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Review of doctoral dissertation of M.Sc. Quadri Agbolade Anibaba

Ecosystem diversity along a successional gradient of post-mining spoil heaps

Zróżnicowanie ekosystemów w gradiencie sukcesyjnym zwałowisk pogórniczych

The main part of doctoral thesis of M.Sc. Quadri Agbolade Anibaba entitled *Ecosystem diversity along a successional gradient of post-mining spoil heaps* (*Zróżnicowanie ekosystemów w gradiencie sukcesyjnym zwałowisk pogórniczych*) are three articles published in two consecutive years (2023-2024):

1. Anibaba Q.A., Dyderski M.K., Woźniak G., Jagodziński A.M. 2023. Native plant community characteristics explain alien species success in post-industrial vegetation. NeoBiota 85: 1-22. https://doi.org/10.3897/neobiota.85.97269

2. Anibaba Q.A., Dyderski M.K., Woźniak G., Jagodziński A.M. 2024. The inhibitory tendency of *Calamagrostis epigejos* and *Solidago spp.* depends on the successional stage in postindustrial vegetation. Land Degradation & Development. https://doi.org/10.1002/ldr.5348

3. Anibaba Q.A., Dyderski M.K., Woźniak G., Jagodziński A.M. 2024. Remote sensing for site selection in vegetation survey along a successional gradient in post-industrial vegetation. Ecology and Evolution 14(8): e70200. https://doi.org/10.1002/ece3.70200

M.Sc. Quadri Agbolade Anibaba is the first and corresponding author in the case of all publications. The declarations of all authors clearly document an important contribution of Mr. Anibaba to the publications. His participation concerns all stages of studies – from conceptual work, through data collection to analyses, statistical analyses, and at the end

preparation of manuscripts and their reviewing and editing. The fundamental part of PhD of M.Sc. Anibaba comprises scientific articles published in reputable journals. They were reviewed by at least six reviewers, thus I restricted to point out these findings, which are the most important for science development and the most interesting in my opinion.

The general aim of dissertation was to amount of vegetation diversity and to assess the role of particular species, especially of some alien species (*Calamagrostis epigejos*, *Solidago canadensis* and *S. gigantea*) during succession in post-mining areas. In particular articles more precise aims were formulated. Similarly, hypotheses in each publications are well and clearly constructed. Each paper describes in detail the methods applied. All of them were adequately used, are well connected to scientific problems and have enabled the achievement of the research objectives. The study was conducted in Upper Silesia, where large area of post-coal mine sites exist. Generally, the study included 60 randomly chosen plots, for which data about their age, size and vegetation were known, and were further divided into smaller areas. The data collected in the field were subjected to detailed statistical analyses using advanced techniques, including different models. I am impressed by their diversity. This proves that Mr. Anibaba has fully mastered the research workshop. Accuracy and diversity of applied methods translates into quality of presented results.

First, I would like to discuss the most important achievements of the doctoral dissertation. The main results presented in the first paper, published in NeoBiota (2023), concern the role of alien species in vegetation succession on post-coal mine habitats and the factors influencing their richness and cover. M.Sc. Anibaba and co-authors found 318 vascular plant species, among which 64 (20.1%) were alien. In the group of alien species the highest frequencies on studied plots were noted for five of them (*Erigeron canadensis*, *Solidago gigantea*, *Solidago canadensis*, *Erigeron annuus* and *Impatiens parviflora*). Moreover, *Solidago gigantea* and *Impatiens parviflora* were characterized by one of the largest cover (about 14% on average in each case). All of these species are invasive. One of the most interesting result of this study is the relatively high proportion of alien species. It is in contradiction with the results of some researchers, who observed a low frequency of alien species in post-industrial areas subject to spontaneous succession. The results of the study presented in the paper proved that the frequency of occurrence of alien species and their coverage depend on the richness of native species. The higher the coverage of native species, the lower the coverage of alien plants. In addition, among the studied life history traits, the weight of seeds and the height of native plants have the greatest impact on the coverage of alien species. In addition to the species mentioned above, the authors also discuss the role of

other plants, such as *Prunus serotina* or *Impatiens parviflora*, considered the most dangerous invasive species in the world. The authors attribute the success of invasive plants to their biological properties, which is fully in line with the current knowledge in this area.

In the second paper, included in the PhD dissertation, Mr. Q. Anibaba focused on the assessment of the role of selected species, both native and alien, in the course of succession on post-mining heaps. Species known for their expansiveness were selected for this study – *Calamagrostis epigejos*, *Solidago canadensis* and *S. gigantea*. Studies were conducted in places being in different phases of succession: early-stage (1–8 years), mid-stage (6–14 years) and late-stage (25–56 years). Authors tested the importance of an inhibitory effect of studied species on diversity across successional phases, and whether the effects of species depend on the successional stage. To resolve these problems, taxonomic, functional, and phylogenetic diversity of plant communities were calculated. Simultaneously, plant species functional traits, such as plant reproductive characteristics, life-history traits, and measures of leaf morphology, were obtained. Additionally, Ellenberg's ecological indicator values were included. Such approach, which includes the analysis of the functional characteristics of species, is rarely used in the study of the succession process. The analyses carried out enabled a positive verification of the hypotheses posed. It was documented, that the role of native *C. epigejos* and alien species from *Solidago* genus differed in distinct phases of succession. These species had significant impacts on diversity indices in the mid-successional stage, where a large diversity of species is observed, which affects the availability of resources. Under such conditions, species with high competitive capabilities have an advantage. Such properties are characteristic of *C. epigejos* and *Solidago spp.* Their fast growth rate, high fertility and the large size of individuals make them good competitors for resources, such as space, light and nutrients. This is a mechanism that limits the development of other plants. As a result, they are displaced, resulting in a reduction in diversity parameters. The influence of *C. epigejos* and *Solidago* species in the early- and the late successional stages was nonsignificant. Authors state, that in the first years of succession, processes are random in their character, and on the other hand, in the late stage of succession the cover of these species is lower, because light availability is restricted. In the late-successional stage dominate trees, shrubs, and shade-tolerant forest herbs.

The third article, being part of dissertation of Q. Anibaba, has methodical character. Its importance for the development of science should be emphasized. In this publication authors tested whether the remote sensing method is useful for classification of vegetation along a successional gradient in post-industrial areas. Remote sensing is increasingly used in ecology, but

mainly to study of natural ecosystems. Using this method M.Sc. Q. Anibaba and co-authors, identified five vegetation clusters across successional gradient on post-mining heaps. They reflected transition in vegetation observed in the field. In parallel with the remote sensing method, the presence, frequency and abundance of vascular plants was noted in the field. The use of these two data sets made it possible to assess the reliability of remote sensing in the assessment of vegetation types in the succession process on post-mining heaps. Moreover, this approach provides more detailed information. It is interesting, that the analyses enable to distinguish species indicative for the different stages of vegetation development on the heaps. Analyses conducted document that the highest number of such species (exclusive indicators) were present in the 1st (early-succession), 3rd (late-succession), and 5th (mid-succession) clusters. In other distinguished clusters species richness was lower. On the other hand, the 3rd cluster (late-succession) had the lowest functional richness and the highest functional dispersion. A comparison of the results from remote sensing and field observations distinguishes the M.Sc. Anibaba research. They provide important input into development of methodology in ecological research.

The publications presented in Mr. Anibaba's dissertation are preceded by short chapters on the first 30 pages. First, these are Acknowledgements and Abstracts in English and Polish. The next chapter is an Introduction, in which author outlines research problems. Then, he presents the objectives of the research and specifies the research hypotheses and presents their premises. In addition, it justifies the need for research, pointing to deficiencies in understanding ecological processes. The final chapter contains the most important research results presented in the publications included in the doctoral dissertation. The introductory chapters are supplemented by a list of literature. It is a pity that M.Sc. Q. Anibaba did not attempt to prepare a general discussion that could tie all the issues together.

Finally, I would like to emphasize the importance of the research conducted by M.Sc. Q. Anibaba. They significantly enrich knowledge in the field of plant ecology, in particular those related to the spontaneous development of vegetation in post-industrial areas. The results of the research contribute to the elucidation of the mechanisms and processes occurring during succession. They also define the role of species participating in the succession process. At a time when biological invasions are one of the main factors threatening biodiversity, assessing the role of alien species in vegetation formation is a very important aspect of ecological research. Q. Anibaba's works fit well into this issue. I would also like to emphasize the contribution of Mr. Anibaba's research to the development of methods used in ecology, because the development of science is to a large extent conditioned

by the development of research tools. The practical relevance of the results should also be highlighted. They can be used in practical actions, in restoration and management of post-coal-mining areas. For example, in his publications, Mr. Anibaba suggests introduction of native species in the first phases of vegetation development in post-industrial areas in order to limit the spread of invasive species.

The high substantive quality of Mr. Anibaba's publication is evidenced not only by the results of the research, but also by their interpretation presented in the discussion. The way the author does it proves his scientific maturity. The knowledge of the literature on the problems he was interested in should also be emphasized. I would like also to pay attention to well-constructed and very informative figures and tables, which clearly illustrate obtained results.

Despite the fact that the publications were peer-reviewed, I have a few minor comments. For example, in the work published in NeoBiota there is the following sentence that refers to *Solidago gigantea*: "The species germinates by seeds and rhizomes". This is a simplification. Only seeds germinate. With the help of rhizomes, plants reproduce vegetatively. In the second paper is: "abiotic requirements of plant communities in each successional class". The habitat requirements of communities are the result of the requirements of individual species. The latter formulation seems to be more accurate due to the specificity of places and processes occurring on the heaps, distinct from those that arise in natural conditions. In the same publication Figure S1 is not indispensable, in my opinion. It is a pity that the discussion did not include the publication of Prof. K. Falińska, who for many years observed succession on abandoned meadows. The information contained there would be very useful in the context of a discussion about the role of species with similar life strategies (e.g., perennial plants, being inhibitors) in the development of vegetation.

Final evaluation statement

In conclusion, I highly appreciate Mr. Anibaba's dissertation. The research issues undertaken by the PhD student are part of the current issues in the field of broadly understood plant ecology with the use of modern research tools. Mr. Anibaba's doctoral thesis provides valuable, new data for science, broadening the knowledge of the mechanisms shaping plant communities. The importance of the results obtained, their mature interpretation, and perfect mastery of the research methods are sufficient grounds to consider Mr. Anibaba an experienced researcher. Therefore, with full conviction and pleasure, I strongly recommend to the to accept M.Sc. Anibaba's doctoral dissertation. I conclude that the reviewed doctoral dissertation of Quadri Agbolade Anibaba, M.Sc., meets all the conditions specified in Article

187 of the Act of July 20, 2018 Law on Higher Education and Science (i.e. Journal of Laws of 2023, item 742, as amended), and I request the Scientific Council of the Institute of Dendrology of the Polish Academy of Sciences to admit M.Sc. Quadri Agbolade Anibaba to further stages of the proceedings for the conferment of the doctoral degree. In addition, I believe that Mr. Anibaba's doctoral dissertation deserves to be awarded an appropriate award.

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