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Protistology

In memoriam

Irma Viktorovna Issi (1930-2022)

Yuliya Sokolova[1], Elena Nassonova[1], and Yuri Tokarev[2]

[1] *Institute of Cytology, Russian Academy of Sciences, St. Petersburg, 194064 Russia*
[2] *All-Russian Institute of Plant Protection, St. Petersburg, Pushkin, 196608, Russia*

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Irma Viktorovna Issi, a world-class biologist, Doctor of Science, Professor, a founder and leader of research on microsporidia in Russia, an artist, poet, a person of the highest standards of integrity, and our beloved friend and colleague passed away on September 29, 2022, at the age of 92.

Irma Viktorovna Issi was born on January 11, 1930 in Leningrad. She was in school during the Second Word War, and spent all 900 days of the Leningrad Blockade in the besieged city. As Irma wrote in her memoirs, "Remembering the blockade, I still cannot understand how we survived and how it was even possible to survive in such conditions. ... I have never regretted and do not regret that I remained in besieged Leningrad. ... And this feeling - I am a winner - helped me both to survive during the war and simply to outlive many difficult or tragic periods of my life". Truly, Irma's personal life, as well the overall being in the Soviet Union and in Russian Federation after the Union's split in 1991 was full of difficulties and sometimes tragic. Her university years fell to the dismal period of Stalin's regime, when anti-Darvinistic concept of Trofim Lysenko, supported by Soviet authorities, prevailed in biology and was officially taught at the Biological Faculty of Leningrad State University, which Irma enrolled in 1949. Due to her natural critical mind and because of a few outstanding professors who in spite of a life-threatening pressure continued teaching their students the science but not ideology, Irma was never influenced by Lysenko's ideas, but instead developed strong skills of independent thinking. Among the professors who shaped Irma as a scientist, first of all, was her uncle Prof. Andrey P. Bystrov, an outstanding paleontologist and anthropologist, who was a part of Irma's family and on everyday basis guided Irma's "natural his-

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tory" education during her childhood. Among the university professors Irma praised, there were geneticist Ivan I. Sokolov, parasitologist Valentin A. Dogiel, protozoologist Yuriy I. Polyanskiy, botanist and paleobotanist Armen L. Takhtadjan, entomologists Aleksander S. Danilevskiy and Eduard K. Grienfeld.

After graduation from the Department of Entomology of Leningrad State University in 1954, for more than 50 year she was working at the All-Union (later All-Russian) Institute of Plant Protection (VIZR) in St. Petersburg, as a Researcher, Leading Researcher and Professor of Entomology and Insect Pathology. VIZR at that time was governed by agronomists and agricultural scientists of the Soviet school. Irma wrote about the period of her establishing as an independently thinking leading scientist in VIZR in her brilliant memoirs full of curious facts, with humor, even though that period was neither smooth nor easy for this broadly educated and ambitious woman. To be able to work completely independently, for her PhD dissertation she deliberately chose the group of organisms that nobody knew and never dealt with, the microsporidia.

Microsporidia research in the USSR and in Russia was initiated by Irma Viktorovna Issi, and this research field cannot be separated from her name. In Russia, if you say "microsporidia", you mean Irma Viktorovna Issi, and vice versa. To study geographical distribution of microsporidia and to screen insect populations in various geographical localities, she undertook numerous field trips – in Carpathians, Crimea, Azerbaijan, Uzbekistan, Karelia, etc. This was facilitated by existence of a vast network of Plant Protection Institutes and research stations all over the country. Being an excellent communicator with good organizing skills, Irma easily made contacts with local scientists and students. She managed to "infect" many of them with her passion for microsporidia, and to convince senior personnel in importance of research on microsporidia. Literally, all "microsporidiologists" in Russia, Belarus, Ukraine, Kazakhstan, Uzbekistan, Tajikistan, Azerbajan, and other former republics of the late USSR are her students, "the scientific children", as Irma loved to call the younger generation of scientist, or the students of her students – "the scientific grandkids".

Research on the Microsporidia in the USSR (and in Russia) started in mid-60s. In 1964, Irma defended her PhD dissertation "The microsporidiosis of cabbage white and other insects, and its biological importance", and soon hereafter established a Microsporidia research group, "Issi's lab", within the Laboratory for Microbiological Control, in VIZR. The lab became an "incubator" for young microsporidiologists: 38 PhD students from all over the former Soviet Union have passed through the lab and graduated under Prof. Issi's supervision. Research covered many aspects of microsporidian biology, including influence of microsporidia on host population dynamics and potential application of microsporidia in biological control of pests; interactions of microsporidia with their insect hosts at the population, organism, cellular and subcellular levels; and taxonomy of microsporidia. One of the brightest research achievements of the lab was a long-term (over 25 years) observation on the epizootics of *Vairimorpha* (*Nosema*) *mesnili* in the cabbage white *Pieris brassicae* that demonstrated how the microsporidium took control over the host population. Peaks and declines in host and parasite densities were accompanied by alterations in the microsporidium life cycle and switches of transmission routes. Peroral, transovarial routes, as well as transmission by three species of parasitoids and hyperparasitoids enabled spreading microsporidia among local populations of *Pieris* spp. This butterfly is widely distributed in North Western Europe, and over a dozen sites demonstrated heavy infection of *P. brassicae* with *V. mesnili*. Amazingly, the pest outbreak in Leningrad region ended abruptly, and since the year 2000 the number of this pierid declined to a hardly detectable level; so did the infection. The monograph "Microsporidia as a Phylum of Parasitic Protists (1986)" summarized Dr. Issi's Doctor of Science Dissertation (equivalent to Habilitated Doctoral Dissertation in Germany). In this book, focused primarily on taxonomy, systematics and origin of microsporidia, Irma Issi presented a new system of the phylum Microsporidia. The monograph also reports the data on the effect these parasites produce on their hosts. It was translated into English by Jerzy Lipa in 1991 and published by the Society for Invertebrate Pathology in the USA. Unfortunately, the English version does not contain perfect Irma's drawings of microsporidia. Irma was a gifted and professionally trained artist, and collection of her ink drawings of microsporidia is a treasure trove, and hopefully it will be published one day separately as a piece of art and science. Refinements and additions to the data presented in "Microsporidia as a Phylum of Parasitic Protists" were published later in two monographs written in collaboration with her

former students (Sokolova and Issi, 2001; Issi and Voronin, 2007) and in numerous papers, mostly all in Russian. Irma Viktorovna Issi and her colleagues described many taxa of microsporidia new to science, including 57 species and 18 genera from various arthropods, primarily agricultural and forest pests, blood-sucking insects, commercial crustaceans and fish. For many of these species, the prevalence levels were determined and life cycles deciphered. An annotated list of microsporidian taxa described from the territory of the Soviet Union was recently published by Irma Viktorovna and her colleagues in English in the journal "Protistology" (Sokolova et al., 2018). During the last two decades, taxonomic system of microsporidia has been utterly challenged by introduction of molecular phylogenetic analyses based on comparison of DNA sequences, and necessity of the taxonomic revision of the phylum became obvious. Irma Viktorovna, unlike many "old-school" taxonomists, understood the importance of the new approach to the Microsporidia taxonomy and advocated for the integrative approach, which would use a combination of morphological and molecular characters to differentiate intraspecific forms, species, and the higher rank taxa, and ultimately to create a natural system of the Microsporidia (Tokarev and Issi, 2018). In this connection, it is worth to note that the book "Microsporidia as a Phylum of Parasitic Protists" (1986) not only includes a key to 68 microsporidia genera, but also provides a table of 11 characters used to differentiate these genera and group them into 16 families. In fact, it was a unique attempt to formalize morphological data and create a matrix for cladistic analysis of microsporidian morphological characters. In the future, this matrix combined with sequence data (yet unavailable for most taxa), could help to understand the hierarchy of molecular and morphological features used in phylogeny and taxonomy of Microsporidia. Probably due to her artistic vision, Irma was an excellent taxonomist. In some cases, her decisions on assigning species to certain genera sounds as amazing provisions. A good example is the genus *Anncaliia* (Issi et al., 1993), which Issi and co-authors erected to accommodate two microsporidia, *Nosema meligheti* and *N. varivestis* from beetles. Comparing literature on ultrastructure, she came to the conclusion that *A. meligheti* shares principal characters with *Nosema algerae*, a famous microsporidium parasitizing mosquitoes and humans that had been transferred to the genus

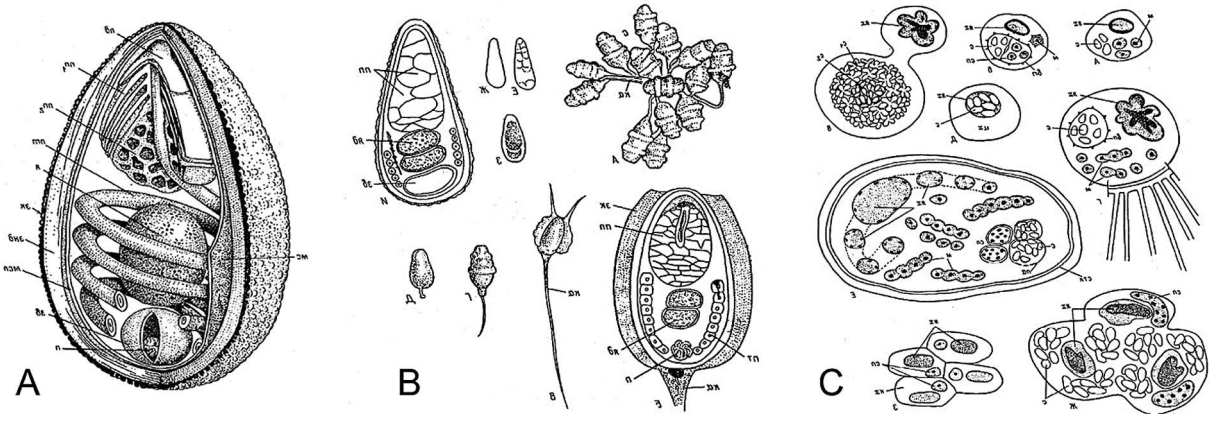
Irma in her lab with Yulia Sokolova. VIZR, St. Petersburg – Pushkin, 1996

Brachiola in 1998 by Ann Cali, alongside with congeneric human microsporidia, *B. vesicularum* and *B. connori*. Irma insisted that those species should be all reassigned to the genus *Anncaliia*. Together with Elena Nassonova she initiated molecular study to prove this morphology-based inference. The existence of the *Anncaliia* lineage was perfectly confirmed by SSU rDNA-based phylogenetic analysis performed in collaboration with Dr. Franzen's lab, and the genus *Brachiola* was abolished as a junior synonym (Franzen et al., 2006).

There was another important mission, fulfilled by Irma Viktorovna: she broke the "iron curtain" in the small community of her research fellows and students much earlier than Gorbachev did it for the rest of Russians. After enrolling in PhD program in VIZR in 1961, Irma Viktorovna started looking for available foreign literature, since practically no studies on Microsporidia were performed in the Soviet Union. At the same time, these pathogens were in the focus of attention in many laboratories in England, Czech Republic, France, USA and many other countries. The libraries of VIZR and the Zoological Institute of the USSR Academy of Sciences were a good but insufficient source of required papers, and Irma actively corresponded with the authors that gladly responded and sent her the copies of the requested reprints. I.V. Issi's perfectly organized collection of reprints of microsporidia papers published all over the world from 1950 till early 2000-s, is a unique and comprehensive compilation, and it is still helpful, since most of the earlier publications are missing from Russian

Left photo: Irma with Ann Cali and Caspar Franzen. Right photo: 2nd Workshop on Microsporidia from Vertebrate and Invertebrate Hosts at the 5th European Congress of Protistologists, St. Petersburg State University, St. Petersburg, 2007; at the back from left to right: Elizabeth Didier, Louis Weiss, Patrick Keeling, Yuri Tokarev; at the front from left to right: Bryony Williams, Toby Wilkinson, Anastasia Simakova, Karen Roennbaeumer; at the right corner: Irma Issi, Ann Cali and Kaspar Franzen.

libraries and not available online. Relations with foreign colleagues that began with correspondence, have grown into a fruitful scientific collaboration and warm human relationships with many world-famous specialists in microsporidia. Irma personally met and collaborated with Eastern-European colleagues: Jerzy Lipa (Poland), Jaroslav Weiser (Czech Republic), and particularly with outstanding Czech scientist Jiří Vávra, who spoke Russian fluently and developed real friendship with Irma, lasted until his death in 2018. These scientists visited Irma and her lab in Leningrad (later St. Petersburg) in 1970-s and 1980-s. In 1990-s, Swedish scientist Ronny Larson visited St. Petersburg a few times in the frame of his collaboration with Dr. Vladimir Voronin, Irma Viktorovna's first PhD student. Dr. Larsson visited Irma's lab then, presented and discussed with us his results on microsporidia ultrastructure and taxonomy. It is worth noting that during the most of Irma's career, contacts of Russian scientists with western scientists were quite limited. Only once Irma Viktorovna managed to attend international meeting held abroad; it was Protozoological Congress in London in 1965. She



Illustrations by Irma Viktorovna Issi depicting the internal structure of microsporidia spores (A), the diversity of the structure of spores of the family Golbergiidae (B), and the response of host cells to infection (C) (Issi, 1986).


Left photo: Irma Viktorovna at home with her cat. St. Petersburg, 2015. Right photo: Irma Issi with her former students – Vladimir Voronin (3rd row, second from the left), Slava Dolgikh (2nd row, first) and Yuri Tokarev (to the right from Irma Viktorovna), and younger colleagues - Anton Naumov (3rd row, first), Anastasia Ignatieva, Sergey Timofeev and Igor Senderskiy (2nd row, from left to right), VIZR, St. Petersburg -Pushkin, 2013.

also participated in Protozoological Congress in Leningrad in 1969. After "perestroyka" during the 5th European Congress of Protistology and the 2nd Workshop on Microsporidia from Vertebrate and Invertebrate Hosts, held in St. Petersburg in 2007, she finally met personally Ann Cali, Caspar Franzen, Louis Weiss, Elizabeth Didier and many other colleagues from Western Europe, Canada and USA whom she used to know only by correspondence and their papers. Irma's broad international connections and excellent reputation as a scientist helped us, her students and colleagues, to become later a part of international research community.

The research initiated by Irma Viktorovna have been continued by her former graduates, leading scientists themselves, like Yuliya Sokolova, Viatcheslav Dolgikh, Elena Nassonova, Yuri Tokarev, and their students. Irma's last paper "Advances in microsporidiology in Russia" published on her 90th birthday (Issi, 2020), covers the major achievements, directions and perspectives of the scientific school she founded 60 years ago. Another paper that Irma published when she was over 90 was a description of a new genus, in co-authorship with Jerzy Lipa and Yuri Tokarev (Lipa et al., 2020). Many scientists all over the world know Irma Viktorovna Issi and cherish her works. Two taxa of microsporidia are named in her honor: the species *Paratelohania issiae* Kiloczycki 1998 and the genus *Issia* with the type species *Issia trichopterae* Weiser 1977.

We brought a tribute to scientific impact of Dr. Irma Issi. However, she was far more than a scientist – heavenly gifted, widely educated and infinitely erudite person with diverse interests. In any of her numerous hobbies, as in science, she reached excellence and it is impossible even to mention all of them in this short article. In childhood, she professionally studied art, and was thinking of a professional career of an artist. She was a fine connoisseur of painting, deeply versed in world and Russian masters. Her preferences were personal and unexpected; particularly, she was fond of Russian painters Arkhip Kuindzhi, Ivan Aivazovsky, Vasily Polenov, as well as Camille Corot and Rembrandt – mostly for their experiments with light. Irma was a great reader and bibliophile; she owned a huge collection of books and continued buying them until the very last year of her life. She gladly shared books and her appreciation with those who were interested. The sphere of her expertise in world and Russian literature was enormous. For example, there was no better expert and passionate lover of British detective novels than Irma. For me (YS), she opened the world of Scandinavian literature, and particularly Sigrid Undset with her epic novel about medieval Norway "Kristin Lavrancedatter", one of Irma's favorite books in world literature, alongside with a Soviet writer Victor Konetski, who also was a professional sailor and seascapes painter. A long period of time, from 1960-s to 2000-s, her hobby was

Запомните меня такой, Какою я была когда-то: Всегда готовою на бой Не в генералах, а солдатом…	Remember me I used to be: Always ready to fight As a soldier, not as generals might.
Можешь в это верить иль не верь, Божий одуванчик я теперь Голова одета в белый пух, Но ещё не сломлен прежний дух.	Now I am a «God's dandelion» With the head dressed in a white dawn, But believe, the one who read it, Unbroken stays my ole spirit.
Страшна не смерть, а умирание, Не акт ухода – боль прощания. Особенно боюсь пророчества, Что всё свершится в одиночестве…	It's not the death that's terrible but dying, The pain of farewell not act of leaving hurts. The prophecy I die alone is fearful. That scares me the worse.*

**Sadly, the prophecy fulfilled, Irma died alone at night…*

gardening. In late 60-ies, some land belonging to the Institute for Plant Protection and located near the Institute, was distributed among VIZR associates who wished to develop private vegetable gardens. Irma grew flowers, greens, vegetables, red and black currants, apples and plums, and provided season fruits and vegetables not only for her family but also for our laboratory gatherings and celebrations that were common in those years.

Irma was a brilliant talker and storyteller, and always - the soul of the company, not to say she was a fan of good wines, and Crimea Sherries were her favorites. At all times, pets were an important part of her life – in early years there were dogs, rabbits, a parrot, even dormice that she brought from one of her fieldtrips, those once lived freely in her kitchen. However, beginning from mid-1980s her heart was given to cats. She bred a particular pedigree – beautiful grey-colored longhaired creatures who adored their "mother" and mistress. They were too many for a small apartment she lived in – more that 20 at some periods, but they were her family, and gave her warmth and plenty of love.

Physically, Irma's last years were hard on her: she lived alone with minimal help from outside, was struggling with aging problems, numerous illnesses, inability to continue working in the lab, but her intellect and spirit were never defeated. At the latest period, her major focus and goal was to complete the book of her life, the Memoirs, in which she described the life in turbulent epochs she witnessed – from surviving Leningrad blockade to working in the Institute of Plant Protection. And she did it, and died only when the last chapter of her memoirs was finished!

If to compare Irma Issi's life with a piece of art, it is undoubtedly an accomplished and brilliant masterpiece. She was a loving mother and daughter, she made a substantial progress in science and brought up a generation of researches that successfully continue her studies, she loved and understood animals and they loved her back, and finally, she completed the book of her life. The difficulties and harshness of times she lived through hardened Irma Viktorovna's spirit, strengthened her moral rules and thirst for justice. She survived the most devastating life tragedy the one can imagine: her son Andrey died in his early thirties because of severe asthma attack and a criminal slowness of the ambulance. But in spite of cruelty of time being, she retained the openness of soul, energy and optimism based on love, knowledge, wisdom, curiosity, and admiration for nature and art. The story of her life is a source of inspiration for those who knew Irma Viktorovna. The bright memory of Irma Viktorovna Issi, a great scientist and wonderful person, will forever remain in the hearts of her colleagues and friends, and her scientific legacy will serve more than one generation of biologists.

Instead of the epilogue. All her life Irma wrote poetry. There are many lovely verses – very different: humoristic, serious, sad; many are quite intimate showing her not as a strong personality struggling for justice and standing firmly for her viewpoints, who she was, but also as a lonely person longing for love, understanding and tenderness, thinking of aging, life and death, as everyone does. We hope that Irma's poems will be published someday, together with her precious Memoirs. At the very end of her life, Irma practiced a particular form of rhymes; she called them "Четвертушки"(Rus.), "Quarters" - four-line poems. Here we present the latest three - in Russian and in English (translated by YS), in order to feel the warmth of Irma's beautiful and so lively personality.

Species and genera of microsporidia authored by Irma V. Issi

Alternosema Lipa, Tokarev, Issi, 2020

1. *Alternosema bostrichidis* Lipa, Tokarev, Issi, 2020

2. *Amblyospora caspius* Pankova, Issi, Simakova, 2000

3. *A. burlaki* Pankova, Issi, Simakova, 2000

4. *A. hybomitrae* Bykova, Krylova, Sokolova, Issi, 1989

Anisofilariata Tokarev, Voronin, Seliverstova, Dolgikh, Pavlova, Ignatieva, 2010

5. *Anisofilariata chironomi* Tokarev, Voronin, Seliverstova, Dolgikh, Pavlova, Ignatieva, 2010

Anncaliia Issi, Krylova, Nikolaeva, 1993

6. *Anncaliia* (*Nosema*) *meligethi* (Issi & Radishcheva 1979) Issi, Krylova, and Nicolaeva, 1993.

7. *Anncaliia azovica* Tokarev, Sokolova, Vasilieva, Issi, 2018

8. *Berwaldia daphnia* Simakova, Tokarev, Issi 2018

Campanulospora Issi, Radischcheva et Dolzhenko, 1983

9. *C. denticulata* Issi, Radischcheva et Dolzhenko, 1983

Crispospora Tokarev, Voronin, Seliverstova, Pavlova, Issi, 2010

10. *Crispospora chironomi* Tokarev, Voronin, Seliverstova, Pavlova, Issi, 2010

Cristulospora Khodzhaeva, Issi, 1989

11. *C. aedis* Khodzhaeva, Issi, 1989

12. *C. cadyrovi* Khodzhaeva, Issi 1989

13. *C. sherbani* Khodzhaeva, Issi 1989

Cylindrospora Issi, Voronin, 1986

14. *C. chironomi* Issi, Voronin, 1986

Evlachovaia Voronin, Issi, 1986

15. *E. chironomi* Voronin, Issi, 1986

16. *Glugea bychowskyi* Gasimagomedov, Issi, 1970

17. *G. dogieli* Gasimagomedov, Issi, 1970

18. *G. shulmani* Gasimagomedov, Issi, 1970

19. *Gurleya sokolovi* Issi, Lipa, 1968

20. *Janacekia wilhelmiae* Khodzhaeva, Krylova, Issi, 1990

Fibrillaspora Simakova, Tokarev, Issi, 2018

21. *Fibrillaspora daphnia* Simakova, Tokarev, Issi, 2018

22. *Mrazekia macrocyclopis* Issi, Tokarev, Voronin, Dolgikh, Seliverstova, Pavlova, 2010

Neoperezia Issi, Voronin 1979

23. *N. chironomi* Issi, Voronin 1979

24. *Nosema hydraeciae* Issi, Tkach, 1975

25. *N. loxostegi* Issi, Simchuk, Radischeva, 1980

26. *N. phalerae* Issi, Lipa, 1968

27. *N. syntomidis* Issi, 1979

28. *Octosporea antiquae* Issi, Radischcheva, Dolzhenko, 1983

29. *O. autumnalis* Bykova, Issi, 1991

30. *O. deliae* Issi, Radischcheva, Dolzhenko, 1983

31. *O. hybomitrae* Bykova, Issi, 1991

32. *O. tabani* Levtchenko, Issi, 1973

33. *Octotetraspora paradoxa* Khodzhaeva, Krylova, Issi, 1990

34. *O. cincta* Khodzhaeva, Krylova, Issi, 1990

Pankovaia Simakova, Tokarev, Issi, 2009

35. *Pankovaia semitubulata* Simakova, Tokarev, Issi, 2009

Paranosema Sokolova, Dolgikh, Morzhina, Nassonova, Issi, Terry, Ironside, Smith, and Vossbrinck, 2003

36. *Paranosema*(*Nosema*) *grylli* (Sokolova, Selesniov, Dolgikh, Issi 1994) Sokolova, Dolgikh, Morzhina, Nassonova, Issi, Terry, Ironside, Smith, and Vossbrinck, 2003

Parapleistophora Issi, Khodzhaeva, Krylova, 1990

37. *P. ectospora* Khodzhaeva, Krylova, Issi, 1990

38. *Pleistophora aidarlovica* Levtchenko, Issi, 1973

39. *P. carpocapsae* Simchuk, Issi, 1975

40. *P. culicoidi* Levtchenko, Issi, 1973

41. *P. hilobii* Issi, 1979

42. *P. hybomitrae* Bykova, Issi, 1991

43. *P. siluri* Gasimagomedov, Issi, 1970

44. *P. tuberifera* Gasimagomedov, Issi, 1970

45. *P. turgenica* Levtchenko, Issi, 1973

Pulicispora Vedmed, Krylova, Issi, 1991

46. *P. xenopsyllae* Vedmed, Krylova, Issi, 1991

Senoma Simakova, Pankova, Tokarev, Issi, 2005

47. *Senoma* (*Issia*) *globulifera* (Issi, Pankova, 1983) Simakova, Pankova, Tokarev, Issi, 2005

Simuliospora Khodzhaeva, Krylova, Issi, 1990

48. *S. uzbekistanica* Khodzhaeva, Krylova, Issi, 1990

49. *Stempellia captshagaica* Levtchenko, Issi, 1973

50. *S. rubtsovi* Issi, 1968

Striatospora Issi, Voronin, 1986

51. *S. chironomi* Issi, Voronin, 1986

Tabanispora Bykova, Issi, 1991

52. *T. bacilifera* Bykova, Issi, 1991

53. *T. hybomitrae* Bykova, Issi, 1991

54. *Thelohania argyresthiae* Issi, Lipa, 1968
55. *Th. culisetae* Levtchenko, Issi, 1973
56. *Th. dasychirae* Issi, Lipa, 1968
57. *Unikaryon oulemi* Issi, Krylova, Morzhina, Sokolova, 1998

Selected publication by Irma V. Issii

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