Université de Bourgogne Franche-Comté

Master Behavioural Ecology and Wildlife Management

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Migration behaviour of Eurasian spoonbill (*platalea leucorodia*) from a triaxial accelerometer



Photo: Eurasian spoonbill (*Platalea leucorodia*) from the Parc des oiseaux.

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This internship was completed at Parc des oiseaux, RD 1083, 01330 VILLARS-LES-DOMBES, at UMR biogéosciences, Université de Bourgogne. 6 bd Gabriel. 21000 DIJON, at tour du Valat, Le Sambuc, 13200 ARLES.

Presentation of the institutions

Tour du Valat

The Tour du Valat is a research center for the conservation of Mediterranean wetlands, it was founded by t Luc Hoffmann, an ornithologist, in 1954.

This domain is located in Provence-Alpes-Côte d'Azur, more precisely in the department Bouches-du-Rhône, within the Parc naturel régional de Camargue.

On this site 80 employees are present, including around 45 people who are part of the scientific team. One aim of this organization is to conserve endangered species, manage conflicts between species and human activities, also manage key species for tourism and / or exploitation. All this is possible thanks to an annual budget of about 5.6 million euros financed by the profits of the domain, also by private and public organizations, the ProValat Foundation, and the MAVA Foundation.

Parc aux oiseaux

The Parc aux oiseaux is a zoo located in Villars-lès-Dombes which opened in 1970. This park is located in the middle of a reserve of 380-hectare, of which 35 hectares are open to the public, with over 3000 birds from all over the world.

This park is part of several associations : the Association européenne des zoos et des aquariums, the Association nationale des parcs zoologiques and the l'Association mondiale des zoos et aquariums.

It also participates in programs for protection and reintroduction of endangered species through genetic conservation of species in case of total extinction in the wild.

UMR biogéosciences

This laboratory is an Unité Mixte de Recherche composed of about a hundred people employed by the Université de Bourgogne, the Centre Nationale de la Recherche Scientifique, the Ecole Pratique de Hautes Etudes and AgroSup Dijon.

Teachers, researchers, technical staff, doctoral students and postdoctoral students are present in this unit.

The research areas of the UMR biogeosciences are evolutionary ecology, environmental sciences, sedimentology, paleontology or climatology.

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INTRODUCTION

Studying animal behaviour is determinant to understand how species interact with each other and with their environment (Sakamoto et al. 2009). But in some cases, observing behaviours in nature can be a major challenge. For example marine species live most of the time under water, which is a difficult to access area in comparison to land, also some species can be very fearful and hard to approach in order to observe them (Brown et al. 2013). The weather and the moment of the day can have an impact on the observations, and doing them without the best settings is too time-consuming to be worth the attempt.

Behaviour is mainly characterised by movement (Wilson et al. 2008). Therefore, the study of animal's movement can help us to learn more about them. The development of new technologies allow researcher to explore new possibilities (Laich et al. 2008). As an example, the use of biaxial accelerometers on marine animals allows to collect useful informations about their behaviour (Yoda et al. 1999). Now in science employing accelerometers is in expansion (Brown et al. 2013), and specifically the use of tri-axial accelerometers become most common. Triaxial accelerometers are tools which are used to detect body-position and posture sensing (Ravi et al. 2005), is a sound alternative compare to the binding field observation. When the animal is moving the triaxial accelerometers measure his inertial acceleration on three axes (Ladds et al. 2017) : the medial-lateral (when the animal swayed), anterior-posterior (when the animal surged), and lastly the inferior-superior or dorso-ventral axe (when the animal heaved) (Nathan et al. 2012). The assembly of the three axes during a certain time determine specific movements, which correspond to an unique behaviour. By means of accelerometers different behaviour can be classify, therefore an ethogram can be built (Bom et al. 2014).

Migratory birds need an important reserve of energy in order to travel long distances, they do fat reserve before and during migration at stopover sites (Lindström 1991). Consequently they increase their feeding time or their rate of food intake before migration (Zwarts et al. 1990; Rappole & Warner 1976). Eurasian spoonbill (*platalea leucorodia*) are migratory, wading and fearful birds which travel many kilometers each days during migration (Overdijk & Navedo 2012), and spend time in hardly accessible sites. Thus determining an ethogram of this

species is a complex task and take time, in particular along the migration route which can overpass 3000 kilometers. The use of a tri axial accelerometer on captive spoonbill can solve this problem, they are accustomed to human presence, then it's possible to be close and to observe them readily.

The aim of this study is to built an ethogram from the accelerometer of one captive spoonbill, in order to describe the behaviour before and after migration of an inaccessible, equipped with accelerometer, wild spoonbill. According to the data it would be possible to know if there is a behaviour change, like in feeding time, before and after migration. The behaviour can also vary according to the post breeding migration and the pre breeding migration.

MATERIAL AND METHOD

Animal

In nature the spoonbill is a wading and migratory bird (Lok et al. 2015) which mainly feed on fishes and small crustaceans (Aguilera et al. 1996). Some spoonbills that breed in France, like the one that breed in the Netherlands, overwinter in north-western African wetlands of Mauritania and Senegal (Bauchau et al. 1998).

Collection of data from ethogram were conducted at Parc des Oiseaux (RD 1083, 01330 Villars-les-Dombes) on one captive Eurasian spoonbill *(platalea leucorodia*) from the 9th may to 21th may. The spoonbill were free in an aviary of 1000m² and 10-12 m high with two conspecifics and thirty others different species of birds, it is feed with dry fishes. In this aviary an artificial waterfall and pond were installed, many differents species of plants were also in the aviary, providing hiding place. An high platform (at 2-3 meters) allowed birds to have a calm spot and to rest with being disturbed by visitors who view this aviary.

This captive individual is a male (determined genetically) banded GK born at the park the 18th may 2010.

Experimental protocol

A tri-axial accelerometer was used (OrniTrack-E25 3G solar powered GPS-GSM/3G transmitter, 58×24×24 mm, 25 grams), on both captive and wild spoonbill, to measure the movement through three axes that are x (sway), y (surge) and z (heave) (Figure 1).

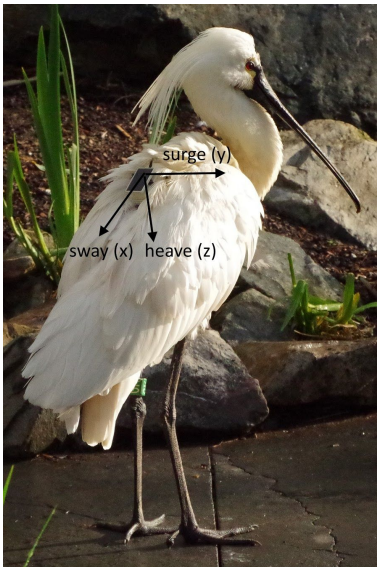


Figure 1 : Representation of the three axes of the accelerometer on the captive spoonbill, the axes x (medial-lateral, sway), y (anterior-posterior, surge), z (inferior-superior, heave).

The accelerometer was attached on the spoonbill back (Figure 2). All the equipment weighed less than 3% of the spoonbill's body mass in order to respect the ethical threshold (max 2.9%) (Thaxter et al. 2014).

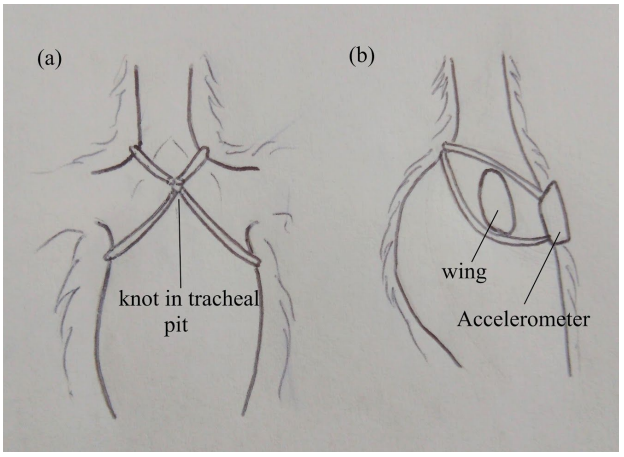


Figure 2 : . Draw representing how the harness was attached and positioned on the captive and wild spoonbill, viewed from below (a) : show the position of the knot and where pass thread, and viewed from the right side (b) : show the accelerometer placed on the spoonbill's back, with thread passing around the wings (Thaxter et al. 2014).

We recorded the captive spoonbill with one camera (Canon LEGRIA HF R106), during on average 6 hours per day for 10 days, on average 3 hours the morning and 3 hours the

afternoon. At each video's beginning the precise hour was noted with universal time in order to synchronize each video with accelerometer data.

First week accelerometer data were setted during 30 seconds every 30 seconds, in other words only half of the behaviour were really recorded. This was in order to preserve the solar powered battery of the accelerometer because the weather were cloudy.

Second week accelerometer data were raised all time the day, and off the night.

Ethogram

In total we observed many different behaviour which was grouped into 5 main categories : flying, grooming, walking, eating, and resting.

Random Forest

Accelerometer data are numerous to analyse, that's why semi-automating the analyses through machine learning is necessary.

Random Forest, an algorithm of machine learning, was used, which is an ensemble of trees. The algorithm consist in collecting randomly a big sample of the data, each data is tested by many trees individually. Each tree choose a behaviour which correspond the best to the data tested. Then the class of behaviour which is selected for a specific data is those which have the more of vote (Svetnik et al. 2003). Random Forest needs to be trained before being applied. To test the algorithm 30% of the data of the captive spoonbill were used, which was data from the 18, 19 and 20 may 2017. This algorithm also requires summary statistics to characterize precisely each behaviour.

Summary statistics

In total, 63 summary statistics were created from the captive spoonbill accelerometer data to put into the algorithme of the Random Forest.

Summary statistics were created from the axes x, y and z.

All calculations were executed using RStudio.

Mean, median, minimum, maximum, range, standard deviation, skewness, kurtosis, inverse covariance, autocorrelation trend, the 10th and 90th percentiles were calculated for each of the three axes x, y and z. The square root of the sum of the three axis named q was also calculated, and included pairwise correlations of the three axis (x-y, y-z, x-z) (Ladds et al. 2017). Azimuth and inclination was calculated using (Nathan et al. 2012) inclination = (cos–1[z/q]) and azimuth = (tan–1[y/x]).

In order to create a value for static acceleration dynamic body acceleration (DBA) was calculated by using a running mean of each axis over one seconds.

To create a value for p artial dynamic body acceleration (PDBA) the static acceleration was subtracted at each point from the raw acceleration value.

Then the overall dynamic body acceleration (ODBA) was calculated using this formula :

ODBA= $|Xdyn| + |Y\,dyn| + |Zdyn|$

The vectorial dynamic body acceleration was calculated using :

VeDBA= $\sqrt{X^2dyn\ +\ Y^2dyn\ +\ Z^2dyn}$

The area under the curve for both ODBA and VeDBA were calculated using the package "MESS". For PDBA, ODBA and VeDBA, the minimum, maximum and 10th and 90th percentiles were calculated (Ladds et al. 2017).

Data of the wild spoonbill

The wild spoonbill was captured in Camargue, on the ilôt de Banaston (43°28'32.6"N 4°29'03.4"E) the 3th may 2017. It is an adult female banded ATZF (determined by the bander, not genetically). Accelerometer data of this one is programmed to collected 10 seconds each 10 minutes.

Thanks to the GPS data of the accelerometer we know where the spoonbill were in Gambia, and also that the captive spoonbill began its post breeding migration from Camargue the 07 october 2017 and arrived in Africa, Gambia, the 18 december 2017. Thus data from 23 to 29 september 2017 (data named AAM1, which correspond to two weeks before migration to Africa), and from 30 september to 06 october 2017 (data named AM1, which correspond to the week before migration to Africa) were collected, which represent data before migration. Data from 20 to 26 december 2017 (data named WIN1, which correspond to a week of wintering) , and from 13 to 19 january 2018 (data named WIN2, which correspond to a second week of wintering) were also collected, which represent data after migration. The spoonbill began its pre breeding migration from Gambia the 01 march 2018 and then drop his migration and stay in Africa. Data from 14 to 20 february (data named AAM2, which correspond to two weeks before migration to France) and from 22 to 28 february 2018 (data named AM2, which correspond to the weeks before migration to France) was also collected to represent again data before migration. Random Forest was used for each day oh each week collected.

Analysis

Analysis of the data of the wild spoonbill was executed thanks to the ethogram of the captive spoonbill, with the Random forest.

In order to test whether there is a difference in each behaviour before and after migration, a Kruskal-wallis test was realized for each different behaviour.

Thanks to the test a posteriori of the Kruskal-Wallis it's also possible to know if there is differences in each behaviour for only weeks before migration, or only weeks during wintering.

RESULTS

Captive spoonbill

In 60 hours of observations of the captive spoonbill we selected 722 sequences of 2 seconds for the behaviour resting, 315 sequences of 2 seconds for the behaviour grooming, 104 sequences of 2 seconds for the behaviour eating, 392 sequences of 2 seconds for the behaviour eating, 73 sequences of 2 seconds for the behaviour flying.

Tableau 1 : Ethogram regrouping the 5 main behaviours of the captive spoonbill.

Behaviour	**Description**
Eat	When the spoonbill is looking for food in the water, or when it swallow fishes with head shots
Fly	When the spoonbill is flying or flap its wings
Grooming	When the spoonbill is grooming his legs, back, wings, neck, chest
Rest	When the spoonbill is immobile, with the head up or with the head into the feathers, on one leg or on two legs
Walk	When the spoonbill is walking or running

Random forest with the 63 summary statistics calculated have an estimate of error rate of 2.93%.

Wild spoonbill

The wild spoonbill spent his wintering along the river Gambia, in many different areas (Figure 4).



Figure 4 : Map of the river Gambia from Google earth, with yellows pins representing the main areas where the spoonbill spent time.

Tableau 2 : Results of the Random forest, representing each behaviour proportion of the wild spoonbill (in % (+/- standard deviation)) according to the weeks analyzed.

	Eat	Fly	Grooming	Rest	Walk
AAM1	5.1 (+/- 4.2)	2.4 (+/- 1.2)	15.1 (+/- 4.2)	54.1 (+/- 4.0)	23.1 (+/- 6.8)
AM1	3.0 (+/- 1.0)	4.1 (+/- 1.5)	14.6 (+/- 2.6)	56.4 (+/- 4.1)	22.7 (+/- 5.0)
WIN1	10.1 (+/- 10.6)	2.1 (+/- 0.9)	19.9 (+/- 6.5)	51.9 (+/- 7.1)	16.0 (+/- 8.8)
WIN2	3.5 (+/- 3.5)	3.6 (+/- 1.5)	27.3 (+/- 2.3)	48.4 (+/- 3.9)	17.1 (+/- 7.0)
AAM2	3.1 (+/- 2.7)	2.4 (+/- 1.7)	19.0 (+/- 6.9)	61.0 (+/- 4.6)	14.4 (+/- 5.1)
AM2	3.3 (+/- 1.6)	3.1 (+/- 1.7)	14.9 (+/- 4.4)	64.9 (+/- 4.5)	13.9 (+/- 4.5)

There is no difference for eating behaviour before and after migration (Kruskal-Wallis chi-squared = 7.4512, df = 5, P = 0.1892, figure 3).

There is no difference for flying behaviour before and after migration (Kruskal-Wallis chi-squared = 8.3253, df = 5, P = 0.1392, figure 3).

The spoonbill spend more time grooming in WIN2 compare to AAM1, AM1, and AM2 (Kruskal-Wallis chi-squared = 17.927, df = 5, P = 0.0030, figure 3).

The spoonbill spend more time resting in AM2 and AAM2 respectively to WIN1 and WIN2, and to WIN2 (Kruskal-Wallis chi-squared = 24.811, df = 5, P = 0.0002, figure 3).

There is a difference for walking behaviour (Kruskal-Wallis chi-squared = 13.064, df = 5, P = 0.0228, figure 3) but post hoc test didn't notice any differences between weeks.

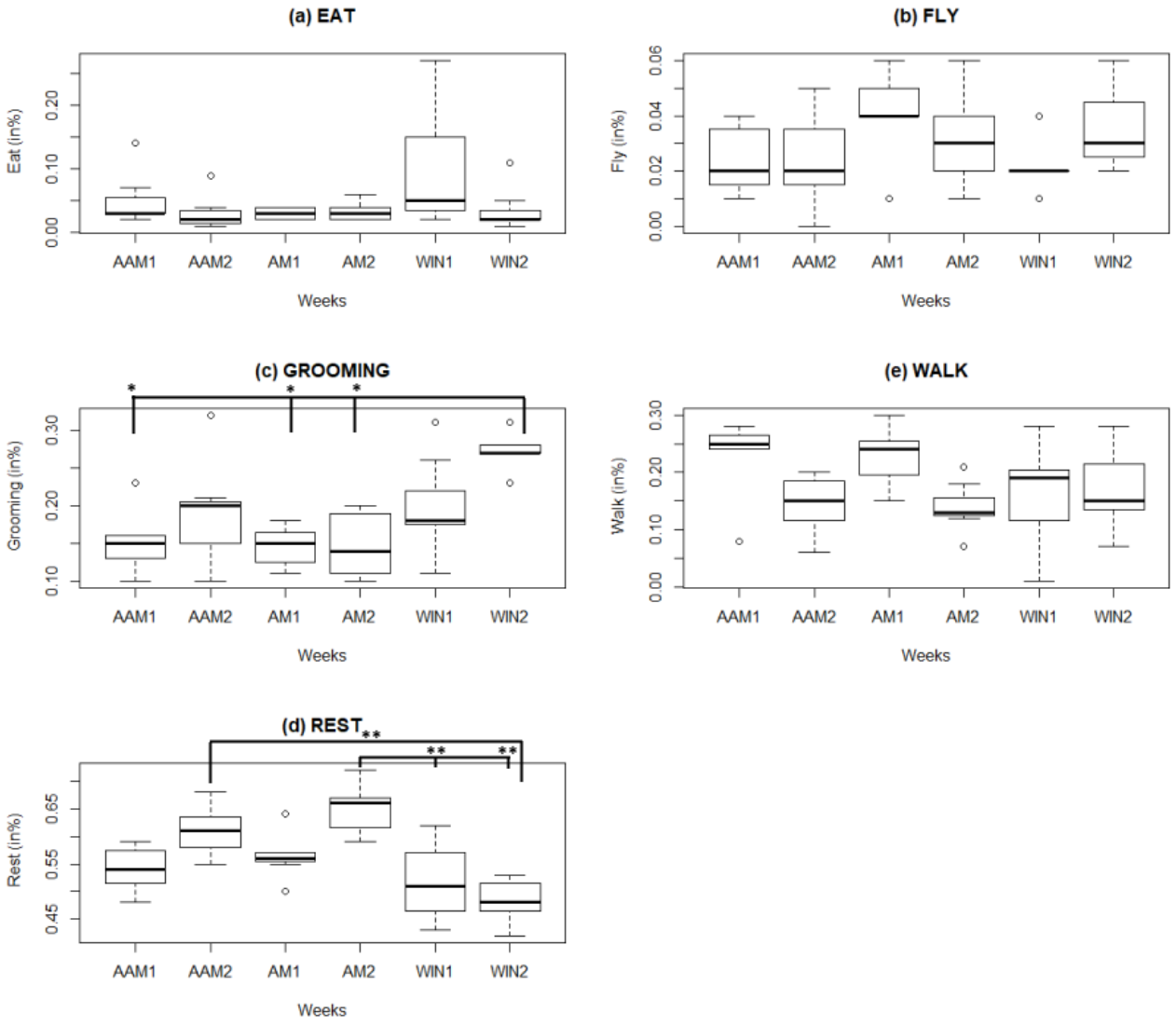


Figure 3 : Boxplot representing the proportion of each behaviour of the spoonbill according to the weeks before and after migration (AAM1 = 23 to 29 september 2017, AM1 = 30 september to 06 october 2017, WIN1 = 20 to 26 december 2017, WIN2 = 13 to 19 january 2018 , AAM2 = 14 to 20 february, AM2 = 22 to 28 february 2018) : (a) Eating behaviour, (b) Flying behaviour, (c) Grooming behaviour (* *p<0.01)*, (d) Walking behaviour and (e) Resting behaviour (**p<0.001).

DISCUSSION

Observing spoonbill in captivity allowed us to build an ethogram with two weeks of observations, and the Random forest algorithm allowed us to analyze the numerous accelerometer data, with a low error rate. According to GPS data during wintering the spoonbill spent his time in many differents spots along the river Gambia.

Results show that there are no differences before and after migration for behaviours eating, walking, and flying. The spoonbill spent more time resting during its pre breeding migration from Gambia compared to wintering period, and it spent more time grooming in a week of wintering compared to before migration period.

Feeding regroup the behaviours eating and walking, when the spoonbill is searching for food it walks in the water. An increase in the feeding time before migration was expected, but no difference was noticed. This results can be due to the fact that spoonbill avoid an unnecessary overload which would increase fly cost during migration (Weber et al. 1998). Other explanation can be that if the feeding time doesn't increase then it's the rate of food intake which increase. By feeding the same time the spoonbill could obtain a higher energy intake, the rate at which food is collected increase (Zwarts et al. 1990). As an example Time-stressed oystercatchers (*Haematopus ostralegus*) are able to increase their rate of food intake when their feeding time is reduced (Swennen et al. 1989).

The spoonbill had the same flying time before and after migration, compare to other behaviours it don't fly a lot (around 3% of the time). They fly to explore their environment and find new patches of food, when a patch is discovered there is no need to move a lot.

The spoonbill spend more time resting before its prebreeding migration compared to wintering period. Birds have energy gains and losses each day which can be influenced by his environment, for example temperature and photoperiod (Farmer & Wiens 1998), or disponibility of food etc. This parameters can have impacted the resting time of the spoonbill.

The spoonbill spent more time grooming in a week of wintering compared to before migration period. Grooming behaviour increase with parasite load (Cotgreave & Clayton 1994). According to the GPS the spoonbill where not exactly in the same area during the differents weeks, dissimilar spots can have more or less parasites. It can be interesting estimate specific diversity of parasites in fonction of the area visited by the spoonbill. Allopreening, which is grooming between individuals (especially in social species), participates in the removal of

parasites (Mo 2016). Allopreening can also promotes the formation of pair bonding (Barbour & DeGange 1982), so wintering interaction probably participate in social cohesion.

To conclude spoonbill behaviour doesn't show striking differences before and after migration. All this study was conducted on only one individual, but they can have differents strategies during migration period (Combreau et al. 1999). That's why equip other individuals is necessary to have a better understanding of the behaviour of this species.

Another behaviours which could be interesting to integrate in this model is the breeding behaviour of adults and the begging behaviour of youngs. Then by combining results of behaviour and gps data would be possible to know where are the area where the spoonbill reproduce and raised his chicks. Another possibility with accelerometer data would be comparing activity of the spoonbill between nights and days, between month, between years etc.

A wild young spoonbill were also equipped the 7th may 2018, when it were 4 weeks old, with an accelerometer on the ilôt de Banaston. Observations need to be completed to add the begging behaviour in the Random forest.

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I would also like to thank all of the staff at Parc aux oiseaux, which welcomed us and permitted to observed the captive spoonbill.

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ABSTRACT

Observer le comportement des espèces sur le terrain peut se révéler être une tâche ardue, certaines espèces peuvent être très craintives ou vivre dans des milieux difficiles d'accès. Le développement d'accéléromètres, qui détectent la position et le mouvement de l'animal, s'avère être une alternative aux observations de terrain. Les spatules blanches (*platalea leucorodia*) sont des oiseaux migrateurs difficile à observer. Nous avons donc équipé une spatule blanche captive d'un accéléromètre afin de caractériser ses principaux comportements facilement et de construire un éthogramme. Les accéléromètres sont des outils qui génèrent un grand nombre de données, l'analyse de celle-ci doivent se faire à l'aide d'un programme de machine learning : le Random Forest. Celui-ci permettra l'analyse des données de l'accéléromètre d'une spatule sauvage à partir des données de la spatule captive. Les oiseaux migrateurs peuvent avoir un changement de comportement avant la migration, notamment au niveau de l'alimentation, nous pouvons donc nous demander si il y a une augmentation dans le temps passé à se nourrir chez la spatule avant de migrer. Aucunes différences frappantes n'ont été trouvées, ces résultats peuvent s'expliquer par le fait que la spatule évite de se surcharger avant le vol. Mais ces données ne proviennent que d'un seul individu et chacun peut élaborer des stratégies différentes.

Mots-clefs : **Spatule blanche *(platalea leucorodia)*, comportement, accéléromètre tri-axial, machine learning, random forest, migration, éthogramme.**

Observing species behaviours in the field can be an hard task, some species can be fearful or live in area with reduced access. Development of accelerometers, which detect position and movement of animals, proves to be an alternative to field observations. Eurasian spoonbill (*platalea leucorodia*) are migratory birds complex to observe. We equipped one captive spoonbill with an accelerometer in order to characterize easily his main behaviours and built an ethogram. Accelerometers are tools that generate large data, machine learning, especially the algorithm Random forest, is necessary to analyze them. This will allow the analysis of accelerometer data of a wild spoonbill from data of the captive spoonbill. Migratory birds can have behavioral change before migration, especially for the feeding, we wonder if the wild spoonbill spend more time feeding before migration. No striking differences were found, these results can be explained by the fact that the spoonbill avoids to overload before the

flight. But these data come from only one individual and differents strategies can exist among individuals.

Keywords : **Eurasian spoonbill (platalea leucorodia), behaviour, triaxial accelerometer, machine learning, random forest, migration, ethogram.**