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Aeshna viridis distribution and habitat choices in South and Central Sweden and the possibility to use a database as a tool in monitoring a threatened species

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Abstract

Aeshna viridis, a dragonfly generally considered to be a specialist as it in most cases chooses *Stratiotes aloides* as its habitat, have suffered badly from habitat loss and fragmentations throughout Europe under the last century as the human demand of land use have grown. It´s thereby considered *near threatened* on EU red list and is included in the Habitat Directive. This means that it is protected by EU law as all EU Member States is committed to protect, monitor and report back to EU the status of the species. Several European countries have designed protection plans for *S. aloides* to improve the preservation of *A. viridis*. My study in South and Central Sweden shows that the strong connection between *A. viridis* and *S. aloides* may not be consistent all over the distribution range of *A. viridis*, as my survey showed that larvae occur among other water plants when *S. aloides* is not present. Another aim in this study was to evaluate the possibility to use occurrence data on *A. viridis* and *S. aloides* from the Species Observations System to monitor *A. viridis* distribution and dispersal. My study implies uncertainties of how well the datasets reflects reality and more research is necessary before clarifying if datasets could be a possible tool in conservation management of *A. viridis*.

Introduction

Human activities have expanded and intensified under the last centuries as industrial, agricultural and urban areas have grown, causing dramatic changes on the environment, both structurally and functionally (Smith, Tilman & Nekola, 1999). This has resulted in habitat loss and fragmentation (Liao et al, 2013) causing heavily decline on the biodiversity (Scherr & McNeely, 2007; Raebel et al, 2012). Dragonfly populations throughout Europe suffered badly and decline severely (Keller et al, 2010; Kalkman et al, 2010). One factor responsible of this is the decreasing number of suitable water bodies (Keller et al, 2010; Raebel et al, 2012) which are important for dragonfly reproduction cycle as most dragonfly species oviposit in water-courses, lakes, ponds and fens and their larvae stage occurs in water (Clausnitzer et al, 2009; Corbet, 1999; Keller et al, 2010). Especially specialists that are depending on a specific habitat can easily go extinct if their habitat disappears (Harabiš and Dolný, 2011; Suutari et al, 2008). One specialist that is suffering from habitat loss and degradation is *Aeshna viridis*, a dragonfly that is considered to be *near threatened* on the red list of European dragonflies (Kalkman et al, 2010). The larva of this dragonfly is strongly associated to *Stratiotes aloides* (Rantala et al, 2004; Suutari et al, 2008; de Vries, 2010; Jaeschke et al, 2012), which is a water macrophyte whose rosette hibernates on the bottom of ponds, lakes and ditches through the winter. The rosette emerges to the surface at spring and then stays floating until autumn and sinks down to the bottom again (Smolders et al, 2003; Strzałek and Koperski, 2008). The rosette with its spine-covered leaves and its dense populations makes a good shelter for dragonfly larvae both against fish predation (Corbert, 1999; Rantala et al, 2004), intraguild predation and interference competition by larvae from other dragonfly species (Corbert, 1999; Hopper, 2001; Suutari et al, 2004). Studies have showed that female *A. viridis* is mainly laying her eggs on *S. aloides* leaves but can sometimes also oviposit on other water plants as for example *Typha* spp. and *Sparganium* spp. (Rantala et al, 2004; Suutari et al, 2008). It have also been shown that larvae can be found among other plants, but only if *S. aloides* is present in the same environment (Rantala et al, 2004).

S. aloides is typically found in eu- and mesotrophic shallow parts of stagnant streams, ponds, lakes and ditches. Because there are nearly only female specimens of *S. aloides* in northern temperate areas the reproduction is mainly asexual as the mother plant sends out tillers and turions which creates dense populations (Nielsen and Borum, 2008; Strzałek and Koperski, 2008; Smolders et al, 2003). It´s special life strategy and asexual reproduction makes it sensitive and eutrophication caused by the modern agriculture and changes in the hydrological structure has led to its decline under the last century (Smolders et al, 2003; Rantala et al, 2004). The eutrophication has caused higher level of ammonium and phosphate in the water which have been to a benefit for free-floating macrophytes (Smolders et al, 2003; Rantala et al, 2004). It is mentioned in Smolders et al (2003) that free-floating species, as *Azolla filiculoides, Lemna gibba* and *Spirodela polyrhiza*, compete with *S. aloides* for light recourses by growing around and inside the rosette. These species can even create a thick blanket on the surface before *S. aloides* has been able to emerge to the surface in spring. There are also problems with filamentous algae that gradually overgrow the rosette over time. Ammonium and sulphide toxidity caused by eutrophication have also had an important role in *S. aloides* decline, as have declining iron level in the groundwater (Smolders et al, 2003).

In addition to *A. viridis* being considered to be *near threatened* on the European red list (Kalkman et al, 2010) it is included in the Habitat Directive. The Habitat Directive is a framework of laws established by the EU government to protect vulnerable and endangered species and nature in Europe which all EU Member States are committed to follow. They are committed to secure exposed populations and nature, continuously monitor its livelihood and report back to the EU (European Commission, 2013). Today's monitoring of threatened dragonfly in Sweden has focused on field surveys, by observations of adult and by netting of adult and larva. These methods can be time consuming and can only be performed at certain periods of the year (Sahlén, 2006) for example observations of adult dragonflies which only can be done the period of time when the species is air borne (Norling & Sahlén, 1997; Corbet, 1999).

However, datasets on species distribution are more and more frequently used to investigate species dispersal ability, ecology and habitat choice in conservation managing (Pressey et al, 2007; Reside et al, 2011). The majority of these datasets contain presence-only data, which signify occurrence data on found species and are often received from natural history collections at museums or from university. Though this data have often been gathered by different collectors with different intentions, methods and knowledge (Graham et al, 2004; Elith et al, 2006, De Ornellas, Milner-Gulland & Nicholson, 2011; Reside et al, 2011), which can result in biased data and errors. So it is important to be aware of this to make rightful decisions from the results of the datasets when doing conservation planning (Graham et al, 2004; Rae, Rothley & Dragicevic, 2007; De Ornellas, Milner-Gulland & Nicholson, 2011). Still the possibility to use natural history collection datasets in conservation managing (Graham et al, 2004; Bunce et al, 2013) could be a major advantage in monitoring *A. viridis* dispersal and distribution as this kind of monitoring would be less expensive and less resource-demanding. The Species Observation System is a web-based report system collecting occurrence data on species in Sweden and Norway and is available for anyone to use and it contains occurrence data on both *A. viridis* and *S. aloides* (Artportalen, 2013). Since there have been reports of strong relationship between *A. viridis* and *S. aloides* (Rantala et al, 2004; Suutari et al, 2008; de Vries, 2010; Jaeschke et al, 2012), makes me speculate if it is possible to use datasets on *S. aloides* to estimate *A. viridis* distribution. It could be favorable as the Species Observation System has larger datasets on *S. aloides* than the dataset on *A. viridis* (Artportalen, 2013) and could thereby give a better estimation of *A. viridis* distribution than only using datasets on *A. viridis.* However there are some uncertainties if this relationship is as strong as it claims since there have been few studies on the ecology and habitat of *A. viridis* larvae particularly in the northern area of its distribution (Rantala et al, 2004; Sahlén & Ekestubbe, 2001). Especially as it have been documented that female *A. viridis* sometimes oviposit in other vegetation than *S. aloides* (Rantala et al, 2004; Suutari et al, 2008) and larvae have been found in other type of vegetation (Rantala et al, 2004; Sahlén & Ekestubbe, 2001).

Because of these uncertainties I have chosen to investigate how strong the relationship is between *A. viridis* and *S. aloides* in Sweden, both by comparing datasets from Species Observation Systems over the species distribution in Sweden and by doing fieldwork in South and Central Sweden. I have also chosen to do field research if it´s possible to find *A. viridis* larvae in other water plants without *S. aloides* present in the environment. I am also investigating how well these occurrence dataset reflects distribution of the species in reality in South and Central Sweden.

Materials and methods

719 locations for *S. aloides* and 240 for *A. viridis* were downloaded from the Species Observation System on the18 of April 2013 (Artportalen, 2013) which means that data reported after 18 April 2013 haven't been used in this study. Species Observation System is a web-based report system for people or organizations to report findings of species in Sweden and Norway and it is open for everyone to use. The system have got more than 35 million findings which stretches back to the 19st century and is collected by more than 16 000 registers. The Species Observation System runs by the Species Observation System Council were representatives from the Swedish Environment Protection Agency (SEPA), different county administrative boards, municipalities and NGOs are involved with the management and developing of the system (Artportalen, 2013)

The downloaded data from Species Observation System were compiled and compared to study in what extent the co-occurrence between the species were. In this thesis I chose to define a site with co-occurrence of *A. viridis* and *S. aloides* by the dispersal ability of the dragonfly species and concluded that dragonflies with the size of *A. viridis* have at least two kilometers dispersal ability (Corbet, 1999). This means that locations with *S. aloides* will be noted to occur within an *A. viridis* dispersal area if the plant species has been found within a radius of two kilometers from where the *A. viridis* coordinate was taken.

The fieldwork was done in May and June 2013 at 34 locations in Västergötland, Bohuslän, Småland, Östergötland, Västmanland, Sörmland and Uppland, in South and Central Sweden. 30 of these locations were chosen from data obtained from the Species Observation System and four were old localities from the 1980s received from Göran Sahlén. The locations from the Species Observation System have been reported by different private individuals, organizations and county administrative boards and have been observed between the years 1976 to 2012. At the locations larvae were collected among different aquatic vegetation by standard water net. The netting was conducted with three swipes in a 100 cm wide section along with the shoreline. This was repeated 3-4 times among each vegetation type as one location could have only two vegetation types or as high as 5 different types.

The species determinations were done in field with guidelines from Norling and Sahlén (1996). It was also noted in which vegetation *A. viridis* larvae were found. The larvae were then released back in the vegetation when all of the netting were complete as *A. viridis* should only be collected if there isn't any other options and if there will be no negative effect on the population as it is under protection of Swedish and European law (SFS 2007:845; European Commission, 2013) .

All statistics were conducted in the R environment version 3.0.0 (R Development Core Team, 2013). Logistic regression was used to investigate if there was an association between presence/absence of *A. viridis* and *S. aloides* with binomial error structure and log-link function.

Results

From the 240 locations where *A. viridis* had been found, 94 of this were in a two kilometer reach of a *S. aloides* site (see Figure 1). Contrary to this, only 72 locations of 719 sites with *S. aloides* lay within an *A. viridis* dispersal area (see figure 2). According to the Species Observation System database *A. viridis* had been observed at 13 of the 30 locations that were visited. *A. viridis* larvae were found at 6 of these locations (see figure 3). At 21 locations on reported *S. aloides* only 8 locations were inhabited by *S. aloides* (see figure 4).

A. viridis and *S. aloides* were found at

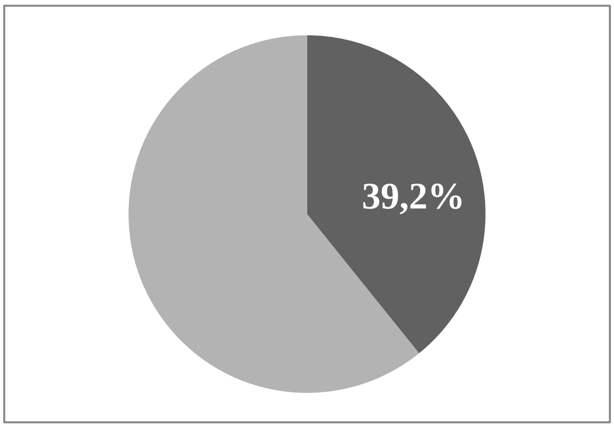

Figure 2, analyzed data from the Species Observation System database shows in what extent found *A. viridis* locations lays in a two kilometer reach of found *S. aloides* location.

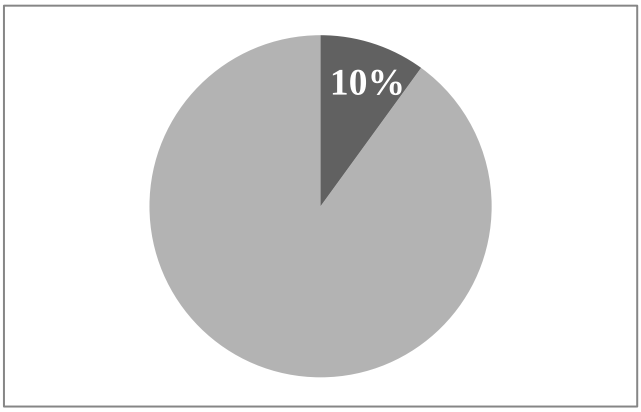

Figure 1, analyzed data from the Species Observation System database shows in what extent found *S. aloides* locations lays in a two kilometer reach of found *A. viridis* location.

17 of the 34 visited locations, both species co-occurred at 8 (47.1 %) of the locations.

At 5 (41.7 %) of the locations *A. viridis* larvae were found in other vegetation than *S. aloides.* These other water plants were *Menyanthes trifoliata, Phragmites australis Sphagnum* spp. and *Potamogeton natans*. *S aloides* were not present in the environment at 4 of these locations.

The statistical analyze of the collected field data showed a significant association between *A. viridis* and *S. aloides* as the p value where 0.01.

At three locations small *S. aloides* specimens were found at the shoreline but no population of *S. aloides* were seen. These locations were therefore not counted as locations inhabited by *S. aloides*.

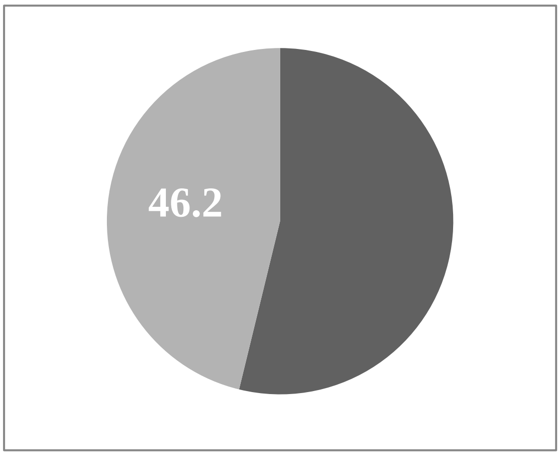

Figure 4, present data of *A. viridis* visited in fieldwork.

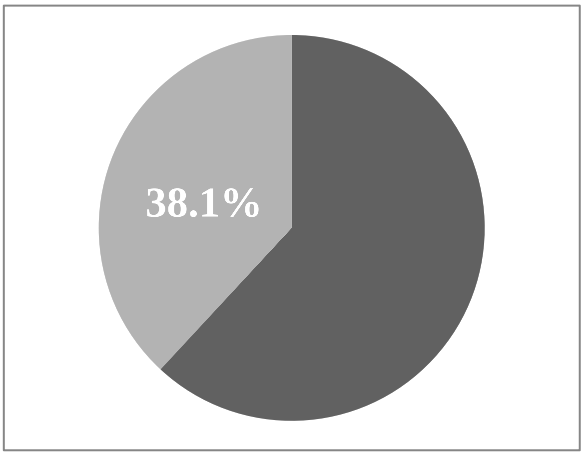

Figure 3, present data of *S. aloides* visited in field.

Discussion

My fieldwork indicated some changes in the occurrence of both *A. viridis* and *S. aloides.* According to The Species Observation System´s database had *A. viridis* been observed at 13 of 30 locations, but larvae were only found at 6 of them (see figure 1). *S aloides* have been observed at 21 of 30 localities, but were only found at 8 of them (see figure 2). At three locations small *S. aloides* specimens were found but no population which makes me speculate that these specimens have floated with connecting rivers or smaller water-courses from a population further away and ended up at these locations. Which is likely as two of the shores are connected with rivers where there have been reported findings further upstream and one is connected with smaller water-courses which might have a population further upstream.

However the numbers of species occurrence, with 6 findings of *A. viridis* and 8 of *S. aloides*, can't clarify if there have been a decrease of occurrence in the populations as we cannot know for sure if the reported sites have had permanent populations. It is important to emphasize that just because the species has been in an area at one time does not mean that it is still there. The data only tells that the species was there when it was found that day, that month or that year. The wide time-span between reports in The Species Observation System database could therefore cause an incorrect picture of the species distribution as the nature is changeable (Graham et al, 2004). Especially as The Species Observation System reports goes several decades back and the last century has seen drastic changes in the environment caused by humans increasing demands of land use (Smith, Tilman & Nekola, 1999; Graham et al, 2004; Raebel et al, 2012). What we can tell is that *S. aloides* is growing or have been growing at these locations, but not in the case of *A. viridis.* It is a highly mobile organism with good dispersal ability which makes it possible for the species to occur in areas where it does not breed in (Corbet, 1962; Corbet, 1999; Soluk, Zercher & Worthington, 2011). This makes me question the use of datasets from the Species Observations System for analyzing *A. viridis* distribution as my result shows such a large difference between the dataset and the field observations. With further question rises if the occurrence data, 46.2 %, might be showing real permanent populations and the absences data, 53.8 %, only shows reports on temporary visitors. So the occurrence could possibly be a good indication of how many permanent *A. viridis* populations that have been reported to the Species Observation System and this could give a glimpse of the actually minimum population size of *A. viridis*. But this would be to disadvantage in monitoring distribution and dispersal as it can’t show the actually geographical distribution of the species as the percent can´t tell which of the reports that is stable populations. However, this is just speculations and is in need of more research.

Several countries in Europe have established steps to protect and preserve *A. viridis* (Volkova et al, 2004; de Vries, 2010; BFN: Federal Agency for Nature Conservation, 2010). Some countries argue that the decreasing populations of *S. aloides* as the biggest threat for *A. viridis* and therefore having a primary focus on protecting *A. viridis* through *S. aloides.* This is done by protecting areas with *S. aloides* and create new suitable habitat for *S. aloides* (de Vries, 2010; BFN: Federal Agency for Nature Conservation, 2010). Though is it credible to see the decline of *S. aloides* as the biggest threat to *A. viridis* when earlier studies have indicated that adult female *A. viridis* in some extent also oviposit in other vegetation than *S. aloides* (Rantala et al, 2004; Suutari et al, 2008)? I find it a bit questionable as studies of *A. viridis* ecology and habitat are few (Sahlén & Ekestubbe, 2001; Rantala et al, 2002). My study do verify that these conclusions about *A. viridis* and *S. aloides* relationship might not be the whole truth or at least not to habitats in northern latitudes of Europe. The fieldwork shows that at 41.7% of the locations with found larvae, the larvae occurred in other vegetation than *S. aloides*. Though it is mentioned in Rantala et al (2004, 78) that larvae can be found in other vegetation than *S. aloides* but only if the *S. aloides* also inhabit the pond or lake. It is also explained that only adult *A. viridis* have been documented to be found at water bodies completely without *S. aloides*. However, my study shows that *A. viridis* larvae can live without presence of *S. aloides* as larvae been found at 4 *S. aloides*-free locations. With such clear difference as 41.7 % of the found larvae inhabit other vegetation than *S. aloides* and when the larvae are found in waters without *S. aloides,* there should be a change in the perspectives of *A. viridis* ecology and habitats choice at least in northern latitudes of its distribution. It is of course important to emphasize that there were a 47.1% co-occurrence of the species at the finding locations, which where further clarified by statistical analyze of the collected field data showing a significant link between the species. Though this link where not as strong as it has been presented in other literature (Rantala et al, 2004; Suutari et al, 2008; de Vries, 2010).

The next step is to hypothesize why *A. viridis* females choose to oviposit in other vegetation, *M. trifoliata, P. australis, Sphagnum* spp. and *P. natans*¸ or why larvae choose it as its habitat. One potential explanation is presented by Sahlén and Ekestubbe (2000, 683) explaining that one Odonata species do not have to have same niche in all of its distribution areas. This could explain dissimilarities between my results and earlier studies as *A. viridis* and *S. aloides* connection could be stronger in Central Europe than in northern latitudes. The theory to why female *A. viridis* choose to oviposit mostly on *S. aloides* have been that this macrophyte has good sheltering characters against predation which could give her offspring's a higher survival rate or it could be an active choice by the larvae to seek shelter in dense vegetation (Elkin & Baker, 1999; Rantala et al, 2004). There have also been ideas that it could be a fixed behavior that have nothing to do with the present of predators (Rantala et al, 2004). Looking at *M. trifoliate* and *P. australis* psychical characters, water plants with well-developed root system, (Stenberg, 1992) roots which can create dense network and good shelter for dragonfly larvae. It is understandable that these plants could works as impressive as dense populations of *S. aloides* to protect against fish predation. *Sphagnum* spp. could also act as a good shelter as it is a bryophyte growing in dense populations. If these water plants would work as good against intraguild predation and interference competition is hard to tell and more research is needed. When looking at *P. natans*, with its few branches and reduced leaves underwater (Stenberg, 1992) questions rises as this water plant doesn't have similar sheltering characters as the other plants mentioned before. Why would *A. viridis* chose it as habitat? Could those locations were *A. viridis* were found in *P. natans* be fish free habitat? That could explain why these larvae can live in less protective vegetations, though it is pointed out in Rantala et al (2003, 81) that it is common with intraguild predation by larger dragonfly larvae in fish-free habitat and in that case still be exposed to threat. As important the density of predating fish has on larvae density and choice of habitat it is also important to recon other dragonfly larvae densities as intraguild predation can be of great important. Some research have shown that with high density of larger dragonfly larvae, smaller dragonfly larvae seems to spread out more in less dense and unprotecting vegetation. This to avoid food competition and aggressive interactions with other dragonfly larvae where they can get injured, killed by another larvae or when trying to escape being detected by fish predators (Elkin & Baker, 1999). This could explain why *A. viridis* larvae choose to live in *P. natans*.

Some of the sampling sites were located next to private people's homes, summer cottage or at public places. I realized in field when meeting people living next to this site that *S. aloides* sometime were looked on as a pest. Two landowners in Östergötland with properties next to the reported *S. aloides* site told that they had problems with *S. aloides* populations. They found it hard to catch crayfish in late summer as the *S. aloides* populations were too dense to get the cages down to the bottom and they wouldn´t go in the water as the spine-covered leaves would cut them. One of the landowners told me that he tried to clear out the area where his boat lay every spring. He said that he only cleared up the dead rosettes, though *S. aloides* is still hibernating on the bottom and has a brownish color at time of their year (Smolders et al, 2003; Strzałek and Koperski, 2008), and as it easily can get damaged as the autumn and spring waves causing the rosette hit the shore and its leaves break looking even more dead. But this doesn't kill it as new leave will grow as it emerges to the surface in the spring (Smolder et al, 2003). These were knowledge the landowner didn't know and this could be a possible reason to why *S. aloides* go locally extinct. People see the plants as pest and want to get rid of it or they think it's dead and clear up the water at spring or autumn.

From the 240 locations with *A. viridis* obtained from The Species Observation System´s database, 94 locations of A. viridis had a site with S. aloides within a 2 km radius. This shows that 39.2 % of *A. viridis* locations were living in an area inhabit or have been inhabit by *S. aloides*. But in contrast only 10 % of the *S. aloides* sites where found within an *A. viridis* dispersal area. The reason for this different data is because there have been more and more widely-spread reports on *S. aloides* than on *A. viridis.* Though this doesn't have to imply that

S. aloides is more widely-spread than *A. viridis,* just that *A. viridis* haven't been found and reported to this database in the same extent. It is not unusual for collectors to only collect data in easily accessible areas, by roads, rivers and near urban areas which can lead to these bias collections that reflect real distribution badly (Graham et al, 2004; Rae, Rothley & Dragicevic, 2007; De Ornellas, Milner-Gulland & Nicholson, 2011). It's a likely explanation to why there have been more widely and more frequent reports of *S. aloides* as it is a sessile organism and is fairly easy to see in summer when it floats on the surface of shallow water (Smolders et al, 2003; Strzałek and Koperski, 2008) which make it easier to find in contrast to *A. viridis* which is mobile, small and either lives in the water hiding in vegetation or is airborne (Corbet, 1962; Corbet, 1999; Soluk, Zercher & Worthington, 2011).

Conclusion

My study showed that there are still some uncertainties concerning the use of occurrence datasets from Species Observations Systems as a monitoring tool on *A. viridis*. These data have been collected by many different observers with different intentions, methods and knowledge which can cause errors and biased information in the datasets (Graham et al, 2004; Elith et al, 2006, De Ornellas, Milner-Gulland & Nicholson, 2011; Reside et al, 2011). It is also important to emphasize that just because the species been in that area at one time doesn't mean that it is still there. Especially *A. viridis* which is a highly mobile organism and can occur in areas where it doesn't breed (Corbet, 1999). All this factors are very important to have in mind to make rightful decision in conservation managing (Graham et al, 2004; Rae, Rothley & Dragicevic, 2007; De Ornellas, Milner-Gulland & Nicholson, 2011). My theories regarding the occurrence data of *A. viridis* from field is that the occurrence percent might be a good indication of how many permanent populations that have been reported to the Species Observation System. Though this is still just theories and more research is needed.

I find it time to reconsider the strong association of *A. viridis* to *S. aloides* at least in northern latitudes as this study have showed that *A. viridis* larvae do occur in other vegetation than *S. aloides* and when larvae been found in *S. aloides*-free waters. Though I want to clarify that my research do verify a link between the species just not as strong as it have been suggested in earlier litterateur (Rantala et al, 2004; Suutari et al, 2008; de Vries, 2010).

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References

SFS 2007:845. Artskyddsförordning. Stockholm: Miljödepartementet

Artportalen; rapportsystem för växter, djur och svampar. https://artportalen.se/ViewSighting/SearchSighting(recieved 2013-03-18)

BFN: Federal Agency for Nature Conservation. 2010. Hamme lowlands (Hammeniederung). http://www.nachhaltigkeitsindikator.bfn.de/0203_hammerniederung+M5054de7a952.html. (recieved 2014-01-15)

Bunce, R. G. H., M. M. B. Bogers, D. Evans, L. Halada, R. H. G. Jongman, C. A. Mucher, B. Bauch, G. de Blust, T. W. Parr & L. Olsvig-Whittaker. 2013. The significance of habitats as indicators of biodiversity and their links to species. Ecological Indicators 33: 22-24

Clausnitzer, V., V. J. Kalkman, M. Ram, B. Collen, J. E. M. Baillie, M. Bedjanič, W. R. T. Darwall, K-D. B. Dijkstra, R. Dow, J. Hawking, H. Karube, E. Malikova, D. Paulson, K. Schütte, F. Suhling, R. J. Villanueva, N. von Ellenrieder & K. Wilson. 2009. Odonata enter the biodiversity crisis debate: The first global assessment of an insect group. Biological Conservation 142: 1864- 1865

Corbet, P. S. 1962. A biology of dragonflies. H. F. & G. Witherby LTD. London. 183-197

Corbet, P. S. 1999. Dragonflies: Behaviour and Ecology of Odonata. Harley Books. Colchester. 10-11, 135-138, 257-264

Elith, J., C. H. Graham, R. P. Anderson, M. Dudík, S. Ferrier, A. Guisan, R. J. Hijmans, F. Huettmann, J. R. Leathwick, A. Lehmann, J. Li, L. G. Lohmann, B. A. Loiselle, G. Manion, C. Moritz, M. Nakamura, Y. Nakazawa, J. McC. Overton, A. T. Peterson, S. J. Phillips, K. Richardson, R. Scachetti-Pereira, R. E. Schapire, J. Sobero´n, S. Williams, M. S. Wisz & N. E. Zimmermann. 2006. Novel methods improve predictions of species´ distributions from occurrence. Ecography 29: 130-148

Elkin, C. M. & R. L. Baker. 1999. Lack of preference for low-predation-risk habitats in larval damselflies explained by costs of intraspecific interactions. Animal behavior 60: 511-520

European Commission; Environment. 2013. Habitats Directive reporting. http://ec.europa.eu/environment/nature/knowledge/rep_habitats/index_en.htm (recieved 2014-01-08)

European Commission; Environment. 2013. Species protected under the Habitats Directive. http://ec.europa.eu/environment/nature/conservation/species/habitats_dir_en.htm (recieved 2014-01-08)

Graham, C. H., S. Ferrier, F. Huettman, C. Moritz & A.T. Peterson. 2004. New developments in museum-based informatics and applications in biodiversity analysis. TRENDS in Ecology and Evolution. 19(9): 497-500

Harabiš, F. & A. Dolný. 2011. Human altered ecosystems: suitable habitats as well as ecological traps for dragonflies (Odonata): the matter scale. Insect Conservation 16: 121

Hopper, K. R. 2001. Flexible antipredator behavior in a dragonfly species that coexists with different predator types. OIKOS 93: 470

Jaeschke, A., T. Bittner, A. Jentsch, B. Reineking, H. Schlumpprecht & C. Beierkuhnlein. 2012. Biotic Interactions in the Face of Climate Change: A Comparison of Three Modelling Approaches. PLUS ON 7:12

Kalkman, V. J., J-P. Boudot, R. Bernard, K-J. Conze, G. De Knijf, E. Dyatlova, S. Ferreira, M. Jović, J. Ott, E. Riservato & G. Sahlén. 2010. European Red List of Dragonflies. Published by IUCN (International Union for Conservation of Nature) in collaboration with the European Union: 14

Keller, D., S. Brodbeck, I. Flöss, G. Vonwil & R. Holderegger. 2010. Ecological and genetic measurements of dispersal in a threatened dragonfly. Biological conservation. 143: 2658

Liao, J., Z. Li, D. E. Hiebeler, M. El-Bana, G. Deckmyn & I. Nijs. 2013. Modelling plant population size and extinction thresholds from habitat loss and habitat fragmentation: Effects of neighbouring competition and dispersal strategy. Ecological modeling. 268: 9-15

Norling, U. & G. Sahlén. 1997. Odonata, Dragonflies and Damselflies. Aquatic Insects of North Europe- A Taxonomic Handbook. 2: 40-41

Nielsen, L. T. & J. Borum. 2008. Why the free floating macrophyte *Stratiotes aloides* mainly grows in highly CO_2-supersaturated waters. Aquatic Botany. 89: 379

De Ornellas, P., E. J. Milner-Gulland & E. Nicholson. 2011. The impact of data realities on conservation planning. Biological Conservation. 144: 1980-1986

Pressey, R. L., M. Cabeza, M. E. Watts, R. M. Cowling & K. A. Wilson. 2007. Conservation planning in a changing world. TRENDS in Ecology and Evolution. 22 (11): 583-590

Rae, C., K. Rothley & S. Dragicevic. 2007. Implications of error and uncertainty for an environmental planning scenario: a sensitivity analysis of GIS-based variables in a reserve design exercise. Landscape and Urban Planning 79: 210-217

Raebel, E. M., T. Merckx, R. E. Feber, P. Riordan, D. J. Thompson & D. W. Macdonald. 2012. Multi-scale effects of farmland management on dragonfly and damselfly assemblages of farmland ponds. Agriculture, Ecosystems and Environment 161: 80-81

Rantala, M. J., J. Ilmonen, J. Koskimäki, J. Suhonen & K. Tynkkynen. 2004. The macrophyte, *Stratiotes aloides,* protects larvae of dragonfly *Aeshna viridis* against fish predation. Aquatic Ecology 38: 77-81

Reside, A. E., I. Watson, J. VanDerWal & A. S. Kutt. 2011. Incorporating low-resolution historic species location data decreases performance of distribution models. Ecological Modelling 222: 3444-3447

Sahlén, G. 2006. Manual för basinventering av trollsländor. 1:3-25

Sahlén, G & K. Ekestubbe. 2000. Identifications of dragonflies (Odonata) as indicators of general species richness in boreal forest lake. Biodiversity and Conservation 10: 673-687

Scherr, S.J. & J.A. McNeely. 2008. Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. Philos. T. Roy. Soc. B 363: 477-491

Smith, V. H., G. D. Tilman & J. C. Nekola. 1999. Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental pollution 100: 179

Smolders, A. J. P., L. P. M. Lamers, C. den Hartog & J. G. M. Roelofs. 2003. Mechanisms involved in decline of *Stratiotes aloides* L. in The Netherlands: sulphate as a key variable. Hydrobiologia 506-509: 603-608

Soluk, D. A., D. S. Zercher & A. M. Worthington. 2011. Influence of roadways on patterns of mortality and flight behavior of adult dragonflies near wetland areas. Biological Conservation 144: 1638-1641

Stenberg, L. 1992. Den nordiska Floran. Second edition. Stockholm. Wahlström & Widstrand. 352: 506-589

Strzałek, M. & P. Koperski. 2008. The *Stratiotes aloides* L. stand as a habitat in oxbow lake Bużysko. Aquatic Botany 90: 1

Suutari, E., M. J. Rantala, J. Salmela & J. Suhonen. 2004. Intraguild predation and interference competition on the endangered dragonfly *Aeshna viridis.* Oecologica 140: 135-138

Suutari, E., J. Salmela, L. Paasivirta, M. J. Rantala, K. Tynkkynen, M. Luojumäki & J. Suhonen. 2008. Macroarthropod species richness and conservation priorities in *Stratiotes aloides* (L.) lakes. Insect Conserv 13: 413-414

Volkova, L. B., N. A. Sobolev, B. V. Beiko, C. V. Kotachkov, N .B. Nikitsky, A. V. Sviridov, E.M.Antonova & E.V.Mimonov. 2004. The present state of the bern convention insects in russian federation and actions for their conservation. Biodiversity Conservation centre. 1-3

de Vries, H. 2010. Species Protection Plan for *Aeshna viridis*. Brachyton 12: 25

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