Plant & Fungal Research (2018) 1(1): 9-17
http://dx.doi.org/10.29228/plantfungalres.2

December 2018

Overview of the genus *Phyllactinia* (Ascomycota, Erysiphales) in Azerbaijan

Dilzara N. Aghayeva[1]
Lamiya V. Abasova
Institute of Botany, Azerbaijan National Academy of Sciences, Badamdar 40, Baku, AZ1004, Azerbaijan
Susumu Takamatsu
Graduate School of Bioresources, Mie University, 1577 Kurima-Machiya, Tsu 514-8507, Japan

Abstract: Intergeneric diversity of powdery mildews within the genus *Phyllactinia* in Azerbaijan was investigated using morphological approaches based on re-examination of herbarium specimens kept in Mycological Herbarium of the Institute of Botany (BAK), Azerbaijan National Academy of Sciences and collections of recent years. To contribute detail taxonomic analysis data given in literatures was revised. Modern taxonomic and nomenclature changes were considered. The host range and geographical distribution of species residing to the genus within the country were clarified. Consequently, 17 powdery mildew taxa were recorded, of which *Ph. alnicola*, *Ph. ampelopsidis*, *Ph. babayanii*, *Ph. carpini*, *Ph. corni*, *Ph. fraxini*, *Ph. guttata*, *Ph. mali*, *Ph. marissalii*, *Ph. moricola*, *Ph. nivea*, *Ph. orbicularis, Ph. paliuri*, *Ph. phaseolina*, *Ph. populi*, *Ph. pyri-serotinae* and *Ph. roboris* on 32 plant species from 11 families were listed. These families belong to the groups Asterids (Cornaceae, Oleaceae) and Rosids (Fabaceae, Betulaceae, Fagaceae, Salicaceae, Moraceae, Rhamnaceae, Rosaceae, Ulmaceae, Sapindaceae, Vitaceae), of which Rosids exceeds in number of host species. The family Rosaceae possess the large amount of host species, but specific affinity of genus *Phyllactinia* is considered to be to the family Betulaceae. In addition, *Phyllactinia* powdery mildews seemed to spread mainly in mountainous areas of Azerbaijan. The highest number of taxa was recorded in the districts belonging to the Southern-East Great Caucasus region of the country, followed by regions Middle Araz and Lesser Caucasus. The lowest number of *Phyllactinia* taxa was recorded from Kur lowland and Lankaran regions. During the present study, it was revealed that herbarium samples of 14 taxa of genus *Phyllactinia* are available in the BAK, information of which is provided in this article.

Accepted for publication: 5 December 2018
[1]E-mail: a_dilzara@yahoo.com

Key Words: *distribution, ectoparasitism, endoparasitism, host plant, plant pathogen, powdery mildews*

INTRODUCTION

Powdery mildews are one of the frequently encountered plant pathogens and most of them are epiphytic (14 genera from 18), in which they tend to produce hyphae and reproductive structures on surface of leaves, young shoots and inflorescence [Braun, Cook, 2012; Glawe, 2008]. These fungi absorb nutrients from plant tissue via haustoria, which develops in epidermal cells of plants [Braun, Cook, 2012]. Among all powdery mildews only four genera demonstrate endoparasitism, of them *Phyllactinia* Lév., have partly endoparasitic nature. Fungi belonging to these genera penetrate into the plant cell via stomata and develop haustoria in parenchyma cells. Endoparasitic genera of powdery mildews (*Phyllactinia*, *Pleochaeta* Sacc. & Speg., *Queirozia* Viégas & Cardoso and *Leveillula* G. Arnaud) form a distinct monophyletic group within Erysiphales which suggests that endoparasitism derived from ectoparasitism in powdery mildews only once in their evolution [Takamatsu, 2013; Takamatsu et al. 2016]. Only genus *Leveillula* exhibits true endoparasitism and elongates internal hyphae between host cells in mesophyll layer [Takamatsu et al. 2008, 2016].

Phyllactinia is distinguishable from other powdery mildews based on its unique characteristics of sexual morphs, viz. large ascomata (chasmothecia) with two different types of appendages. One of them is acicular appendages with bulbous swellings at the base, which arise equatorially and play role in orientation of ascomata through the air during dispersal. Second one, penicillate cells composed of foots (outgrows of the ascomatal walls), filaments [Shin, Lee, 2002] and grouped together on the dorsal surface of chasmothecia [Glawe, 2008]. Penicillate cells perform a role as anchor for attaching of chasmothecia to the new plant surface by gelatinizing of filaments under humid condition [Takamatsu et al., 2008]. There is a speculation that unique characteristics of appendages are an evolutionary adaptation to the tree parasitism of this genus [Takamatsu et al., 2008]. Powdery mildews from this genus form whitish to grayish colony under the leaf surface. The genus is characterized by having 2–3-spored asci, main-

ly monomorphic, sometimes dimorphic conidia with clavate, dumble-like, subcylindric, broadly ellipsoid-ovoid, lanceolate shape, almost indistinct and nipple or rod-shaped appressoria [Braun, Cook, 2012] (Fig. 1).

According to the monograph of the Erysiphales, 102 species were counted within the genus *Phyllactinia* [Braun, Cook, 2012] and they are strictly woody parasitic fungi, which are known on about 700 plant species from 69 families [Amano, 1986]. Totally, 108 plant species from family Rosaceae were dedected as host for genus *Phyllactinia* and the order is followed by families Betulaceae (91 species), Fagaceae (56 species), Oleaceae (50 species), etc. [Takamatsu et al., 2008].

The aims of this study were to reveal diversity of powdery mildews from the genus *Phyllactinia*, to clarify the ratio of *Phyllactinia* taxa within the Erysiphales in Azerbaijan, to update species composition by taking into the consideration modern taxonomic and nomenclature changes, and to investigate their host range and geographical distribution within country.

MATERIAL AND METHODS

Herbarium samples kept at the Mycological Herbarium of the Institute of Botany, ANAS (BAK) and new samples collected from 2016 to 2018 were investigated using classic morphological approaches. To contribute detail taxonomic investigations, literature data were summarized.

Morphological examinations were done under the optical microscope (Vert. A1, Carl Zeiss, Axio Imager, Göttingen, Germany). To examine asexual structures a little piece of infected leaf was rehydrated using lactic acid method [Shin, La, 1993]. For observation of sexual morphs, chasmothecia were mounted in 3% NaOH solution [Meeboon, Takamatsu, 2015]. Thirty measurements for each structure were taken. Measurements of asexual structures were done based on the length of conidiophores, size and shape of conidia and appressoria. For sexual structures diameter of chasmothecia, and number, size and shape of asci and ascospores were considered. Bulmer's factor (l × 1.5; w × 1.2) was used to reconstruct the original size of conidia for herbarium samples [Braun, Cook, 2012]. Drawings were made by freehand using scale bar.

Identification of fungal species was carried out by using the latest literature [Braun, Cook, 2012]. Nomenclature changes were done according to the Mycobank and Index Fungorum. Systematic assignment of plants was performed based on APG IV system [APG IV, 2016].

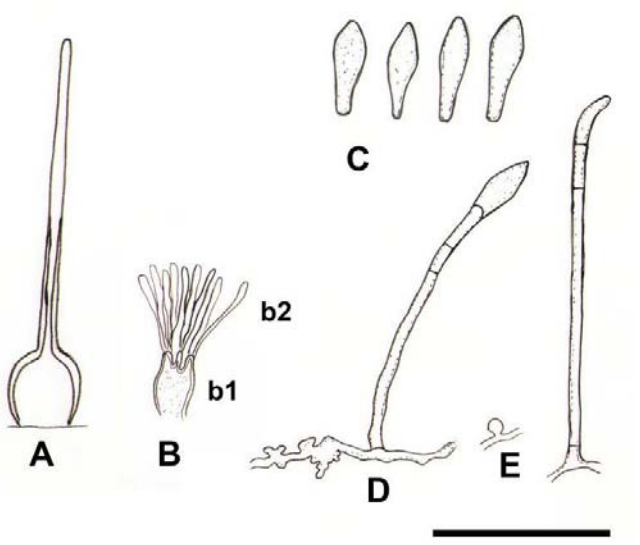

Figure 1. *Phyllactinia moricola;* A. acicular appendage with bulbous swelling; B. penicillate cell, b1. foot, b2. filaments; C. conidia; D. conidiophores; E. appressoria; Bar = 100 μm.

RESULTS AND DISCUSSION

*Taxonomy***.** Diversity of powdery mildews in Azerbaijan is currently represented with 134 fungal taxa from ten genera on 420 plant species from 51 families [Abasova, Ağayeva, 2018]. The genus *Erysiphe* R. Hedw. ex DC. dominates by possessing the largest number of fungal taxa, followed by the genus *Podosphaera* Kunze, *Golovinomyces* (U.Braun) Heluta, *Phyllactinia*, and *Leveillula*. Genera *Arthrocladiella* Vassilkov, *Blumeria* Golovin ex Speer, *Neoërysiphe* U.Braun and *Sawadaea* Miyabe are quite small and consist of one or two species for each genus [Abasova, Ağayeva, 2018]. Intergeneric diversity of the genus *Phyllactinia*, their host range, geographical distribution within the country, and traditional names put on the specimens and BAK numbers of were given below.

Ph. alnicola U. Braun, Braun & Cook 226, 2012; = *Ph. suffulta* f. *alni* Hammarl.; Host: *Alnus glutinosa* (L.) Gaertn. (Betulaceae); BAK 5612, 5614, 5615; Distribution: Qusar, Zaqatala (Fig.2.1).

Ph. ampelopsidis Y.N. Yu & Y.Q. Lai, Acta Microbiol. Sin. 19 (1): 14, 1979; Host: *Vitis vinifera* L. (Vitaceae); BAK 5778; Distribution: Khojavend. Previously a powdery mildew fungus on *Vitis vinifera* from Azerbaijan was described as *Phyllactinia suffulta* f. *vitis* Jacz. [Huseynova, 1961a]. Herbarium specimen was examined morphologically in this study, but not any other structure characterizing genus *Phyllactinia* was

observed. Description of *Ph. suffulta* f. *vitis* provided by B. Huseynova is quite similar to those of *Ph. ampelopsidis* in 180–200 µm diameter of chasmothecia [in monograph 150–280 µm], 6–8 number [5–14] and up to 250 µm length [250–370 µm] of acicular appendages, 54–76 × 22–30 µm [50–100 × 20–45 µm] and ellipsoid-ovoid, 2(–3)-spored of asci. However, *Ph. suffulta* f. *vitis* was given the affinity and status unclear taxa in monograph of the Erysiphales [Braun, Cook, 2012], but this taxon was revised as *Ph. ampelopsidis* according to the description given in the literature. Additional collections are required to clarify taxonomic status of this species using molecular-phylogenetic and detail morphological approaches.

Ph. babayanii Simonyan, Mikol. Fitapatol. 18(6): 465, 1984; = *Ph. salmonii* f. *amygdali* Babayan; Host: *Prunus fenzliana* Fritsch. (Rosaceae); BAK 5607; Distribution: Julfa.

Ph. carpini (Rabenh.) Fuss, Arch. Ver. Sibenb. Landesk. 14(2): 463, 1878; = *Ph. suffulta* f. *carpini-betuli* Jacz.; Host: *Carpinus betulus* L. (Betulaceae); BAK 5618–5623, 5627; Distribution: Qusar, Zaqatala, Astara, Gadabay, Askeran.

Ph. corni H.D.Shin & M.J.Park, Braun & Cook, 241, 2012; = *Ph. suffulta* f. *corni* Jacz.; Host: *Cornus mas* L., *C. sanguinea* L. (Cornaceae); BAK 5628–5632, 5634, 5635, 5636; Distribution: Zaqatala, Balakan, Askeran, Khojavend, Ordubad (Fig.2.2).

Ph. fraxini (DC.) Fuss, Arch. Ver. Siebenb. Landesk. 14(2): 463, 1878; Host: *Fraxinus excelsior* L., *F. sogdiana* Bunge (Oleaceae); BAK 5667–5677, 5679; Distribution: Qusar, Khachmaz, Absheron, Zaqatala, Lerik, Shusha, Khojavend, Ordubad (Fig.2.3). Two *Phyllactinia* species, *Ph. fraxini* and *Ph. fraxinocola* U.Braun & H.D.Shin were known on *Fraxinus* spp. worldwide [Braun, Cook, 2012]. According to the monograph of the Erysiphales [Braun, Cook, 2012] there is not major differences in sexual morphs between these two species. Mainly they could be distinguished based on their asexual structures [Scholler et al., 2018]. Specimens namely *Ph. suffulta* f. *fraxini* DC. collected in Azerbaijan were in sexual stage. Therefore identification of samples was done based on characteristics of sexual structures, principally on asci. Asci with 2–4-spors are usual for both species, but 3–4-spored ones are frequent in *Ph. fraxini*, which was observed in our specimens. Length of asci in our specimens varies between 70–101 µm, but it is 50–105 µm in *Ph. fraxini* and 50–90 µm in *Ph. fraxinicola* according to the Manual [Braun, Cook, 2012]. Based on these similarities our specimens were identified as *Ph. fraxini*.

Ph. guttata (Wallr.: Fr.) Lév., Bot., 3 Sér., 15: 144, 1851; ≡ *Ph. corylea* (Pers.) P.Karst.; = *Ph. suffulta* f. *coryli-avellanae* Jacz.; Host: *Corylus avellana* L., *C. colurna* L. (Betulaceae); BAK 5597–5601, 5637–5645, 5648, 5650–5658; Distribution: Qusar, Khachmaz, Shabran, Shaki, Oghuz, Qakh, Zaqatala, Lankaran, Lerik, Shusha, Kalbajar, Askeran, Ordubad (Fig. 2.4). Nowadays *Erysiphe corylacearum* U. Braun & S. Takam. was recorded as a new powdery mildew pathogen on hazelnut in Azerbaijan and become well distribute here [Abasova et al., 2018]. However, both surface of leaf, and nuts of hazelnut are became heavily infected by this pathogen, faint colonies of *Ph. guttata* also occur on the same leaves. Thus, now *Ph. guttata* coexists on the same host with *E. corylacearum* in the country.

Ph. mali (Duby) U. Braun, Feddes Repert. 88(9–10): 657, 1978; ≡ *Ph. mespili* (Castagne) S. Blumer; = *Ph. suffulta* f. *pruni* Jacz., f. *piri* Jacz.; = *Ph. guttata* f. *crataegi-oxyacanthae* Sacc.; Host: *Crataegus meyeri* A.Pojark, *C. monogyna* Jacq., *C. orientalis* M.Bieb., *C. pentagyna* Waldst. et Kit. ex Willd., *Mespilus germanica* L., *Pyrus communis* L., *P. salicifolia* Pall., *P. syriaca* Boiss., *Cerasus microcarpa* (C.A.Mey.) Boiss. (Rosaceae); BAK 5602–5604, 5660, 5661, 5663, 5691–5697, 5702–5709, 5711, 5712, 10027; Distribution: Baku, Shabran, Quba, Qusar, Zaqatala, Qazakh, Khojavend, Lerik, Shusha, Ordubad, Shahbuz.

Ph. marissalii (Westend.) U. Braun, Braun & Cook 262, 2012; = *Ph. suffulta* f. *aceris* Jacz.; Host: *Acer platanoides* L. (Sapindaceae); Distribution: Oghuz, Zaqatala. Information about distribution of this fungus in the country was given according in the Ibrahimov et al. [1956]. But herbarium specimen of fungus was not deposited in BAK. New collections are needed to confirm distribution of this fungus in the country.

Ph. moricola (Henn.) Homma, Trans. Sapporo Nat. Hist. Soc. 11: 174, 1930; = *Ph. suffulta* f. *moricola* Jacz.; Host: *Morus alba* L., *M. australis* Poir. (Moraceae); BAK 5605, 5680–5688, 5690, 10032; Distribution: Absheron, Zaqatala, Ordubad (Fig. 2.5).

Ph. nivea (Castagne) U. Braun, Braun & Cook 263, 2012; Host: *Ulmus glabra* Huds., *U. minor* Mill., *U. densa* Litv. (Ulmaceae); BAK 5713–5717; Distribution: Khojavend, Ordubad, Babek (Fig. 2.6). Information about distribution of this species in the country was given in monograph of the Erysiphales [Braun, Cook, 2012]. But herbarium specimen of this fungus is not stored in BAK. While, samples of *Phyllactinia* fungus on *Ulmus* spp. collected in Azerbaijan were previously

identified as *Ph. suffulta* f. *ulmi* Jacz. and distribution of this fungus within the country reported in numerous local literature [Akhundov, 1965; Huseynova, 1961b; Ibrahimov et al., 1956]. Currently this taxon was renamed as *Ph. angulata* var. *ulmi* U. Braun based on modern taxonomic changes [Braun, Cook, 2012]. In morphological re-analysis of specimens of *Ph. suffulta* f. *ulmi*, clavate conidia in 33–72 × 18–22(–26) µm were observed. On whole, characteristics of sexual and asexual morphs are in good agreement with *Ph. nivea* by having clavate, 50–70 × 15–22 µm conidia [Braun, Cook, 2012]. Whereas *Ph. angulata* var. *ulmi* is characterized by its unique shape of conidia (dumb-bell-shape), which was not found in our specimens. Therefore, specimens previously reported as *Ph. suffulta* f. *ulmi* were re-identified as *Ph. nivea*.

Ph. orbicularis (Ehrenb.) U. Braun, Braun & Cook 264, 2012; Host: *Fagus orientalis* L. (Fagaceae); BAK 5665; Distribution: Zaqatala (Fig. 2.7). *Ph. suffulta* f. *fagi* Duby was known on beech trees in Azerbaijan to date [Ibrahimov, 1956]. Information of this taxa was found neither in monograph of the Erysiphales [Braun, Cook, 2012], nor in Index Fungorum. According to the morphological re-examination of specimen of *Ph. suffulta* f. *fagi*, fungus was revised as *Ph. orbicularis* based on identity of sexual morphs in 150–190 µm diam. of chasmothecia [175–265 µm]; 6–12 [4–18] number of acicular appendages; 54–72 × 26–30 µm size [(50–)60–95 × 25–45 µm] and having 2-spored asci.

Ph. paliuri U. Braun, Braun & Cook, 265, 2012; Host: *Paliurus spina-christi* Mill. (Rhamnaceae); BAK 5699, 5700; Distribution: Oghuz, Lankaran, Astara (Fig. 2.8). *Phyllactinia* powdery mildew fungus on thorn plants was reported as *Ph. suffulta* f. *paliuri* Sacc. in Azerbaijan, so far [Ibrahimov et al., 1956]. In Monograph [Braun, Cook, 2012] and Index Fungorum this taxa was not mentioned. The fungus from specimens of *Ph. suffulta* f. *paliuri* was re-identified as *Ph. paliuri* according to the morphological analysis.

Ph. phaseolina N. Ahmad, D.G. Agarwal & A.K. Sarbhoy, Mycotaxon 29: 68, 1987; =? *Ph. suffulta* f. *viciae* Guseinova; Host: *Vicia sepium* L. (Fabaceae); BAK 5719; Distribution: Shusha. Fungi from the genus *Phyllactinia* are known as strictly woody parasitic plant pathogens worldwide. However, fungus was first described on herbaceous plant (*V. sepium*) as *Ph. suffulta* f. *viciae* in Azerbaijan [Huseynova, 1961] and currently was renamed as *Ph. phaseolina* based on modern taxonomic changes [Braun, Cook, 2012]. This species is considered as doubtful, due to the type material is not applicable for morphological examination and there is not any other additional collection to proof the status of this species.

Ph. populi (Jacz.) Y.N.Yu, in Yu & Lai, Acta Microbiol. Sin. 19(1): 18, 1979; = *Ph. suffulta* f. *populi* Jacz.; Host: *Populus* sp. L. (Salicaceae); Distribution: Quba, Zaqatala. Morphological description and information about distribution of this species were given according to the local literature [Ibrahimov et al., 1956]. However, herbarium specimen was not deposited to BAK.

Ph. pyri-serotinae Sawada, Rep. Dept. Agric. Gov. Res. Inst. Formosa 49:83, 1930; =*Ph. suffulta* f. *cotoneastri* Jacz.; Host: *Cotoneaster racemiflorus* (Desf.) C.Koch. (Rosaceae); BAK 5659; Distribution: Shahbuz.

Ph. roboris (Gachet) S. Blumer, Beitr. Krypt-Fl. Schweiz 7(1): 389, 193; Host: *Quercus iberica* M.Bieb., *Q. robur* L. (Fagaceae); BAK 5606, 5616, Distribution: Shusha, Ganja. Distribution of *Ph. roboris* on oak species in Azerbaijan was mentioned by Huseynov [Huseynov, 1988]. Fungus was collected in asexual stage from Ganja district. Besides, information about powdery mildew belonging to the genus *Phyllactinia* on *Quercus* spp., which was identified as *Ph. suffulta* var. *angulata* (E.S. Salmon) Sacc. & Trotter given in some local manuscripts [Huseynova 1961 a, b]. This fungus is mentioned as *Ph. angulata* (E.S. Salmon) S. Blumer var. *angulata* in Index Fungorum and this species is characterized by having dumb-bell-shaped conidia and endemic to North America. Two specimens of *Ph. suffulta* var. *angulata* were revised morphologically. Herbarium sample (BAK 5617) collected from Khojavend district was re-examined and was identified as *E. alphitoides* (Griff. & Maubl.) U. Braun & S. Takam.

Specimen (BAK 5616) collected from Shusha was in sexual stage and conidia were not found to proof the taxonomic status of this species. Thus, the specimens of *Ph. suffulta* var. *angulata* were re-named as *Ph. roboris*. Thereby, the sum of *Phyllactinia* powdery mildews occupies 13% of all powdery mildew species in this country (Fig. 3), which is a little bit higher compared with the percentage in the world (10%) (Fig. 4).

Host range. In the current study, 32 plant species from 12 families were recorded as hosts for the genus *Phyllactinia* in Azerbaijan. This is only 5% of total number of host plants for this genus in the world. These families allocated among Asterids (Cornaceae, Oleaceae) and Rosids (Fabaceae, Betulaceae, Fagaceae, Salicaceae, Moraceae, Rhamnaceae, Rosaceae, Ulmaceae, Sapindaceae, Vitaceae) groups. Economically im-

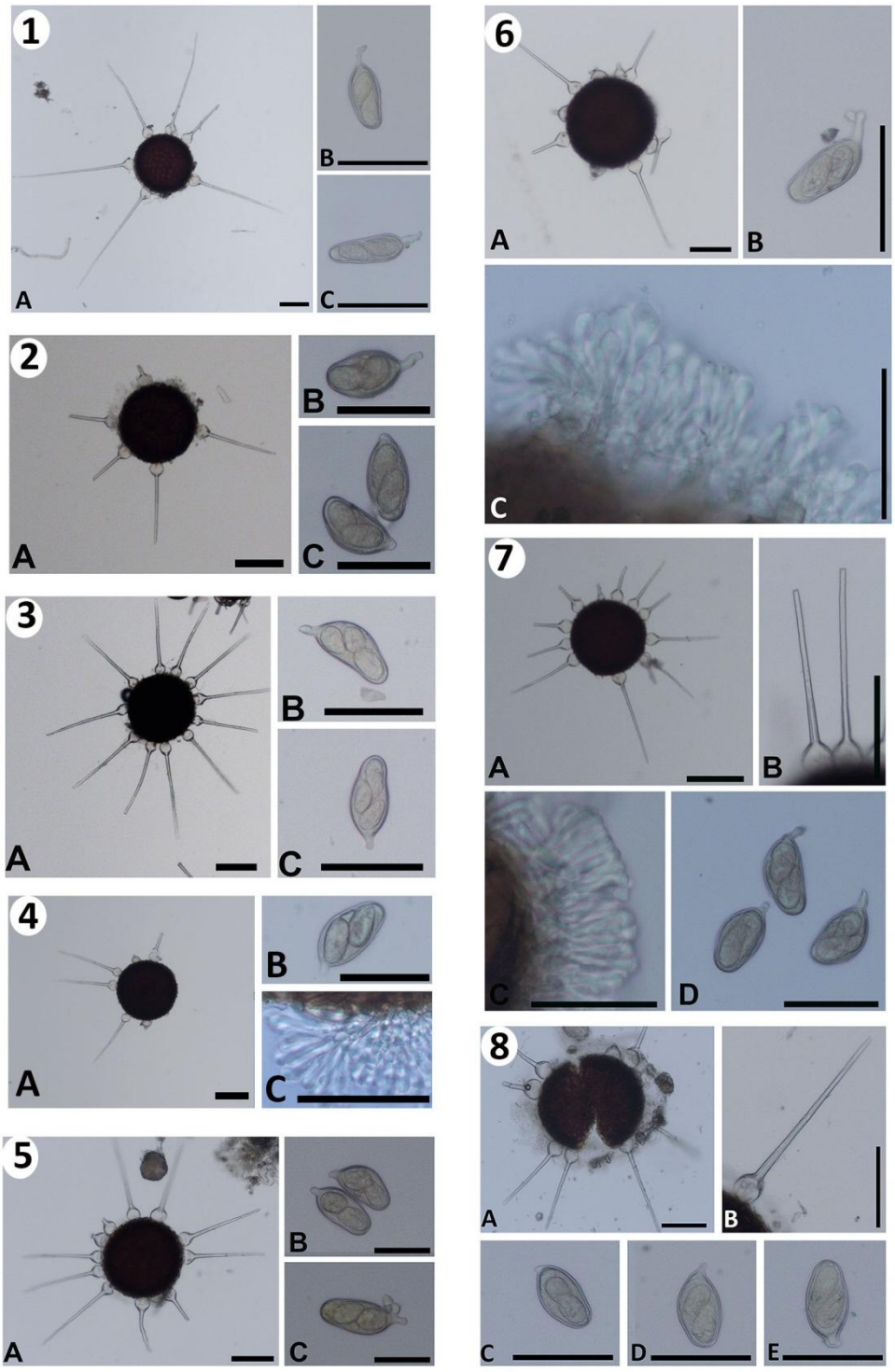

Figure 2.1. *Phyllactinia alnicola* on *Alnus glutinosa* (BAK 5612): A. chasmothecia; B,C. asci and ascospores; **2.2.** *Ph. corni* on *Cornus mas* (BAK 5630): A. chasmothecia; B,C. asci and ascospores; **2.3.** *Ph. fraxini* on *Fraxinus excelsior* (BAK 5670): A. chasmothecia; B, C. asci and ascospores; **2.4.** *Ph. guttata* on *Corylus avellana* (BAK 5645): A. chasmothecia; B. ascus and ascospores; C. penicillate cells; **2.5.** *Ph. moricola* on *Morus australis* (BAK 5685): A. chasmothecia; B, C. asci and ascospores; **2.6.** *Ph. nivea* on *Ulmus minor* (BAK 5713): A. chasmothecia; B. ascus and ascospores; C. penicillate cells; **2.7.** *Ph. orbicularis* on *Fagus orientalis* (BAK 5665): A. chasmothecia, B. acicular appendages with bulbous swelling; C. penicillate cells; D. asci and ascospores; **2.8.** *Ph. paliuri* on *Paliurus spina-christi* (BAK 5700): A. ruptured casmothecia; B. acicular appendage with bulbous swelling; C, D, E. asci and ascospores; Bar = 100 μm.

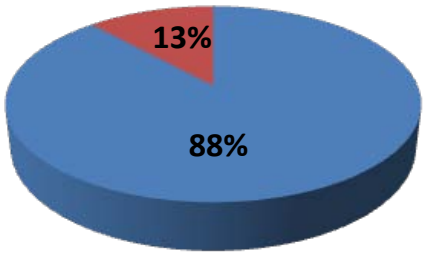

Figure 3. Fungi from genus *Phyllactinia* within all powdery mildew fungi in Azerbaijan: 88% all powdery mildew taxa; 13% *Phyllactinia* species.

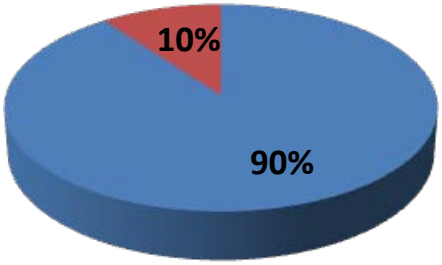

Figure 4. Fungi from genus *Phyllactinia* within all powdery mildew fungi worldwide: 90% all powdery mildew taxa; 10% *Phyllactinia* species.

portant plant species, as fruits, medicinal, ornamental and forest trees are included in the hosts.

Rosaceae composes the highest number of hosts (11 species) for two powdery mildew species from this genus, followed by family Betulaceae, in which four plant species are infected by three fungal taxa (Fig. 5). According to the S. Takamatsu et al. [2008] special affinity of *Phyllactinia* powdery mildews is to the hosts from family Betulaceae. Because the highest number of hosts from family Rosaceae does not definitely indicate their special affinity to the genus *Phyllactinia*, essentially for being of Rosaceae the large family within angiosperms. It is noted that, species from genus *Phyllactinia* expand their host range within a single family or genus [Takamatsu et al., 2008], which is confirmed from our study, too.

Geographical distribution. Study on geographical distributions of *Phyllactinia* powdery mildews was carried out to reveal that these fungi are detected in mountainous areas of five regions in Azerbaijan (Fig. 6). Of these five regions, South-Eastern Great Caucasus region, which covers north part of the country, has largest number (10 taxa) of *Phyllactinia* species. Absheron peninsula, Quba, Qusar, Khachmaz, Shabran, Shaki, Oghuz, Qakh and Zaqatala districts, from where powdery mildews given in this study were recorded, belong to this region.

Middle Araz region composed of the Ordubad, Shahbuz, Julfa, and Babek administrative divisions, which covers area belonging to the Nakhchivan Autonomous Republic. In this region seven of the 17 *Phyllactinia* taxa were recorded. The west part of the country, which situated on the Lesser Caucasus mountain range, has records of six from the 17 *Phyllactinia* taxa. Samples of these taxa were collected from Shusha, Gadabay, Ganja, Askeran and Kalbajar districts of this region.

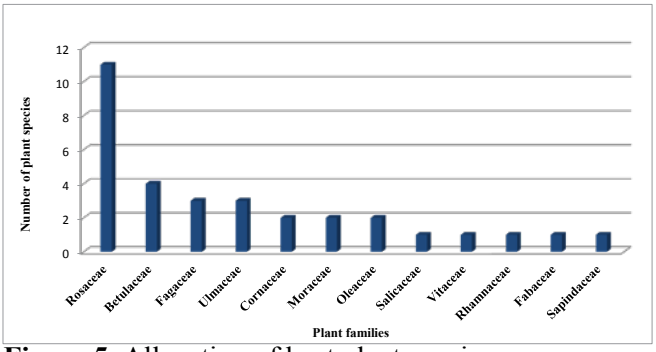

Figure 5. Allocation of host plant species among families.

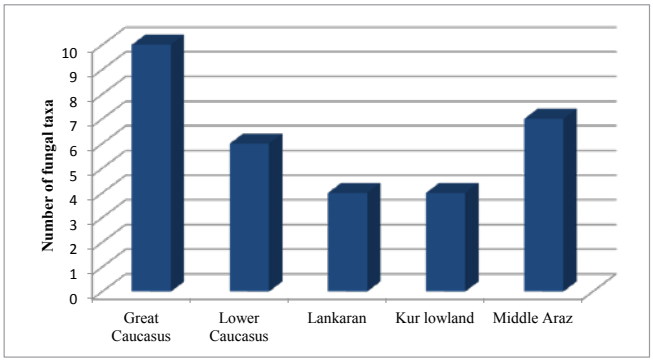

Figure 6. Geographical distribution of powdery mildews among physic-geographical regions of Azerbaijan.

The lower number of powdery mildew species were detected from regions Kur lowland and Lankaran, in which each four fungal taxa were recorded for the respective regions. Kur lowland covers central part of country, along the river Kur and *Phyllactinia* species were recorded from Qazakh, Khojavend and Balakan districts. Samples of *Phyllactinia* were collected from districts Astara, Lerik, and Lankaran in the Lankaran region. Districts where the samples were reported are shown on the map (Fig. 7).

Ph. fraxini, Ph. guttata and *Ph. mali* are commonly distributed throughout Azerbaijan. Thus, these species were found in most of the 19 districts (Absheron, Baku, Quba, Qusar, Khachmaz, Shabran, Shaki, Oghuz, Qakh, Zaqatala, Lankaran, Lerik, Shusha, Kalbadgar, Askeran, Ordubad, Shahbuz, Khodgavand, Qazakh) from all five regions.

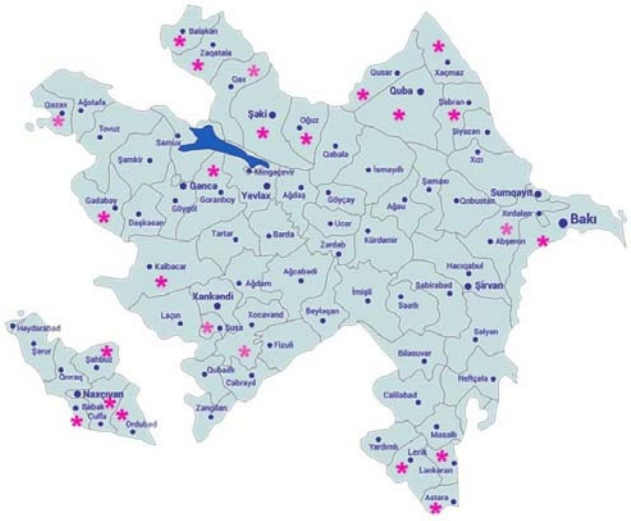

Figure 7. Geographical distribution of powdery mildews within Azerbaijan.

CONCLUSIONS

This study examines diversity of *Phyllactinia* species in Azerbaijan. Flora of the country is very rich in number of indigenous angiosperm species. About 900 powdery mildew species of Erysiphales were recorded on 10 thousand hosts worldwide [Braun, Cook, 2012; Amano, 1986]. Our recent studies reported 134 powdery mildew taxa on 420 plant species, which is 9% of all plant species, naturally growing in this country. Taking into account the rich flora and favorable condition for powdery mildew infection in this country, much more new *Phyllactinia* species and their new hosts are expected to be found in the future.

Consequently, herbarium samples of 14 taxa of the genus *Phyllactinia* are available in Mycological Herbarium of Institute of Botany. The examined herbarium samples were collected in different years, and most of them were useful for only morphological investigation of teleomorph and anamorph structures. New collections are needed for resolving intergeneric and interspecific variability of *Phyllactinia* based on molecular analyses (DNA barcoding) by using genus specific primers. Further investigations are urgently required to clarify the exact mycoflora of powdery mildews in Azerbaijan.

REFERENCES

Abasova L.V., Ağayeva D.N. (2018) Azərbaycanda Erysiphales sırası göbələklərinin sahib bitkiləri. Azərbaycan Botaniklər Cəmiyyəti, V.C.Hacıyevin 90 illiyinə həsr edilmiş "Botaniki tədqiqatlarda yeni çağırışlar" adlı konfransın materialları, 20/21.05, Bakı, 111-113. (in Azerbaijani)

Abasova L.V., Aghayeva D.N., Takamatsu S. (2018) Notes on powdery mildews of the genus *Erysiphe* from Azerbaijan. *CREAM*, 8(1): 30-53.

Akhundov T.M. (1965) Muchnisto-rosyaniye qribi rodov *Phyllactinia*, *Sphaerotheca*, *Podosphaera* Nakhichevanskoy ASSR. *Izvestiye Akademii Nauk Azerbaidjanskoy SSR, seriya bioloqicheskikh nauk,* 3: 24-33. (in Russian)

Amano K. (1986) Host range and geographical distribution of the powdery mildew fungi. *Japan Scientific Societies Press*, Tokyo, 741 p.

An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG IV (2016) *Bot. J. Linn. Soc.* 181: 1-20.

Braun U., Cook R.T.A. (2012) Taxonomic manual of the Erysiphales (Powdery mildews). CBS Biodiversity series No. 11. Netherlands, Utrecht: CBS-KNAW Fungal Biodiversity Centre, 707 p.

Glawe D.A. (2008) The powdery mildews: a review of the world's most familiar (yet poorly known) plant pathogens. *Annu Rev Phytopathol*, 1(12): 27-51.

Huseynova B.F. (1961a) Noviye I redko vstrechayushiesya vidi qribov sobranniye v Naqorna-Karabakhskoy avtonomnoy oblasti. *Izv. Akad. Azerb. SSR, ser. biol. i med. nauk*, 9: 3-9. (in Russian)

Huseynova B.F. (1961b) Nekotoriye danniye o vidovom sostove qribov Naqorna-Karabakhskoy avtonomnoy oblasti. *Izv. Akad. Azerb. SSR, ser. biol. i med. nauk,* 12: 17-23. (in Russian)

Huseynov E.S. (1988) Sumchatiye qribi osnovnikh lesoobrazuyishikh porod Azerbaidjana. *Izv. Akad. Azerb. SSR, ser. biol. nauk*, 5: 139-147. (in Russian)

Ibrahimov H.R., Israfilbeyov L.A., Akhmadzade Z. (1956) Obzor nekotorikh vidov muchnisto-rosyonikh qribov Azerbaidjana. *Ucheniye zapiski Azerbaidjanskoy Qosudarstvennoy Universiteta*, imeni S.M. Kirova, 6: 59-69. (in Russian)

Kirk P. Index Fungorum. http://www.indexfungorum.org.

Meeboon J., Takamatsu S. (2015) *Erysiphe takamatsui,* a powdery mildew of lotus: Rediscovery of teleomorph after 40 years, morphology and phylogeny. *Mycoscience,* 56: 159-167.

Scholler M., Schmidt A., Meeboon J., Braun U., Takamatsu S. (2018) *Phyllactinia fraxinocola*, another Asian fungal pathogen on *Fraxinus excelsior* (common ash) introduced to Europe? *Mycoscience*, 59: 85-88.

Shin H.D., La Y. (1993) Morphology of edge lines of chained immature conidia on conidiophores in powdery mildew fungi and their taxonomic significance. *Mycotaxon*, 46: 445–451.

Shin H.D., Lee H.J. (2002) Morphology of penicillate cells in the genus *Phyllactinia* and its taxonomic application. *Mycotaxon,* 83: 301-325.

Takamatsu S. (2013) Molecular phylogeny reveals phenotypic evolution of powdery mildews (Erysiphales, Ascomycota). *J. Gen. Plant Pathol.,* 79: 218-226.

Takamatsu S., Inagaki M., Niinomi S., Khodaparast S.A., Shin H.D., Grigaliunaite B., Havrylenko M. (2008) Comprehensive molecular phylogenetic analysis and evolution of the genus *Phyllactinia* (Ascomycota: Erysiphales) and its allied genera. *Mycol. Res.*, 112: 299-315.

Takamatsu S., Siahaan S.A.S., Moreno-Rico O., Cabrera de Alvarez M.G., Braun U. (2016) Early evolution of endoparasitic group in powdery mildews: molecular phylogeny suggests missing link between *Phyllactinia* and *Leveillula. Mycologia,* 108(5): 837-850.

Vincent R., Duong V., Amor A., de Wiele N. (2013) MycoBank gearing up for new horizons. *IMA Fungus,* 4(2): 371-379, http://www.mycobank.org.

Azərbaycanda *Phyllactinia* (Ascomycota, Erysiphales) cinsinə ümumi baxış

Dilzarə N. Ağayeva
Lamiya V. Abasova
AMEA Botanika İnstitutu, Badamdar şossesi 40, Bakı, AZ1004, Azərbaycan

Susumu Takamatsu
Bioresurslar Məktəbi, Mie Universiteti, 1577 Kurima-Maçiya, Tsu 514-8507, Yaponiya

Azərbaycan Milli Elmlər Akademiyasının Botanika İnstitutunun Mikoloji herbarisində (BAK) saxlanılan və son illərdə toplanılan nümunələrin morfoloji yanaşmaların istifadəsi ilə təhlili əsasında Azərbaycanda *Phyllactinia* cinsi daxilində unlu şeh göbələklərinin növ müxtəlifliyi tədqiq edilmişdir. Ətraflı taksonomik təhlilin aparılması üçün ədəbiyyat məlumatları da təftiş olunmuşdur. Müasir taksonomik və nomenklatur dəyişiklər nəzərə alınmışdır. Cinsə daxil olan göbələklərin sahib bitkiləri və ölkə daxilində coğrafi yayılması aydınlaşdırılmışdır. Nəticədə, 17 unlu şeh göbələyi taksonu aşkar edilmişdir ki, bunlar 11 fəsilədən olan 32 növ bitki üzərində *Ph. alnicola*, *Ph. ampelopsidis*, *Ph. babayanii*, *Ph. carpini*, *Ph. corni*, *Ph. fraxini*, *Ph. guttata*, *Ph. mali*, *Ph. marissalii*, *Ph. moricola*, *Ph. nivea*, *Ph. orbicularis*, *Ph. paliuri*, *Ph. phaseolina*, *Ph. populi*, *Ph. pyri-serotinae* və *Ph. roboris* göbələkləri olaraq qeyd edilmişdir. Bitki fəsilələri Asteridlər (Cornaceae, Oleaceae) və Rosidlər (Fabaceae, Betulaceae, Fagaceae, Salicaceae, Moraceae, Rhamnaceae, Rosaceae, Ulmaceae, Sapindaceae, Vitaceae) qruplarına daxil olub, bunlardan Rosidlər qrupu sahib bitki sayına görə üstünlük təşkil edir. Onlar arasında Rosaceae fəsiləsinə aid növlərin üstünlük təşkil etməsinə baxmayaraq, *Phyllactinia* cinsinin Betulaceae fəsiləsinə aid bitkilərlə xüsusi yaxınlığının olması ehtimal edilir. Əlavə olaraq, bu cinsin nümayəndələrinin əsasən dağlıq ərazilərdə yayılmağa meylli olması müşahidə edilmişdir. *Phyllactinia* cinsinin daha çox sayda nümayəndələri ölkənin Böyük Qafqazın cənub-şərq vilayətinə aid olan rayonlarından qeydə alınmışdır. Bu sıra Orta Araz və Kiçik Qafqaz vilayəti ilə davam edilir. Ən az sayda göbələk növünə Kür dağarası çökəkliyi və Lənkəran vilayətlərində qeydə alınmışdır. Tədqiqat işi zamanı müəyyən edilmişdir ki, *Phyllactinia* cinsindən olan 14 göbələk taksonuna aid herbari nümunələri BAK herbarisində mövcuddur və bu nümunələr haqqında məlumatlar məqalədə öz əksini tapmışdır.

Açar sözlər: *yayılma, ektoparazitizm, endoparazitizm, sahib bitki, bitki patogeni, unlu şeh göbələyi*

Обзор рода *Phyllactinia* (Ascomycota, Erysiphales) в Азербайджане

Дильзара Н. Агаева
Ламия В. Абасова
Институт Ботаники НАНА, Бадамдар 40, Баку, AZ1004, Азербайджан

Сусуму Такаматсу
Школа Биоресурсов, Университет Мие, 1577 Курима-Мация, Цу 514-8507, Япония

Изучено внутривидовое разнообразие мучнисто-росяных грибов из рода *Phyllactinia*, встречающихся в Азербайджане. Повторно исследованы гербарные образцы, хранящиеся в Микологическом гербарии Института Ботаники (БАК) Национальной Академии Наук Азербайджана, и проанализированы вновь собранные в последние годы материалы с использованием морфологических методов. Для проведения детального таксономического анализа были пересмотрены имеющиеся литературные данные и учтены современные таксономические и номенклатур-

ные изменения. Был выяснен ряд растений хозяев и определено географическое распространение грибов из рода *Phyllactinia* в регионах Азербайджана. В итоге зарегистрировано распространение 17 таксонов мучнисто-росяных грибов из данного рода, из которых *Ph. alnicola*, *Ph. ampelopsidis*, *Ph. babayanii*, *Ph. carpini*, *Ph. corni*, *Ph. fraxini*, *Ph. guttata*, *Ph. mali*, *Ph. marissalii*, *Ph. moricola*, *Ph. nivea*, *Ph. orbicularis*, *Ph. paliuri*, *Ph. phaseolina*, *Ph. populi*, *Ph. pyriserotinae* и *Ph. roboris* были перечислены на 32 видах растений, относящихся к 11 семействам. Эти семейства относятся к группам Астеридов (Cornaceae, Oleaceae) и Розидов (Fabaceae, Betulaceae, Fagaceae, Salicaceae, Moraceae, Rhamnaceae, Rosaceae, Ulmaceae, Sapindaceae, Vitaceae), причем группа Розидов по количеству видов превышает число видов хозяев. Несмотря на то, что семейство Rosaceae обладает самым большим количеством видов растений-хозяев, считается, что род *Phyllactinia* по специфическому родству скорее ближе к растениям из семейства Betulaceae. Было обнаружено, что грибы из рода *Phyllactinia* имеют склонность к распространению в основном в горных районах Азербайджана. Наибольшее количество представителей рода *Phyllactinia* было зафиксировано в районах Азербайджана, относящихся к южно-восточной области Большого Кавказа. Области Средний Араз и Малый Кавказ следует за ним. Наименьшее количество грибов *Phyllactinia* зафиксировано в Куринской межгорной впадине и Лянкяранском области. В ходе исследования выявлено, что 13 гербарных образцов рода *Phyllactinia*, о которых приведена информация в данной статье, имеются в БАК.

Ключевые слова: *распространение, эктопаразитизм, эндопаразитизм, растение-хозяин, растительный патоген, мучнистая роса*