# SCIENTIFIC CURRICULUM VITAE

**1. Name and Surname**

**Adrian Zwolicki**

**2. Diplomas or scientific degrees awarded, including the name, place and year of the award and the title of the PhD thesis:**

2001 – **MSc in Biology**, Faculty of Biology, Geography and Oceanology, University of Gdańsk.

2010 – **PhD in Biological Sciences: Biology**, Faculty of Biology, Geography and Oceanology, University of Gdańsk; PhD thesis: *"Foraging ecology of European beaver Castor fiber L. in the Tucholskie Forest"*, supervised by Prof. dr hab. Lech Stempniewicz.

**3. Information on previous and current employment in research institutions:**

15.10.2012 – present: **researcher and lecturer/adjunct**; Department of Vertebrate Ecology and Zoology, Faculty of Biology, University of Gdańsk.

01.07.2007 – 30.06.2012: **researcher and lecturer /adjunct**; Department of Vertebrate Ecology and Zoology, Faculty of Biology, University of Gdańsk.

28.02.2005 – 30.06.2007: **technician**; Department of Vertebrate Ecology and Zoology, Faculty of Biology, University of Gdańsk.

**4. INDICATION OF THE RESEARCH ACHIEVEMENT, according to article 16, paragraph 2 of the Act on Degrees and Titles in Science and Arts from 14 March 2003 (Journal of Laws, 2016 no 65, point 882 with amendments from 2016, point 1311.):**

**a) Title of the research achievement**

***The influence of colonial seabirds on the diversity of plant communities in the terrestrial polar ecosystems***

The research achievement consists of five papers, published in 2009–2016.

## b) author(s), title(s) of publications, year of publication, name of publisher

| No. | Paper | Points MNiSW 2013-2016 | Impact Factor (IF) |
|---|---|---|---|
| 1. | **Zwolicki, A.**, Zmudczyńska-Skarbek, K. M., Iliszko, L., Stempniewicz, L. (2013) Guano deposition and nutrient enrichment in the vicinity of planktivorous and piscivorous seabird colonies in Spitsbergen. *Polar Biology* 36: 363-372.<br>*My contribution to this paper included: developing the concept of the study, participating in sampling, selecting literature, conducting all statistical analyses, interpretation of the results, preparation of the manuscript and figures, and final edition of the text.*<br>*I assess my contribution in this paper at 75%.* | 30 | 2.071 |
| 2. | **Zwolicki, A.**, Zmudczyńska-Skarbek, K., Matuła, J., Wojtuń, B., Stempniewicz, L. (2016a) Differential responses of Arctic vegetation to nutrient enrichment by plankton-and fish-eating colonial seabirds in Spitsbergen. *Frontiers in Plant Science*, 7, 1959. DOI: https://doi.org/10.3389/fpls.2016.01959<br>*My contribution to this paper included: developing the concept of the study, participating in sampling, selecting literature, conducting all statistical analyses, interpretation of the results, preparation of the manuscript including figures, and final edition of the text.*<br>*I assess my contribution in this paper at 75%.* | 40 | 4.291 |
| 3. | **Zwolicki, A.**, Barcikowski, M., Barcikowski, A., Cymerski, M., Stempniewicz, L., Convey, P. (2015) Seabird colony effects on soil properties and vegetation zonation patterns on King George Island, Maritime Antarctic. *Polar Biology* 38(10) 1645-1655.<br>*My contribution to this paper included: developing the concept of the study, participating in sampling, conducting all statistical analyses, selection of literature, interpretation of the results, preparation of the manuscript including figures, and final edition of the text.*<br>*I assess my contribution at 60%.* | 30 | 1.711 |
| 4. | **Zwolicki, A.**, Zmudczyńska-Skarbek, K., Richard, P., Stempniewicz, L. (2016b) Importance of marine-derived nutrients supplied by planktivorous seabirds to High Arctic tundra plant communities. *PloS One*, 11(5), e0154950.<br>*My contribution to this paper included: developing the concept of the study, participation in sampling, selection of literature, conducting all statistical analyses, interpretation of the results, preparation of the manuscript including figures, and final edition of the text.*<br>*I assess my contribution at 75%.* | 40 | 2.806 |
| 5. | Zmudczyńska, K., **Zwolicki, A.**, Barcikowski, M., Barcikowski, A., Stempniewicz, L. (2009) Spectral characteristics of the Arctic ornithogenic tundra vegetation in Hornsund area, SW Spitsbergen. *Polish Polar Research* 30: 249-262.<br>*My contribution to this paper included participation in: developing of the concept of the study, fieldwork, statistical analyses, interpretation of the results, and final edition of the text.*<br>*I assess my contribution at 40%.* | 20 | 0.767 |
| **Total** | | **160** | **11.646** |

**c) description of the scientific objective(s) of the papers listed above and the results achieved results, including the discussion of their possible implementation**

**Introduction and hypotheses**

Severe climate of terrestrial polar regions enforces functioning of ecosystems of a relatively simple structure, which are characterized by low primary production and poor number of species. Such ecosystems function in the ice-free coastal zones characterized by the permanent deficiency of nutrients, whereas production in the adjacent seas is usually very high. However, oases of productivity, rich in species, develop in the vicinity of seabirds colonies. Their functioning is based on the allochtonic matter, so they provide a good example of transboundary subsidiary ecosystems.

Seabirds is a group of long-lived species permanently associated with marine environment, which usually breed late in their life, and have a few, usually one, offspring. They are associated with terrestrial environment only during the breeding season. In the polar regions, seabirds dominate in terms of number of species and their abundance. The most common Arctic seabirds represent the Alcidae family, including the little auk *Alle alle,* the most numerous Palearctic seabird of a population estimated at 35 million of breeding pairs. Other abundant species are also the Brünnich's guillemot *Uria lomvia* (ca 15 million of pairs) and the common guillemot *Uria aalge* (7 million pairs), and the common kittiwake *Rissa tridactyla* of the Laridae family, the numbers of which are estimated at 9 million pairs (del Hoyo et al. 1996).

In the Antarctic the dominant seabirds are penguins Sphenisciformes. The most numerous populations of several million are: the macaroni penguin *Eudyptes chrysolophus* (ca 9 million of breeding pairs), chinstrap penguin *Pygoscelis antarctica* (ca 4 million pairs), gentoo penguin *P. papua*, and Adélie penguin *P. adeliae* (Ellis et al. 1998). The order Procellariiformes is also abundant and rich in species, including the Wilson's storm petrel *Oceanites oceanicus*, with the population estimated at 4 to 10 million pairs (del Hoyo et al. 1996).

During the polar summer, during the several months when the seabirds breeding colonies are active, birds that forage in the sea and breed on the land deposit large amounts of matter of marine origin, mainly in the form of guano, and remains of food, eggshells, feathers and carcasses (Bokhorst et al. 2007, Smith & Froneman 2008). In the species breeding single the zone of their influence is restricted to the direct vicinity of the nest, which might be locally important. However, the scale of influence of the birds is much greater, as 90% of seabird

species breed colonially, forming the most numerous aggregations of birds on the Earth. Thus the scale of the influence of large seabird colonies is of highest importance in generally poor polar ecosystems. The vicinity of a colony, intensively fertilized throughout the breeding season, fosters lush development of tundra communities, which forms attractive habitat for organisms of the remaining trophic levels (e.g. Zmudczyńska et al. 2012).

Although regular studies of ecosystems depending on seabird colonies have begun at the beginning of the last century and brought the description of unique plant and invertebrate communities and the suggestion of one of the first food webs, presented for the Bear Island (Summerhayes & Elton 1923), hypotheses on the influence of seabirds, and identification of the reasons for variability of plant communities and habitats formed by seabirds in the effect of the enrichment in allochtonic matter of the marine origin, have not been quantitatively verified until recently.

The proposed habilitation thesis is formed by a series of five research papers (Table 4.b.) published in well-ranked international journals. The main aim of the series of the papers was to assess the importance of enrichment by the matter of marine origin transported by colonial seabirds for functioning of terrestrial polar ecosystems, with a special focus on development of habitats and plant communities.

The following hypotheses have been formulated:

1. The main ecological factor explaining the variability of species composition in ornithogenic tundra are the nutrients of marine origin that are transported to land by colonial seabirds.
2. Composition of plant communities depends on habitat conditions that are modified by seabirds. Proportions and distribution of plants would change along the gradient of bird guano deposition.
3. Colonies of seabirds of different diet create habitats that differ in physical and chemical properties, which favours development of unique plant communities, where species composition depend on the species of seabird and its diet.

**Results**

1. **Zwolicki, A.,** Zmudczyńska-Skarbek, K. M., Iliszko, L., Stempniewicz, L. (2013). Guano deposition and nutrient enrichment in the vicinity of planktivorous and piscivorous seabird colonies in Spitsbergen. *Polar Biology*, 36, 363-372.

Hutchison (1950) considered that strong influence of seabirds on the habitat was associated with their colonial breeding, which results in high density of nests, the use of faeces as material for building nests, and deposition of large proportion of produced in the direct vicinity of nesting places. The first publication of the research achievement (Zwolicki et al. 2013) tests the hypothesis of the different influence of the two most important types of seabird colonies in the Arctic that differ in the diet on physical and chemical properties of soil.

The research was conducted in the vicinity of two large breeding colonies of seabirds, a colony of planktivorous little auks and a mixed colony of piscivorous Brunnich's guillemots and kittiwakes, on the Hornsund fjord at south-west Spitsbergen, the largest island of the Svalbard archipelago. Collecting samples was based on the transect method, with linear location of square sampling plots. The research transects were established under each colony, and the control transects for each of them.

Based on the conducted analyses, we found that amount of guano deposition next to both colonies was considerably greater than that in control plots not influenced by seabirds. In both types of colonies the gradient of guano deposition decreased with the distance from the nesting places, but in the colony of guillemots and kittiwakes the decrease was more rapid. The difference in the spatial distribution of faeces, was described using piecewise regression, which showed that the distance of main guano deposition was in piscivores up to 50 m from the colony, and in in planktivores it exceeded 300 m. These differences were related with different types of breeding and the size of the so-called zone of bird circling around the colony. Guillemots and kittiwakes breed on a rocky cliff right next to the sea, while little auks breed in rock rubble on the rocky slopes, usually located in a greater distance from the seashore.

In the vicinity of both colonies guano deposition significantly enhanced concentrations of nitrogen ($NO_3^-$, $NH_4^+$), potassium ($K^+$) and phosphate ($PO_4^{3-}$) ions, increased soil conductivity (µS/m), and led to reduced pH values, in comparison with the control plots. The strength of effect of fertilization by birds was verified using redundancy analysis with the Monte Carlo permutation test (RDA). Guano deposition was the dominant factor that influenced the variety of habitat parameters within the zones affected by both bird colonies, and explained

84% (colony of piscivores) and 67% (colony of planktivores) of their total variation. Such high values of explained variation show the dominant role of seabirds in formation of habitats in the vicinity of their colonies, especially along the distance between the colony and the seacoast.

Despite similar amounts of guano deposition, the influence of the two studied types of colonies on physical and chemical properties of soil was significantly different. We found that the concentration of ammonium ($NH_4^+$) and phosphate ($PO_4^{3-}$) ions, and soil pH were significantly higher near the colony of piscivores than of planktivores. These results illustrate how strong soil enrichment by seabirds is additionally modified by qualitative differences between the colonies related with the birds' species, their diet and the content of guano deposited on tundra. Faeces of birds feeding on plankton, fish or mussels differ in quantitative proportions of organic and inorganic content, including mineral salts (Bedard et al. 1980). Consequently, different bacterial communities develop on particular types of guano, which follow different biochemical pathways, and different quantity, content and proportions of products of these pathways of biogenic salts available for plants.

2. **Zwolicki, A.,** Zmudczyńska-Skarbek, K., Matuła, J., Wojtuń, B., Stempniewicz, L. (2016a). Differential responses of Arctic vegetation to nutrient enrichment by plankton- and fish-eating colonial seabirds in Spitsbergen. *Frontiers in Plant Science*, 7, 1959.

The most important factors that influence the dynamics of plant communities in the polar regions are: temperature, soil moisture, habitat age, soil pH, inflow of nutrients and natural disturbances of homeostasis (Raup 1969, Rannie 1986, Gould & Walker 1999, Körner 2003). Birds can modify the three latter factors. Previous research on plant communities on Spitsbergen showed that a group ornithocoprophilous plant communities, i.e. dependent on fertilization by birds, was heterogeneous and represented by different communities (Eurola & Hakala 1977, Elvebakk 1994). The reasons for such diversity have not been studied. Therefore in the second paper of the presented research achievement (Zwolicki et al. 2016a) the hypothesis was tested that colonies of planktivorous and piscivorous seabirds create specific habitats, which in consequence favour development of plant communities specific for each type of colony.

The study was based on the data collected in the same areas as in the first paper (Zwolicki et al. 2013). Additionally, we included data on the occurrence of vascular plants and mosses, lichens and algae, as well as on content of carbon and nitrogen stable isotopes in soil

and in plant tissues. In this paper we skipped comparison of transect in favour of analysis that would distinguish plant communities. Using multidimensional linkage tree analysis (LINKTREE) we conducted a row of dichotomous divisions of datasets, and distinguished five homogenous plant communities, arranged according to the decreasing gradient of the influence by birds. LINKTREE analysis, which used at the same time the datasets describing plant composition and physical and chemical properties of soil, showed values of habitat variables, which distinguished the plant communities. Differences between plant communities formed under different types of colonies were additionally conferment by the analysis of similarity profile (SIMPROOF).

The two types of colonies promoted development of ornithocoprophilous plant communities that differed completely in species composition. In the direct vicinity of the colony of planktivorous little auks the *Deschampsia alpina–Cerrastium arcticum* community was described, while under the colony of piscivorous guillemots and kittiwakes the *Cochlearia groenlandica–Poa alpina* community occurred. These differences were found despite similar numbers of birds in the colonies and similar magnitude of guano deposition, and were associated mostly with the higher phosphate content in the soil ($PO_4^{3-}$ concentration > 395 mg $1000g^{-1}$) near the of colony of piscivores. Considering total variability of vegetation, the $PO_4^{3-}$ concentration was the variable of the greatest statistical efficiency, which explained 38.9% of variation. The remaining factors that separated plant communities were the content of nitrogen ions and, to a smaller extent, soil conductivity . The differences between the distinguished plant communities corresponded with the levels of stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$), which indicated that soil and plants from the studied communities used the matter originating from different trophic levels, which resulted from different diet of the studied seabirds in both types of colonies.

Apart from verifying ecological hypotheses, the paper also describes five plant communities, i.e. the proportion of vascular plant and mosses, presence of lichens and algae, species diversity, average similarity within each group, and differences in habitat parameters. Additionally, responses of plant species to the level of guano deposition separately in each colony was shown using General Linear Models.

The results presented in this paper show that seabirds shape habitats and and influence the diversity of ornithocoprophilous plant communities in more complex ways than previously considered. They not only change the composition of plant species in relation to the areas which

are not affected by birds, but also promote formation of specific plant communities in the vicinity of different types of colonies, in which seabirds diet is a key factor.

3. **Zwolicki, A.**, Barcikowski, M., Barcikowski, A., Cymerski, M., Stempniewicz, L., Convey, P. (2015). Seabird colony effects on soil properties and vegetation zonation patterns on King George Island, Maritime Antarctic. *Polar Biology*, 38(10), 1645-1655.

Terrestrial ecosystems of the Antarctic, similarly as in the Arctic, develop only on ice-free coastal areas (Convey & Smith 2006). These ecosystems are also influenced by colonial seabirds, but in contrast to the Arctic, multiyear guano accumulation processes are observed in the Antarctic, especially on flat terraces near the coastal zone, where penguin colonies are usually located. Low precipitation and temperatures promote such accumulation of guano (Tatur 1989).

About 50 000 pairs of penguins from the *Pygoscelis* genus, nesting on the west side of Admiralty Bay (King George Island), deposits about 6.35 tons of guano per day, which equals to 10 kg of dry excreta per square meter of the colony area during a breeding season (Tatur 2002). This impressive amount of nutrients of marine origin favours development of relatively rich plant communities which form typical zonation of vegetation with increasing distance from penguin colonies (Smith 1984, Olech 2002). Smykla et al. (2007) identified five vegetation zones formed near a colony of the gentoo penguin *Pygoscelis papua*. The aim of the third publication of research achievement was to examine if the zonation of plant communities depended on species of seabirds forming a colony and the physical and chemical properties of soil. The study was conducted in the vicinity of colonies of Adélie penguins *Pygoscelis adeliae* and gentoo penguins *P. papua*, and of giant petrels *Macronectes giganteus*.

Based on the TWINSPAN classification, five distinct vegetation zones were distinguished out of 568 sampling plots along the gradient of influence of three seabird colonies. Their differences was tested and confirmed using multidimensional analysis of similarities (ANOSIM). In the closest vicinity of all three colonies, a zone with dominance of nitrophilous foliose alga *Priasiola crispa*, and the Antarctic hair grass *Deschampsia antarctica* dominated in the next two zones. The two subsequent zones were dominated by mosses, with the increased importance of *Usnea* lichens and the presence of *Colobanthus quitensis* noted in the latter zone. This zonation of vegetation was related to the strong gradient of habitat, related with decreasing influence of the colony, associated mainly with fertilization. Each zone had different habitat

parameters, which was confirmed by the multivariate analyses ANOSIM and detailed comparisons of each habitat parameter using the analysis of variance. We found that the concentration of nutrients, including ammonium, nitrate, phosphate, potassium ions in soil, decreased with the increased distance from bird colonies.

To our surprise, the vegetation zones was non-random and had the same sequence of zones under all three seabird colonies, which resulted from formation of similar habitats properties. The differences in vegetation in the vicinity of colonies of the three bird species were only quantitative, i.e. greater cover of *Prasiola crispa* in the sampling plots (in the first zone) near the Adélie penguin colony, which was the largest one, than near the other colonies. This means that neither quantitative (the colony size) nor qualitative (different diet of birds) differences between the seabird colonies influenced the sequence of vegetation zones. The same pattern of zone formation near different bird colonies in the Antarctic ecosystem is in contrast with the Arctic ecosystem. This is probably because the Antarctic tundra has a limited number of species (i.e. only two species of vascular plants), and as a consequence consequently of a restricted number of possibilities to develop different stable phytocenoses in the vicinity of different seabird colonies in the Arctic.

4. **Zwolicki, A.,** Zmudczyńska-Skarbek, K., Richard, P., & Stempniewicz, L. (2016b). Importance of marine-derived nutrients supplied by planktivorous seabirds to High Arctic tundra plant communities. *PLoS One*, 11(5), e0154950.

The main environmental factor influencing the diversity of plant communities in High Arctic is ambient air temperature, which changes rapidly with increasing latitude, forming separate bioclimatic zones (Walker et al. 2017, Zwolicki et al. 2019b). In the following paper of the research achievement (Zwolicki et al. 2016b) we compared the relative importance of geographical location of a colony in terms of the amount of marine-derived matter by seabirds on formation of the high Arctic plant communities.

The study was based on the samples collected in five colonies of little auks located within the Arctic archipelago of Svalbard: from Bjørnøya in the south, through the Hornsund fjord in the south-western Spitsbergen, centrally located Isfjorden, to Aasefjelet and Magdalenefjorden in the north-west coast of Spitsbergen. These locations clearly differed in oceanographic and climatic regimes.

The first part of the paper has a methodical character and proves the positive correlation between the amount of guano deposition and the level of $\delta^{15}$N ($\delta^{15}$N/ $\delta^{14}$N ratio) in the soil. We also found that the total nitrogen content (N) increased with the level of $\delta^{15}$N isotope in the soil. This means that the level of stable isotope $\delta^{15}$N is a good predictor of marine-derived matter in the terrestrial ecosystem. Additionally, we the level of $\delta^{15}$N in tissues of vascular plants and mosses was linearly correlated with its level in the soil. This means that the level of soil fertility depended on fertilization by birds, and that the plants freely incorporated marine-derived matter into their tissues.

The importance of bird fertilisation was tested with multidimensional Variation Partitioning based on many unimodal models of Canonical Correspondence Analysis (CCA). We used an arrangement of competing hypotheses, with the soil properties (including the proportion of the marine-derived matter transported by the birds) was placed against the factor that described geographical locations of the five little auk colonies. A model of high efficiency was derived (92%), which implies that this model included all most important environmental factors. Geographical location explained the most (39.8%) of variation in the composition of plant communities, which is in line with the knowledge on the role of latitudinal gradient in shaping plant communities and, consequently, bioclimatic zones. The second most important factor, which influenced species composition of vascular plants, but the most important at a local scale, was the level of nitrogen delivered by the birds ($\delta^{15}$N, 32.4%)

Statistically significant response to the level of fertilization by birds was found in nine out of 36 species of vascular plants. Occurrence and proportion of coverage of five species (*Ranunculus pygmaeus, Oxyria digyna, Poa alpina, Cerastium arcticum, Cochlearia groenlandica*) were positively correlated with $\delta^{15}$N content in soil, and significant negative relationships were found for four species (*Saxifraga oppositifolia, Festuca rubra, Salix polaris* and *Equisetum boreale*). These results indicate that birds influence promotes short-lived plant species of high growth rate, but of low efficiency of nutrient use, and impedes growth of slow-growing plants with long-lived leaves, which have high efficiency of nutrient use and high resistance to environmental stress. The division of species that exhibit different strategies and life forms occurred at the level of 8‰ content of $\delta^{15}$N in soil. The same value was reported for the guano of the little auk (Skrzypek et al. 2015).

The results of this study show that fertilisation by seabirds was the key ecological factor for functioning of terrestrial polar ecosystem in the vicinity of a colony. Furthermore, since little auks are the most numerous polar seabirds in the northern hemisphere, and the main

providers of marine-derived matter, any potential changes in their population size or distribution range would significantly influence functioning of the Arctic terrestrial ecosystems.

5. Zmudczyńska, K., **Zwolicki, A.,** Barcikowski, M., Barcikowski, A., Stempniewicz, L. (2009). Spectral characteristics of the Arctic ornithogenic tundra vegetation in Hornsund area, SW Spitsbergen. *Polish Polar Research*, 30, 249-262.

The last paper presented in research achievement (Zmudczyńska et al. 2009) has mainly methodological character, which would enable future research on identification of ornithogenic tundra at a large geographical scale e.g. based on satellite or plane measurements, or in situations when direct identification of species composition in a plant community is not feasible logistically. In this paper we analysed solar radiation reflectance of ornithogenic tundra in the vicinity of large breeding colony of Brunnich's guillemots and kittiwakes in the Hornsund fjord. We showed that the main gradient of variability in plant community was significantly correlated with the main gradient of variability of radiometric data, which proved that radiometric data to describe variation of tundra formations, which was a novelty in studies of ornithocoprophilous plant communities. Additionally, we proved that plant communities in the zone of seabird influence, differed significantly from those not influenced by birds, thus are easily distinguishable by large scale spectral measurements. In ecological terms, the use of spectral characteristics of plant communities enables to follow their functional traits, such as changes of water content in tissues, content of chlorophyll or proportion of biomass.

**Summary**

The papers that form the research achievement proved significant influence of large seabird colonies on formation of plant communities in the Arctic and Antarctic. Habitat parameters and the structure of tundra vegetation changed along the gradient of fertilization by birds. Habitats influenced by colonial seabirds were generally characterised by higher nutrients content and lower soil pH in comparison to those not influenced by birds. Furthermore, marine-derived matter transported by colonial seabirds to terrestrial ecosystems was locally the most important ecological factor shaping the dynamics of plant communities. In the Arctic, seabird assemblages that differ in diet promoted development of plant communities specific for colonies of planktivorous and piscivorous birds. In contrast, in the Antarctic the observed sequence of vegetation zones was constant regardless of the type of colony.

In polar regions, climate change leads to changes in the circulation of ocean currents and hydrological regime (Hurrell 2000). The intensified inflow of Atlantic waters into the Arctic Ocean determines the distribution, density and structure of zooplankton assemblages in the regions of the sea which has been so far influenced by Arctic waters. Changes in zooplankton assemblages will influence energy transfer in pelagic food web and thus might be critical for the species of higher trophic levels, such as planktivorous seabirds.

The size of seabirds population and, as a consequence, their ecological importance reflects the quality of food resources and hydrological conditions in the oceans (Węsławski et al. 1999). Climate change may induce serious consequences for the structure and functioning of terrestrial part of the ecosystem, through changes in the Arctic avifauna. The dominance of large copepods in the Arctic water masses favours planktivorous seabirds as the little auk, while the domination of small zooplankton forms typical of Atlantic waters redirects the food chain towards planktivorous fish and next to piscivorous seabirds (as guillemots). Thus planktivorous seabirds should dominate avifauna in a cold climate scenario, and retreat during warmer periods when piscivorous seabirds would dominate (Stempniewicz et al. 2007).

Changes in avifauna, related to climate warming, might considerably modify animal and plant communities of the Arctic tundra. Location of colonies of piscivores on vertical cliffs that descent directly to the sea, or in its direct vicinity, drastically limits the area where ornithogenic tundra is able to develop. Moreover, differences in physical and chemical properties of guano of birds from the two dietary groups may lead to the dominance of one type of tundra, which would influence species of higher trophic levels, and in consequence, the functioning of the polar terrestrial ecosystems.

In the maritime Antarctic, changes in population size of penguins related to climate change i.e. local decline of Adélie penguin population size and increase of gentoo penguin (Korczak et al. 2013) may lead to quantitative and spatial changes in marine matter delivery. In contrast to the Arctic, in the Antarctic such changes would result in the modification of terrestrial plant communities of a more quantitative character influencing their distribution, rather than the qualitative changes in species composition.

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## 5. Description of other research achievements.

### Remaining research achievements

Since my MSc studies in 1996-2001 in Biology, at the Faculty of Biology, Geography and Oceanology of the University of Gdańsk, my scientific interests have focused on ecology, especially on animals-plants interactions and application of multidimensional analyses and ordination techniques in testing of complex ecological hypotheses.

My MSc thesis focused on feeding ecology of the European beaver, especially on its spatio-temporal use of woody and aquatic plants. During this study, I cooperated with prof. Ryszard Dzięciołowski from the Forestry Faculty of the Warsaw University of Life Sciences, who became my scientific supervisor. I developed this research for my doctoral thesis *"Foraging ecology of European beaver Castor fiber L. in the Tucholskie Forest"*, which was supervised by prof. dr hab. Lech Stempniewicz from the Department of Vertebrate Ecology and Zoology at the University of Gdańsk. During PhD studies at the Faculty of Biology, Geography and Oceanology of the University of Gdańsk (2001-2006), I continued the research on multidimensional logistic regression models of feeding decisions of beavers and the influence of their selective cutting of trees and bushes on the structure and diversity of forest plant communities. Moreover, these studies included analysis of clearances and gaps in the forest

canopy created in the effect of feeding of beavers on large trees, and the effect of these gaps on composition of plant species in forest undergrowth. I conducted this research within the PhD research grant *"Feeding ecology of European beaver Castor fiber L. in the Tucholskie Forest. The role of beaver in shaping forest phytocoenoses"* funded by the Committee for Scientific Research. At that time, I was also involved in research on the influence of ponds and gaps in canopy caused by beavers on the activity of bats over selected watercourses in Tucholskie Forest, which resulted in co-authored publication in the *European Journal of Wildlife Research* (Ciechanowski et al. 2011)

I developed my floristic interests, especially on rare and protected species of vascular plants and fungi, during fieldwork in Tucholskie Forest, which was conducted in collaboration with prof. dr. hab. Martin Kukwa from the Department of Plant Taxonomy and Nature Conservation at the University of Gdańsk. This cooperation resulted in three co-authored papers in the journal *Acta Botanica Cassubica* (Kukwa & Zwolicki 2004a, Kukwa & Zwolicki 2004b, Kukwa & Zwolicki 2005).

In 2005, I was employed as a technician in the Department of Vertebrate Ecology and Zoology at the University of Gdańsk, and after obtaining a PhD in 2006, I was employed as an adjunct in 2007. Since 2005, I begun research in polar regions, which was focused on relationships between seabirds and various elements of terrestrial ecosystem, such as habitat, vegetation and soil invertebrates. I took part in five expeditions to Spitsbergen (archipelago of Svalbard) in the Arctic, and one to King George Island in the South Shetland archipelago in Maritime Antarctica. I carried out this research working as a co-investigator staff in three projects from the National Science Centre, and one international project called ALKEKONGE *("Response of marine and terrestrial ecosystems to climate changes in Arctic - links between physical environment, biodiversity of zooplankton and seabird populations"*, Norway Grants), and as the principal investigator of the "Young Researcher" project awarded by the University of Gdańsk (*"The influence of large colonies of Little Auk (Alle alle) on the structure, species diversity and functioning of plant communities in Spitsbergen")*. My participation in these projects enabled the team of the Department of Vertebrate Ecology and Zoology, in which I work, to contribute to numerous scientific conferences and publish a series of research papers, which was appreciated by receiving four times the team award of the Rector of the University of Gdańsk for the publishing activity. During these projects I have established an international cooperation with prof. Peter Convey from the British Antarctic Survey (UK), prof. Steven Coulson from the University Centre in Svalbard (Norway) and dr Pierre Richard from the

University of la Rochelle (France). This collaboration resulted in five researchpapers on the functioning of polar terrestrial ecosystems have been published in highly ranked international journals (Zmudczyńska et al. 2012, Zwolicki et al. 2015, Zmudczyńska-Skarbek et al. 2015, Zwolicki et al. 2016b, Zwolicki et al. 2019).

In 2011, I was invited by the Pomeranian Office of Melioration and Hydrotechnical Structures in Gdańsk as an expert to participate in works related to the survey of damage and implementation of the system minimizing the negative impact of beavers on hydrotechnical constructions in Żuławy Wiślane. This study was conducted at the request of the Management Board of Melioration and Hydrotechnic Structures of the Pomeranian Voivodship in Gdańsk and the Regional Directorate for Environmental Protection in Gdańsk, who funded the project *"Inventory of the European beaver population in Żuławy, Vistula delta fens in the Pomeranian province and designation of methods to minimize damage caused by the beaver"*, in which I was the principal investigator. Intensive fieldwork was conducted in 2012-2013, and resulted in three reports presenting proposed activities to minimize economic damage caused by beavers, related to damaging flood embankments and floods, and conservation measures to minimize the pressure on beaver as a protected species. Ecological research on spatial variability of habitat selection by beaver was also conducted during this project, and resulted in a publication in the prestigious international journal *Ecography* (Zwolicki et al. 2019a).

I have also collaborated with the Institute of Oceanology of the Polish Academy of Sciences in Sopot, on ecology of Arctic zooplankton, which resulted in a co-authorship of two publications in well recognized international journals. The first paper focussed on the influence of temperature on eggs development of the key representatives of the Arctic zooplankton, copepods of the genus *Calanus*, and was a part of the international project *Arctic Tipping Points* (ATP) financed within the 7th Framework EU Programme (Weydmann et al. 2015). The second paper comprised a comparison of the effects of sampling zooplankton ith two different sets of gear during midwinter in the Arctic fjord (Błachowiak-Samołyk et al. 2017).

The research on beavers in Tucholskie Forest, which I conducted during my PhD studies, and my subsequent scientific activity in this field, were recognised by the local community, which resulted in inviting me to the Scientific Council of the Wda Landscape Park, in which I act as the head. Moreover, my research conducted in polar areas and publications on these topics brought invitations to review scientific articles in leading international journals, such as *Polar Biology*, *Arctic, Antarctic and Alpine Research*, *Scientific Reports*, *Marine Ecology Progress Series*, and *Plos One*, for which I reviewed 8 papers. I also reviewed one

international project for the FONDECYT Regular 2018 grant competition, an initiative of the Chilean National Science and Technology Commission (CONICYT - Chile). Additionally, since 2018 I have worked as an Academic Editor with the authority to decide on acceptance of the papers in the international journal Plos One.

**Teaching, outreach and organizational achievements**

I have been teaching students of the University of Gdańsk since 2002, initially as a PhD student and later as lecturer/adjunct. Totally, I have taught 16 courses, including five series of lectures for Biology and Medical Biology (Faculty of Biology), Nuclear Safety and Bioinformatics (Faculty of Mathematics, Physics and Informatics), and Environmental Protection (Faculty of Chemistry), on both BSc and MSc levels. The majority of these courses were on ecology, including animal and plant ecology as well as behavioural ecology, or on the application of statistical methods in ecology research. Since 2012 I have been lecturing my original course *"The application of numerical methods in ecology"*, which aims to teach students how to apply multidimensional techniques of classification and ordination to ecological data using specialised software such as Canoco or the programming language R.

So far, I have successfully supervised 16 MSc and six BSc theses, and recently I have co-supervised of two PhD students of the University of Gdańsk, whose research focus on the ecology of semiaquatic mammals, including environmental stress in the Eurasian otter and the use of spatial and food niches by European beaver, Eurasian otter, American mink, and European water vole. Furthermore, I took part in the program council designing a new course of studies, the Protection of Natural Resources, planned to launch at the Faculty of Biology.

Since 2008 I have worked for "AZB analysis & software" company, where I coordinated environmental monitoring and statistical side of pre-investment reports. As a result, I am the main author of 67 statistical reports based on scientific (mainly biological) data, for many research institutions, including National Marine Fisheries Research Institute, Medical University of Gdańsk, Institute of Oceanology Polish Academy of Sciences in Sopot, Wrocław University of Environmental and Life Sciences, University of Warsaw or Warsaw University of Life Sciences. Additionally, I coordinated and co-authored 20 environmental monitoring and pre-investment reports mainly considering mammals, especially the protected semiaquatic species as the European beaver and the Eurasian otter, which were commissioned i.e.

by Regional Directorate for Environmental Protection in Gdańsk, Management Board of Melioration and Hydrotechnic Structures of the Pomeranian Voivodship in Gdańsk, the Polish Society for the Protection of Birds (OTOP), and the Regional Director for National Roads and Motorways.

My outreach activities in popularising science mainly focus on issues related to beavers, although I have also been leading workshops on tracking animals and statistical courses for scientists, such as "*Statistics for naturalists"* in the Institute of Oceanology Polish Academy of Sciences in Sopot.

I also took part in two nature documentary movies, entitled *"Beaver is not that bad"* („Nie taki straszny bóbr", 2009) and *"Human face of a beaver"* („Ludzka twarz bobra", 2010) produced by the Academic Educational Television and the Polish Television. Within the project *"Inventory of the European beaver population in Żuławy, Vistula delta fens in the Pomeranian province and designation of methods to minimize damage caused by the beaver"* I organised an educational trip during the XI Baltic Science Festival and I coordinated six educational workshops *"Beaver in Żuławy"* for school children from the region of the Vistula delta fens. I also co-authored a popular science paper entitled *"Beaver from the Vistula River Delta"*, published in the Socio-Cultural Quarterly Journal of Powiśle and Żuławy ("Kwartalnik Społeczno-Kulturalny Dolnego Powiśla i Żuław") *Prowincja* in 2013.

## SUMMARY

In total, I authored or co-authored **17 original research papers** published in English (16 after the PhD), in international journals indexed in the ISI databases, and of **12 papers** not listed in these databases Additionally, I co-authored 20 environmental monitoring and pre-investment reports, and 67 statistical reports. According to the Web of Science, my **Hirsh index** is **8**, and my papers have been **cited 187** times (154 without self-citations). The total ***Impact Factor***, according to Journal Citation Reports list (JCR) from the year the manuscripts were published in is **34.075**, and according to their mean 5-year IF it is **38.292**. The total the Ministry of Science and Higher Education (MNiSW) points for papers (according to the 2013-2016 list) is **510**.

I presented my research at many international conferences and symposia as I authored or co-authored **37 oral and poster presentations**. I have also been the Principal Investigator

of **two research projects** and a contract staff in another six projects. Furthermore, four times I have received the team award of the Rector of the University of Gdansk for publishing activity. I have supervised **16 MSc theses**, **six BSc theses**, and I am currently co-supervising **two PhD students**. Additionally, I act as the head of the Scientific Council of the Wda Landscape Park.