N.I. Vorobyov, V.N. Pishchik, Y.V. Pukhalsky, O.V. Sviridova, S.V. Zhemyakin, A.M. Semenov. **The Fractal Model of the Microorganism's Frequencies Spectrum for Determining the Diversity of the Biochemical Processes in Soil** / Proceedings of the International Conference "Information Technologies in the Research of Biodiversity", 11–14 September 2018, Irkutsk, Russia. Editors: Bychkov Igor; Voronin Victor (Eds.) // Series: "Springer Proceedings in Earth and Environmental Sciences". 2019. P. 37-41. ISBN 978-3-030-11720-7, https://doi.org/10.1007/978-3-030-11720-7.

Springer Proceedings in Earth and Environmental Sciences

Igor Bychkov
Victor Voronin *Editors*

Information Technologies in the Research of Biodiversity

Proceedings of the International Conference "Information Technologies in the Research of Biodiversity", 11–14 September, 2018, Irkutsk, Russia

Springer

Springer Proceedings in Earth and Environmental Sciences

Series editor

Natalia S. Bezaeva, The Moscow Area, Russia

nik.ivanvorobyov@yandex.ru

The series Springer Proceedings in Earth and Environmental Sciences publishes proceedings from scholarly meetings and workshops on all topics related to Environmental and Earth Sciences and related sciences. This series constitutes a comprehensive up-to-date source of reference on a field or subfield of relevance in Earth and Environmental Sciences. In addition to an overall evaluation of the interest, scientific quality, and timeliness of each proposal at the hands of the publisher, individual contributions are all refereed to the high quality standards of leading journals in the field. Thus, this series provides the research community with well-edited, authoritative reports on developments in the most exciting areas of environmental sciences, earth sciences and related fields.

More information about this series at http://www.springer.com/series/16067

nik.ivanvorobyov@yandex.ru

Igor Bychkov · Victor Voronin
Editors

Information Technologies in the Research of Biodiversity

Proceedings of the International Conference "Information Technologies in the Research of Biodiversity", 11–14 September, 2018, Irkutsk, Russia

Springer

nik.ivanvorobyov@yandex.ru

Editors
Igor Bychkov
Matrosov Institute for System Dynamics and Control Theory
Siberian Branch of Russian Academy of Sciences
Irkutsk, Russia

Victor Voronin
Siberian Institute of Plant Physiology and Biochemistry
Siberian Branch of Russian Academy of Sciences
Irkutsk, Russia

ISSN 2524-342X ISSN 2524-3438 (electronic)
Springer Proceedings in Earth and Environmental Sciences
ISBN 978-3-030-11719-1 ISBN 978-3-030-11720-7 (eBook)
https://doi.org/10.1007/978-3-030-11720-7

Library of Congress Control Number: 2018967733

© Springer Nature Switzerland AG 2019
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

nik.ivanvorobyov@yandex.ru

Preface

This volume contains the proceedings of the First International Conference "Information Technologies in the Research of Biodiversity" that was held from 11 to 14 September 2018 in Irkutsk, Russia. The conference includes plenary and sectional reports, round tables and master classes on the publication of biodiversity data for use in basic and applied research to provide you with principles for working with existing biodiversity information systems.

Chapters in this book cover areas of interaction of knowledge on biodiversity and information technologies. Integration of modern information technologies and classical methods of biodiversity research enables reaching new levels of knowledge acquisition. New demands on researchers require coordination, standardization and unification of data and methods.

The main topics include methods, models, software systems for the analysis of biodiversity data; global data portals; information and analytical systems on biodiversity; application of remote methods in vegetation mapping; and theoretical fundaments and organization technologies of the information and telecommunications infrastructures.

The conference was organized by Matrosov Institute for System Dynamics and Control Theory SB RAS in cooperation with Siberian Institute of Plant Physiology and Biochemistry SB RAS, V.B. Sochava Institute of Geography SB RAS, Institute of Mathematical Problems of Biology RAS—the Branch of the Keldysh Institute of Applied Mathematics RAS. The conference was held with the support of the GBIF—Global Biodiversity Information Facility and Department of Nanotechnology and Information Technologies RAS.

The organizers would like to thank all the authors for their participation, Technical Program Committee, Editorial Board and associated reviewers for their good work and important contribution to the conference.

September 2018

Igor Bychkov
Victor Voronin

nik.ivanvorobyov@yandex.ru

Organization

General Chair

Igor Bychkov	Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Russia

Program Chairs

Igor Bychkov	Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Russia
Victor Voronin	Siberian Institute of Plant Physiology and Biochemistry of Siberian Branch of Russian Academy of Sciences, Russia

Program Committee

Anne-Sophie Archambeau	University Pierre and Marie Curie GBIF, France
Oleg Borodin	State Scientific and Production Association "State Research and Development Center for Biological Resources of the National Academy of Sciences of Belarus", Minsk, Republic of Belarus
Ingimar Erlingsson	Swedish Museum of Natural History, Stockholm, Sweden
Alexei Hmelnov	Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Russia

nik.ivanvorobyov@yandex.ru

Mikhail Kalyakin	Lomonosov Moscow State University, Moscow, Russia
Ma Keping	Institute of Botany, Chinese Academy of Sciences, Beijing, China
Dmitry Schigel	Global Biodiversity Information Facility Secretariat, Copenhagen, Denmark
Nadezhda Konstantinova	PABGI KSC RAS, Apatity, Russia
Svetlana Kubrak	Institute of Genetics and Cytology of the National Academy of Sciences of Belarus, Minsk, Republic of Belarus
Otso Ovaskainen	University of Helsinki, Helsinki, Finland
Varos Petrosyan	Severtsov IPEE RAS, Moscow, Russia
Gennadiy Ruzhnikov	Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Russia
Alexey Seregin	Lomonosov Moscow State University, Moscow, Russia
Alexey Shekhovtsov	V.B. Sochava Institute of Geography SB RAS, Russia
Mikhail Ustinin	IMPB RAS—the branch of Keldysh IAM RAS, Pushchino, Russia
Igor Vladimirov	V.B. Sochava Institute of Geography SB RAS, Russia
Andrey Zverev	Tomsk State University, Tomsk, Russia

nik.ivanvorobyov@yandex.ru

Contents

The Use of NDVI for the Analysis of the Effect of Drought on Vegetation Productivity in the Pre-Urals Steppe Area Where a Population of the Przewalski Horse Equus Ferus Przewalskii Polj., 1881 Had Been Established 1
Nikolay I. Fedorov, Tatyana L. Zharkikh, Oksana I. Mikhailenko, and Rafilya T. Bakirova

Regional Information and Analytical System on Insect Biodiversity of the Baikal Region 8
Igor A. Antonov

Use of Remote Sensing Data and GIS Technologies for Monitoring Stocks of Medicinal Plants: Problems and Prospects 14
N. B. Fadeev, T. N. Skrypitsyna, V. M. Kurkov, and N. I. Sidelnikov

Digital Herbarium Collections of the Central Siberian Botanical Garden SB RAS, Novosibirsk, Russia 22
Nataliya Kovtonyuk, Irina Han, and Evgeniya Gatilova

Taxonomic and Phytogeograpical Databases in Systematics of the Flowering Plant Family Umbelliferae/Apiaceae 28
Michael G. Pimenov, Michael V. Leonov, and Tatiana A. Ostroumova

The Fractal Model of the Microorganism's Frequencies Spectrum for Determining the Diversity of the Biochemical Processes in Soil 37
N. I. Vorobyov, V. N. Pishchik, Y. V. Pukhalsky, O. V. Sviridova, S. V. Zhemyakin, and A. M. Semenov

Actualization of Herbarium Labels Information 42
Olga Pisarenko, Igor Artemov, Sergey Kazanovsky, and Ekaterina Prelovskaya

nik.ivanvorobyov@yandex.ru

Ground Surveys Versus UAV Photography: The Comparison of Two Tree Crown Mapping Techniques 48
Maxim Shashkov, Natalya Ivanova, Vladimir Shanin, and Pavel Grabarnik

Creation of Information Retrieval System on the Unique Research Collections of the Zoological Institute RAS 57
Oleg Pugachev, Natalia Ananjeva, Sergey Sinev, Leonid Voyta, Roman Khalikov, Andrey Lobanov, and Igor Smirnov

The Use of Mathematical Methods in Analysis of Antibioticresistans of Microorganisms of Lake Baikal 66
E. V. Verkhozina, A. S. Safarov, V. A. Verkhozina, and U. S. Bukin

Mapping of Model Estimates of Phytoplankton Biomass from Remote Sensing Data 73
Svetlana Ya Pak and Alexander I. Abakumov

About the Project of the Web GIS "Electronic Atlas of Bryophytes of the Republic of Bashkortostan" 80
T. U. Biktashev, N. I. Fedorov, and E. Z. Baisheva

Bioclimatic Data Optimization for Spatial Distribution Models 86
Mikhail Orlov and Alexander Sheludkov

Forest Resources of the Baikal Region: Vegetation Dynamics Under Anthropogenic Use 96
Anastasia K. Popova, Evgeny A. Cherkasin, and Igor N. Vladimirov

DNA Barcoding of *Waldsteinia* Willd. (Rosaceae) Species Based on ITS and *trnH-psbA* Nucleotide Sequences 107
Marina Protopopova, Vasiliy Pavlichenko, Aleksander Gnutikov, and Victor Chepinoga

Technology of Information and Analytical Support for Interdisciplinary Environmental Studies in the Baikal Region 116
Igor V. Bychkov, Gennady M. Ruzhnikov, Roman K. Fedorov, Yurii V. Avramenko, Alexander S. Shumilov, Alexei O. Shigarov, Alla V. Verhozina, Natalia V. Emelyanova, and Andrei A. Sorokovoi

Geoinformational Web-System for the Analysis of the Expansion of the Baikal Crustaceans of the Yenisei River 125
A. V. Andrianova and O. E. Yakubailik

Some Problems of Regional Reference Plots System for Ground Support of Remote Sensing Materials Processing 131
Alina Bavrina, Anna Denisova, Lyudmila Kavelenova, Eugeny Korchikov, Oksana Kuzovenko, Nataly Prokhorova, Darya Terentyeva, and Victor Fedoseev

nik.ivanvorobyov@yandex.ru

Late Cenozoic Lagomorphs Diversity in Eurasia 144
M. A. Erbajeva

An Instrumental Environment for Metagenomic Analysis 151
Evgeny Cherkashin, Alexey Shigarov, Fedor Malkov,
and Alexey Morozov

Experience in the Use of GIS Tools in Plant Systematics and Conservation 159
M. Olonova, D. Feoktistov, and T. Vysokikh

Diatom Analysis Using SOQL Language Interpreter 169
Y. V. Avramenko, R. K. Fedorov, and A. D. Firsova

Database of Barguzinsky Reserve 174
Evgeniya Bukharova, Alexander Ananin, and Tatiana Ananina

Development of Complex GIS Monitoring of the Angara River 181
Andrey S. Gachenko and Alexei E. Hmelnov

Current State and Rational Use of Landscapes in the Border Area of Mongolia and Russia 187
Alexey I. Shekhovtsov, Irina A. Belozertseva, Igor N. Vladimirov,
and Darya N. Lopatina

Environmental Aspects of Urbanized Territories in the Baikal Region 193
Olga V. Gagarinova, Andrey Sorokovoy, Irina A. Belozertseva,
Natalia V. Emelyanova, and Roman Fedorov

Author Index 201

nik.ivanvorobyov@yandex.ru

The Fractal Model of the Microorganism's Frequencies Spectrum for Determining the Diversity of the Biochemical Processes in Soil

N. I. Vorobyov[1(✉)], V. N. Pishchik[2], Y. V. Pukhalsky[1], O. V. Sviridova[1], S. V. Zhemyakin[3], and A. M. Semenov[4]

[1] ARRIAM, Podbelsky sh., 3, Pushkin, Saint-Petersburg, Russia
Nik.IvanVorobyov@yandex.ru
[2] AFI, Grazhdansky pr., 14, Saint-Petersburg, Russia
[3] Company "Petersburg's Biotechnologies", Tinkoff lane 7D, Pushkin, Saint-Petersburg, Russia
[4] MSU named Lomonosov MV, The Lenin Hills, 1, Moscow, Russia

Abstract. Modern molecular genetic methods have provided a extended opportunities for studying the frequency taxonomic composition of soil microbial communities, including uncultivated strains of microorganisms. Modern spectrum analysis of operational taxonomic units (OTU) identified by 16Sr RNA gene is limited to the comparison of the nucleotide sequences. We propose to use a fractal model to describe the frequency spectrum of microorganisms. This model necessary to study the network self-organization of microbial communities and the functional diversity of the processes of biological systems. The power series from three frequencies of OTU are the fractal model of frequencies spectrum of OTU (for example: 0.1, 0.01, 0.001). Because there are many OTU's peaks in the original spectrum, peaks grouped with the same or similar amplitudes to form OTU-groups. Fractal topological analysis of the location of OTU-groups on a fractal portrait of the microbial community was been used to search for degenerate triangles with OTU-groups at the vertices, since these OTU-groups correspond to a microbial biosystem and to fractal model for the grouped OTU's frequencies. The functional diversity index (I_{FD}) of biochemical processes is been determined by number of OTU-groups in microbial community and by number of OTU-groups in biosystem. The I_{FD}-dynamics was been calculated with using the daily data of molecular-genetic analysis of soil samples. As a result, we revealed the periodic fluctuations in I_{FD}-values and the periodic replacing of OTU-groups in a soil microbial biosystems that provide a wide diversity of a biochemical processes in soil microbial communities.

Keywords: Fractal model of microorganism's frequency spectrum · Functional diversity of biochemical processes in soil microbial communities · Fractal portrait of microbial community

© Springer Nature Switzerland AG 2019
I. Bychkov and V. Voronin (Eds.): *Information Technologies in the Research of Biodiversity,* SPEES, pp. 37–41, 2019.
https://doi.org/10.1007/978-3-030-11720-7_6
nik.ivanvorobyov@yandex.ru

1 The Fractal Model of Frequencies Spectrum of OTU-Groups

As components of biological systems, soil microorganisms with maximum efficiency convert organic substrates into nutrients for plants. To analyze the diversity of biochemical processes in microbial biosystems, it is been proposed to use molecular-genetic data of microbial communities. Since there are many peaks in the original frequency spectrum of the operational taxonomic units (OTU) of microbial communities, the peaks were been first grouped with the same or similar amplitudes to form OTU-groups. To group OTU, the entire range of values of $ln(p_i/p_{max})$ is divided into intervals in steps of 0.1, where pi, p_{max} are the OTU-frequencies with the serial number (i) and the highest OTU-frequency. The OTU's frequencies which falling into one interval are been summed to form the common frequency of the OTU-group. As a result, the initial spectrum of the OTU-frequencies can been reduced to 20–40 frequencies of OTU-groups.

In the frequencies OTU-group spectrum, it is necessary to select three OTU-groups, which frequencies corresponding to a power series as the fractal model [1]. We assume that these three OTUs form a biosystem and perform one biochemical function. The fractal model is a power series of three frequencies of OTU-groups (for example, 0.1, 0.01, 0.001). The logarithms of these frequencies vary linearly (for example, −ln (10), −2ln (10), −3ln (10),…). This property of the fractal model was been used to search for the OTU-groups belonging to biosystems.

2 The Topological Analysis of OTU-Groups Location on the Fractal Portrait of the Microbial Community

The fractal portrait of a microbial community is the two-dimensional field with points representing the OTU-groups (See Fig. 1) [2]. The Y-coordinate of the OTU-group determines by $ln(q_i/q_{max})$. The X-coordinate of the OTU-group determines by the fractional part of $ln(q_i/q_{max})$, where q_i, q_{max} are the OTU-group's frequency with the serial number (i) and the highest OTU-group's frequency.

The fractal measure of topological analysis is a triangle with three OTU-groups at the vertices. The smallest height (h_i, see Fig. 1) of the triangle is a scale of the fractal measure. At the vertices of the triangles, there must be OTU-groups for which the integral parts of $ln(q_i/q_{max})$ are not equal. For example, the integral parts of $ln(q_1/q_{max})$, $ln(q_{10}/q_{max})$, $ln(q_{17}/q_{max})$ are equal respectively 0, −1, −3 (see the points A, B, C in Fig. 1). All triangles that constructed on the fractal portrait can been arranged in ascending order of the smallest height of the triangles (h_N, see Fig. 2), where N is the serial number of the triangle in this series.

The logarithmic dependence (see Fig. 2) is a quasilinear dependence and it is equivalent to the classical fractal logarithmic dependence [3]. An unusual way of covering by triangles the points on the fractal portrait has led to the fact that the coefficient of fractal dimension has acquired a negative value (−0.86, see Fig. 2).

nik.ivanvorobyov@yandex.ru

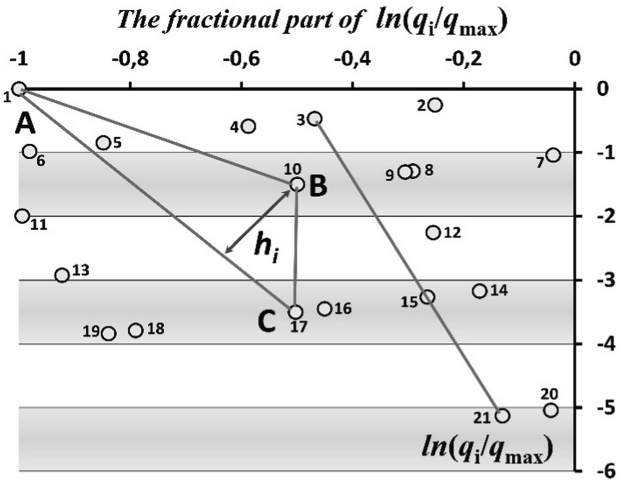

Fig. 1. The topological analysis of OTU-groups location on fractal portrait of the microbial community. Notes: The OTU-group's frequency determines Y and X coordinates corresponding point on the portrait. The ABC-triangle with OTU-groups No. 1, 10, 17 at the vertices is a fractal measure of topological analysis. The smallest height of the triangle (h_i) is a scale of the fractal measure. Since the OTU-groups No. 3, 15, 21 are located on the same straight line and corresponding to a degenerate triangle, we assume that these OTU-groups form a biosystem and perform one biochemical function.

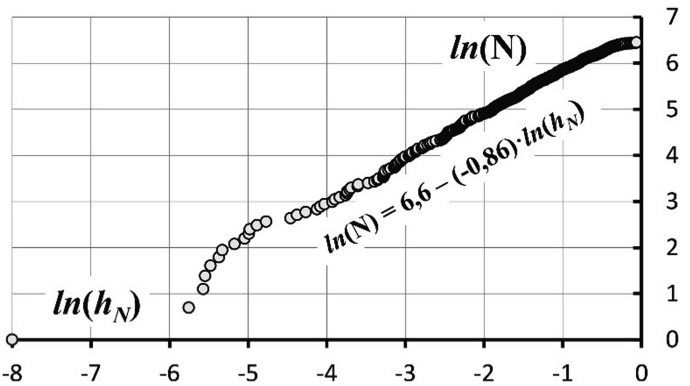

Fig. 2. The logarithmic dependence of the serial number (N) of triangles constructed on a fractal portrait and arranged in ascending order of the smallest height of the triangles (h_N).

Among all triangles that were constructed on the fractal portrait we choose degenerate triangles for which $ln(h_N) < -5$. We believe that the OTU-groups of these triangles form a biosystem and perform one biochemical transformative function. For example, the OTU-groups No. 3, 15, 21 (see Fig. 1) correspond to a degenerate triangle and to a biosystem performing one biochemical function.

nik.ivanvorobyov@yandex.ru

3 The Functional Diversity Index of Biochemical Processes in Soil Microbial Biosystem

The number of degenerate triangles found on a fractal portrait determines the number of different processes of biochemical transformation performed by the soil microbial community. The number of OTU-groups (M_B) corresponding to degenerate triangles divided by the total number of OTU-groups in the microbial community (M_C) is the functional diversity index of a biochemical processes in microbial communities (I_{FD}, see Formula (1)).

$$I_{FD} = M_B/M_C. \tag{1}$$

In accordance with the proposed computational method, the daily dynamics of I_{FD} (1) was been calculated with using the molecular-genetic data of soil samples obtained in September 2006 in Moscow Region [4] (see Fig. 3).

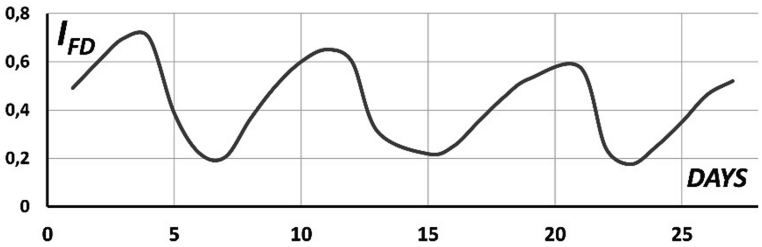

Fig. 3. The computational daily dynamics of the functional diversity index (I_{FD}) of biochemical processes in microbial communities from the Moscow Region soils [4].

The observed I_{FD} fluctuations (see Fig. 3) mean that in the soil there are constant changes in the structure of microbial biosystems and changes in the direction of biochemical processes. The periodic rearrangement of microbial biosystems with the replacement of OTU-groups and the change in the number of different biochemical transformations points to a wide range of biochemical processes which can supported by the soil microbial community.

Acknowledgements. This work is been partially supported by the Russian National Fund grant No. 14-26-00094.

References

1. Schroeder, M.: Fractals, Chaos, Power Laws: Minutes from an Infinite Paradise. W.H. Freeman, NY (1991)
2. Vorobyov, N.I., Sviridova, O.V., Patyka, N.V., Dumova, V.A., Mazirov, M.A., Kruglov, Y. V.: Fractal-taxonomic portrait of microbial community as bioindicator of a type of soil

nik.ivanvorobyov@yandex.ru

destructive processes. In: Book of Abstracts of the International Conference "Bioindication in the Ecological Assessment of Soil and Related Habitats", p. 38. Moscow, BINOM (2013)
3. Mandelbrot, Benoit B.: The Fractal Geometry of Nature. W.H. Freeman and Company, NY (1982)
4. Semenov, A.M., Bubnov, I.A., Semenov, V.M., Semenova, E.V., Zelenev, V.V., Semenova, N.A.: Daily dynamics of bacterial numbers, CO_2 emissions from soil and relationships between their wavelike fluctuations and succession of the microbial community. Eurasian Soil Science, vol. 46(8), pp. 869–884. Pleiades Publishing, Ltd. (2013)

nik.ivanvorobyov@yandex.ru

Author Index

A
Abakumov, Alexander I., 73
Ananin, Alexander, 174
Ananina, Tatiana, 174
Ananjeva, Natalia, 57
Andrianova, A. V., 125
Antonov, Igor A., 8
Artemov, Igor, 42
Avramenko, Yurii V., 116, 169

B
Baisheva, E. Z., 80
Bakirova, Rafilya T., 1
Bavrina, Alina, 131
Belozertseva, Irina A., 187, 193
Biktashev, T. U., 80
Bukharova, Evgeniya, 174
Bukin, U. S., 66
Bychkov, Igor V., 116

C
Chepinoga, Victor, 107
Cherkasin, Evgeny A., 96, 151

D
Denisova, Anna, 131

E
Emelyanova, Natalia V., 116, 193
Erbajeva, M. A., 144

F
Fadeev, N. B., 14
Fedorov, Nikolay I., 1, 80
Fedorov, Roman K., 116, 169, 193
Fedoseev, Victor, 131
Feoktistov, D., 159
Firsova, A. D., 169

G
Gachenko, Andrey S., 181
Gagarinova, Olga V., 193
Gatilova, Evgeniya, 22
Gnutikov, Aleksander, 107
Grabarnik, Pavel, 48

H
Han, Irina, 22
Hmelnov, Alexei E., 181

I
Ivanova, Natalya, 48

K
Kavelenova, Lyudmila, 131
Kazanovsky, Sergey, 42
Khalikov, Roman, 57
Korchikov, Eugeny, 131
Kovtonyuk, Nataliya, 22
Kurkov, V. M., 14
Kuzovenko, Oksana, 131

© Springer Nature Switzerland AG 2019
I. Bychkov and V. Voronin (Eds.): *Information Technologies in the Research of Biodiversity*, SPEES, pp. 201–202, 2019.
https://doi.org/10.1007/978-3-030-11720-7

nik.ivanvorobyov@yandex.ru

L
Leonov, Michael V., 28
Lobanov, Andrey, 57
Lopatina, Darya N., 187

M
Malkov, Fedor, 151
Mikhailenko, Oksana I., 1
Morozov, Alexey, 151

O
Olonova, M., 159
Orlov, Mikhail, 86
Ostroumova, Tatiana A., 28

P
Pak, Svetlana Ya, 73
Pavlichenko, Vasiliy, 107
Pimenov, Michael G., 28
Pisarenko, Olga, 42
Pishchik, V. N., 37
Popova, Anastasia K., 96
Prelovskaya, Ekaterina, 42
Prokhorova, Nataly, 131
Protopopova, Marina, 107
Pugachev, Oleg, 57
Pukhalsky, Y. V., 37

R
Ruzhnikov, Gennady M., 116

S
Safarov, A. S., 66
Semenov, A. M., 37
Shanin, Vladimir, 48
Shashkov, Maxim, 48
Shekhovtsov, Alexey I., 187
Sheludkov, Alexander, 86
Shigarov, Alexei O., 116, 151
Shumilov, Alexander S., 116
Sidelnikov, N. I., 14
Sinev, Sergey, 57
Skrypitsyna, T. N., 14
Smirnov, Igor, 57
Sorokovoi, Andrei A., 116, 193
Sviridova, O. V., 37

T
Terentyeva, Darya, 131

V
Verhozina, Alla V., 116
Verkhozina, E. V., 66
Verkhozina, V. A., 66
Vladimirov, Igor N., 96, 187
Vorobyov, N. I., 37
Voyta, Leonid, 57
Vysokikh, T., 159

Y
Yakubailik, O. E., 125

Z
Zharkikh, Tatyana L., 1
Zhemyakin, S. V., 37

nik.ivanvorobyov@yandex.ru