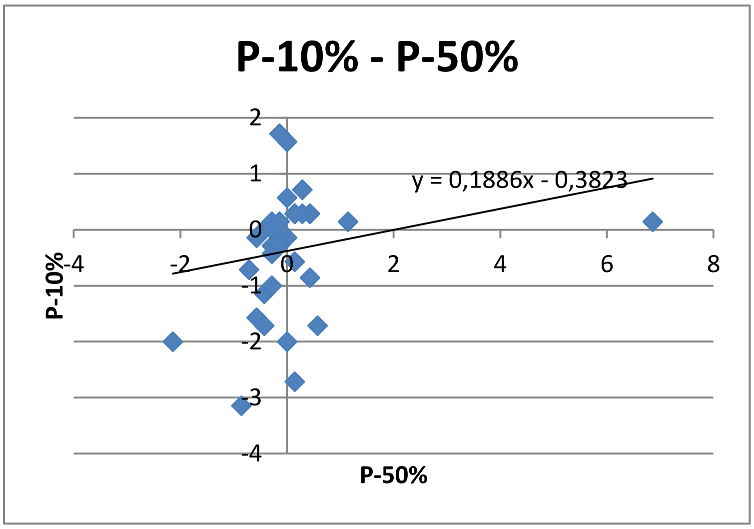


Figure 10. The relation of the main migratory period and the peak migratory period during autumn in 37 common migrants in The Netherlands.

Figure 10 shows that the Δ P10%_90% and the Δ P25%_75% are not proportional to each other. The formula of the trend line shows that the P10%_90% extends around 2,5 times as fast as the P25%_75%. This means that when the peak migratory extends, the main migratory period extends two times as fast. In the same way, we can read from the graph that an extension in the main migratory period almost always brings an extension of the peak migratory period. The other way around, a decrease in the length of the main migratory period is often connected to a decrease in the length of the peak migratory period.



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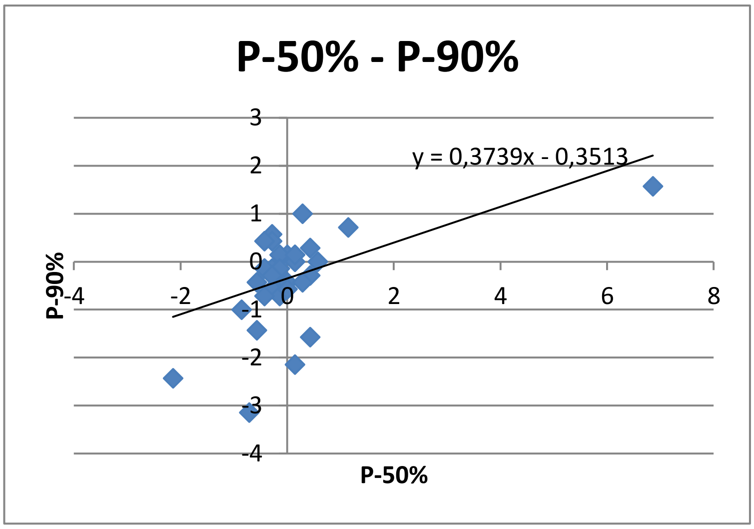

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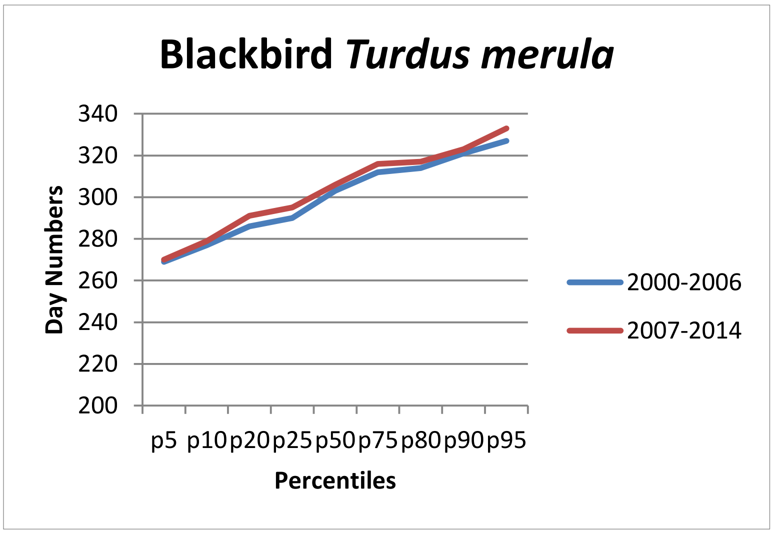
Figure 11. Relationship between changes in median date (P-50%) and P-10% and P-90% for 37 common autumn migrants in The Netherlands.

Figure 11 shows the relation between the median date and the onset and the end of the migration. *11a* shows that the onset of the autumn migration has advanced slightly. *11b* shows the same for the end of the migration, which has advanced slightly too, more or less as strong as the onset advanced.



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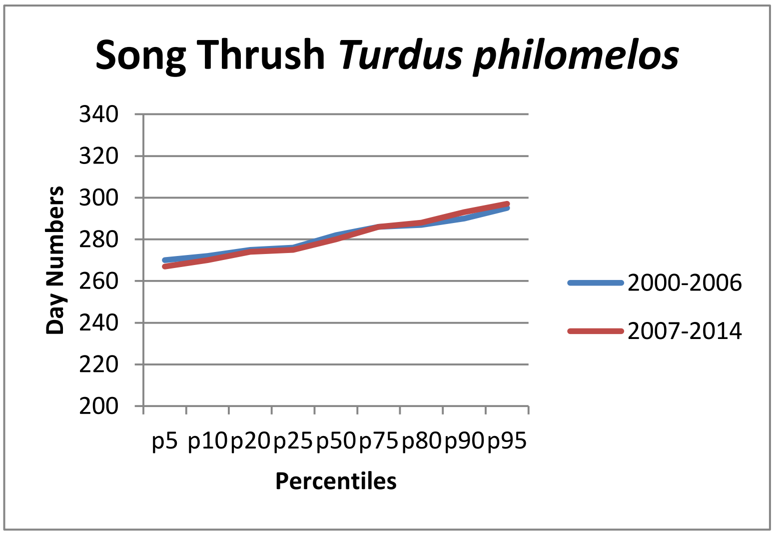

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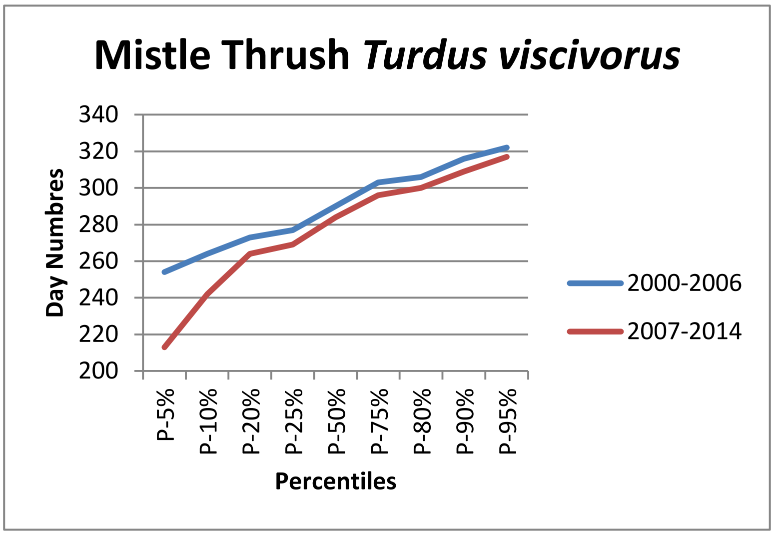

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Figure 12. Timing differences between three *Turdus*-genus species, which all three breed in The Netherlands.

Blackbirds, Song Thrushes and Mistle Thrushes all breed in The Netherlands and are all three from the same genus *Turdus*. *Figure 12* shows significant changes between these species though, especially during the first part (P-5% - P-25%). There are fewer differences in the rest of the migration period, though still Mistle Thrush is the only species really advancing its migration, while there is almost no difference in timing in Song Thrush. Blackbird has delayed its migration only a little bit. Also the length of migration differs a bit. For Mistle Thrushes, the main migratory period takes the longest, with 52 – 67 days. Blackbirds and Song Thrushes migrate during a much shorter period of respectively 44 and 18 – 23 days.

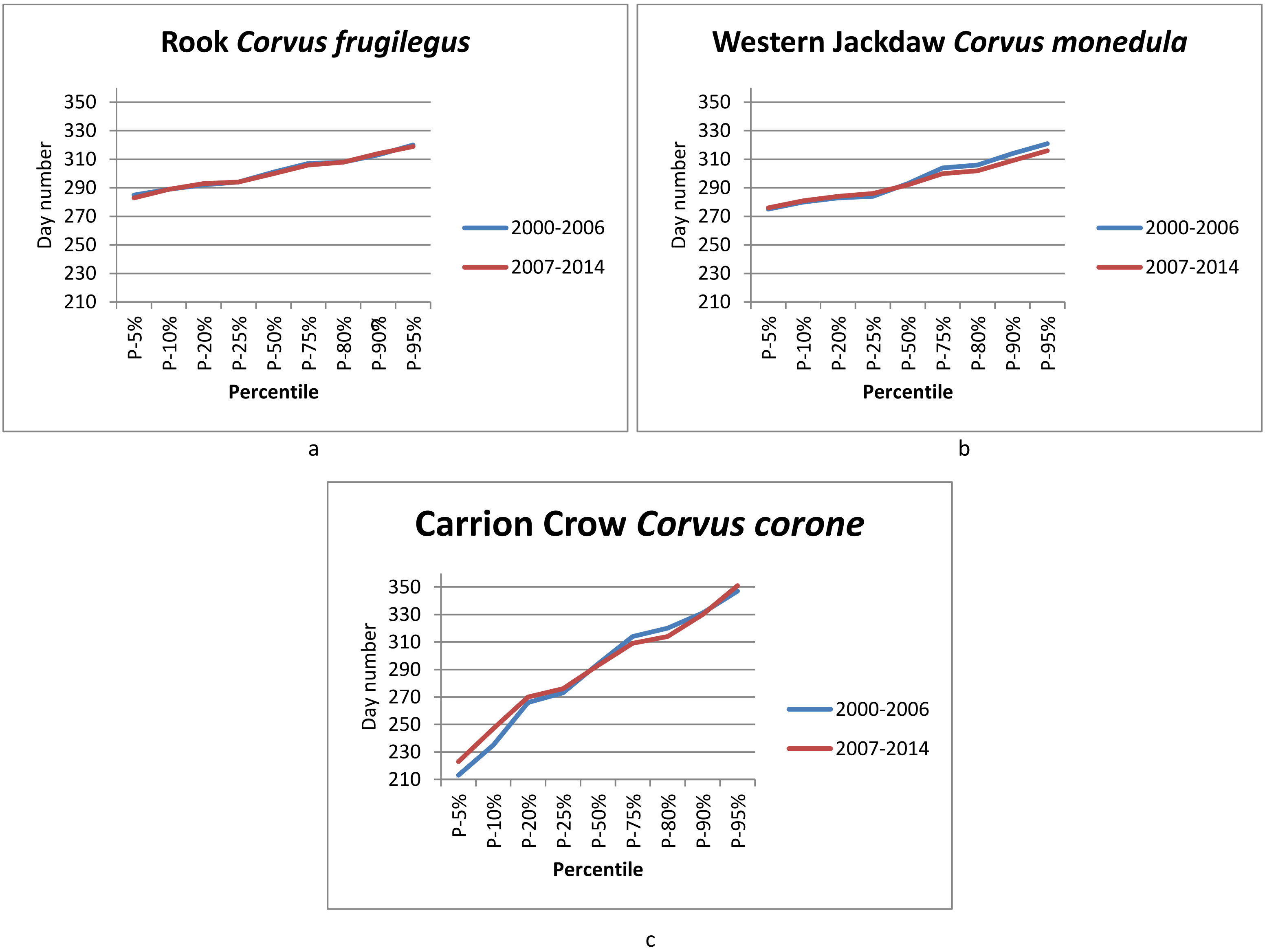

Figure 13. Timing differences between three *Corvus*-genus species, which all three breed in The Netherlands.

All three of the above species breed in The Netherlands and are from the genus *Corvus*. Still, there are some remarkable differences in their autumn migration timing, which is showed by *Figure 13.* For Rooks, almost no timing changes were found. For Western Jackdaw though, the beginning of the migration did not change; the end (P-50% - P-95%) though did. Carrion Crows have especially delayed the onset of their migration (P-5% - P-20%). The third quarter (P-50% - P-75%) of their migration has been advanced though. Another point is the big difference in the duration of the migration. The main migratory period of Carrion Crows takes 83 – 96 days, while the main migratory period of Rook and Western Jackdaw is respectively 24 – 25 days and 28 – 34 days.

Conclusion

Answer on the main question: Are there timing differences in the periods 2000 – 2006 and 2007 – 2014?

There are definitely timing differences between the two studied periods. Per species, these changes differ a lot, though in almost all species, changes are clearly visible. Only White Wagtail, Song Thrush, Redwing, Common Buzzard, Great Tit and Rook show changes which only changes slightly.

The length of the migration though did not change that much, as is shown by *Figure 11* and *Table 9*.

Hypothesis 1: Trends of 2000 – 2006

Only 51.6% of all values show a corresponding value, while 48.4% shows a nonconforming value. There are only eleven species out of 37 (29.7%) which show a trend with ≥ 4 corresponding values. Four species out of these eleven, are species which migrate to Africa, while there are only five bird species in the Trans Saharan group. Furthermore, two species are from the group which migrates to Southwest Europe (out of eleven); five species are from the group of species which migrates to Northwest Europe (out of 21).

With only eleven species out of 37 showing the same changes as in 2000 – 2006, and so showing a trend, this hypothesis turns out not to be true.

Hypothesis 2: Timing differences between species which hibernate in NW-EU, in SW-EU and in Africa

Table 8 shows an overview of the averages for each three groups. The differences between these three groups are quite big. For the Trans-Saharan group, the three watched at percentiles (P-25%, P-50% and P-75%) all show an advance, especially in the P-25%. In the group with Southwest Europe migrants, a delay is visible in all three percentiles, most strongly in the median date. In the Northwest Europe migrants, all dates in the three given percentiles have been advanced, the most in the P-75%. The median date only advanced with 0,082 days a year.

This hypothesis turns out to be partially true. It shows that migrants to Africa advance their migration quite strongly, which I had expected to happen. However, I did not expect this difference between the Southwest Europe – group and the Northwest Europe – group, which I had expected to be the other way around.

Hypothesis 3: Correlation between the main migratory period and the peak migratory period

Figure 10 definitely shows a positive correlation between the main and the peak migratory period. After all, it shows that when the main migratory period extends, the same happens to the peak migratory period. They do not extend or decrease proportionally though, which I did not expect beforehand.

Hypothesis 4: Correlation between the median migrating date (P-50%) and the 10%- and 90%-percentiles

The results showed that the onset of the migration as well as the end of the migration advanced, in contrast to what I had expected to happen. It is interesting to see that the end of the migration period has advanced strongly with respect to the onset of the migration, which is quite different from the results from 2000 – 2006. During that first period, the onset of the migration advanced, while the end of the migration was delayed.

Discussion

Comparing with 2000 – 2006

For the research to the period 2000 – 2006, *Table 4* was created with the help of a statistical program. I did not have this program, and therefore, it was not possible for me to compare the changes properly to the period 2000 – 2006. I could only compare whether a certain species had still advanced its migration or not. I was not able to compare numbers.

Big differences in some species

Great Cormorant, Blue Tit, Mistle Thrush, Skylark and Redpoll all three show very big changes in certain periods. Great Cormorant has a change of 6,857 and 3,000 days a year in respectively P-50% and P-75%, which brings the average of the Southwest Europe migrants up to a delay of 0,154. In the same group, Skylark has a delay of 4,571 days a year in P-95%. Both are values totally unconnected with values in the other percentiles. This should be kept in mind when watching the averages.

Also in the group with Northwest Europe migrants, we see some numbers which are too high in comparison with the other percentiles. Blue Tit for example shows an advance of 8,571 days a year in P-5%, which is much and much higher compared to the other percentiles. The same applies to Mistle Thrush (-5,857 days in P-5%, -3.143 in P-10%) and to a lesser extent also to Redpoll (-3,000 in P-5%). Also in this case, they cause the average to lower quite a bit.

Inaccuracies in counting migration

Like discussed in Chapter §3.5, there are some inaccuracies in counting migration. It is well possible that estimations of the number of birds have been too high or too low, due to duplications or no standardization in the counts.

Strange values in Bean Goose and Greater White-Fronted Goose

Surprisingly, the migration of Bean Goose *Anser serrirostris/fabalis* and Greater White-Fronted Goose *Anser albifrons* did not advance during the whole period, while previous research showed both species are advancing their migration significantly.[24] According to *Table 3*, both species did advance the onset of their migration, though the second part stayed equal or even delayed. A possible explanation, is that both species are counted as migrating in December, while it is likely to be migration from or to their roosts. This may influence the data quite a lot, because it seems as if there are lots of geese migrating during the end of December, while that is not always the case.

Probably due to this problem, *Figure 8* does not correspond to the values of 2000 – 2006 in *Table 1.* There may have been done some corrections to the figure, in order to compensate for the strange dates given.

Further research

Of course, further research could mainly focus on whether current trends will continue or not. As mentioned in *Conclusion*, only half of the species continues its trend of 2000 – 2006. It would be very interesting to see whether it will be the same species continuing their trend in the next period, or if there will be others.

Furthermore, the length of the migration did not change a lot in this period, while it did in 2000 – 2006. Further research may focus on this point as well.

Lastly, there should be done research on the strange values in Bean Goose and Greater White-Fronted Goose, in order to come to know if the changes on the percentiles are influenced by wrong migration counts in December.

[24] De Jong, A. (4 October 2013), http://www.naturetoday.com/intl/nl/nature-reports/message/?msg=19401

Chapter 5: Three species with notable timing changes

§5.1: Barn Swallow *Hirundo rustica*

General information

Figure 14. Barn Swallow *Hirundo rustica*

The Barn Swallow *Hirundo rustica* is a well-known species in The Netherlands, also among non-birders. Barn Swallows breed almost everywhere between 30° and 60° north. Barn Swallows breeding in Europe hibernate south of the Sahara; those breeding in Asia hibernate in Southwest Asia, while those breeding in North America migrate to Latin and South America during autumn.[25] In The Netherlands, Barn Swallows stay from April to the beginning of October. The number of breeding Barn Swallows is estimated to be around 100.000 to 200.000. Especially from 1970 to 1985, the numbers fell dramatically, from almost 450.000 to around 100.000. The last few decades, the Dutch population seems to recover bit by bit, though the Barn Swallow is still found on the 'Rode Lijst'[26].

Migration Pattern

The migration of Barn Swallows takes place between the end of July and the beginning of October. Most years, the biggest numbers pass between half August and half September. The migration of Barn Swallows is not being funneled at all. The highest numbers of migrating Barn Swallows in the inland in autumn are 10598 on September 23, 2010 (Aan de Majoor, Koningsbosch) and 9028 on September 22, 2010 (Ketelbrug/Kamperhoek); near the coast the numbers are much lower: 2360 on August 21, 2011 (Camperduin) and 885 on September 9, 2012 (Castricum)[27]. A well-known phenomenon in Barn Swallows is that huge groups can stay for quite a long time on the same place, usually above marshes and reed beds. In summer, most Barn Swallows migrate in groups, while twittering busy. Migrants could pass low, though on sunny days, they can fly by in tight flight.

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[25] IVN Vecht- en Plassengebied, Lucienne van Ek, *Boerenzwaluw (Hirundo rustica)*, August 1989 (Grasduinen) http://www.ivnvechtplassen.org/ivn_vogels_veen_weide/Boerenzwaluw_Hirundo-rustica.html

[26] Vogelbescherming.nl http://www.vogelbescherming.nl/vogels_kijken/vogelgids/zoekresultaat/detailpagina/q/vogel/11/tab/Aantal

[27] Trektellen.nl, http://www.trektellen.nl/species/records/1/-1/271/-2/0?g=&l=&k=

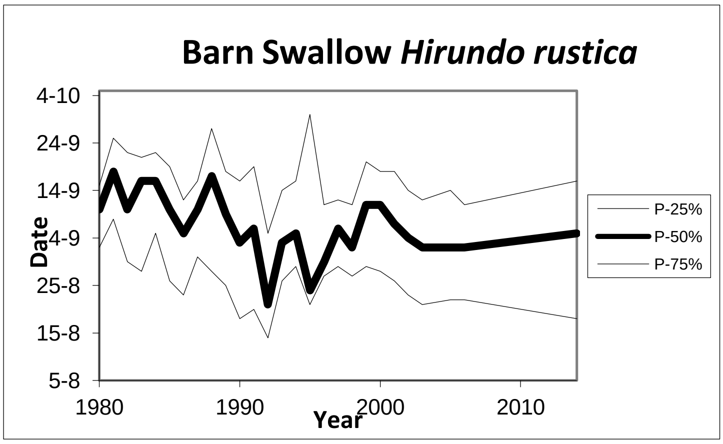

Figure 15. Changes in Barn Swallow *Hirundo rustica* in autumn 1980 – 2014, expressed in P-25%, P-50% and P-75%. Data from 2007 – 2014 was only available in the average percentiles.

Differences comparing 2000 – 2006 and 2007 – 2014

Figure 15 and *Figure 16* visualize the changes of Barn Swallow in the two periods. Especially the first part changes greatly, just like the other birds from the Trans-Saharan group, which is also being studied by Jenni & Kéry. It is interesting though that it is mainly the first half of the migration which advances. The blue line, which indicates the date when there would be neither an advance nor a delay, is only touched from the median date. Only from then, the migration of Barn Swallows stays more or less during the same time period.

Figure 14 though shows that the median date and the P-75% have delayed. This is not shown by the average percentiles, so it would be interesting to see whether the advance of the Barn Swallow will continue or not.

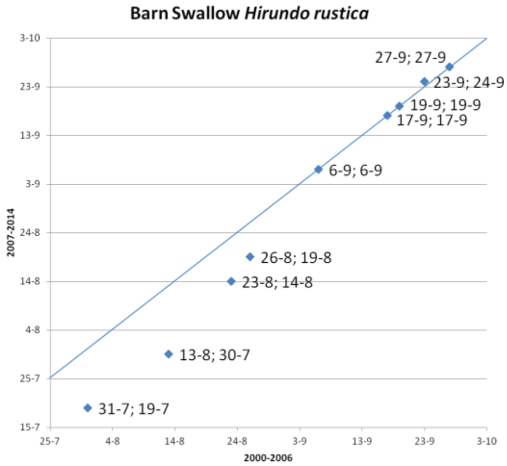

Figure 16. Changes of Barn Swallow *Hirundo rustica* visualized. The bigger the distance to the blue line, the bigger the advance or delay in migration.

Differences in numbers per year

Figure 17 shows that the number of migrating Barn Swallows has been quite stable during the last decade. It also shows that 2010 and 2011 were years with an above average number of migrating Barn Swallows. It is therefore that many day records have been broken in those two autumns. The reason that the number is stable is because the migration of Barn Swallows is not really dependable from wind direction. Besides, it is not an invasive species, so every year, more or less the same number migrates south to Africa through The Netherlands.

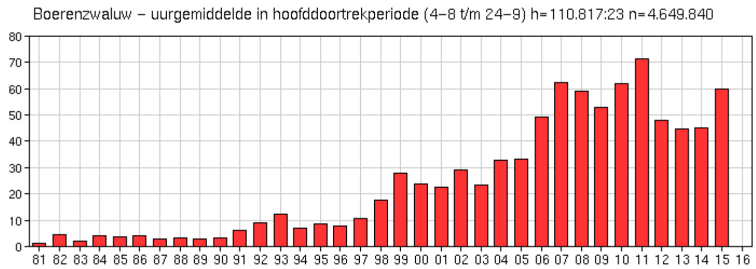

Figure 17. Hourly averages of migrating Barn Swallows for each year. It shows an strong upward trend over the last few decades.

§5.2: Wood Pigeon *Columbus palumbus*

General Information

Figure 18. Wood Pigeon *Columbus palumbus*

Wood Pigeons have a wide distribution range. They breed in almost the whole of Europe, except in some southern regions and in Lapland. Further east, they breed in Turkey, Siberia and parts of the Middle East.[28] In autumn, northern breeding Wood Pigeons migrate to Southwest Europe and North Africa, while those breeding in West Europe don't migrate. The number of breeding Wood Pigeons in the Netherlands is being estimated on around 450.000 couples. That is much less than the estimation around 1975. At that time, the number of breeding couples was estimated on 500.000 – 800.000 couples. The decline in this number is mainly due to changes in agriculture, which became more large-scaled.[29]

Migration Pattern

Wood Pigeons mainly migrate between half October and half November, though this can vary from year to year. Most migration takes place on clear days with a slight tailwind. Wood Pigeons from Scandinavia have a very narrow migration track to Spain via Germany. Therefore, wind from the east is required to have large numbers of Wood Pigeons migrating over The Netherlands. By far the biggest part is counted southeast of the line Enschede – Eindhoven. Therefore, almost all the high numbers have been counted in the southeast of The Netherlands: 260090 on November 1, 2014 (Vlagheide, Schijndel) and 247200 on November 1, 2014 (Loozerheide, Weert). Near the coast, the highest number has only once passed the 10000-mark, on October 27, 2005 (De Vulkaan, Den Haag).[30] Wood Pigeons are known for migrating in huge groups up to sometimes tens of thousands individuals a group.

[28] Svensson L., Mullarney K. & Zetterström D., 2005

[29]Vogelbescherming.nl http://www.vogelbescherming.nl/vogels_kijken/vogelgids/zoekresultaat/detailpagina/q/vogel/89/tab/Aantal

[30] Trektellen.nl http://www.trektellen.nl/species/records/1/-1/233/-2/0?g=&l=&k=

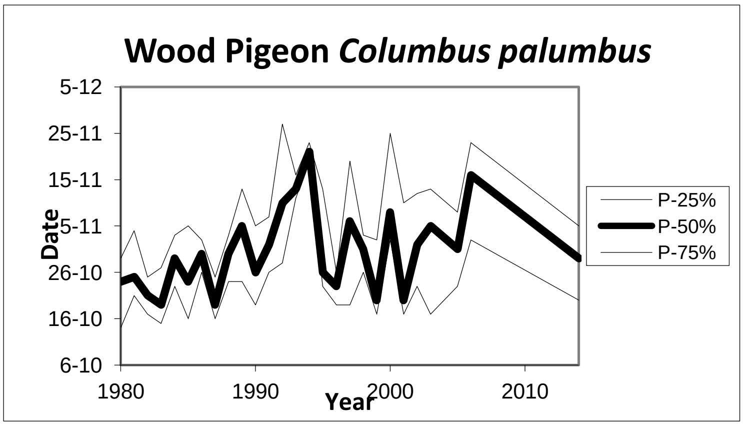

Figure 19. Changes in Wood Pigeon *Columbus palumbus* in autumn 1980 – 2014, expressed in P-25%, P-50% and P-75%. Data from 2007 – 2014 was only available in the average percentiles.

Differences comparing 2000 – 2006 and 2007 – 2014

In *Figure 19* and *Figure 20* is clearly shown that the migration of the Wood Pigeon has advanced a lot over the years. *Figure 17* shows almost all the percentiles, except for P-95%, under the blue line, which means the migration has only advanced during the past couple of years. When looking to *Figure 19*, it looks as if there has been a very strong advance in the migration dates, though this is only relative to 2006, not to the whole period, of which the average is lower.

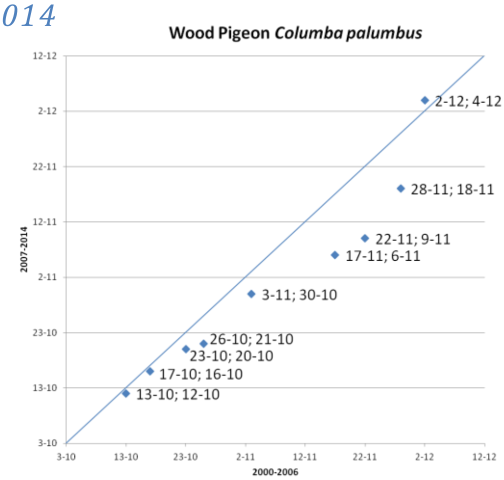

Figure 20. Changes of Wood Pigeon *Columbus palumbus* visualized. The bigger the distance to the blue line, the bigger the advance or delay in migration.

Differences in numbers per year

Each year, in total a hundred of thousands Wood Pigeons migrate over The Netherlands. It however differs a lot per year how many. This is not because it is an irruptive species, though it is more because variable wind directions. Wood Pigeons do have a very narrow migration track, which usually only brushes the east of the Netherlands. During autumns with lots of southeastern winds though, the migration track shifts east. It is therefore that there are years with very low numbers of migrating Wood Pigeons, like the autumn of 2009, like shown in *Figure 21*. In 2014 however, the migration track of Wood Pigeons was clearly shifted east, with many day records as a result.

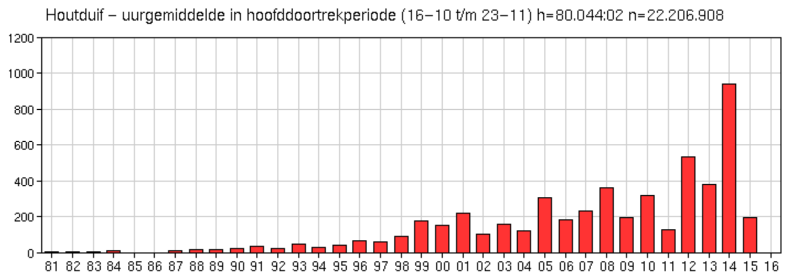

Figure 21. Hourly averages of migrating Wood Pigeons for each year, which shows a high number in 2014, caused by strong eastern winds.

§5.3: Blue Tit *Cyanistes caeruleus*

General Information

Blue Tits can be seen breeding in the whole of Europe, excepted northern Lapland, Iceland and Malta, in parts of West Asia and some northern countries in Africa.[31] Many of the Scandinavian Blue Tits hibernate in West and Mid Europe. Around 2000, the estimated number of breeding Blue Tits in The Netherlands was estimated on 275.000 – 325.000, though this number has been increasing over the last years, due to the aging of forests and urbanization focusing on landscaping.[32]

Figure 22. Blue Tit *Cyanistes caeruleus*

Migration Pattern

Blue Tits are partial migrants. Usually, only parts the Scandinavian population migrate southwards, while for example the Dutch population stays in their breeding ranges. However, the migration of the Blue Tit has an invasion-like character, meaning that in some years, big numbers from Northeast Europe migrate to West and Mid Europe. This happens mostly when there is a shortage of food or high population densities.[33] Funneling is a very common phenomenon in Blue Tits, for most of them only migrate via areas where there are enough trees or bushes. Besides, they are mostly funneled to the coast. Therefore, all the highest numbers have been counted at migration sites near the coast. The highest number ever counted in The Netherlands is 6230 at October 13, 2008 (De Nolle, Vlissingen), directly followed by 6145 at October 11, 2008 (De Vulkaan, Den Haag). The highest numbers east of the line Leeuwarden – Tilburg are much lower, though still high, with 2240 on October 7, 2008 (Ketelbrug/Kamperhoek) and 1197 at October 18, 2012 (Aan de Majoor, Koningsbosch).[34]

[31] Wikipedia.org, http://www.nl.wikipedia.org/wiki/Pimpelmees
[32] Vogelbescherming.nl http://www.vogelbescherming.nl/vogels_kijken/vogelgids/zoekresultaat/detailpagina/q/vogel/167/tab/Aantal
[33] Nyquist L., 2006
[34] Trektellen.nl, http://www.trektellen.nl/species/records/1/-1/376/-2/0?g=&l=&k=

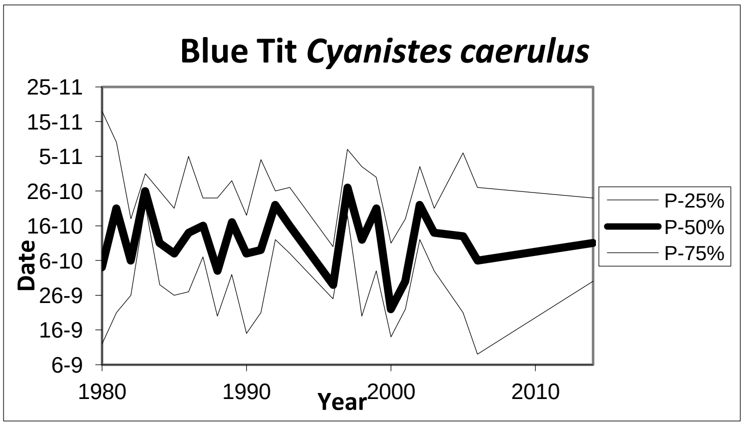

Figure 23. Changes in Blue Tit *Cyanistes caeruleus* in autumn 1980 – 2014, expressed in P-25%, P-50% and P-75%. Data from 2007 – 2014 was only available in the average percentiles.

Differences comparing 2000 – 2006 and 2007 – 2014

As shown in *Figure 24*, especially the onset of the migration has advanced sharply. P-5% has advanced the most of all species, while also P-10% still has quite a big advance. The rest of the migration has neither been advanced nor delayed on average. Just like in the Barn Swallow, *Figure 23* shows that P-25% and P-50% are delaying in comparison with 2006, while P-75% is advancing slightly, which is a totally different image compared to *Figure 24.* This difference may have occurred probably because the first Blue Tits might have migrated very early in 2006, which makes it look like as if Blue Tits are delaying their migration significantly. On average though, this image is not true at all.

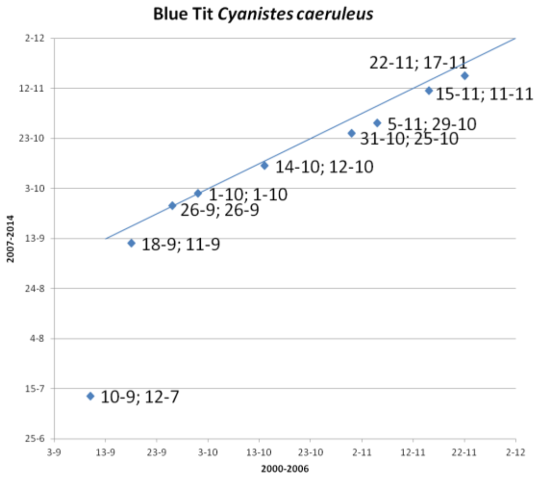

Figure 24. Changes of Blue Tit *Cyanistes caeruleus* visualized. The bigger the distance to the blue line, the bigger the advance or delay in migration.

Differences in numbers per year

Blue Tits probably show the most variable numbers of migrating individuals per year. According to *Figure 25,* in 2006 less than 10.000 individuals were counted, while in 2008 there were counted more than 120.000. This is not the result of favorable or non-favorable winds, but more because Blue Tits are a typical example of an irruptive species. This is clearly being reflected in the numbers of migrating Blue Tits. Again, it is no surprise that many day records have been broken in 2008.

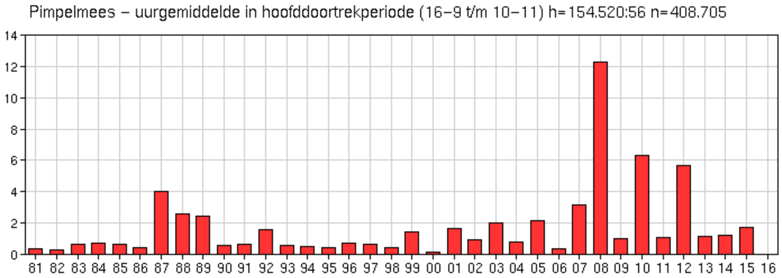

Figure 25. Hourly averages of migrating Blue Tits for each year. Years like 2008, 2010 and 2012 show a very high average, because in these years, there were strong irruptions of migrating Blue Tits.

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(II) Figure 2 : chart.apis.google.com/chart?cht=bvs&chco=4d89f9,c6d9fd&chds=0,1500&chd=t:51,86,357,121,135,197,41,388,312,491,1262|0,0,0,0,0,1,0,1,0,0,0&chs=600x200&chxl=1:|2005|2006|2007|2008|2009|2010|2011|2012|2013|2014|2015&chxp=&chxt=y,x&chdl=ter%20plaatse|overvliegend&chxr=0,0,1500&chg=0,33.3333333333&chtt=Tjiftjaf+-+Phylloscopus+collybita

(III) Figure 3 : http://www.borntotravelcampaign.com/FlyWays

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(V) Figure 5 : ©Luuk Punt, http://www.vogelpunt.wordpress.com/2015/08/29/de-puinhoop-weinig-pap-maar-wel-wat-krentjes/

(VI) Figure 6 : http://www.trektellen.nl/maps/index/1/-1

(VII) Figure 7: http://www.orn.mpg.de/134087/header_image.jpg

(VIII) Figure 8: Turnhout C. van, Troost G. et al., *Veranderingen in timing van zichtbare najaarstrek over Nederland: een pleidooi voor hernieuwde standaardisatie van trektellingen*, LIMOSA 82 (2009): 68-78, p. 72

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Attachment 1: Tables

	p5_2000_2006	p5_2007_2014	p10_2000_2006	p10_2007_2014
Great Cormorant *Phalacrocorax carbo*	18-6	19-6	21-6	22-6
Bean Goose (Total) *Anser serrirostris/fabalis*	31-10	23-10	8-11	2-11
Greater White-Fronted Goose *Anser albifrons*	19-10	5-10	27-10	15-10
Sparrowhawk *Accipiter nisus*	30-8	30-8	11-9	11-9
Common Buzzard *Buteo buteo*	26-8	28-8	11-9	13-9
Stock Dove *Columba oenas*	31-7	18-7	22-8	8-8
Wood Pigeon *Columba palumbus*	13-10	12-10	17-10	16-10
Swift *Apus apus*	18-6	19-6	21-6	23-6
Woodlark *Lullula arborea*	20-9	21-9	28-9	27-9
Skylark *Alauda arvensis*	8-10	7-10	10-10	11-10
Barn Swallow *Hirundo rustica*	31-7	19-7	13-8	30-7
House Martin *Delichon urbicum*	29-7	18-7	9-8	1-8
Tree Pipit *Anthus trivialis*	4-8	22-7	14-8	3-8
Meadow Pipit *Anthus pratensis*	18-9	19-9	22-9	21-9
Yellow Wagtail *Motacilla flava*	7-8	29-7	14-8	11-8
White Wagtail *Motacilla alba*	24-7	22-7	9-8	13-8
Dunnock *Prunella modularis*	27-8	27-8	1-9	3-9
Blackbird *Turdus merula*	26-9	27-9	4-10	6-10
Fieldfare *Turdus pilaris*	17-10	16-10	25-10	20-10
Song Thrush *Turdus philomelos*	27-9	24-9	29-9	27-9
Redwing *Turdus iliacus*	8-10	7-10	10-10	10-10
Mistle Thrush *Turdus viscivorus*	11-9	1-8	21-9	30-8
Coal Tit *Periparus ater*	7-9	8-9	11-9	12-9
Blue Tit *Cyanistes caeruleus*	10-9	12-7	18-9	11-9
Great Tit *Parus major*	13-9	5-9	26-9	22-9
Western Jackdaw *Corvus monedula*	2-10	3-10	7-10	8-10
Rook *Corvus frugilegus*	12-10	10-10	16-10	16-10
Carrion Crow *Corvus corone*	1-8	11-8	23-8	4-9
Tree Sparrow *Passer montanus*	13-9	30-8	28-9	26-9
Chaffinch *Fringilla coelebs*	1-10	2-10	5-10	5-10
Brambling *Fringilla montifringilla*	10-10	8-10	13-10	13-10
Greenfinch *Chloris chloris*	7-8	3-8	30-8	4-9
Goldfinch *Carduelis carduelis*	22-7	8-7	31-7	19-7
Siskin *Spinus spinus*	26-9	25-9	30-9	2-10
Common Linnet *Linaria cannabina*	20-7	23-7	11-8	22-8
Redpoll *Carduelis cabaret/flammea*	5-11	15-10	11-11	23-10
Reed Bunting *Emberiza schoeniclus*	21-9	22-9	27-9	29-9

	p20_2000_2006	p20_2007_2014	p25_2000_2006	p25_2007_2014
Great Cormorant *Phalacrocorax carbo*	27-6	3-7	3-7	11-7
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Meadow Pipit *Anthus pratensis*	26-9	24-9	27-9	25-9
Yellow Wagtail *Motacilla flava*	19-8	18-8	21-8	20-8
White Wagtail *Motacilla alba*	5-9	12-9	14-9	19-9
Dunnock *Prunella modularis*	8-9	13-9	13-9	17-9
Blackbird *Turdus merula*	13-10	18-10	17-10	22-10
Fieldfare *Turdus pilaris*	29-10	24-10	31-10	26-10
Song Thrush *Turdus philomelos*	2-10	1-10	3-10	2-10
Redwing *Turdus iliacus*	13-10	15-10	14-10	16-10
Mistle Thrush *Turdus viscivorus*	30-9	21-9	4-10	26-9
Coal Tit *Periparus ater*	17-9	19-9	19-9	21-9
Blue Tit *Cyanistes caeruleus*	26-9	26-9	1-10	1-10
Great Tit *Parus major*	9-10	7-10	11-10	9-10
Western Jackdaw *Corvus monedula*	10-10	11-10	11-10	13-10
Rook *Corvus frugilegus*	19-10	20-10	21-10	21-10
Carrion Crow *Corvus corone*	23-9	27-9	30-9	3-10
Tree Sparrow *Passer montanus*	5-10	4-10	7-10	6-10
Chaffinch *Fringilla coelebs*	9-10	9-10	10-10	11-10
Brambling *Fringilla montifringilla*	19-10	18-10	22-10	20-10
Greenfinch *Chloris chloris*	27-9	28-9	1-10	3-10
Goldfinch *Carduelis carduelis*	30-8	21-8	16-9	7-9
Siskin *Spinus spinus*	6-10	9-10	9-10	12-10
Common Linnet *Linaria cannabina*	16-9	24-9	24-9	27-9
Redpoll *Carduelis cabaret/flammea*	13-11	6-11	14-11	13-11
Reed Bunting *Emberiza schoeniclus*	4-10	7-10	8-10	10-10

	mediaa_2000_2006	mediaan_2007_2014	p75_2000_2006	p75_2007_2014
Great Cormorant *Phalacrocorax carbo*	6-8	23-9	19-10	9-11
Bean Goose (Total) *Anser serrirostris/fabalis*	9-12	12-12	19-12	19-12
Greater White-Fronted Goose *Anser albifrons*	11-12	15-12	22-12	22-12
Sparrowhawk *Accipiter nisus*	19-10	18-10	2-11	29-10
Common Buzzard *Buteo buteo*	16-10	17-10	28-10	28-10
Stock Dove *Columba oenas*	30-10	15-10	21-11	7-11
Wood Pigeon *Columba palumbus*	3-11	30-10	17-11	6-11
Swift *Apus apus*	10-7	13-7	24-7	22-7
Woodlark *Lullula arborea*	19-10	19-10	29-10	28-10
Skylark *Alauda arvensis*	24-10	22-10	30-10	30-10
Barn Swallow *Hirundo rustica*	6-9	6-9	17-9	17-9
House Martin *Delichon urbicum*	29-8	26-8	6-9	6-9
Tree Pipit *Anthus trivialis*	4-9	31-8	16-9	11-9
Meadow Pipit *Anthus pratensis*	3-10	2-10	11-10	11-10
Yellow Wagtail *Motacilla flava*	30-8	28-8	7-9	6-9
White Wagtail *Motacilla alba*	2-10	2-10	12-10	11-10
Dunnock *Prunella modularis*	28-9	29-9	11-10	12-10
Blackbird *Turdus merula*	30-10	2-11	8-11	12-11
Fieldfare *Turdus pilaris*	10-11	5-11	18-11	10-11
Song Thrush *Turdus philomelos*	9-10	7-10	13-10	13-10
Redwing *Turdus iliacus*	24-10	21-10	29-10	31-10
Mistle Thrush *Turdus viscivorus*	17-10	11-10	30-10	23-10
Coal Tit *Periparus ater*	24-9	2-10	6-10	12-10
Blue Tit *Cyanistes caeruleus*	14-10	12-10	31-10	25-10
Great Tit *Parus major*	16-10	17-10	22-10	24-10
Western Jackdaw *Corvus monedula*	20-10	19-10	31-10	27-10
Rook *Corvus frugilegus*	28-10	27-10	3-11	2-11
Carrion Crow *Corvus corone*	21-10	20-10	10-11	5-11
Tree Sparrow *Passer montanus*	14-10	13-10	26-10	23-10
Chaffinch *Fringilla coelebs*	21-10	18-10	29-10	26-10
Brambling *Fringilla montifringilla*	30-10	28-10	9-11	5-11
Greenfinch *Chloris chloris*	19-10	21-10	8-11	8-11
Goldfinch *Carduelis carduelis*	16-10	13-10	7-11	6-11
Siskin *Spinus spinus*	24-10	26-10	10-11	12-11
Common Linnet *Linaria cannabina*	7-10	7-10	17-10	17-10
Redpoll *Carduelis cabaret/flammea*	20-11	21-11	1-12	25-11
Reed Bunting *Emberiza schoeniclus*	19-10	20-10	30-10	30-10

	p80_2000_2006	p80_2007_2014	p90_2000_2006	p90_2007_2014
Great Cormorant *Phalacrocorax carbo*	28-10	30-11	6-12	17-12
Bean Goose (Total) *Anser serrirostris/fabalis*	22-12	21-12	27-12	25-12
Greater White-Fronted Goose *Anser albifrons*	24-12	24-12	28-12	28-12
Sparrowhawk *Accipiter nisus*	5-11	1-11	12-11	9-11
Common Buzzard *Buteo buteo*	1-11	31-10	11-11	11-11
Stock Dove *Columba oenas*	26-11	12-11	12-12	25-11
Wood Pigeon *Columba palumbus*	22-11	9-11	28-11	18-11
Swift *Apus apus*	28-7	24-7	9-8	29-7
Woodlark *Lullula arborea*	1-11	31-10	11-11	7-11
Skylark *Alauda arvensis*	31-10	1-11	7-11	11-11
Barn Swallow *Hirundo rustica*	19-9	19-9	23-9	24-9
House Martin *Delichon urbicum*	9-9	8-9	15-9	14-9
Tree Pipit *Anthus trivialis*	19-9	14-9	25-9	22-9
Meadow Pipit *Anthus pratensis*	14-10	14-10	24-10	25-10
Yellow Wagtail *Motacilla flava*	9-9	8-9	14-9	13-9
White Wagtail *Motacilla alba*	15-10	13-10	22-10	19-10
Dunnock *Prunella modularis*	14-10	16-10	25-10	25-10
Blackbird *Turdus merula*	10-11	13-11	17-11	19-11
Fieldfare *Turdus pilaris*	20-11	12-11	8-12	16-11
Song Thrush *Turdus philomelos*	14-10	15-10	17-10	20-10
Redwing *Turdus iliacus*	31-10	2-11	9-11	8-11
Mistle Thrush *Turdus viscivorus*	2-11	27-10	12-11	5-11
Coal Tit *Periparus ater*	10-10	14-10	17-10	22-10
Blue Tit *Cyanistes caeruleus*	5-11	29-10	15-11	11-11
Great Tit *Parus major*	27-10	27-10	7-11	8-11
Western Jackdaw *Corvus monedula*	2-11	29-10	10-11	5-11
Rook *Corvus frugilegus*	4-11	4-11	9-11	10-11
Carrion Crow *Corvus corone*	16-11	10-11	27-11	26-11
Tree Sparrow *Passer montanus*	28-10	26-10	3-11	2-11
Chaffinch *Fringilla coelebs*	1-11	28-10	9-11	4-11
Brambling *Fringilla montifringilla*	12-11	8-11	18-11	16-11
Greenfinch *Chloris chloris*	14-11	13-11	27-11	24-11
Goldfinch *Carduelis carduelis*	12-11	12-11	25-11	28-11
Siskin *Spinus spinus*	14-11	17-11	24-11	1-12
Common Linnet *Linaria cannabina*	21-10	19-10	30-10	26-10
Redpoll *Carduelis cabaret/flammea*	4-12	26-11	18-12	3-12
Reed Bunting *Emberiza schoeniclus*	1-11	2-11	10-11	11-11

	p95_2000_2006	p95_2007_2014
Great Cormorant *Phalacrocorax carbo*	23-12	25-12
Bean Goose (Total) *Anser serrirostris/fabalis*	29-12	29-12
Greater White-Fronted Goose *Anser albifrons*	30-12	30-12
Sparrowhawk *Accipiter nisus*	20-11	16-11
Common Buzzard *Buteo buteo*	29-11	25-11
Stock Dove *Columba oenas*	21-12	15-12
Wood Pigeon *Columba palumbus*	2-12	4-12
Swift *Apus apus*	13-8	3-8
Woodlark *Lullula arborea*	19-11	15-11
Skylark *Alauda arvensis*	15-11	17-12
Barn Swallow *Hirundo rustica*	27-9	27-9
House Martin *Delichon urbicum*	19-9	19-9
Tree Pipit *Anthus trivialis*	30-9	26-9
Meadow Pipit *Anthus pratensis*	2-11	2-11
Yellow Wagtail *Motacilla flava*	19-9	17-9
White Wagtail *Motacilla alba*	29-10	23-10
Dunnock *Prunella modularis*	31-10	2-11
Blackbird *Turdus merula*	23-11	29-11
Fieldfare *Turdus pilaris*	27-12	30-11
Song Thrush *Turdus philomelos*	22-10	24-10
Redwing *Turdus iliacus*	16-11	12-11
Mistle Thrush *Turdus viscivorus*	18-11	13-11
Coal Tit *Periparus ater*	26-10	28-10
Blue Tit *Cyanistes caeruleus*	22-11	17-11
Great Tit *Parus major*	15-11	25-11
Western Jackdaw *Corvus monedula*	17-11	12-11
Rook *Corvus frugilegus*	16-11	15-11
Carrion Crow *Corvus corone*	13-12	17-12
Tree Sparrow *Passer montanus*	10-11	9-11
Chaffinch *Fringilla coelebs*	16-11	10-11
Brambling *Fringilla montifringilla*	23-11	4-12
Greenfinch *Chloris chloris*	6-12	7-12
Goldfinch *Carduelis carduelis*	2-12	13-12
Siskin *Spinus spinus*	1-12	15-12
Common Linnet *Linaria cannabina*	10-11	2-11
Redpoll *Carduelis cabaret/flammea*	24-12	13-12
Reed Bunting *Emberiza schoeniclus*	18-11	19-11

Table 1. Timing of visible land migration over the Netherlands, comparing the periods 2000 – 2006 and 2007 – 2014, showing the dates on which a certain amount of the migrants has passed.

	P10-90_2000_2006	p10-90_2007_2014	p25-75_2000_2006	p25-75_2007-2014
Great Cormorant *Phalacrocorax carbo*	168	178	108	121
Bean Goose (Total) *Anser serrirostris/fabalis*	49	53	24	32
Greater White-Fronted Goose *Anser albifrons*	62	74	33	38
Sparrowhawk *Accipiter nisus*	62	59	28	27
Common Buzzard *Buteo buteo*	61	59	23	22
Stock Dove *Columba oenas*	112	109	47	54
Wood Pigeon *Columba palumbus*	42	33	22	16
Swift *Apus apus*	49	36	26	20
Woodlark *Lullula arborea*	44	41	20	20
Skylark *Alauda arvensis*	28	31	15	14
Barn Swallow *Hirundo rustica*	41	56	22	29
House Martin *Delichon urbicum*	37	44	17	22
Tree Pipit *Anthus trivialis*	42	50	23	23
Meadow Pipit *Anthus pratensis*	32	34	14	16
Yellow Wagtail *Motacilla flava*	31	33	17	17
White Wagtail *Motacilla alba*	74	67	28	22
Dunnock *Prunella modularis*	54	52	28	25
Blackbird *Turdus merula*	44	44	22	21
Fieldfare *Turdus pilaris*	44	27	18	15
Song Thrush *Turdus philomelos*	18	23	10	11
Redwing *Turdus iliacus*	30	29	15	15
Mistle Thrush *Turdus viscivorus*	52	67	26	27
Coal Tit *Periparus ater*	36	40	17	21
Blue Tit *Cyanistes caeruleus*	58	61	30	24
Great Tit *Parus major*	42	47	11	15
Western Jackdaw *Corvus monedula*	34	28	20	14
Rook *Corvus frugilegus*	24	25	13	12
Carrion Crow *Corvus corone*	96	83	41	33
Tree Sparrow *Passer montanus*	36	37	19	17
Chaffinch *Fringilla coelebs*	35	30	19	15
Brambling *Fringilla montifringilla*	36	34	18	16
Greenfinch *Chloris chloris*	89	81	38	36
Goldfinch *Carduelis carduelis*	117	132	52	60
Siskin *Spinus spinus*	55	60	32	31
Common Linnet *Linaria cannabina*	80	65	23	20
Redpoll *Carduelis cabaret/flammea*	37	41	17	12
Reed Bunting *Emberiza schoeniclus*	44	43	22	20

Table 2. Comparing the length of the main migratory period and the peak migratory period during two periods.

	P-5%	P-10%	P-20%	P-25%	P-50%
Great Cormorant *Phalacrocorax carbo*	0,142857	0,142857	0,857143	1,142857**	6,857143**
Bean Goose (Total) *Anser serrirostris/fabalis*	-1,14286	-0,85714**	-1,28571	-1,14286**	0,428571
Greater White-Fronted Goose *Anser albifrons*	-2	-1,71429**	-1	-0,71429**	0,571429
Sparrowhawk *Accipiter nisus*	0	0*	-0,28571	-0,42857**	-0,14286**
Common Buzzard *Buteo buteo*	0,285714	0,285714	0,142857	0,142857	0,142857
Stock Dove *Columba oenas*	-1,85714	-2**	-3,14286	-3**	-2,14286**
Wood Pigeon *Columba palumbus*	-0,14286	-0,14286	-0,42857	-0,71429	-0,57143
Swift *Apus apus*	0,142857	0,285714	0,428571	0,571429	0,428571**
Woodlark *Lullula arborea*	0,142857	-0,14286**	-0,14286	-0,14286	0*
Skylark *Alauda arvensis*	-0,14286	0,142857**	0	0,142857**	-0,28571
Barn Swallow *Hirundo rustica*	-1,71429	-2**	-1,28571	-1**	0*
House Martin *Delichon urbicum*	-1,57143	-1,14286**	-0,85714	-0,71429**	-0,42857**
Tree Pipit *Anthus trivialis*	-1,85714	-1,57143**	-0,85714	-0,71429**	-0,57143**
Meadow Pipit *Anthus pratensis*	0,142857	-0,14286**	-0,28571	-0,28571**	-0,14286**
Yellow Wagtail *Motacilla flava*	-1,28571	-0,42857**	-0,14286	-0,14286**	-0,28571**
White Wagtail *Motacilla alba*	-0,28571	0,571429	1	0,714286	0*
Dunnock *Prunella modularis*	0	0,285714**	0,714286	0,571429**	0,142857**
Blackbird *Turdus merula*	0,142857	0,285714	0,714286	0,714286	0,428571**
Fieldfare *Turdus pilaris*	-0,14286	-0,71429	-0,71429	-0,71429	-0,71429
Song Thrush *Turdus philomelos*	-0,42857	-0,28571**	-0,14286	-0,14286**	-0,28571**
Redwing *Turdus iliacus*	-0,14286	0*	0,285714	0,285714**	-0,42857**
Mistle Thrush *Turdus viscivorus*	-5,85714	-3,14286**	-1,28571	-1,14286	-0,85714
Coal Tit *Periparus ater*	0,142857	0,142857	0,285714	0,285714	1,142857
Blue Tit *Cyanistes caeruleus*	-8,57143	-1**	0	0*	-0,28571**
Great Tit *Parus major*	-1,14286	-0,57143**	-0,28571	-0,28571**	0,142857
Western Jackdaw *Corvus monedula*	0,142857	0,142857	0,142857	0,285714	-0,14286**
Rook *Corvus frugilegus*	-0,28571	0*	0,142857	0*	-0,14286**
Carrion Crow *Corvus corone*	1,428571	1,714286	0,571429	0,428571	-0,14286**
Tree Sparrow *Passer montanus*	-2	-0,28571**	-0,14286	-0,14286**	-0,14286
Chaffinch *Fringilla coelebs*	0,142857	0*	0	0,142857**	-0,42857
Brambling *Fringilla montifringilla*	-0,28571	0*	-0,14286	-0,28571	-0,28571
Greenfinch *Chloris chloris*	-0,57143	0,714286	0,142857	0,285714	0,285714**
Goldfinch *Carduelis carduelis*	-2	-1,71429**	-1,28571	-1,28571**	-0,42857**
Siskin *Spinus spinus*	-0,14286	0,285714	0,428571	0,428571	0,285714
Common Linnet *Linaria cannabina*	0,428571	1,571429	1,142857	0,428571	0*
Redpoll *Carduelis cabaret/flammea*	-3	-2,71429**	-1	-0,14286	0,142857**
Reed Bunting *Emberiza schoeniclus*	0,142857	0,285714	0,428571	0,285714	0,142857**

	P-75%	P-80%	P-90%	P-95%	P-10_90%	P-25_75%
Great Cormorant *Phalacrocorax carbo*	3**	4,714286	1,571429**	0,285714	1,428571	1,857143
Bean Goose (Total) *Anser serrirostris/fabalis*	0*	-0,14286	-0,28571	0	0,571429	1,142857
Greater White-Fronted Goose *Anser albifrons*	0*	0	0*	0	1,714286	0,714286
Sparrowhawk *Accipiter nisus*	-0,57143**	-0,57143	-0,42857**	-0,57143	-0,42857	-0,14286
Common Buzzard *Buteo buteo*	0*	-0,14286	0*	-0,57143	-0,28571	-0,14286
Stock Dove *Columba oenas*	-2	-2	-2,42857	-0,85714	-0,42857	1
Wood Pigeon *Columba palumbus*	-1,57143	-1,85714	-1,42857	0,285714	-1,28571	-0,85714
Swift *Apus apus*	-0,28571	-0,57143	-1,57143	-1,42857	-1,85714	-0,85714
Woodlark *Lullula arborea*	-0,14286	-0,14286	-0,57143	-0,57143	-0,42857	0
Skylark *Alauda arvensis*	0*	0,142857	0,571429**	4,571429	0,428571	-0,14286
Barn Swallow *Hirundo rustica*	0*	0	0,142857**	0	2,142857	1
House Martin *Delichon urbicum*	0*	-0,14286	-0,14286**	0	1	0,714286
Tree Pipit *Anthus trivialis*	-0,71429**	-0,71429	-0,42857**	-0,57143	1,142857	0
Meadow Pipit *Anthus pratensis*	0*	0	0,142857**	0	0,285714	0,285714
Yellow Wagtail *Motacilla flava*	-0,14286**	-0,14286	-0,14286**	-0,28571	0,285714	0
White Wagtail *Motacilla alba*	-0,14286**	-0,28571	-0,42857	-0,85714	-1	-0,85714
Dunnock *Prunella modularis*	0,142857**	0,285714	0*	0,285714	-0,28571	-0,42857
Blackbird *Turdus merula*	0,571429**	0,428571	0,285714**	0,857143	0	-0,14286
Fieldfare *Turdus pilaris*	-1,14286	-1,14286	-3,14286	-3,85714	-2,42857	-0,42857
Song Thrush *Turdus philomelos*	0*	0,142857	0,428571	0,285714	0,714286	0,142857
Redwing *Turdus iliacus*	0,285714	0,285714	-0,14286	-0,57143	-0,14286	0
Mistle Thrush *Turdus viscivorus*	-1	-0,85714	-1	-0,71429	2,142857	0,142857
Coal Tit *Periparus ater*	0,857143**	0,571429	0,714286	0,285714	0,571429	0,571429
Blue Tit *Cyanistes caeruleus*	-0,85714**	-1	-0,57143**	-0,71429	0,428571	-0,85714
Great Tit *Parus major*	0,285714	0	0,142857**	1,428571	0,714286	0,571429
Western Jackdaw *Corvus monedula*	-0,57143**	-0,57143	-0,71429	-0,71429	-0,85714	-0,85714
Rook *Corvus frugilegus*	-0,14286**	0	0,142857**	-0,14286	0,142857	-0,14286
Carrion Crow *Corvus corone*	-0,71429	-0,85714	-0,14286	0,571429	-1,85714	-1,14286
Tree Sparrow *Passer montanus*	-0,42857**	-0,28571	-0,14286**	-0,14286	0,142857	-0,28571
Chaffinch *Fringilla coelebs*	-0,42857	-0,57143	-0,71429	-0,85714	-0,71429	-0,57143
Brambling *Fringilla montifringilla*	-0,57143	-0,57143	-0,28571	1,571429	-0,28571	-0,28571
Greenfinch *Chloris chloris*	0*	-0,14286	-0,42857	0,142857	-1,14286	-0,28571
Goldfinch *Carduelis carduelis*	-0,14286	0	0,428571**	1,571429	2,142857	1,142857
Siskin *Spinus spinus*	0,285714	0,428571	1	2	0,714286	-0,14286
Common Linnet *Linaria cannabina*	0*	-0,28571	-0,57143	-1,14286	-2,14286	-0,42857
Redpoll *Carduelis cabaret/flammea*	-0,85714	-1,14286	-2,14286	-1,57143	0,571429	-0,71429
Reed Bunting *Emberiza schoeniclus*	0*	0,142857	0,142857**	0,142857	-0,14286	-0,28571

Table 3. Timing differences in 37 common migrants during 2007 – 2014. Corresponding values with *Table 4* have been marked with two asterisk (**). Values of 0 have been marked with one asterisk (*).

Soort *Species*	P-10%	P-25%	P-50%	P-75%	P-90%	P-10-90	P-25-75
Aalscholver *Phalacrocorax carbo*	-0.242	0.415	0.703	0.391	0.168	0.411	-0.024
Rietgans *Anser serrirostris/fabalis*	-0.446	-0.224	0.14	0.132	0.149	0.595**	0.356*
Kolgans *Anser albifrons*	-1.45**	-0.899**	-0.48**	-0.125	0.018	1.467**	0.774**
Sperwer *Accipiter nisus*	-0.695**	-0.446*	-0.245	-0.244	-0.129	0.565*	0.201
Buizerd *Buteo buteo*	-0.524**	-0.41	-0.419	-0.384	-0.309	0.215	0.026
Holenduif *Columba oenas*	-1.214*	-0.797	-0.269	0.036	0.216	1.43*	0.833
Houtduif *Columba palumbus*	0.111	0.247	0.429**	0.621**	0.752**	0.641**	0.375**
Gierzwaluw *Apus apus*	-0.075	-0.052	0.116	0.35	0.511	0.585*	0.402*
Boomleeuwerik *Lullula arborea*	-0.166	0.101	0.328*	0.376	0.186	0.352	0.275
Veldleeuwerik *Alauda arvensis*	0.069	0.079	0.099	0.126	0.116	0.047	0.0476
Boerenzwaluw *Hirundo rustica*	-0.192	-0.332**	-0.418**	-0.248*	-0.187	0.005	0.084
Huiszwaluw *Delichon urbica*	-0.121	-0.165	-0.421*	-0.373*	-0.358**	-0.237	-0.208
Boompieper *Anthus trivialis*	-0.002	-0.035	-0.029	-0.136	-0.068	-0.067	-0.101
Graspieper *Anthus pratensis*	-0.082	-0.0232	-0.07	0.009	0.17	0.252	0.032
Gele kwikstaart *Motacilla flava*	-0.429**	-0.208*	-0.1447	-0.1752**	-0.1874**	0.241*	0.033
Witte kwikstaart *Motacilla alba*	-1.057	-1.353**	-0.386**	-0.1801**	0.0031	1.06	1.173**
Heggenmus *Prunella modularis*	0.159	0.233	0.243*	0.377*	0.463**	0.305	0.143
Merel *Turdus merula*	-0.35	-0.232	0.229	0.372**	0.256	0.606	0.604
Kramsvogel *Turdus pilaris*	0.41**	0.311**	0.237	0.184	0.12	-0.29	-0.128
Zanglijster *Turdus philomelos*	-0.014	-0.023	-0.076	-0.082	-0.048	-0.034	-0.059
Koperwiek *Turdus iliacus*	0.161	0.067	-0.041	-0.042	0.073	-0.089	-0.109
Grote Lijster *Turdus viscivorus*	-0.071	0.003	0.183	0.29	0.211	0.281	0.287
Zwarte Mees *Parus ater*	-0.57*	-0.602*	-0.254	0.021	-0.06	0.51	0.624**
Pimpelmees *Parus caeruleus*	-0.27	-0.126	-0.145	-0.255	-0.109	0.161	-0.128
Koolmees *Parus major*	-1.282**	-0.479*	-0.314	-0.194	0.173	1.455**	0.284
Kauw *Corvus monedula*	-0.945**	-0.664*	-0.165	-0.074	0.127	1.072**	0.59*
Roek *Corvus frugilegus*	-0.2479**	-0.1917*	-0.153	-0.055	0.115	0.363**	0.137
Zwarte Kraai *Corvus corone*	-2.063**	-1.453**	-0.3	0.079	0.272	2.335**	1.532**
Ringmus *Passer montanus*	-0.702**	-0.109	0.0075	-0.119	-0.046	0.657	-0.009
Vink *Fringilla coelebs*	0.07	0.0672	0.244**	0.27**	0.284**	0.214	0.2027**
Keep *Fringilla montifringilla*	0.217*	0.181	0.312**	0.23	0.068	-0.149	0.048
Groenling *Carduelis chloris*	-0.808	-0.44	0.016	0.154	0.367	1.175**	0.594*
Putter *Carduelis carduelis*	-2.297**	-1.592**	-0.482*	0.291	0.153	2.45**	1.883**
Sijs *Carduelis spinus*	-0.114	-0.1	-0.061	-0.216	-0.05	0.064	-0.116
Kneu *Carduelis cannabina*	-1.532**	-0.824**	-0.092	0.16	0.311**	1.844**	0.984**
Barmsijs *Carduelis cabaret/flammea*	-0.192	0.094	0.392	0.853**	0.705**	0.897**	0.759**
Rietgors *Emberiza schoeniclus*	-0.275	-0.043	0.109	0.25*	0.131	0.406	0.292*

Table 4. Timing differences in 37 common migrants during 2000 – 2006.

TRANS-SAHARAN MIGRANTS	P-5%	P-10%	P-25%	P-50%	P-75%	P-90%	P-95%	P-10-90%	P-25-75%
Swift	0,143	0,286	0,571	0,429	-0,286	-1,571	-1,429	-1,857	-0,857
Barn Swallow	-1,714	-2,000	-1,000	0,000	0,000	0,143	0,000	2,143	1,000
House Martin	-1,571	-1,143	-0,714	-0,429	0,000	-0,143	0,000	1,000	0,714
Tree Pipit	-1,857	-1,571	-0,714	-0,571	-0,714	-0,429	-0,571	1,143	0,000
Yellow Wagtail	-1,286	-0,429	-0,143	-0,286	-0,143	-0,143	-0,286	0,286	0,000
AVERAGE	***-1,257***	***-0,971***	***-0,400***	***-0,171***	***-0,229***	***-0,429***	***-0,457***	***0,543***	***0,171***

Table 5. Timing differences of 5 common migrants which in autumn migrate to Africa.

SOUTHWEST EUROPE MIGRANTS	P-5%	P-10%	P-25%	P-50%	P-75%	P-90%	P-95%	P-10-90%	P-25-75%
Great Cormorant	0,143	0,143	1,143	6,857	3,000	1,571	0,286	1,429	1,857
Wood Pigeon	-0,143	-0,143	-0,714	-0,571	-1,571	-1,429	0,286	-1,286	-0,857
Woodlark	0,143	-0,143	-0,143	0,000	-0,143	-0,571	-0,571	-0,429	0,000
Skylark	-0,143	0,143	0,143	-0,286	0,000	0,571	4,571	0,429	-0,143
Meadow Pipit	0,143	-0,143	-0,286	-0,143	0,000	0,143	0,000	0,286	0,286
White Wagtail	-0,286	0,571	0,714	0,000	-0,143	-0,429	-0,857	-1,000	-0,857
Song Thrush	-0,429	-0,286	-0,143	-0,286	0,000	0,429	0,286	0,714	0,143
Redwing	-0,143	0,000	0,286	-0,429	0,286	-0,143	-0,571	-0,143	0,000
Chaffinch	0,143	0,000	0,143	-0,429	-0,429	-0,714	-0,857	-0,714	-0,571
Common Linnet	0,429	1,571	0,429	0,000	0,000	-0,571	-1,143	-2,143	-0,429
Reed Bunting	0,143	0,286	0,286	0,143	0,000	0,143	0,143	-0,143	-0,286
AVERAGE	***0,000***	***0,182***	***0,169***	***0,442***	***0,091***	***-0,091***	***0,143***	***-0,273***	***-0,078***

Table 6. Timing differences of 11 common migrants which in autumn migrate to Southwest Europe. The averages have been calculated over the P-5% until the P-95%.

NORTHWEST EUROPE MIGRANTS	P-5%	P-10%	P-25%	P-50%	P-75%	P-90%	P-95%	P-10-90%	P-25-75%
Bean Goose (Total)	-1,143	-0,857	-1,143	0,429	0,000	-0,286	0,000	0,571	1,143
Greater White-Fronted Goose	-2,000	-1,714	-0,714	0,571	0,000	0,000	0,000	1,714	0,714
Sparrowhawk	0,000	0,000	-0,429	-0,143	-0,571	-0,429	-0,571	-0,429	-0,143
Common Buzzard	0,286	0,286	0,143	0,143	0,000	0,000	-0,571	-0,286	-0,143
Stock Dove	-1,857	-2,000	-3,000	-2,143	-2,000	-2,429	-0,857	-0,429	1,000
Dunnock	0,000	0,286	0,571	0,143	0,143	0,000	0,286	-0,286	-0,429
Blackbird	0,143	0,286	0,714	0,429	0,571	0,286	0,857	0,000	-0,143
Fieldfare	-0,143	-0,714	-0,714	-0,714	-1,143	-3,143	-3,857	-2,429	-0,429
Mistle Thrush	-5,857	-3,143	-1,143	-0,857	-1,000	-1,000	-0,714	2,143	0,143
Coal Tit	0,143	0,143	0,286	1,143	0,857	0,714	0,286	0,571	0,571
Blue Tit	-8,571	-1,000	0,000	-0,286	-0,857	-0,571	-0,714	0,429	-0,857
Great Tit	-1,143	-0,571	-0,286	0,143	0,286	0,143	1,429	0,714	0,571
Western Jackdaw	0,143	0,143	0,286	-0,143	-0,571	-0,714	-0,714	-0,857	-0,857
Rook	-0,286	0,000	0,000	-0,143	-0,143	0,143	-0,143	0,143	-0,143
Carrion Crow	1,429	1,714	0,429	-0,143	-0,714	-0,143	0,571	-1,857	-1,143
Tree Sparrow	-2,000	-0,286	-0,143	-0,143	-0,429	-0,143	-0,143	0,143	-0,286
Brambling	-0,286	0,000	-0,286	-0,286	-0,571	-0,286	1,571	-0,286	-0,286
Greenfinch	-0,571	0,714	0,286	0,286	0,000	-0,429	0,143	-1,143	-0,286
Goldfinch	-2,000	-1,714	-1,286	-0,429	-0,143	0,429	1,571	2,143	1,143
Siskin	-0,143	0,286	0,429	0,286	0,286	1,000	2,000	0,714	-0,143
Redpoll	-3,000	-2,714	-0,143	0,143	-0,857	-2,143	-1,571	0,571	-0,714
AVERAGE	***-1,279***	***-0,517***	***-0,293***	***-0,082***	***-0,327***	***-0,429***	***-0,054***	***0,088***	***-0,034***

Table 7. Timing differences of 21 common migrants which in autumn migrate to Northwest Europe.

	P-5%	P-10%	P-25%	P-50%	P-75%	P-90%	P-95%	P10-90%	P25-75%
Trans-Saharan	***-1,257***	***-0,971***	***-0,400***	***-0,171***	***-0,229***	***-0,429***	***-0,457***	***0,543***	***0,171***
Southwest Europe	***0,000***	***0,182***	***0,169***	***0,442***	***0,091***	***-0,091***	***0,143***	***-0,273***	***-0,078***
Northwest Europe	***-1,279***	***-0,517***	***-0,293***	***-0,082***	***-0,327***	***-0,429***	***-0,054***	***0,088***	***-0,034***

Table 8. Overview of the averages for each group of species for each percentile.

	P-5%	*P-10%*	*P-20%*	*P-25%*	*P-50%*	*P-75%*	*P-80%*	*P-90%*	*P-95%*	*P10%-90%*	*P-25%-P75%*
AVERAGE	*-0,896*	*-0,371*	*-0,197*	*-0,170*	*0,062*	*-0,189*	*-0,189*	*-0,328*	*-0,050*	*0,042*	*-0,019*

Table 9. Averages of all the species together per percentile and per period.