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Abstract

My internship took place at the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) in Berlin in the team of Dr. Robert Arlinghaus, who heads the Baggersee Project, among others. This project studies artificial lakes that are created by the exploitation of mineral resources. They form aquatic habitats for freshwater ecosystems and thus provide a refuge for rare and endangered species, helping to maintain and increase biodiversity. Although artificial gravel lakes are becoming an increasingly common type of freshwater lake, they have received little attention in the scientific field.

My work was based on the potential of gravel lakes for dragonfly reproduction. As bioindicators, dragonflies are important aquatic organisms. Dragonflies use almost all types of freshwater biotopes. The adult dragonfly is much more mobile than its larva. It can move away from its development site and be observed in habitats other than those necessary for reproduction (e.g. foraging). This study is organised around two questions : Is there a difference in dispersal ability between species that breed in gravel lakes and those that only visit them? What determines the breeding and/or visiting potential ?

An analysis of variance (ANOVA) was performed to investigate a potential difference in dispersal ability between species that breed in gravel lakes and species that only visit them. Breeding and visiting potential were then investigated in parallel with the different environmental parameters via correlations.

The results showed that there was no significant difference in dispersal ability between lake breeding and lake visiting species. The distance to the next river and the next lake are determining factors in the reproduction of dragonflies. Visitor potential correlates with all parameters of habitat quality, complexity of shoreline and riparian habitats and percentage of water by about 30%.

Summary

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Introduction

Freshwater ecosystems are important reservoirs of biodiversity that concentrate several issues such as the importance for maintaining terrestrial biodiversity, ecological services (e.g. water regulation and purification) and regulatory commitments. Freshwater ecosystems are the subject, for example, of the commitment to the DCE, which requires the return to good ecological status of all water bodies by 2015 (Beisel et al., 2010). Freshwater ecosystems show a decline in biodiversity due to certain threats that can be grouped into five categories: overexploitation, water pollution, flow modification, habitat destruction or degradation, and invasion by exotic species (Dudgeon et al., 2006). These threats interact with each other and impact freshwater ecosystems at different scales. It is important to find solutions to these threats because inland waters are an essential natural resource for economic, cultural, aesthetic and scientific reasons (Dudgeon et al., 2006). It is therefore essential to implement actions to conserve and restore these freshwater ecosystems so that they are functional for both nature and people. The preservation of these aquatic environments goes through different stages, starting with a diagnosis of the study area, followed by the definition of the territory's issues, which will allow the drawing up of a future action programme, and then ending with the evaluation of the effectiveness of the actions implemented. These conservation methods are diverse, given the diversity of existing ecosystems (Lemerle, 2018).

Artificial gravel lakes are usually created by the exploitation of mineral resources. More than 109 t of sand and gravel were extracted from more than 24,500 quarries and ditches in the European Union in 2017 alone (Nikolaus et al., 2020). At present, artificial lakes are part of many cultural landscapes. They form aquatic habitats for freshwater ecosystems and thus provide a refuge for rare and endangered species, helping to maintain and increase biodiversity (Nikolaus et al., 2020). In addition, these lakes provide many ecosystem services to humans, such as fish yield and recreation (Nikolaus et al., 2020). Although artificial gravel pit lakes are becoming an increasingly common type of freshwater lake, they have received little attention in the scientific field (Søndergaard, M. et al., 2018).

This is the reason why it is important to develop research projects on artificial lakes. The Baggersee Project, held by the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), focuses on artificial lakes from former mining operations. These gravel pit lakes are not taken into account in the German government's actions concerning the European Water Framework Directive. Within the Baggersee project, a comparison was made between artificial gravel pit lakes managed by representatives of recreational fishing and artificial gravel pit lakes not managed by representatives of recreational fishing, in order to find out whether recreational fishing can have an impact on fauna and flora species (odonates, amphibians, birds, macrophytes, etc.), thus limiting their richness and abundance. It turned out that recreational fishing did not seem to impact these species (Nikolaus et al., 2020).

Within this project several studies are carried out at different scales. The overall aim of this study is to understand the potential of gravel pit lakes for the reproduction of dragonflies. As bioindicators, dragonflies are important aquatic organisms (Harabiš et al., 2010). Dragonflies use almost all types of freshwater biotopes. Some species specialise in lotic aquatic environments and others use lentic ecosystems (Harabiš et al., 2010). For example, the Ornate Agrion (Ceonagrion ornatum) only thrives in small sunny streams (Harabiš et al., 2010). Species which are habitat-specialists can therefore be used for rapid mapping of the habitats they represent (Harabiš et al., 2010).

The life cycle of a dragonfly is characterised by a radical change of habitat from an aquatic to a terrestrial insect. Dragonfly larvae are adapted to many types of aquatic environments, but they are all predators (Raebel et al., 2010). Once adult, the dragonfly frequents the terrestrial environment while maintainng a link with aquatic environments, which represent a potential reproduction area (Raebel et al., 2010). Thus, despite their complex life cycle, with stages living in different environments, the larval and adult stages of dragonflies are not necessarily independent (Kietzka, 2019), and the assessment of the quality of a given body of water as dragonfly habitat depends on the suitability of it as foraging and reproduction habitat (Raebel et al., 2010).

The adult dragonfly is much more mobile than its larva. It can move away from its development site and be observed in habitats other than those required for reproduction (e.g. foraging). It is therefore important to distinguish between recruitment and foraging habitats (McCauley, 2006). Indeed, the dispersal capacity during the adult stage can lead to a distorted interpretation of the results in terms of reproduction and recruitment (Raebel et al., 2010).

Dragonfly adults seek specific microhabitats in terrestrial environments for foraging, resting, and reproduction (Dolný et al., 2014). The dispersal ability is important for effective management of endangered species (Dolný et al., 2014). It is not impossible to determine which species are recruiting and which are not. Species that are particularly mobile can be identified by monitoring and observation (Dijkstra, 2020). If the observed species is primarily engaged in hunting behavior during monitoring, the observer can assume that the species is not recruiting at that lake. In the case where the observed species is engaged in reproductive behavior (storming in the lake or copulation), it can be assumed that this species is recruiting (Dijkstra, 2020).

This study is organised around two questions : Is there a difference in dispersal capacity between species that breed in gravel lakes and species that only visit them ? What determines the breeding and/or visiting potential ? We assume that there is no difference in dispersal ability between species that breed in gravel lakes and species that only visit them.

Material and methods

Area of study

The study was conducted in the Central Plain ecoregion of Lower Saxony in noth-westem Germany (Nikolaus et al., 2020). The majority of lakes in this region are managed for recreational fishing by anglers' associations and clubs. The lakes studied were classified into 3 types : control lakes, lakes with added wood and shallow lakes with added wood (*Figure 1*). Intrinsic characteristics such as surface, shoreline, depth have been determined to characterise these lakes.

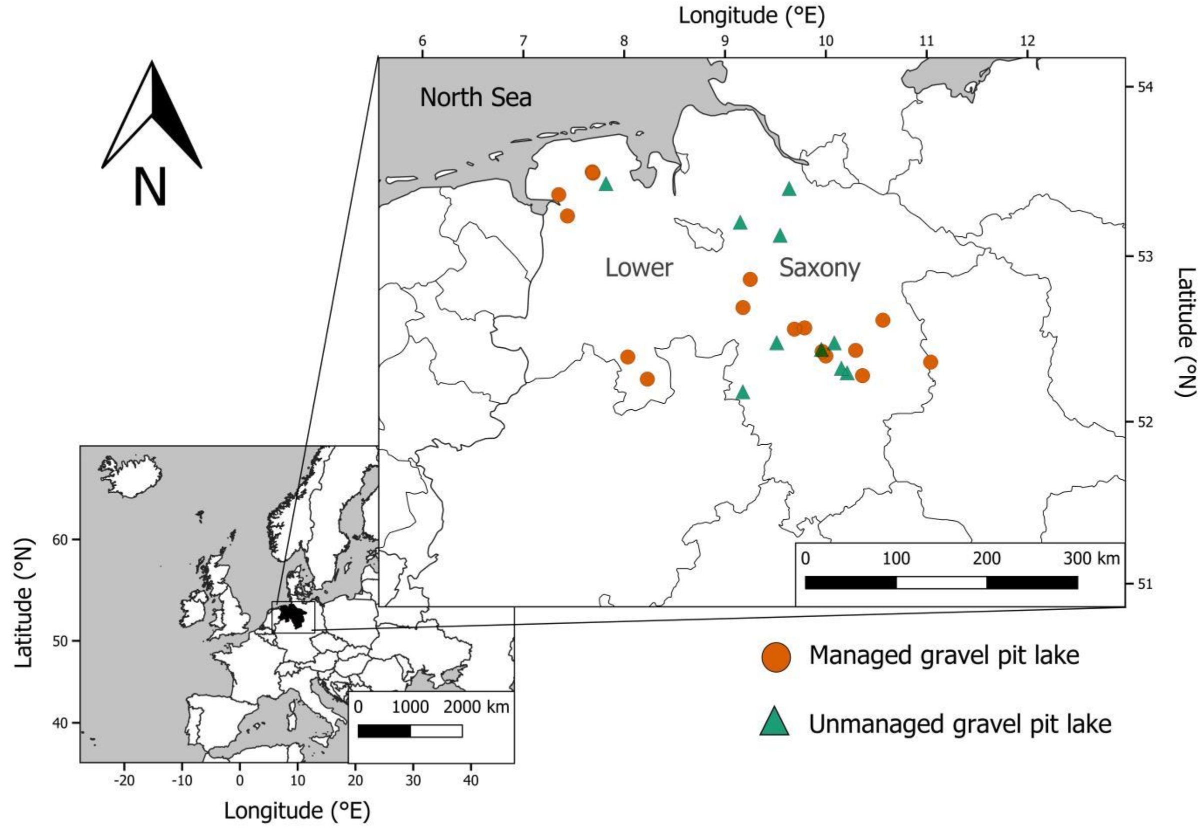

Figure 1 : All gravel pit lakes surveyed in Lower Saxony

Data collection and species collection

During the fieldwork, several samplings were carried out. Firstly, bird song was recorded every morning to determine the species of birds that frequent the lakes. Secondly, adult Odonata were sampled on each lake using random sampling : species were determined by observation and by capture (in the case where the species was difficult to identify) using a net. GPS points were recorded for each species. This sampling was carried out by making a single tour of the lake in order to avoid coming across the same species and thus avoid distorting the sampling. Identification was carried out using a determination key (Dijkstra, 2020). Abundance was also recorded by assigning three categories of abundance: the perception of one to two individuals per m^2 for the same species assigned a Low category, Medium when there were between 2 and 5 individuals and High when there were more than 5 individuals. Only Anisoptera were counted individually as they were less frequent than Zygoptera. It should be noted that the abundance of Odonata was highly dependent on the weather on the day of sampling. Rain and wind prevented Odonata from flying and therefore they remained on the ground, limiting their visibility and therefore the sampling.

On the other hand, the exuviae were sampled. They were collected in the lakes where the Macrozoobenthos sampling was carried out, i.e. a total of 12 lakes were concerned by the collection of exuviae (*Figure 2*). The number of sampling sites varied according to the type of lake. For control lakes, 4 sites per lake were sampled, which is the minimum based on the method and to cover enough riparian habitat. Sites were selected based on accessibility and shoreline coverage (Brauns et al., 2011). For the wood addition lakes, there were 6 sites : 3 control sites and 3 sites where wood was added. For wood addition and shallow lakes, 9 sites were sampled: 3 control sites, 3 wood addition sites and 3 shallow lake improvement sites. The number of sites was chosen to ensure statistical stability (Brauns et al., 2011). Exuviae collection time differed according to the number of sites : when there were only 4 sites to be studied, 30 minutes of exuviae search time was allowed per site. For lakes with 6 sites, the search time was 20 minutes per site. For lakes with 9 study sites, the search time was 15 minutes per site. The exuviae were stored in tubes and on each tube the name of the lake, the date, the site number and the type of vegetation were recorded. The exuviae were then brought back to the laboratory to be identified using a binocular magnifying glass and the identification key of Mr Tachet (Tachet, 2010). The identification was carried out up to the genus or even the species when possible.

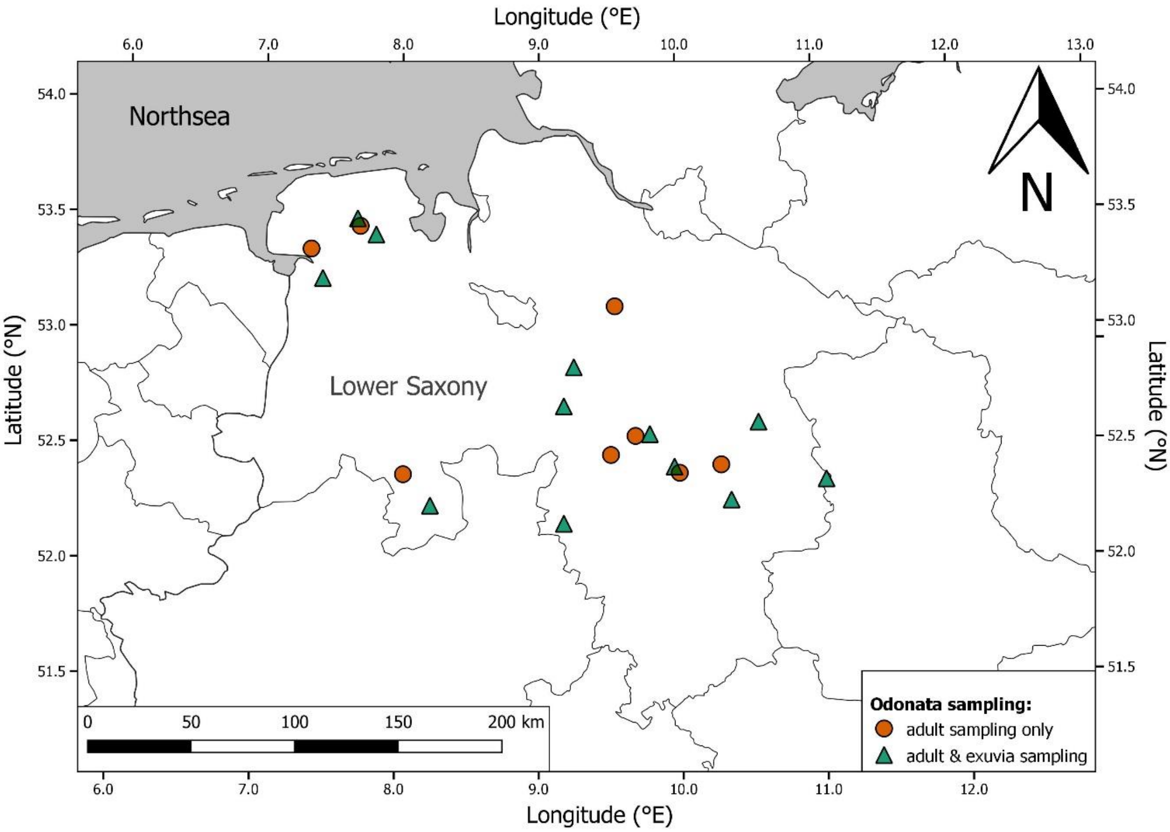

Figure 2 : Gravel pit lakes where adult dragonflies only and adult dragonflies and exuviae were sampled

Littoral index and other environmental co-variates

Un indice littoral a été développé les années précédentes pour les lacs sélectionnés en utilisant la méthode de Kaufmann et al. (2014). Après avoir étudié la structure de l'habitat physique du rivage et des zones riveraines ainsi que les activités anthropiques sur les lacs, un ensemble de paramètres de l'habitat physique ont été calculés tels que les paramètres de la végétation riveraine et de la couverture du rivage (Kaufmann et al., 2014). L'ensemble de ces paramètres vont être comparés au nombre d'espèces qui se reproduisent par lac et au nombre total d'espèces par lac (*Table 1*). Among these parameters, RDis_IX is calculated from agricultural and non-agricultural disturbances near the shoreline (Kaufmann et al., 2014). The RVegQ index is used to assess the availability of plants on the shoreline of the studied lake. As the potential vegetation cover differs between regions, 3 variants of this index were calculated in order to apply it according to the ecoregion studied (Kaufmann et al., 2014). LitCvrQ is based on visual estimates of the surface cover of several coastal features including aquatic macrophytes but excluding artificial structures. The littoral riparian habitat Complexity index is calculated from RVegQ and LitCvrQ. Lakeshore Physical Habitat Quality Index (LkShoreHQ) is calculated by averaging the indices of Riparian Vegetation Cover Complexity, Littoral Cover Complexity, and [lack of] near-shore anthropogenic disturbance (Kaufmann et al., 2014). Other parameters such as distance to the next lake, percentage of water in a 100 meter buffer, will be compared to the number of Odonata species depending on whether they breed or not.

Table 1 Environmental parameters and their definition

RDis_IX	Lakeshore Human Disturbance Index : Near-shore extent and intensity
RVegQ_2	Riparian Vegetation Cover Complexity Index
LitCvrQ_c	Littoral Cover Complexity Index
LitRipCvQ	Littoral–Riparian Habitat Complexity Index
LakeShoreHQ	Lake Shore Habitat Quality Index

Data analysis

Species were divided into 3 reproductive stages depending on whether they were found in at least the exuvial, larval or adult stage. The larval stage was studied based on data processed in 2017 and 2020. Then, each species was assigned a level of dispersal ability. An analysis of variance (ANOVA) will be performed to investigate a potential difference in dispersal ability between species that breed in gravel lakes and species that only visit them. The hypothesis H0 illustrates that there is no difference in dispersal ability between species that breed in gravel pit lakes and species that only visit them.

The potential for breeding and visiting will then be investigated by drawing a parallel with the different environmental parameters mentioned above. The Pearson correlation coefficient will be calculated to see whether or not there are correlations between the number of breeding and visiting species and the environmental parameters.

Results

Dispersal ability between species that breed in gravel lakes and species that only visit them

In order to find out whether there is a difference in dispersal capacity between species that breed in gravel pit lakes and species that only visit them, we constructed a table illustrating for each lake the name of the species present as well as its level of reproduction (3 for a species found at least in the exuvial stage in 2021, 2 for a species found at least in the larval stage in 2017 or 2020, and 1 for a species only found in the adult stage in 2017 or 2020 (*Annex 1*). This table was used to construct the following Boxplot (*Figure 3*). The dispersion capacity is divided into 3 levels: 0 for low dispersion capacity, 1 for medium dispersion capacity and 2 for high dispersion capacity.

Figure 3 : Dispersal capacity of the three Odonata breeding groups

The latter shows that there is a significant difference in dispersal ability between species with level 3 reproduction and species with level 1 reproduction. Indeed, species only present in the adult stage have a higher dispersal capacity (median of 1.5 for level 1 and a median of 1.3 for level 3). However, there is no significant difference for species with level 2 reproduction.

In order to verify the boxplot results, an analysis of variance (ANOVA) was performed. The sum of the squares (SS) for the Inter classes and Intra classes was calculated. These calculations were followed by a Fisher-Snedecor (Figure *4* and *Table 2*). In terms of interpretation, the greater the calculated F, the more significantly the class means differ and therefore the more dispersal capacity explains the reproductive levels of Odonata. It is recalled that the null hypothesis H_0 illustrates the independence between dispersal ability and reproductive success. In other words, the null hypothesis H_0 assumes that there is no difference in dispersal capacity between species that breed in gravel pit lakes and species that only visit them.

$$\text{Test F calculated} = \frac{\frac{SS\ inter\ classes}{(k-1)}}{\frac{SS\ intra\ classes}{(n-k)}}$$

Figure 4 : F-test formula with k the number of species reproduction categories and n the total sample size (145)

Table 2 : Calculation of the F-test

SS Inter Classes	1,19
SS Intra Classes	52,44
k-1	2
n-k	142
Test F calculated	1,62
F read from the table	2,99

The calculated F is lower than the F read in the Fisher-Snedecor table (*Annex 2*), Therefore, the H_0 hypothesis is validated. There is therefore no significant difference in dispersal ability between species that breed in gravel pit lakes and species that only visit them. This lack of difference in dispersal can be explained by the fact that species A can be considered as breeders in some lakes but also as visitors in other lakes, knowing that they have the same dispersal capacity. Therefore, it is the environmental parameters of the lakes studied that could determine the reproductive potential of these species.

Potential for reproduction and visits

After checking that the different variables follow a normal distribution, the Pearson correlation coefficient was calculated using the following formula (*Figure 5*) :

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

Figure 5 : Pearson formula with $\bar{X}$ the sample mean for the first variable and $\bar{y}$ the sample mean for the second variable

Species considered to be breeding are part of breeding level 3 and potentially breeding species include both level 2 and level 3 species. Whether we are talking about breeding species, potentially breeding species or the total number of species per lake, the RDis_IX index reflecting the human disturbance index of the lakeshore does not correlate with the presence of species (*Table 3*, *Table 4* and *Table 5*). The habitat quality index of the lakeshore does not correlate with breeding and potentially breeding species (*Table 3* and *Table 4*). It is therefore not a decisive index for reproductive success. However, there is a significant correlation between this index and the total number of species (*Table 5*). Indeed, this index illustrates 30% of the distributions of the total number of species per lake. The same is true for the environmental parameters LitCvrQ_c and LitRipCvQ, which show practically the same Pearson values with the total number of species (*Table 5*). These indices reflect the complexity of shoreline and riparian habitats. Thus, in some cases, the better and more complex the habitat, the more likely dragonflies are to be found along the lake shore for territorial and food supply purposes, and thus the greater their numbers. On the other hand, the percentage of water explains 35% of the distributions of the total number of species per lake, but does not correlate with species with breeding level 2 and 3. In other words, as the percentage of water increases, there is a 35% probability that the total number of Odonata species will increase (*Table 5*). This is interesting for lakes with a large surface area and therefore a large percentage of water.

The distance to the next river and the distance to the next lake are decisive distances for dragonfly reproduction (*Table 3* and *Table 4*). The correlation is significant for both breeding and potentially breeding species. It is, however, more significant for species at breeding level 3 (*Table 3*). Thus, the smaller the distance between the lake studied and the nearby river/lake, the lower the likelihood that a significant number of level 3 breeding species will be found (*Figure 6*). The latter will probably prefer to breed in the nearby aquatic environment (lake or river). However, the distance to the next canal does not correlate with the species in level 2 and level 3 breeding (*Table 3* and *Table 4*).

Table 3 : Study of the correlation between the number of breeding species and environmental parameters

	Pearson Coefficient
RDis_IX	0,015
RVegQ_2	0,169
LitCvrQ_c	-0,045
LitRipCvQ	0,037
LakeShoreHQ	0,014
% Water in 100m-Buffer	-0,423
Distance to next water (m)	0,149
Distance to next river (m)	0,659
Distance to next lake (m)	0,634
Distance to next canal (m)	-0,216

Table 4 : Study of the correlation between the number of potentially breeding species and environmental parameters

	Pearson Coefficient
RDis_IX	-0,002
RVegQ_2	0,262
LitCvrQ_c	0,038
LitRipCvQ	0,143
LakeShoreHQ	0,087
% Water in 100m-Buffer	-0,117
Distance to next water (m)	0,270
Distance to next river (m)	0,548
Distance to next lake (m)	0,489
Distance to next canal (m)	-0,218

Table 5 : Correlation study between the total number of species and environmental parameters

	Pearson Coefficient
RDis_IX	-0,153
RVegQ_2	0,230
LitCvrQ_c	0,361
LitRipCvQ	0,385
LakeShoreHQ	0,309
% Water in 100m-Buffer	0,356
Distance to next water (m)	0,148
Distance to next river (m)	-0,011
Distance to next lake (m)	-0,010
Distance to next canal (m)	0,265

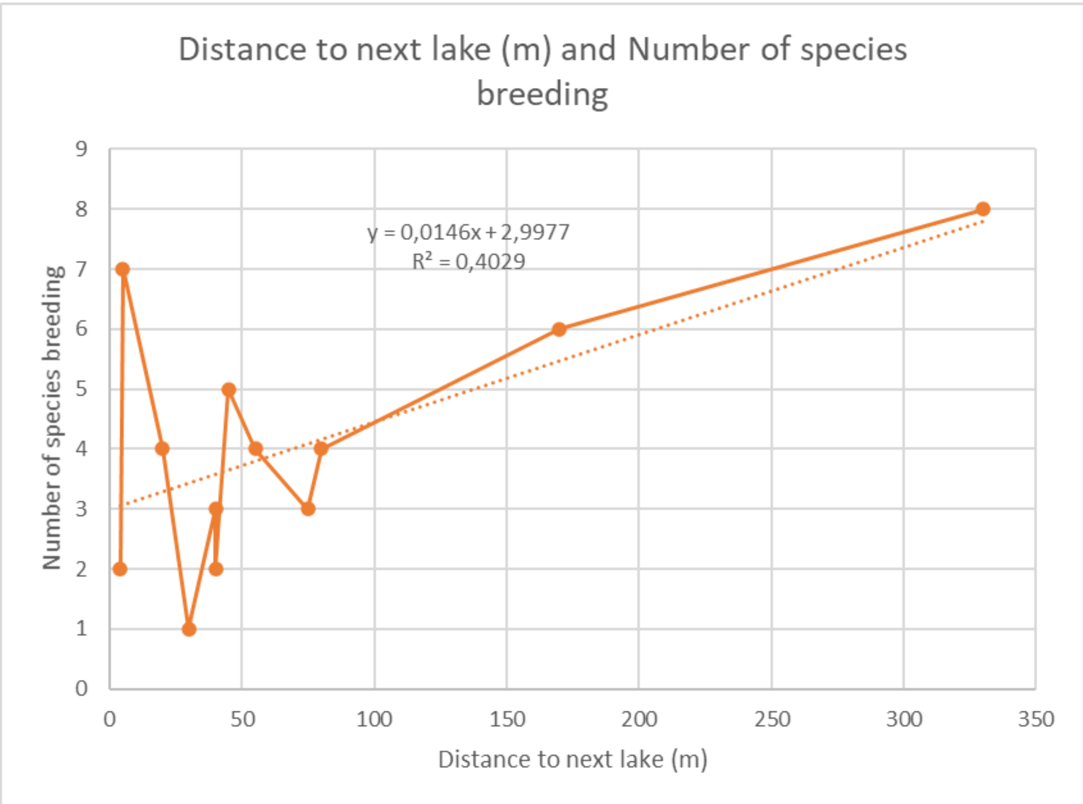

Figure 6 : Linear regression between distance to next lake and number of breeding species

The canopy complexity index does not show a significant correlation between the different species categories. The latter is not a determining factor for dragonfly reproduction.

According to the *Table 6*In this study, we can see interesting correlations between the average dispersal capacity and certain environmental parameters. There is a significant correlation (72%) between the average dispersal capacity and the percentage of water in a 100 meter buffer. According to the Figure 7, the higher the percentage of water, the higher the dispersal capacity. This can be interpreted as the fact that species prefer to "spread out" around the lake for territorial reasons, but also for reproduction : the more different areas are used for reproduction, the more likely it is that reproduction will be successful. This increase in percentage of water with the increase in average dispersal capacity may reduce the effects of competition between species for territory and predation for food. A significant correlation between the average dispersal capacity and the habitat quality index of the lakeshore (33%). Thus, a certain quality of lakeshore habitat could explain 33% of the average dispersal capacity (*Table 6*). Quality habitat means diversity of habitat and therefore more 'choice' in terms of habitat for species. Consequently, this results in an average capacity to breed for 33% of the cases (*Table 6*). The correlations between the average dispersion capacity and the RVegQ_2, LitCvrQ_c and LitRipCvQ indices are between 22% and 28%. (*Table 6*). There are therefore some cases where these indices of habitat complexity explain a significant average dispersal capacity.

Table 6 : Study of the correlation between the average dispersal capacity and environmental parameters

	Pearson coefficient
RDis_IX	-0,312
RVegQ_2	0,255
LitCvrQ_c	0,225
LitRipCvQ	0,289
LakeShoreHQ	0,332
% Water in 100m-Buffer	0,724
Distance to next water (m)	0,104
Distance to next river (m)	-0,382
Distance to next lake (m)	-0,397
Distance to next canal (m)	0,198

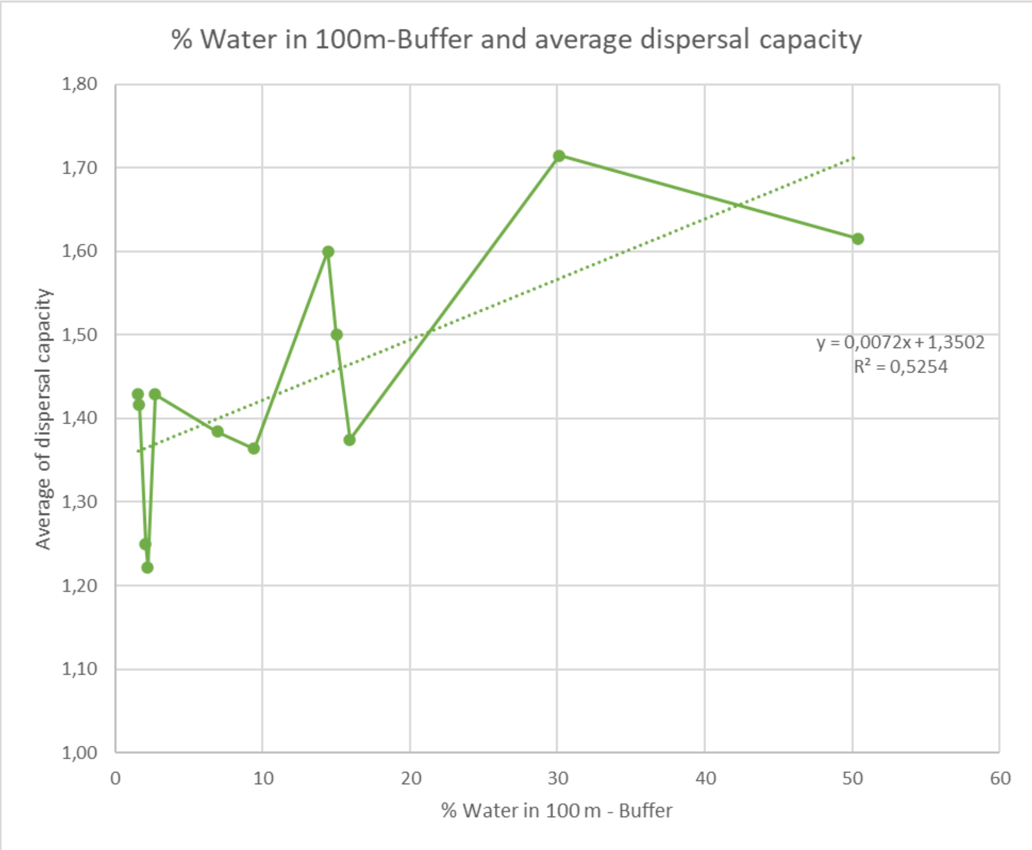

Figure 7 : Linear regression between the percentage of water in a 100 meter buffer and the average dispersal capacity

Discussion

The results showed that there was no significant difference in dispersal ability between lake-breeding and lake-visiting species. This can be explained by the fact that dispersal ability is classified on only three levels (low, medium and high) and that only two species (Ceriagrion tenellum and Erythromma najas) show a low dispersal ability. The majority of the species have a medium and high dispersal capacity, so the results are highly concentrated around these two dispersal levels. In addition, dispersal can vary according to the behaviour of the species: a species like Erythromma najas with a low dispersal ability may find itself dispersing further than usual for territorial and breeding reasons. The dispersal ability of species is therefore a very relative and biased parameter.

It would seem that the study of species movements and routes is more reliable, but more complex. Indeed, it has been shown that a male moving to its breeding site and a sun roost repeatedly uses the same flight route (Bried, 2006). Although few studies have been carried out on this subject, it is likely that dragonflies use familiar landmarks to move to breeding and feeding grounds. It would be interesting to study the fidelity of species to gravel lakes for both breeding and feeding. This loyalty could be reflected in the ability to return to areas of certain lakes even after bad weather has forced them into a long absence (Bried, 2006).

In terms of determining reproductive potential, one would have thought that certain environmental parameters (such as the human disturbance index of the lake shore and the complexity index of the riparian vegetation cover) could be strongly correlated with the number of species reproducing. However, when analysing the results, the human disturbance index, for example, is not correlated at all with species in breeding level 2 and 3. In addition, the complexity index of the riparian vegetation cover explains the reproductive potential poorly. In fact, during the collection of exuviae in the field, exuviae could be present in very large numbers at sites with no vegetation or structures favourable to the ascent of the larvae to the surface. Conversely, several sites had abundant structures but on several occasions contained few or no exuviae. The weather seems to be a more important factor in determining reproductive success. Wind and rain repeatedly prevented the larvae from surfacing for hatching, while sunshine and warmth strongly favoured this phenomenon in our field studies. Other environmental parameters, such as the distance to the next river and lake, are determining factors in dragonfly reproduction. Some of the lakes studied had water bodies nearby. Depending on the distance between the lake and the water body (river or other lake), Odonata species that want to breed are likely to use the lake and the water body to increase their breeding chance, instead of "banking" only on the study lake. This may explain why at the time of collection the exuviae were not as numerous as expected.

Other parameters can influence the selection of breeding sites considerably. For example, the interactions of dragonflies with their predators and conspecifics can be a major issue. These interactions can be both positive and negative. Interactions with predators, for example, are clearly negative and so species will try to minimise these interactions. Conversely, some males will locate themselves in such a way as to maximise their ability to detect and interact with females.

Visitor potential correlates with the overall parameters of habitat quality, complexity of littoral and riparian habitats and percentage of water by about 30%. Indeed, the complexity and abundance of water quantity may allow Odonata to feed in these areas where prey is abundant. In addition, dragonflies require perches when light levels are low or weather conditions are unfavourable. The complexity of the habitat may therefore be favourable to this situation.

The average dispersal capacity increases with the percentage of water in the lake. Breeding areas usually have high densities of dragonflies. Therefore, dragonflies tend to disperse further when the water surface is larger in order to find other favourable locations for food supply. Thus, interference and competition between breeding and visiting species is reduced.

During the study of some lakes, species were found in the exuvial and larval stages but not in the adult stage. This is the case for several Anisoptera such as Cordulia aenea and Orthetrum cancellatum. There are therefore two possible hypotheses. The capture of Anisoptera is very complicated because their flight is very fast and unpredictable and their static time is very short. In addition, the capture period could vary between several lakes and therefore at a time t certain species were absent at the time of capture but could be present at a time t+1 when the capture was completed. This hypothesis is very likely. A second possible hypothesis is that certain species simply frequent the gravel pit lakes for their reproduction and from the adult stage onwards these species disperse to other areas.

In addition, during the identification of the exuviae, a significant number of exuviae could not be identified because of the absence of the mask and caudal lamellae, which are essential elements for identification. This limits the possibility of having species present at the exuvial stage for certain lakes.

Conclusion

My internship was carried out in the Baggersee project team. The aim of this project is to analyse and improve the biodiversity of gravel pit lakes. These lakes have a high biodiversity potential but are currently not protected by the EU WFD. In this report, the work was based on the study of Odonata on 12 study lakes. We showed that there was no significant difference in dispersal ability between lake-breeding and lake-visiting species. We also showed that some parameters were determinant of the reproductive potential, such as the distance to the next lake. And others were determinants of visiting potential (e.g. habitat complexity and quality). This study revealed how complex the behaviour of Odonata is and how interesting it is to study them.

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Annexs

Annex 1 : Extract from the table referring to the reproduction level and dispersal capacity of each species by lake

Name of the lake	Name of the specie	Reproduction level	Dispersal capacity	Dispersal capacity (number)
Hopels	Brachytron pratense	3	Medium	1
Hopels	Coenagrion puella	3	High	2
Hopels	Cordulia aenea	3	Medium	1
Hopels	Enallagma cyathigerum	3	Medium	1
Hopels	Erythromma najas	3	Low	0
Hopels	Gomphus pulchellus	3	Medium	1
Hopels	Ischnura elegans	3	High	2
Hopels	Libellula quadrimaculata	3	High	2
Hopels	Somatochlora metallica	2	Medium	1
Hopels	Calopteryx splendens	1	Medium	1
Hopels	Orthetrum cancellatum	1	High	2
Hopels	Pyrrhosoma nymphula	1	Medium	1
SAA	Erythromma najas	3	Low	0
SAA	Ischnura elegans	3	High	2
SAA	Orthetrum cancellatum	3	High	2
SAA	Platycnemis pennipes	3	Medium	1
SAA	Coenagrion puella	2	High	2
SAA	Enallagma cyathigerum	2	Medium	1
SAA	Libellula depressa	1	High	2
KOL	Coenagrion puella	3	High	2
KOL	Erythromma najas	3	Low	0
KOL	Ischnura elegans	3	High	2
KOL	Anax imperator	2	High	2
KOL	Enallagma cyathigerum	2	Medium	1
KOL	Platycnemis pennipes	2	Medium	1
KOL	Anax parthenope	1	High	2
KOL	Calopteryx splendens	1	Medium	1
KOL	Crocothemis erythraea	1	High	2
KOL	Gomphus pulchellus	1	Medium	1
KOL	Lestes sponsa	1	High	2
KOL	Orthetrum cancellatum	1	High	2
KOL	Pyrrhosoma nymphula	1	Medium	1
KOL	Sympetrum sanguineum	1	Medium	1

Annex 2 : Fisher-Snedecor table

ν_2 \ ν_1	1	2	3	4	5	6	8	12	24	>25
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	249.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.45	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.84	8.74	8.64	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.77	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.53	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.84	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.41	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.12	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.90	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.74	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.61	2.40
12	4.75	3.88	3.49	3.26	3.11	3.00	2.85	2.69	2.50	2.30
13	4.67	3.80	3.41	3.18	3.02	2.92	2.77	2.60	2.42	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.35	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.29	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.24	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.19	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.15	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.11	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.08	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.42	2.25	2.05	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.03	1.78
23	4.28	3.42	3.03	2.08	2.64	2.53	2.38	2.20	2.00	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	1.98	1.73
25	4.24	3.38	2.99	2.76	2.60	2.49	2.34	2.16	1.96	1.71
26	4.22	3.37	2.98	2.74	2.59	2.47	2.32	2.15	1.95	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.30	2.13	1.93	1.67
28	4.20	3.34	2.95	2.71	2.56	2.44	2.29	2.12	1.91	1.65
29	4.18	3.33	2.93	2.70	2.54	2.43	2.28	2.10	1.90	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.89	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.79	1.51
60	4.00	3.15	2.76	2.52	2.37	2.25	2.10	1.92	1.70	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.02	1.83	1.61	1.25
>120	3.84	2.99	2.60	2.37	2.21	2.10	1.94	1.75	1.52	1.00