IX Apiales Symposium

Abstract Book

31 July – 2 August 2017

The Gold Coast Marina Club
Guangzhou, China

Compiled and edited by:
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Introduction

We are pleased to announce that the Apiales IX Symposium will be held from 31 July to 2 August 2017 at the The Gold Coast Marina Club in Guangzhou, China. This meeting will continue the series of very successful gatherings in Reading (1970), Perpignan (1977), St. Louis (1999), Pretoria (2003), Vienna (2005), Moscow (2008), Sydney (2011) and Istanbul (2014), where students of this interesting group of plants had the opportunity to share results of recent studies. As with the previous symposia, the meeting in Guangzhou will focus on all research fields relating to the systematics and phylogeny of Apiales (including morphology, anatomy, biogeography, floristics), as well as to ecology, ethnobotany, pharmaceutical and natural products research in this plant group.

Organizing Commettee

Chairman: Alexei Oskolski (Johannesburg – St. Petersburg)
Vice-Chairman: Maxim Nuraliev (Moscow)
Scientific Committee:
Yousef Ajani (Tehran)
Emine Akalin (Istanbul)
Stephen Downie (Urbana)
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Tatiana Ostroumova (Moscow)
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Gregory Plunkett (New York)
Mark Schlessman (Poughkeepsie)
Krzysztof Spalik (Warsaw)
Patricia Tilney (Johannesburg)
Ben-Erik van Wyk (Johannesburg)

Program of the IX Apiales Symposium

31 July 2017

Lobby of the Gold Coast Marina Club

14.00 – 18.00. Registration of participants.

"Shi fu zai" room (4th floor of the Gold Coast Marina Club)

19.00 – 21.00. Welcome party

1 August 2017

Meeting room (5th floor of the Gold Coast Marina Club)

Chair: Dr. Alexei Oskolski

9.00 – 9.20. Opening ceremony.

9.20 – 9.50. B.-E. Van Wyk. Chemosystematic studies of African Apiaceae (Umbelliferae).

9.50 – 10.10. M. Miski. Unique chemotaxonomical markers of Apiaceae family for the identification of inter-species, inter-genera and inter-family relations.

10.10 – 10.30. V. Valcárcel. The early radiation of the Asian Palmate group (Araliaceae) as inferred from phylogenomic data.

10.30 – 11.00. Tee break.

Chair: Prof. Ben-Erik Van Wyk

11.00 – 11.20. J. Baczyński. Evolution of pollen morphology in Apiaceae.

11.20 – 11.40. Ł. Banasiak. Selecting calibration points for the chronogram of Apiaceae based on the reconstruction of pollen evolution.

11.40 – 12.00. S.R. Downie. Species delimitations in the perennial, endemic North American clade of Apiaceae: *Cymopterus glomeratus*, *Pseudocymopterus montanus*, and *Pteryxia terebinthina* revisited.

"Shi fu zai" room (4th floor of the Gold Coast Marina Club)

12.00 – 14.00. Lunch (fast food)

Meeting room (5th floor of the Gold Coast Marina Club)

Chair: Prof. Stephen Downie

14.00 – 14.20. M. Miski. A new chapter in the legend of *Ferula silphion*.

14.20 – 14.40. S.F. Song. Molecular phylogeny of the genus *Pleurospermum* (Apiaceae) inferred from four DNA regions.
14.40 – 15.00. B.C. Wu. The study on variations under species and systematic evolution of *Cryptotaenia japonica*, Apiaceae.
15.00 – 15.20. G.V. Degtjareva. Molecular appraisal of *Peucedanum* and some related Apiaceae–Apioideae taxa.

15.20 – 15.50. Tee break

Chair: Prof. Regine Claßen-Bockhoff
15.50 – 16.10. P.M. Tilney. A revision of *Lichtensteinia* (tribe Lichtensteinieae, Apiaceae).
16.10 – 16.30. D. Lyskov. European *Prangos* species complexes: when classic morphological features are not enough to distinguish resembling species.
16.30 – 16.50. J.-P. Reduron. Progress in the knowledge of the *Daucus carota* specific complex in Corsica and description of new taxa.
16.50 – 17.10. J.Z. Zhang. Comparative analysis on the micromorphological characteristics of leaf and fruit epidermis of *Ostericum* (Apiaceae).

"Shi fu zai" room (4th floor of the Gold Coast Marina Club)
19.00-21.00 – Dinner

2 August 2017
Meeting room (5th floor of the Gold Coast Marina Club)
Chair: Prof. Krzysztof Spalik
9.00 – 9.30. R. Claßen-Bockhoff. Black spots, galls and open questions: Studies in *Artedia squamata* and *Echinophora trichophylla*.
9.30 – 9.50. P. Karpunina. Patterns of carpel arrangement in gynoecia of Araliaceae: evidence from *Polyscias*.
9.50 – 10.10. M. Nuraliev. Reproductive morphology in *Osmoxylon* (Araliaceae): flower merism, perianth innervation and inflorescence structure.
10.10 – 10.30. A. Oskolski. Floral polymery versus andromonoecy: a case of Araliaceae.

10.30 – 11.00 Tea break

Chair: Dr. Maxim Nuraliev

11.00 – 11.20. E. Yembaturova. Fruits of *Pittosporum* and related genera (Pittosporaceae) in relation to their dispersal.
11.20 – 11.40. A. Konstantinova. Pseudomonomerous fruits in *Cussonia* and related genera.

"Shi fu zai" room (4th floor of the Gold Coast Marina Club)
12.00 – 14.00 Lunch (fast food)

Meeting room (5th floor of the Gold Coast Marina Club)
Chair: Prof. Chunfeng Song
14.00 – 14.20. K. Spalik. Secondary woodiness in umbellifer subfamily Apioideae: a preliminary survey.
14.20 – 14.40. K. Frankiewicz. *Daucus decipiens* and *Daucus edulis* – sister cases of secondary woodiness in Daucineae with dissimilar wood anatomy.
14.40 – 15.00. A. Stepanova. Wood anatomy of *Aralia* L. (Araliaceae): systematic and ecological implications.

15.00 – 15.30. Tea break

15.30 – 16.30. Poster session
16.30 – 17.00. Closing ceremony

"Shi fu zai" room (4th floor of the Gold Coast Marina Club)
19.00 – 21.00. Farewell party

3 -5 August 2017
Post-conference tour to the Geopark Danxiashan
Departure on 3 August at 8.30 am from the Gold Coast Marina Club.
Coming back on 5 August at 8:30am come back to the Gold Coast Marina Club.

Abstracts

Evolution of pollen morphology in Apiaceae

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Key words: Apioideae, Saniculoideae, Azorelloideae, Mackinlayoideae, palynology

The aim of this study was to reconstruct the evolution of pollen morphology in Apiaceae and to identify phylogenetically informative traits useful for the taxonomy of the group.

In the analyses, we included 137 species of extant umbellifers representing all major phylogenetic lineages identified in hitherto published surveys (Calviño and Downie, 2007; Nicolas and Plunkett, 2009; Downie *et al.*, 2010) and 13 species corresponding to a broadly defined outgroup representing other families of Apiales. Ancestral states for 28 morphological traits (17 categorical and 11 continuous) were inferred through mapping onto a phylogenetic tree obtained from nrDNA ITS and five plastid markers: *mat*K and *rbc*L genes and introns in *rpl16*, *rps16*, and *rpoC1* genes.

Basal lineages of umbellifers are characterized by a plesiomorphic morphology and their pollen can be easily distinguished from other members of Apiales by having an elongated shape and non-reticulate ornamentation with well-pronounced columellae. Apomorphic morphology (bone-shaped outline, exine apiculation, reduction of compound aperture and undulating, sharply bent mesocolpium in polar view) is typical for the crown apioids (apioid superclade, Scandiceae, Aciphylleae, Smyrnieae and the *Acronema* clade) and can be interpreted as resulting from the transfer of the harmomegathic function from the aperture region to the pollen wall (Katifori *et al.*, 2010). This change may have arisen as an adaptation to arid ecosystems reducing the chance of grain desiccation. None of the analysed traits alone allows for an unequivocal delimitation of the early-branching apioids and subfamilies Saniculoideae, Azorelloideae and Mackinlayoideae. They are, however, satisfactorily characterized by a combination of several traits.

Calviño CI, Downie SR. 2007. Circumscription and phylogeny of Apiaceae subfamily Saniculoideae based on chloroplast DNA sequences. *Molecular Phylogenetics and Evolution* 44: 175–191.
Downie SR, Spalik K, Katz-Downie DS, Reduron J-P. 2010. Major clades within Apiaceae subfamily Apioideae as inferred by phylogenetic analysis of nrDNA ITS sequences. *Plant Diversity and Evolution* 128: 111–136.
Katifori E, Alben S, Cerda E, Nelson DR, Dumais J. 2010. Foldable structures and the natural design of pollen grains. *Proceedings of the National Academy of Sciences* 107: 7635–7639.
Nicolas A, Plunkett GM. 2009. The demise of subfamily Hydrocotyloideae (Apiaceae) and the re-alignment of its genera across the entire order Apiales. *Molecular Phylogenetics and Evolution* 53: 134–151.

Selecting calibration points for the chronogram of Apiaceae based on the reconstruction of pollen evolution

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Key words: phylogeny calibration, calibration points, fossil and extant pollen

The evolutionary history of Apiaceae is poorly known because of their mostly herbaceous life form resulting in a low fossilisation potential. There are no macrofossils that can be unequivocally assigned to Apiaceae and used for the calibration of molecular phylogenetic trees. Among microfossils, some pollen records are available but their phylogenetic affinities within the family have never been formally ascertained. Because of these limitations, the estimates of the age of the family and its subclades vary considerably among studies.

In this work, we analyse the palynomorphs assigned to Apiaceae in the previous studies as well as provide descriptions of new findings from the Oligocene and Miocene of Eastern Anatolia. For each fossil pollen grain, 17 discrete and 11 continuous characters were scored; these grains were classified into distinctive morphotypes based on co-occurrence in the same strata and the results of discriminative morphology analysis. Subsequently, the fossil evidence was compared against the variability of 150 representative species of extant Apiales, for which the same characters were scored. First, using maximum parsimony and maximum likelihood approaches, we mapped pollen morphological characters onto a molecular phylogenetic tree inferred from combined nrDNA ITS and five plastid markers: *mat*K and *rbc*L genes and introns in *rpl16*, *rps16*, and *rpoC1* genes. Second, we matched the inferred ancestral morphologies with the fossil morphotypes. Although few fossils can be unequivocally assigned to particular clades, we were able to identify a set of palynomorphs that may be used for phylogeny calibration.

In order to verify the robustness of the proposed calibration points and to identify potential conflicts among them we repeated phylogeny calibration considering the following modifications: (1) random subsets of calibration points were used, (2) *a priori* assumptions on the age of clades were modelled using a variety of distributions and maximum age limits, (3) the effect of branch lengths estimation method was assessed comparing Bayesian and penalized likelihood approaches, (4) various models of molecular clock—strict, local and relaxed—were applied.

A comparative study of floral merism in different populations of *Schefflera subintegra* (Craib) C.B.Shang (Araliaceae)

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Key words: *Schefflera subintegra*, gynoecium, androecium, merism

The genus *Schefflera* J.R.Forst. & G.Forst. is the largest in the family Araliaceae. It includes more than 300 species which are spread in tropical regions of the world. The delimitation of species and subspecies of *Schefflera* has often been difficult. One of such problematic taxa is a widespread Asian species *Schefflera subintegra* s.l. which is characterized by polymerous flowers. It is known for its significantly variable floral merism and some other morphological traits; for that reason one should consider defining some circles of affinity within this species (Nuraliev *et al.*, 2014). Earlier research conducted by M.S. Nuraliev and collaborators showed the morphological difference between two populations (growing in Vietnam and Thailand) manifested in the pubescence and the time of the appearance of hairs on the flowers. It is necessary to find out whether this diversity remains within the limits of interpopulational change, or whether we should consider dividing the species into subspecies. In this connection, there is a need to study the merism of the androecium and gynoecium and to verify the data statistically.

We studied two populations of *S. subintegra* growing naturally in the forests of Vietnam and Thailand. The material was collected by A.A. Oskolski and M.S. Nuraliev in natural habitats of *Schefflera* in Thailand (Phu Rua National Park) and Vietnam (Chu Mom Ray National Park), and fixed in 70% ethanol. We estimated the merism of the androecium and gynoecium from different inflorescences of both populations in flower cross sections using a stereomicroscope. It is impossible to evaluate the calyx and corolla merism in this species because the petals are fused into calyptra. Our sampling comprised 100 flowers from each population. Research results have been statistically processed and correlation graphs drawn.

The average number of stamens per flower is 31.5±0.29 (range 25–40) in the Vietnamese population and 34.4±0.28 (range 27–42) in the Thai population. The average number of carpels per flower is 26.6±0.24 (range 20–36) and 27.5±0.26 (range 21–33) for the Vietnamese and Thai populations, respectively. Based on these results, we conclude that merism of the androecium and gynoecium is highly variable within different populations. Besides, populations show statistically significant differences ($p<0.01$) from each other in these traits; the Vietnamese population is found to have much greater floral merism than that of the Thai. Our results support the idea that the species *S. subintegra* can be divided into segregate taxa. The study is supported by the Russian Foundation of Basic Research (project 15-04-05836).

Nuraliev MS, Degtjareva GV, Sokoloff DD, Oskolski AA, Samigullin TH, Valiejo-Roman CM. 2014. Flower morphology and relationships of *Schefflera subintegra* (Araliaceae, Apiales): an evolutionary step towards extreme floral polymery. *Botanical Journal of the Linnean Society* 175: 553–597.

Black spots, galls and open questions: studies in *Artedia squamata* and *Echinophora trichophylla*

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Key words: andromonoecy, multicyclic protandry, beetle marks, mimicry, sex distribution, structural homology, umbel architecture and development

The wild carrot (*Daucus carota*) is famous for its black flowers interpreted as structures mimicking insects and/or galls, protecting plants from grazing animals or just being inherited abnormalities (reviewed in Lamborn and Ollerton, 2000). However, black structures not only appear in wild carrots, but in at least six genera of Apiaceae from five different clades. It is evident that they evolved in parallel. Interestingly, they all occur in an area ranging from the (Eastern) Mediterranean to SW Asia. What is specific in this area stimulating the formation of black centers?

To understand the evolutionary significance of the black spots in Apiaceae, we started a project in Anatolia where most of the black spotted species are distributed. We intend to study *Artedia squamata, Echinophora trichophylla, Daucus carota, D. carota* ssp. *maxima, D. guttatus, Tordylium aegyptiacum*, and *T. cappadocicum* in their natural environment, to observe pollinators and pollinator behavior and to conduct manipulation experiments. We are furthermore interested in the morphology of the black structures and include developmental studies in our project.

Studies in *Artedia squamata* and *Echinophora trichophylla* (endemic) reveal andromonoecy and multicyclic protandry in both species. *Echinophora* has a single perfect flower in the center of each otherwise male umbellet, while *Artedia* shows an umbel-centered sex distribution not previously described for Apiaceae. Beetles (not flies) are the dominant visitors, but only those are pollinators appearing on the umbels in both male and female flowering stages. Manipulation experiments indicate that some beetles associate the black structures with a female partner, while others attack them or flee. The dark structure in *Echinophora* originates from the receptacle of the umbel sometimes carrying a small leaf on its top indicating homology to a reduced umbellet. In *Artedia*, the hairy filaments of the brush-like structure appear first, while intercalary elongation follows later. In *Echinophora*, black galls occasionally appear in the umbel occupying just the site of the black structure.

To sum up our preliminary results, the dark structures in *Artedia* and *Echinophora* are most likely inherited abnormalities stabilized by selection due to their adaptive function. The function, however, can vary dependent on the signal receiver. The black structures may generally increase the attractiveness of the umbel, act more specifically as `beetles mark´ or mimic gall infection. The broad range of functions corresponds to the generalistic pollination syndrome, which has no specific adaptation to a single pollinator group.

Lamborn E, Ollerton J. 2000. Experimental assessment of the functional morphology of inflorescences of *Daucus carota* (Apiaceae): testing the `fly catcher effect´. *Functional Ecology* 14: 445–454.

Molecular appraisal of *Peucedanum* and some related Apiaceae–Apioideae taxa

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Key words: nrITS DNA, Eurasia, fruit anatomy, taxonomy, phylogeny

The genus *Peucedanum* L. in the broadest sense is taxonomically one of the most complex groups in the Umbelliferae. According to the International Plant Name Index, 852 records of species and subspecies names are attributed to it. All species of *Peucedanum* s.ampl. are aggregated due to similarity in dorsally compressed fruits, but in many other characters they possess significant differences. Unfortunately, attempts to segregate new genera from *Peucedanum* have not always lead to convincing results. Nevertheless, independent genera have been recognized: (1) the North American *Cymopterus* Raf., *Lomatium* Raf., *Oxypolis* Raf., *Pseudotaenidia* Mackenzie; (2) mono- or oligotypic Euro-Asian *Cervaria* N.M.Wolf, *Ferulopsis* Kitag., *Oreoselinum* Mill., *Ormosolenia* Tausch, *Thysselinum* Adans., *Xanthoselinum* Schur, *Demavendia* Pimenov, *Kafirnigania* Kamelin & Kinzik., *Kitagawia* Pimenov and *Fergania* Pimenov; (3) the African *Afrosciadium* P.J.D.Winter, *Nanobubon* Magee and *Notobubon* B.-E.van Wyk. The separate taxonomic status of the above mentioned genera was confirmed by molecular phylogenetic studies (Spalik *et al.*, 2004; Sun *et al.*, 2004; Valiejo-Roman *et al.*, 2006; Ajani *et al.*, 2008; Winter *et al.*, 2008; van Wyk *et al.*, 2013). As a result, now in sub-Saharan Africa as well as in North America there are no species of actual *Peucedanum*. The group *Peucedanum* s.str. with the generitype *P. officinale* L., is composed of only five species, distributed in the Medirerranean and Submediterranean Europe and in Western Siberia.

Revision of Umbelliferae, attributable to *Peucedanum*, is far from complete. Recently, the object of our study has become the Eurasian and Mediterranean representatives of the genus, many of which were proposed as monotypic (*Haloselinum* Pimenov, *Macroselinum* Schur, *Rhizomatophora* Pimenov, *Pinacantha* Gilli) or oligotypic (*Taeniopetalum* Vis., *Dichoropetalum* Fenzl) genera. The resulting molecular phylogenetic tree, including most of the critical Eurasian taxa of *Peucedanum* s.l. indicates the polyphyly of the group as a whole and supports the separate position of mono- or oligotypic genera.

The genus *Taeniopetalum* (SE and B in Europe and SW Asia) is usually considered to be a section of *Peucedanum*. All species (*P. arenarium* Waldst. & Kit., *P. borysthenicum* Klokov ex Schischk., *P. neumayeri* (Vis.) Rchb.f., *P. urbani* Freyn & Sint. ex H.Wolff, and *P. obtusifolium* Sm.) form a highly supported clade and this grouping correlates with morphology (the presence of large exocarp cells with strongly thickened convex outer walls). The revealed features testified in favor of isolation of a separate genus *Taeniopetalum* (Ostroumova *et al.*, 2016). A similar situation has been identified for the newly restored genus *Dichoropetalum* (from Afghanistan to Morocco), all species of which, including *D. nebrodense* (Guss.) Soldano, Galasso & Banfi from Sicily, form a compact clade.

In the ITS tree, *Haloselinum* (southern Siberia and Mongolia) forms a clade with *Ferulopsis*. The presence of sufficiently long branches leading to these taxa allows us to consider them as independent monotypic genera. *Macroselinum* (E Europe up to North Caucasus) and *Rhizomatophora* (Caucasus, Turkey, the Balkans) occupy a separate position, not grouping with other representatives of *Peucedanum* s.l. The affinity of two local endemics of South Western Asia, *Pinacantha* and *Peucedanum mogoltavicum* Korovin, is shared with *Ferula*. The imperfectly described monotypic genus *Pinacantha* (Afghanistan) occupies a position in *Ferula* L., not in *Peucedanum*, and most probably should be included in *Ferula*. The attribution of *Peucedanum mogoltavicum* to *Ferula* confirmed its earlier transfer to *Ferula* under the name *F. lithophila* Pimenov, due to the existence of an earlier described name of unrelated *F. mogoltavica* Korovin.

Especially strong divergence from the rest of the studied taxa was found for a rare little-known Korean endemic, *Peucedanum podagraria* H.Boissieu (= *P. insolens* Kitag.), which is clearly distinct from both *Peucedanum* s.str. and *Peucedanum* s.l. segregate genera in fruit (pericarp structure and secretory system) and leaf characters, as well as in nrDNA ITS sequence data. It is proposed to be included into the monotypic genus *Sillaphyton* Pimenov, closely related to the Chinese endemic *Arcuatopterus* Sheh Menglan & Shan Renhwa (Pimenov *et al.*, 2016).

Peucedanum s.l. is a polyphyletic group of plants. Before more is known about the biodiversity in this group, it seems rational to separate, step-by-step, some of the most distinctive taxa; otherwise, a revision of the whole "*Peucedanum*-alliance" may never be practicable.

The taxonomic and morphological studies were supported by grants from the Russian Foundation of Basic Research (grants # 13–04–00648, # 16–04–00525). The molecular phylogenetic analysis conducted by G.V. Degtjareva and T.H. Samigullin was funded by the Russian Science Foundation (grant #14–50–00029).

Ajani Y, Ajani A, Cordes JM, Watson MF, Downie SR. 2008. Phylogenetic analysis of nrDNA ITS sequences reveals relationships within five groups of Iranian Apiaceae subfamily Apioideae. *Taxon* 57: 383–400.

Ostroumova TA, Pimenov MG, Degtjareva GV, Samigullin TH. 2016. *Taeniopetalum* Vis. (Apiaceae), a neglected segregate of *Peucedanum* L., supported as a remarkable genus by morphological and molecular data. *Skvortsovia* 3: 20–44.

Pimenov MG, Ostroumova TA, Degtjareva GV, Samigullin TH. 2016. *Sillaphyton*, a new genus of the Umbelliferae, endemic to the Korean Peninsula. *Botanica Pacifica* 5: 31–41.

Spalik K, Reduron J-P, Downie SR. 2004. The phylogenetic position of *Peucedanum* sensu lato and allied genera and their placement in tribe Selineae (Apiaceae, subfamily Apioideae). *Plant Systematics and Evolution* 243: 189–210.

Sun FJ, Downie SR, Hartman RL. 2004. An ITS-based phylogenetic analysis of the perennial, endemic Apiaceae subfamily Apioideae of Western North America. *Systematic Botany* 29: 419–431.

Valiejo-Roman CM, Terentieva EI, Samigullin TH, Pimenov MG, Ghahremani-Nejad F, Mozaffarian V. 2006. Molecular data (nrITS-sequencing) reveal relationships among Iranian endemic taxa of the Umbelliferae. *Feddes Repertorium* 117: 367–388.

Van Wyk B-E, Tilney PM, Magee AR. 2013. African Apiaceae: a synopsis of the Apiaceae/Umbelliferae of sub-Saharan Africa and Madagascar. Pretoria: Briza Academic Books.

Winter PJD., Magee AR, Phephu N, Tilney PM, Downie SR, Van Wyk B-E. 2008. A new generic classification for African peucedanoid species (Apiaceae). *Taxon* 57: 347–364.

Species delimitations in the perennial, endemic North American clade of Apiaceae: *Cymopterus glomeratus*, *Pseudocymopterus montanus*, and *Pteryxia terebinthina* revisited

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Key words: PENA, DNA sequencing, cpDNA *psb*M-*psb*D, *ndh*F-*rpl32*, *rpl32*-*trn*L

The perennial, endemic North American (PENA) clade of Apiaceae contains 21 genera (200 taxa) distributed primarily in the western United States, with the largest genera being *Cymopterus* and *Lomatium*. Considerable taxonomic confusion surrounds the proper delimitation of and relationships among many of its taxa, with this confusion extending to infraspecific levels (Downie *et al.*, 2002; Sun *et al.*, 2004). Five varieties are recognized within *Cymopterus glomeratus*, yet their status is controversial and results of multivariate analysis of morphological characters from specimens throughout their range suggested that the complex be recognized as having no infraspecific taxa (Sun *et al.*, 2005). *Pseudocymopterus montanus* (syn. *Cymopterus lemmonii*) is highly variable morphologically, with its members subdivided in the past into several poorly defined taxa showing similarities to *Cymopterus* and *Pteryxia*. Results of an examination of morphological discontinuities in *Pseudocymopterus* using multivariate analyses revealed overlap among these putative taxa, with *P. montanus* distinct from *P. longiradiatus* and the former also having no infraspecific taxa (Sun *et al.*, 2006). The 4–6 varieties of *Pteryxia terebinthina* (syn. *Cymopterus terebinthinus*) are each fairly distinct geographically but are also morphologically heterogeneous, with many characters overlapping among them; as such, only two varieties (*foeniculacea* and *terebinthina*) were recognized (Sun *et al.*, 2008). The results of previous molecular systematic studies have done little to resolve the phylogenetic relationships within each of these three species and their placements within the PENA clade (Sun and Downie, 2010a,b). The monophyly of *C. glomeratus* is confirmed, but resolution of relationships among its five varieties is unclear due to a lack of informative characters, conflicting tree topologies, and the use of only single exemplars for each taxon. The two examined accessions of *P. montanus* unite as monophyletic alongside *C. beckii*, *Pteryxia* (*Cymopterus*) *davidsonii*, and *Aletes* (*Cymopterus*) *macdougalii* subsp. *macdougalii* in a well-supported clade, but away from its congener *P. longiradiatus*. In contrast, *P. terebinthina* is resolved as highly polyphyletic, with its few examined members occupying at least four distinct branches throughout the PENA clade; vars. *foeniculacea* and *terebinthina* are sister taxa falling away from vars. *albiflora*, *californica*, and *calarea*. In general, the paucity of sampling and lack of informative characters in the molecular studies and the difficulties in reconciling the results of the multivariate analyses with those of the molecular investigations have hindered the realization of a modern classification of these species. Three species also represent the nomenclatural types of their respective genera, thus a better understanding of their placements within the PENA clade has great taxonomic value.

To resolve relationships within the PENA clade, a group representing one of the largest endemic plant radiations in North America and one whose genera are largely artificial, a multidisciplinary collaborative study has been undertaken incorporating comprehensive sampling of all known species and infraspecific taxa (e.g., George *et al.*, 2014). A resolved phylogeny will be used for testing hypotheses on the forces driving species diversification and radiation. To test monophyly, multiple accessions of each taxon from throughout their ranges are being examined using DNA evidence. A comparative analysis of entire plastid genomes from the Apiales has identified highly divergent loci that may offer the best choices for systematic studies at low taxonomic levels (Downie and Jansen, 2015). These loci include (in descending order of their ability to provide variable and informative characters) *rpl32*-*trn*L, *psb*M-*psb*D (especially the embedded *trn*D-*trn*T region), and *ndh*F-*rpl32*. These data will be combined with existing sequence data for the group, such as that from the *rps16* and *ndh*A introns, *trn*F-*trn*L-*trn*T intergenic spacers, and nrDNA ITS and ETS regions, to provide the information necessary to yield well-supported, highly resolved trees with structure supporting the recognition of infraspecific taxa.

Our immediate objectives are twofold: 1) to expand upon the pioneer molecular studies of Sun, Downie and others by adding additional sequence data from the *rpl32*-*trn*L, *psb*M-*psb*D, and *ndh*F-*rpl32* regions and increasing sampling of taxa (including representation from the closely related *Arracacia* clade) in an effort to increase resolution of relationships and branch support, assess monophyly of genera and species, and confirm the major clades within PENA that have been identified through previous and ongoing molecular studies; and 2) to resolve species boundaries and infrageneric relationships in three major species complexes (*Cymopterus glomeratus*, *Pseudocymopterus montanus*, and *Pteryxia terebinthina*) that have implications for the classification of the clade as a whole and where results from recent, multivariate analyses are available for comparative purposes. This research is still very much in progress, with sequencing ongoing and results forthcoming, but it is presumed that the combination of morphology, ecology, geographic distribution, and molecular phylogenetic analyses of additional, highly variable loci will resolve the depth and breath of taxonomic problems exhibited by these taxa and others within the PENA clade.

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Daucus decipiens and *Daucus edulis* – sister cases of secondary woodiness in Daucineae with dissimilar wood anatomy

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Key words: insular woodiness, paedomorphosis, *Monizia*, *Melanoselinum*

Scandiceae subtribe Daucineae comprises mostly herbaceous species of umbellifers with the notable exception of two rosette treelets, *Daucus decipiens* (≡ *Melanoselinum decipiens*) and *Daucus edulis* (≡ *Monizia edulis*), endemic to Madeira. Molecular phylogenetic tree clearly shows that these species are sisters and represent secondary woodiness, i.e. their ancestor was herbaceous. According to Carlquist's theory of paedomorphosis, secondarily woody plants usually demonstrate primary xylem traits protracted into secondary xylem. For instance, their wood lacks rays or, if present, rays mostly consist of upright cells; additionally, the length of vessel elements usually decreases with the distance from the pith while the intervessel pitting is scalariform. However, stem anatomy of *D. decipiens* and *D. edulis* does not fully conform to these expectations; moreover, wood traits in both species are notably different. *Daucus decipiens* has diffuse-porous wood with rays consisting of procumbent cells; vessels have alternate pitting. The length of vessel elements increases with the distance from the pith: a rare condition among the secondarily woody species. The pith is narrow and parenchymatous while the bark is rather thin. The stem of *D. edulis* consists mostly of scanty vessels aligned in radial rows interspersed with pervasive and wide rays consisting of mixed procumbent and upright cells. Vessel elements have scalariform pitting. The pith occupies a considerable proportion of the stem cross-section and the bark is thick and corky. *D. decipiens* and *D. edulis* differ in maximum height and leaf size. *Daucus decipiens* grows up to 2 (–3) m while *D. edulis* reaches a height of 1.2 m. The former has also larger leaves than the latter. We hypothesize that taller and heavier *D. decipiens* is in need of greater support provided by wood while smaller *D. edulis* may rely on bark stiffness and parenchyma turgor without investing in energy-consuming wood production.

Patterns of carpel arrangement in gynoecia of Araliaceae: evidence from *Polyscias*

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Key words: flower development, flower symmetry, gynoecium, merism

Lateral flowers of angiosperms usually develop under a morphogenetic gradient between a subtending bract and an inflorescence axis (Endress, 1999). This gradient provides a median symmetry plane for most monosymmetric flowers (Ronse De Craene, 2010). Although the monosymmetry of perianth and androecium is most conspicuous for a researcher (as well as for a pollinator), some gynoecia also show pronounced monosymmetry or disymmetry. Particularly, monomerous gynoecia (composed of a single carpel) are almost always monosymmetric (as any carpel normally has a single dorsiventral symmetry plane) whereas dimerous gynoecia, if composed of two equal carpels, are disymmetric. In many angiosperms with monomerous and dimerous gynoecia in lateral flowers, the carpel position relative to the flower-subtending bract is constant. The position of a single carpel is usually median, and its ventral slit is most often directed towards the inflorescence axis (e.g., in all papilionoid legumes). In taxa with dimerous gynoecia, two carpels can be either in a transversal, e.g. in Brassicaceae, or median position, e.g. in Apiaceae and many other asterid families with bicarpellate flowers (Ronse De Craene, 2010). Constant carpel orientation does not necessarily require monosymmetry or disymmetry of the perianth and/or androecium. Disymmetric (e.g. most Apiales) or monosymmetric (e.g. *Prunus* s.l.) gynoecia can co-occur with polysymmetry of other floral whorls. These observations suggest an apparent direct morphogenetic influence of a flower-subtending bract on carpel position.

Despite such strong regularities of carpel arrangement in many angiosperms, some members of the family Araliaceae show a totally unstable carpel orientation in monomerous gynoecia. This instability is especially intriguing in comparison with the very constant flower groundplan in the closely related family Apiaceae. We studied three species of the genus *Polyscias* s.l. (*P. compacta* from subg. *Maralia*, *P. diversifolia* and *P.* cf. *schultzei* from subg. *Arthrophyllum*) belonging to lineages with independent gains of unicarpellate gynoecia. We found that in all three species carpel orientation varies in relation to the flower-subtending bract as well as with respect to the stamen position (Karpunina *et al*., 2016). Moreover, the unstable carpel orientation is not confined to unicarpellate *Polyscias* species. For example, *P. aubrevillei* (subg. *Maralia*) has 4–5 sepals, 4–5 petals, 4–5 stamens and 2–3 carpels. Carpels of its dimerous gynoecia can be either in median or in transversal planes, whereas its trimerous gynoecia can consist either of an adaxial and two obliquely abaxial carpels, or one abaxial carpel and two obliquely adaxial ones. Different patterns of orientation of dimerous and trimerous gynoecia are found also in *P. andrearum* (subg. *Maralia*), where gynoecium merism ranges between 2 and 4 and sepal/petal/stamen numbers between 4 and 7.

The unstable carpel position in monomerous, dimerous and trimerous gynoecia of *Polyscias* can be explained (1) as the result of a loss of direct morphogenetic influence of the flower-subtending bract onto positions of carpel initiation or (2) as an effect of general loss of stability of number and positions of sepals, petals and stamens, i.e. the floral organs appearing before carpels, or (3) as a combination of the two effects. Our preliminary data show that the degree of variation in number and position of sepals, petals and carpels varies from species to species within *Polyscias*. Their strong variation was found in subg. *Maralia*, for example, in *P. aubrevillei*, where variation in merism of calyx, corolla and androecium was not always coordinated, and sepals were sometimes unequal and their arrangement relative to the flower-subtending bract was not stable among flowers with the same sepal number. In contrast, flowers of *P.* cf. *schultzei* almost always possessed in our material five sepals, five petals and five stamens in a fixed position and only rarely were the three outer whorls hexamerous. As these data suggest, the subtending bract determines the orientation of the perianth and androecium in the latter species, but it has lost morphogenetic influence on their position in subgenus *Maralia*. At the same time, the determination of gynoecium orientation in all *Polyscias* species under study is seemingly independent both of the subtending bract, and of the outer floral whorls.

Unstable gynoecium orientation found in *Polyscias* is uncommon among angiosperms. Future studies should clarify how common this phenomenon is in Araliaceae. A rough preliminary survey of a few available Araliaceae with dimerous gynoecia (*Harmsiopanax*, *Cheirodendron*, *Cussonia*, *Seemannaralia*, *Eleutherococcus*, *Brassaiopsis*) has shown that these taxa have two carpels in a median position, like in most other asterids. The only exception is *Cheirodendron trigynum* whose gynoecium merism varies between 2 and 3, and both types of arrangement of two carpels are recorded. Curiously, *Cheirodendron* shares with some *Polyscias* studied here the presence of a calyculus, i.e. an annular appendage on the pedicel. In *Polyscias*, the calyculus is located at the point of pedicel articulation. Articulate pedicels are present in most species of *Polyscias*, even those that have no clear calyculus. One can speculate that the articulation and/or calyculus are responsible for the breakdown of the morphogenetic influence of the flower-subtending bract. This hypothesis would be most plausible if the calyculus is a modified leaf homologue (or a group of united phyllomes). However, our developmental and anatomical data on *Polyscias* do not support this idea. The calyculus appears late in development (after the sepals), has no vascularisation and initiates as an entire or irregularly lobed structure.

Our preliminary study highlights a need for comparative quantitative studies of variation in organ number and position as well as calyculus development across Araliaceae.

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Anatomic and micromorphological characteristics of *Bupleurum dichotomum, B. eginense, B. koechelii* and *B. lycaonicum* from Turkey

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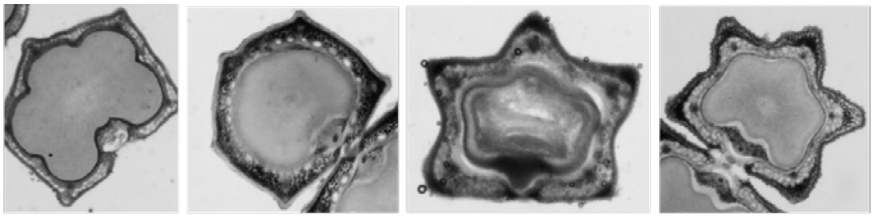
Key words: *Bupleurum dichotomum, Bupleurum eginense, Bupleurum koechelii, Bupleurum lycaonicum,* anatomy, micromorphology

Bupleurum is one of the large genera of the Apiaceae and is represented by 50 taxa (21 of them are endemics) in Turkey. In this study, fruits of *B. dichotomum* Boiss., *B. eginense* (Wolff) Snogerup (end.), *B. koechelii* Fenzl (end.) and *B. lycaonicum* Snogerup (end.) were anatomically and micromorphologically examined.

The fruits of the selected *Bupleurum* species were collected from natural habitats and different localities in Turkey by the authors. The fruits were preliminarily observed using a light microscope to make sure that they were of normal size and maturity. For scanning electron microscopy (SEM) analysis, at least 5 samples were prepared. The samples were mounted on stubs and coated with gold before they were studied with a FEI Quanta 450 FEG-EDS model SEM. The dried fruits were kept in warm water for anatomical studies and then all transverse sections were cut by hand with a blade. Samples were investigated in Sartur reagent. Photographs were taken with a Nikon 80i trinocular light microscope and Kameram 21 Digital micro structure analysis system.

In the "Flora of Turkey", it is stated that these 4 species are similar to one another but our studies have found that there are some differences in fruit anatomy and micromorphology especially in B. *eginense*. All fruit surface patterns are colliculate except in B. *eginense* which has a colliculate-tuberculate pattern. *B. eginense* has 23–25 circularly arranged vittae in the mesocarp and the others have 6 vallecullar vittae.



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Electronic carpological atlas and identification system of the Umbelliferae of Russia

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Key words: carpology, anatomy, morphology, micromorphology, Apiaceae

Traditionally, since the time of G.F. Hoffmann in the Botanical Garden of Moscow State University, fundamental research of Umbelliferae has been conducted. Now research is based on the use of both classical and modern methods including scanning electron microscopy (SEM). Revision of critical groups of the family, the description of new taxa and the compilation of regional treatments, as well as participation in the global international project of FGVP, are the result of this research. One of the recent large realized projects of our team was the compilation and publication of the monographic treatment "Umbelliferae of Russia" (Pimenov and Ostroumova, 2012).

Fruits of Umbelliferae are diverse and their characteristics are considerable for the taxonomy of Umbelliferae. The carpological characteristics are important for the delimitation of genera. Within some genera, especially those that are polymorphic, fruits are also variable. Often species identification is very difficult without fruits. In the monographic treatment "Umbelliferae of Russia", anatomo-morphological fruit characteristics are presented; however, micromorphological characteristics of the fruit surface were not studied. Illustrations of transsections of mericarps were provided only for one species of each genus. The investigation of fruit surfaces by SEM enables new diagnostic characteristics to be revealed.

The compilation of regional carpological atlases is a significant step forward in the knowledge and diagnostics of the Umbelliferae of Russia. In the recently published carpological atlas of Umbelliferae of the Kemerovo region (Kljuykov *et al.*, 2016), descriptions, colored pictures of fruits, transsections of mericarps, and for some species SEM photographs of the fruit surface were provided. Currently, comparative fruit morphologo-anatomical investigations using SEM for the compilation of an electronic atlas-manual of fruits of Umbelliferae of Russia, based on the carpological collection of the Botanical Garden of Moscow State University, are being conducted.

In this project it is planned to study fruit morphology, micromorphology and anatomy of 300 species from 111 genera occurring in the territory of Russia. In the atlas there will be colour macrophotographs of fruits under a light stereomicroscope, SEM microphotos of the fruit surface, illustrations of mericarp transsections, detailed photos of the anatomical structure of fruits, descriptions of fruits, and the species distribution for each species.

We are developing the database and multientry electronic key for the identification of genera and species of Umbelliferae of Russia based on carpological characteristics. At present, colour macrophotos of the fruits of 160 species have been taken, as well as the fruit anatomy of 200 species and the fruit surface microsculpture of 160 species, studied. The cadaster of carpological characteristics and their states for the description of fruits was developed, and detailed descriptions of the fruit for 100 species of Umbelliferae of Russia were compiled.

A list of descriptors to describe the fruit of Umbelliferae of Russia

Fruit morphology (23 characteristics): separating at maturity; fruit shape/outline; separation of carpophore; presence and form of beak; symmetry of mericarps; mericarp pubescence; mericarp length, minimum; mericarp length, maximum; mericarp width, minimum; mericarp width, maximum; mericarps in transection; mericarp ribs; mericarp primary ribs; mericarp dorsal ribs; mericarp marginal ribs; mericarp secondary ribs; margin of mericarp ribs; calyx teeth on fruit; calyx teeth shape and size; stylopod shape; style length; style shape.

Fruit anatomy (15 characteristics): exocarp cell size; commissure width; inner fibrous mesocarp (hypendocarp); mesocarp ground tissue; vascular bundle structure; vascular bundle position in mesocarp; presence of vittae; vallecular vittae; commissural vittae; rib secretory ducts; endocarp; crystals in pericarp; endosperm commissural side; embryo.

SEM-microsculpture (11 characteristics): mericarp surface if cell borders indistinct; cell pattern; cell outlines; cell borders; outer periclinal cell wall; cuticle folds; hair types; surface of unicellular hairs; exocarp cell size; stomata; epicuticular secretions.

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Pseudomonomerous fruits in *Cussonia* and related genera (Araliaceae)

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Key words: Araliaceae, pseudomonomerous gynoecium, pericarp structure, pyrene disjunction

The genus *Cussonia* comprises 21 tree and shrub species from Africa, the Comoro Islands and Arabian Peninsula (Frodin and Govaerts, 2003). Historically, it was the leaves, clustered in the upper part of the branches and very diverse in shape that served as the main diagnostic trait in the genus's taxonomy (De Villiers *et al*., 2010). However, fruit structure traits are also very informative for the genus *Cussonia*. Besides the number of seeds and locules, *Cussonia* fruits differ in the degree of fusion of stylodes into styles (separate stylodes in *C. ostinii, C. angolensis, C. arenicola*; fully fused in *C. holstii, C. corbisieri, C. zimmermannii*), and anatomically, by the peculiar overgrowth of sterile tissue in the upper part of the carpels, the obvious presence of the floral tube outside the ovary (Konstantinova and Yembaturova, 2010, p. 351), which is conspicuous in *C. arenicola, C. holstii, C. angolensis, C. bancoensis, C. ostinii, C. spicata,* etc.), abundant secretory canals and tanniferous cells in the pericarp (numerous in *C. nicholsonii, C. bancoensis, C. spicata, C. zuluensis,* etc.), the inner pyrene outline (undulate in *C. angolensis, C. nicholsonii* and *C. spicata*), traits of the ventral bundles in the commissural zone, etc.

All families within Apiales, except Myodocarpaceae, are known to have pseudomonomerous fruits (Konstantinova and Nilova, 2014). This phenomenon is also true for the families Griseliniaceae, Torricelliaceae (Yembaturova and Konstantinova, 2013) and Pennantiaceae. However, most representatives of Araliaceae lack pseudomonomerous fruits.

Our carpological study involved 14 species of *Cussonia* from different sections, as well as *Seemannaralia gerrardii*. It was pointed out that fruits are formed by two carpels of an initially syncarpous gynoecium and normally possess two seeds. Potentially, each locule contains a seed, however, some fruits complete their development as one-seeded.

Two trends of the pseudomonomerous fruit formation have been traced:
(1). The fruit becomes pseudomonomerous as a result of incomplete carpel development. This trend is the most common and found in Torricelliaceae (*Aralidium, Torricellia*) and Griseliniaceae (*Griselinia*). In *Cussonia*, this can be seen in some fruits of *C. bancoensis, C. arenicola* and *C. natalensis.* In this case, the fruit retains its round shape but one of the locules fails to develop, being compressed and at times hardly noticeable (*C. natalensis*).
(2). A pseudomonomerous fruit develops by destroying the septum and forms only one seed: this is an extremely rare case. A kind of pyrene disjunction in the central part of the fruit has also been observed in some species of *Schefflera*, a genus closely related to *Cussonia* (*S. wallichiana, S. oxyphylla, S. bodinieri*) (Konstantinova, 2008; Konstantinova and Suchorukow, 2010). In a fertilized dimeric fruit of *C. ostinii,* the pyrene disjunction towards the centre, resulting in the cavity formation in the central part of the fruit, has been reported. Within one fruit aggregation of *C. thyrsiflora* (all fruits in it - at different developmental stages), both regular fertilized two-seeded fruits and unfertilized ones without seeds but with a rounded cavity in the centre, just like in fruits of *C. ostinii,* are

found. The pericarp of these unfertilized fruits is fleshy and well-developed, lacking supporting tissues and, apparently, is attractive to birds. Presumably, the fact of such fruit formation itself indicates a certain resemblance to the "pseudofruits" of the genus *Osmoxylon*, however, the "pseudofruits" of *Osmoxylon* possess no central cavity, just the ovary locules end up reduced in number and seedless (Konstantinova, original data). Such a tendency towards pseudomonomerous fruit formation by destroying the central zone in the bicarpellate syncarpous gynoecium of *Cussonia* seems particularly interesting. In this regard, the structure of a pseudomonomerous fruit in *Seemannaralia gerrardii* is worth mentioning. In *Seemannaralia*, the seed somehow pushes on the central septum thereby destroying it (Oskolski *et al*., 2010). This septum disappears in the same way as in *C. ostinii* and *C. thyrsiflora*. Therefore, the trend to destroy the septum in the syncarpous gynoecium, observed in some *Cussonia* species (*C. ostinii, C. thyrsiflora*), reaches its logical conclusion in *Seemannaralia.*

It is noteworthy that the listed species with pseudomonomerous fruits have simple palmatilobate, deeply palmatisected or compound palmate leaves of simple leaflets. According to R.G. Strey's system (Strey, 1973), pseudomonocarpy is, first of all, a trait of the subgenus *Protocussonia* (*C. natalensis*) and subgenus *Cussonia* sect. *Capitata* (*C. thyrsiflora, C. arenicola*). No pseudomonomerous fruits have been recorded so far in *C. spicata* (subgenus *Cussonia* sect. *Cussonia*) and *C. paniculata* (subgenus *Paniculata*). Thus, further investigations of the fine anatomical structure of fruits and revealing the occurrence of pseudomonomerous fruits appear to be of great importance for verifying and proving molecular and genetic data as well as for explaining some ecological traits of the genus *Cussonia* – one of the key genera in Araliaceae.

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Wood and bark anatomy of *Andriana* (Heteromorpheae, Apiaceae) with phylogenetic and ecological implications

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Key words: Apioideae, Madagascar, helical thickenings, secretory canals

Andriana B.-E.van Wyk comprises three shrubby species restricted to the high elevation scrubs in mountains of northern Madagascar. This genus is placed in the Malagasy Clade of the tribe Heteromorpheae. We examined the stem structure of *Andriana marojejyensis* (Humbert) B.-E.van Wyk and *A. tsaratananensis* (Humbert) B.-E.van Wyk, to clarify the relationships of this clade to other Heteromorpheae on the basis of their wood and bark traits. Two *Andriana* species show certain similarities to southern African genera of this tribe (*Heteromorpha* Cham. & Schltdl., *Anginon* Raf., *Glia* Sond., and *Polemannia* Eckl. & Zeyh.) in their wood anatomy, but they are distinctive from the latter by the absence of helical thickenings on vessel walls. Thus this feature may not be considered as a synapomorphic trait for the Heteromorpheae, as was previously suggested.

Unlike other members of this tribe, the species of *Andriana* show no growth rings in their wood which may be the result of a short and mild dry season in the mountains of northern Madagascar. *A. marojejyensis* shows a combination of bark anatomical traits (narrow cortex with a single ring of secretory canals, presence of secretory canals in secondary phloem, and radial dilatation of the secondary phloem) that has been considered as diagnostic for the Heteromorpheae. *A. marojejyensis* is distinctive, however, from other members of this tribe by bottle-shaped epidermal cells with very thick cuticles. Unlike some Heteromorpheae (i.e. *Heteromorpha* and *Polemannia*), we did not find any traits of photosynthetic capacity of the bark in *Andriana*, such as translucent phellem or the presence of chloroplasts in phelloderm. In *Andriana*, sheath axial parechyma cannot be distinguished from other strands of axial parenchyma occurring in secondary phloem. Parenchymatous sheaths near secretory canals have been reported in *Dracosciadium*, also belonging to Malagasy Heteromorpheae. This means that the absence of sheath axial parenchyma is unique to *Andriana* within the suborder Apiineae.

European *Prangos* species complexes: when classic morphological features are not enough to distinguish similar species

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Key words: Mediterranean region, molecular phylogeny, morphology, nrITS, nrETS

Prangos Lindl. is an Apiaceae genus containing over 50 species distributed from western Portugal to western China and northern India. The main diversity centres of the genus are Iran, Turkey and Middle Asia. Only two species are known in Europe to date: *Prangos ferulacea* (L.) Lindl. and *P. trifida* (Mill.) Herrnst. & Heyn. The first species is distributed mostly in SW Asia. The second species has a European only distribution.

The populations of these species in Europe are mostly sporadic and were often described as distinct species. But in the monographic treatment of *Prangos* by Herrnstadt and Heyn (1977) all these species were reduced to synonymy under *P. ferulacea* and *P. trifida*. Both species comprise many different forms which are impossible to subdivide because of the continuous variation of the main diagnostic characters such as size and shape of leave blades and leaf terminal lobes, shape of bracts and bracteoles, and size and shape of fruits. This conception is mainly based on morphological, anatomical and biosystematical studies of Israeli populations of *P. ferulacea* (1975). Unclear species limits and different interpretations of *P. ferulacea* and *P. trifida*, together with the absence of molecular studies, make the number of *Prangos* species in the flora of Europe an open-ended question.

We analyzed sequences of nuclear ribosomal (nrITS/ETS) spacer DNA to clarify phylogenetic relations of European *Prangos* species and ascertain their taxonomic position. 97 accessions of 52 species of *Prangos*, *Bilacunaria* Pimenov & V.N.Tikhom. and *Cachrys* L. were involved in the analysis, including critical European specimens from different parts of the distribution area.

The results of the molecular analysis show that representatives of *P. trifida* form two well supported distantly related clades: I and II, the latter includes two well supported groups. The results of the molecular study are not in line with morphological features. Intraspecific nrITS/ETS variability is frequently higher than morphological differences between the two clades. European populations of *P. ferulacea* (clade III) and *P. ferulacea* from SW Asia (clade IV) also form distantly related clades. Morphological features of these two clades are labile and frequently overlap. Such similarity in the main distinguishing features could be interpreted as an ecological adaptation for identical climatic conditions. In general, the observed patterns of morphological characters in the molecular tree support the traditional view on the key role of fruit specialization in the evolution of Apiaceae. Thus, our data suggest that all these morphological characters should be used together with other characters more narrowly.

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A new chapter in the legend of *Ferula silphion*

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Key words: Silphion, ancient medicinal resin, extinction, conservation

Silphion is a well known ancient medicinal resin; Dioscorides dedicates a comprehensive monograph in his "De Materia Medica" to this drug. In addition to the description of the plant source of Silphion, he provides a detailed documentation of its medicinal uses for the treatment of many diseases such as goitre, sciatica, tooth ache, intestinal disorders, hormonal disorders, epilepsy, tetanus, polyps, malignant tumors in his monograph (Osbaldeston and Wood, 2000). According to some medicinal historians, Silphion was also used as an aphrodisiac (Koerper and Kolls, 1999) and as a powerful contraceptive (Riddle and Worth Estes, 1992). Probably due to these virtues, the source plant of Silphion was over harvested and became extinct in the 1st century AD (Kiehn, 2006).

Unfortunately, no specimen of the source plant of Silphion exists to confirm its genus or family, but analogue descriptions provided by Dioscorides in his monograph and descriptions of the other ancient authors strongly suggest that the genus of this plant is *Ferula* (Osbaldeston and Wood, 2000; Kiehn, 2014). An extremely rare endemic species of *Ferula* growing in Central Anatolia resembles the description and numismatic figures of this plant. Furthermore, the organoleptic qualities of its oleo-gum-resin exudate are also in close agreement with the description of Dioscorides. Preliminary phytochemical analyses of this plant species yielded highly complex sesquiterpenoid and coumarin compounds with unique novel structures but also some known compounds that were previously described from other well known medicinal plants such as *Acorus calamus* (i.e., Sweet Flag). The biological activities of some of these compounds also corroborates the medicinal uses mentioned by Dioscorides in his Silphion monograph.

Only a limited number of living specimens of this plant species exist in two locations; a conservation study has been initiated to preserve and propagate this species. The details of the conservation studies and the training of local villagers to protect this plant species, while providing them with an extremely valuable source of income, will be discussed.

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Unique chemotaxonomical markers of Apiaceae family for the identification of inter-species, inter-genera and inter-family relations

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Key words: Coumarins, *Petroedmondia*, *Heptaptera*, Opopanax clade, Apioideae

Complex ecological interactions between the plant and predator species are the driving force of evolution that ultimately yields the formation of a new species via phenotypic and genetic changes. Plant secondary metabolites play a crucial role in these interactions as defense compounds and insect attractants to ensure survival of the plant species (Gutzeit and Ludwig-Müller, 2014). Although general structures of the secondary metabolites are well defined, each plant species produces unique compounds that suit its specific purpose during the ecological interactions with another species.

The Apiaceae is one of the most complex flowering plant families; identification of the boundaries of various clades within the subfamily Apioidae is still under discussion. Various phylogenetic analyses such as the cDNA *rps*16 intron and the nrDNA ITS sequences, as well as serotaxonomical analyses of seed storage proteins, have been carried out (Shneyer *et al.*, 1992; Downie *et al.*, 2001; Ajani *et al.*, 2008; Downie *et al.*, 2010). Nevertheless, some inconsistencies still remain with the placement of certain genera into these clades.

While investigating the secondary metabolites of *Petroedmondia syriaca* (Boiss.) Tamamsch. and various *Heptaptera* species, we isolated several unique coumarin derivatives that clearly delineate the placement of these genera into the Opopanax clade as well as their association with the other neighboring genera. Advances in computer and analytical instrumentation technologies during the last couple of decades streamlined the phylogenetic analysis via DNA sequence determination. The very same technologies also simplified and expedited the isolation and structure elucidation of secondary metabolites at such a level as to provide rapid critical information to corroborate or revise the taxonomical status of each genus/species. Taking unique secondary metabolites into account during the taxonomical classification provides direct evidence since their sole purpose of existence is the regulation of inter-species interactions.

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Reproductive morphology in *Osmoxylon* (Araliaceae): flower merism, perianth innervation and inflorescence structure

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Key words: development, anatomy, vasculature, Malesia, systematics

The Malesian genus *Osmoxylon* is a remarkable member of the order Apiales due to its complicated floral morphology. Unlike the majority of the other members of this order, the *Osmoxylon* species show a long corolla tube with hardly distinguishable lobes. This is combined with significant interspecific variation in androecium and gynoecium merism, which can number at least from 3 to 30 elements in a whorl. These features make it problematic to estimate the number of petals in a flower in many species of *Osmoxylon,* as well as of the sepals which are often obsolete in a mature flower. Furthermore, apart from the fertile flowers (which bear calyx, corolla, androecium and gynoecium), there are so-called "bacciform flowers" in each species of this genus, which are believed to be sterile and known to possess a fleshy ovary. No other details of their morphology and function are currently known.

We conducted a study of the development and anatomy of the flowers of four species of *Osmoxylon*: *O. boerlagei* (Warb.) Philipson, *O. geelvinkianum* Becc., *O. insidiator* Becc. and *O. lineare* (Merr.) Philipson. Both the calyx and corolla of their fertile flowers show distinct free lobes at early developmental stages, which allows direct counting of sepals and petals. The mode of corolla development is early sympetaly as the free petal lobes arise on the common ring primordium (tube). The calyx, vice versa, shows late congenital fusion, i.e. the sepal primordia appear before the tube. Very short free petal lobes are visible in the mature flower bud of a species with oligomerous flower (*O. lineare*) and completely disappear in the other studied species (all with polymerous flowers). In the mature corolla of some species (e.g. *O. geelvinkianum*), the vascular traces are in the same number as the stamens and alternate with them; these traces most likely represent median petal veins. In other cases (*O. insidiator*), there are additional corolla traces which are smaller and arranged on the radii of stamens; we interpret them as fused lateral petal veins. Thus, the vascular anatomy can be used for indirect estimation of corolla merism in *Osmoxylon*. The sterile flowers possess both perianth whorls but completely lack an androecium. Both calyx and corolla usually bear a tube and sometimes also free lobes. Perianth merism of the sterile flowers often differs significantly from that of the fertile ones. The gynoecium forms a prominent style which is covered by a massive corolla. Unlike fertile flowers, the calyx of the sterile ones bears numerous hairs.

Finally, we found some variation in the inflorescence morphology. Generally, *Osmoxylon* is characterized by an umbel which bears dichasia of umbels. In each dichasium, the terminal umbel is composed of sterile flowers, while the lateral umbels possess fertile flowers. In some fertile umbels of *O. geelvinkianum*, the prophylls bear additional developing umbels (most probably, also fertile) in their axils. Furthermore, these additional umbels sometimes possess their own lateral umbel primordia. Thus, inflorescences of *Osmoxylon* have a structural potential to develop at least two additional orders of branching. Further observations are needed to check if these additional umbels are functional or always stay underdeveloped.

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Floral polymery *versus* andromonoecy: a case of Araliaceae

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Key words: polyandry, flower merism, sexual systems, dichogamy, resource allocation

Andromonoecy is a sexual system in which plant individuals have both hermaphroditic and (functionally) male flowers. This condition is thought to be a mechanism enabling independent allocation of resources to female and male functions. Particularly, the reduction of carpels in male flowers allows redirecting of resources to other flowers, which can form fewer larger fruits without a decrease of pollen production (e.g. Miller and Diggle, 2007). The evolutionary shift from hermaphroditism to andromonoecy is regarded either as a result of an unequal allocation of limited resources between earlier- and later-blooming flowers, or/and as an effect of interfloral protandrous dichogamy (e.g, Schlessman, 2010).

These explanations are relevant only for the plant groups sharing constant numbers of stamens and carpels in their flowers. The increase in fruit size can be accomplished, however, not only by the enlargement of carpels, but also by their multiplication. Similarly, sufficient pollen production can be achieved not only by the formation of staminate flowers, but also by the multiplication of stamens in hermaphroditic flowers. Thus, non-isomerous meristic changes of androecium and gynoecium can be interpreted as a mechanism of resource reallocation to female and male functions that is different from the shift to andromonoecy. Contrastingly with the latter, it seems unlikely that these changes are promoted by the different timing of flower maturation within an inflorescence. If so, the uneven polymerisation of androecium and gynoecium may be assumed as a way to fruit enlargement in plant groups showing no interfloral dichogamy.

To test this hypothesis, we examined the relationships between merism of androecium and gynoecium, the sexual system, the presence of interfloral dichogamy and fruit diameter in 168 species from 30 genera of Araliaceae. Andromonoecy has been reported in several groups of this family (Schlessman, 2010). At the same time, the Araliaceae members show a wide range of floral merism: although pentamerous flowers (occasionally with a dimerous gynoecium) are common in this family, strong polymerization of androecium and gynoecium occurs at least in four lineages within this group (Nuraliev *et al.*, 2010). Information on floral merism, fruit size, sexual systems and sequence of flower maturation in different species of Araliaceae was taken from numerous publications and personal observations.

The association between large fruits and andromonoecy [that has been reported, for instance, for two sections of the genus *Solanum* (Miller and Diggle, 2007)], is not confirmed for Araliaceae. Large fruits (15 mm and more in width) are found in 15 species belonging to the genera *Plerandra*, *Polyscias* (subgenera *Tetraplasandra* and *Indokingia*), *Osmoxylon*, *Trevesia* and Asian *Schefflera*. In most of them (14 species), the increase in fruit size is associated with gynoecium polymerization. Twelve of the 15 large-fruited species are hermaphroditic. Only one andromonoecious species (*Polyscias flynnii*) has relatively large fruits (10–16 mm in diameter) developing from an oligomerous (5-

carpellate) gynoecium. Besides, andromonoecy was reported in three *Plerandra* species having polymerous gynoecia.

Polymery of androecium and gynoecium (derived from pentamery) is associated in Araliaceae with hermaphroditism and with the absence of interfloral protandry. Among 19 species [belonging to *Plerandra*, *Polyscias* (subgen. *Tetraplasandra*), *Osmoxylon*, *Aralia*, *Trevesia*, and Asian *Schefflera*] which have polymerous flowers with (nearly) isomerous whorls of stamens and carpels, only a single species (*Plerandra plerandroides*) is andromonoecious and dichogamous at the same time. The loss of isomery due to multiplication of stamens in polymerous flowers is found in 25 species of *Plerandra* and *Polyscias*. Andromonoecy was reported in five of these species (*Polyscias flynnii* and four *Plerandra* species), but none of them show interfloral protandry.

Nevertheless, we can confirm the association of andromonoecy with interfloral protandry (Schlessman, 2010): this condition is found in the majority (30 of 35) of andromonoecious species. The absence of interfloral protandry was not reported only in five andromonoecious species [*Polyscias flynnii* and four species of *Plerandra* (subg. *Plerandra*)]. Noteworthy, these species show extreme figures of stamen numbers within the order Apiales (up to 350–500 stamens in *P. pickeringii*) due to the multiplication of androecium whorls (Nuraliev *et al.,* 2010). Such a multistaminate flower can be considered as a functional unit which corresponds to an umbel of the second or third order in a dichogamous inflorescence with oligomerous flowers. We can hypothesize that interfloral protandry in these *Plerandra* species is displayed as sequential maturation of flowers within their simple umbels; additional observations are required, however, to prove this hypothesis.

A relative increase in stamen number can also be achieved by the reduction of carpels in pentamerous flowers up to the formation of (pseudo)monomerous gynoecia. The unicarpellate gynoecium is characteristic for some hermaphroditic species of *Polyscias* from subgenera *Arthrophyllum* (4 species) and *Maralia* (2 species), and it occasionally occurs also in *Osmoxylon micranthum*. Among them, all examined species of subgenus *Arthrophyllum* and apparently one species of subgenus *Maralia* have interfloral protandry.

As our results suggest, non-isomerous polymerization of androecium and gynoecium has evolved in Araliaceae as a way to reallocate resources to female and/or male functions (increase in fruit size or of stamen multiplication, respectively). Unlike andromonoecy, these meristic changes arose independently from the timing of flower maturation within an inflorescence, i.e. from the interfloral protandry. At the same time, this mechanism is not an alternative to andromonoecy: it can be realized in some andromonoecious species as a way to increase the stamen number per plant.

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Chloroplast DNA evidence for phylogenetic investigation of Turkish *Pimpinella* species

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Key words: *Pimpinella, trn*L-*trn*F, *psb*M-*psb*D, Turkey

Chloroplast DNA sequences of *Pimpinella* L. species growing in Turkey were compared to determine their phylogenetic relationships. DNA isolations were made using the DNeasy Plant Mini Kit and then isolated DNA solutions were PCR-amplified. Two highly variable noncoding chloroplast DNA regions were examined (*trn*L-*trn*F, *psb*M-*psb*D), and for the latter nine primers were required to sequence the entire region. Raw DNA sequences were edited using Sequencher 5.4, aligned with Clustal W (Thompson *et al*., 1994), and phylogenetic trees were constructed using PAUP* 4.0a152 (Swofford, 2002). Comparisons of sequence data and phylogenetic results indicated that the *psb*M-*psb*D region provides more information than the *trn*L-*trn*F region for the species of *Pimpinella* examined. This information includes abundant insertions/deletions between two sets of primers: pair *psb*M and *trn*E and pair *trn*D and *trn*T. An insertion within the later region (*trn*D-*trn*T) is of phylogenetic significance.

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Phylogenetic relationships of *Bupleurum* (Apiaceae) species growing in Turkey

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Key words: *Bupleurum*, ITS, *cp*DNA, Turkey

Bupleurum L. species growing in Turkey were examined for the first time to determine their phylogenetic relationships at the sectional/group level. DNA isolations were made using the DNeasy Plant Mini Kit and then isolated DNA solutions were PCR-amplified. In this study, the nuclear ribosomal DNA internal transcribed spacer (ITS) and three chloroplast DNA (*trn*L-*trn*F, *ndh*F-*trn*L and *psb*M-*psb*D) regions were considered. DNA sequences were edited using Sequencher 5.4, aligned using Clustal W (Thompson *et al*., 1994), and phylogenetic trees were inferred using PAUP* 4.0a152 (Swofford, 2002). According to both ITS and chloroplast data sets, *Bupleurum* is a monophyletic genus that is not fully differentiated at the sectional/group level. While members of Group A (sect. *Perfoliata*) are distinguished from the other groups, they show a close affinity to members of Group D (*B. falcatum*). Some of the members of Group B (i.e., *B. flavum*, *B. erubescens*, *B. sulphureum*, *B. pulchellum*) and some members of Group C (i.e., *B. koechelii*, *B. eginense*, *B. lycaonicum*) are each monophyletic at the group level. The members of Group B and C, however, are transitioning between these groups. A new sectional or group classification is required for Turkish *Bupleurum*.

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Biomorphological polyvariation in the genus *Sium* L. (Apiaceae)

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Key words: life form, substitutional vegetative short-lived polycarpic, ontogenesis

According to various literature data the genus *Sium* L. includes from 5 to 10–14 species (Pimenov and Leonov, 1993; Vinogradova, 2004). The majority of species are distributed in the Old World, only one is also found in North America. All of them grow in wet habitats – riversides, swamps, waterlogged grasslands, shallows; some species can be partly submerged in the water. An analysis of the herbarium specimens, as well as the descriptions of species in the regional Floras could not give complete information about the biomorphological specificity of *Sium* species. Different species are rather similar in the structure of their vegetative organs which makes it difficult to identify plants in the areas of overlapping ranges. We studied five species, *S. latifolium*, *S. sisaroideum*, *S. medium*, *S. suave*, *S. tenue* and *S. repandum*, as model plants representing specific life forms.

Observations of plants in nature and in herbarium collections have shown that the basic biomorphological type of the genus *Sium* is a type of the substitutional vegetative short-lived polycarpic with adventive roots. This type is characterized by special features of plant development: the daughter vegetative diasporas, which appear from the axillary buds, quickly lose contact with the short-lived mother plant and take on an autonomous lifestyle. Therefore, normally there are no real perennial rhizomes at the base of the generative shoots in *Sium* species, though they are polycarpics. Another feature typical of the genus is the formation of a special shoot system where the primary shoot has an incomplete developmental cycle and does not go through all the stages of development from bud to bloom; flowering shoots are formed by separated daughter diasporas.

In addition to the general architectural type, specific species have some individual structural features of biomorpha. So, *S. latifolium* can produce root suckers, *S. sisaroideum* and *S. repandum* usually develop thick adventive roots with storage functions, and some individuals of *S. medium* can form a compact clone. On the other hand these features are not always an integral part of biomorphs. A detailed study of plants in nature indicates that adventive roots have a tendency to thicken in almost all species, but more often this is realized in species which do not grow in water. Species growing in the shallows form special underwater aerenchymatic adventive roots. The clonal type of development is also quite variable and can sometimes occur also in other species. The greatest range of variability was found in *S. sisaroideum* when we studied its ontogenesis.

So, at the early stages of ontogenesis the primary shoot of *S. sisaroideum* often behaves in different ways: it can be a rosette, semirosette or elongated. The type of architecture influences the further development: it determines whether the primary shoot blooms in the first or in the second year of life and whether it would have a complete or an incomplete development cycle, as well as the rate and intensity of occurrence of the substitutional shoots that develop from axillary buds. The primary and lateral shoots may be orthotropic or hemiplagiotropic. In an experiment, when the main shoot was placed horizontally in moist soil, it was shown that all the axillary buds emerging at the inhibition zone and at the lateral paracladia of the inflorescence are able to develop their own root system of thickened adventive roots, and separate from the mother shoot. Some forms of polyvariation described in

S. sisaroideum can be also found in other *Sium* species, and some could be assumed to be a hidden reserve of structural lability.

The revealed features of the life forms of studied species indicate that in amphibic conditions considerable lability in the structure of the vegetative organs and ontogenetic polyvariation, not typical for rather conservative architectural type of Apiaceae, appear. The one and the same species can obtain different life forms. Such polyvariation is rich material for the selection and evolution of new forms. Some of the observed features can be of practical importance when one distinguishes species in nature, as well as in systematics when one tries to find unique morphological features for plants from the “amphibious” tribe Oenantheae.

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The life forms of Apiaceae distributed in the Crimean Peninsula

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Key words: polycarpics, monocarpics, annuals, Crimea

The spectrum of life forms in Apiaceae, distributed in the Crimean Peninsula, were studied, based on: longevity, fruiting periodicity, the structure of shoot and root systems (according to the terms proposed in Petrova, 2015). We identified the following life-forms (in parentheses the number of species are indicated): short-rhizomatous perennial polycarpics with a tap root system (21); short-rhizomatous perennial polycarpics with a tap and adventitious roots (3); short-rhizomatous perennial polycarpics with adventitious roots (2, *Chaerophyllum aureum, Sanicula europaea*); long-rhizomatous perennial polycarpics (1, *Aegopodium podagraria*); bud-rooting substitutional vegetative short-lived polycarpics (4, *Oenanthe, Sium*); vegetative short-lived polycarpics with tuberous adventitious roots (3, *Oenanthe pimpinelloides*, *O. silaifolia*, *Sium sisaroideum*); stoloniferous (1, *Berula erecta*); soboliferous (surculose) (1, *Falcaria vulgaris*); (short rhizomatous) biannual-perennial mono-oligocarpics with a tap root (22); biannual-perennial monocarpics with a tuberous tap root (4, *Rumia crithmifolia, Trinia* species); polycarpics (1, *Bunium ferulaceum*) and biannual-perennial monocarpics (3, *Chaerophyllum bulbosum, Elaeosticta lutea, Smyrnium perfoliatum*) with a tuberous hypocotyl-stem; annuals-biennials with a tap root (35); short-rhizomatous subshrub (1, *Crithmum maritimum*), shrub with a tap root system (1, *Bupleurum fruticosum*). The majority of species have sympodial semirosette shoots, only some *Bupleurum* annuals have long ones. *Bupleurum fruticosum* has a system of long shoots that after fruiting become a part of the extensive perennial lignified shoot system; only several metamers with apical umbels die off each year. Above-ground shoots are di-polycyclic, orthotropic, rarely plagiotropic (*Berula erecta, Crithmum maritimum*). Among Crimean species, 76 are monocentric plants, 16 non-obvious polycentric and only 3 polycentric plants. The main strategy of spreading is seed propagation.

The life forms of Crimean Apiaceae depend on the habitat sets and specific climate of the region. The Crimean Peninsula is surrounded by sea and composed mostly by arid steppe and, in the southern areas where the climate resembles the Mediterranean one, by mountains and foothills. The influence of climatic factors is expressed in the large number of monocarpic plants (59 species), and especially annuals (37 species).

The ratio of geographical elements of Apiaceae revealed in our work illustrates the widespread opinion that the greatest influence on the formation of the flora of the Crimea is the Mediterranean region, Asia Minor and Caucasus. Among the studied taxa there are about 33 species with areas covering more or less the Mediterranean region, about 17 species with areas covering Southwest Asia and Asia Minor, 10 species belong to the Caucasus group and 6 species with a broad Euro-Asian distribution. So Apiaceae can be a quite suitable model for a better understanding of the florogenesis and the vegetation of the Crimea.

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Taxonomic and phytogeographic conspectus of Chinese Umbelliferae (Apiaceae)

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Key words: Apiaceae, carrot family, China, East Asia, systematics, taxonomy, phytogeography, endemic species, new combinations and synonyms, lectotypification

China shows the highest taxonomic diversity in the Umbelliferae at the specific level among all countries of the world. This country possesses 657 species and 44 infraspecific taxa (in 110 genera) of the family. The number of endemic species is also considerable – 355. The main center of diversity of the Umbelliferae is SW part of the country, with 357 species, including 126 endemic ones. This center includes Sichuan (277 species and 40 endemics), Yunnan (256 species and 43 endemics), and adjacent parts of Guizhou and Xizang A. R. The largest Umbelliferae genera in Chinese flora are *Angelica* (49 species), *Bupleurum* (47), *Pimpinella* (46), *Seseli* (39), *Hymenidium* (37), *Heracleum* (31), *Ferula* (27), *Pternopetalum* (21), and *Acronema* (21). There are 8 endemic genera of the family in China: *Sinolimprichtia, Cyclorhiza, Chaerophyllopsis, Harrysmithia, Sinodielsia, Dickinsia, Melanosciadium,* and *Changium.* Grounded on long-term examination of Chinese and especially foreign herbarium collections and available electronic resources, the checklist includes a new generic arrangement of many species, based on morphological and molecular analyses, revised synonymy, typification and distribution of species, with regard to Chinese provinces and autonomous regions. For 309 accepted specific and infraspecific names and synonyms, lectotypification had been proposed for the first time. Thirteen new nomenclatural combinations in the genera *Kitagawia* Pimenov, *Ligusticopsis* Leute, *Oreocomopsis* Pimenov & Kljuykov, *Seseli* L., and *Stenocoelium* Ledeb. have been proposed.

It is of interest to compare large Asiatic countries with high Umbelliferae biodiversity in average number of Umbelliferae species per genus. In China this ratio is the highest, near 6.0 (5.97), against Turkey with 4.38, Asiatic Russia (2.57), Kazakhstan (2.99), and India (3.02). These data could be interpreted as an indicator of the incomplete generic separation in China, a retension of traditional polymorphic genera. Indeed, some genera of Chinese Umbelliferae remain actually non monophyletic and critical (*Peucedanum*, *Ligusticum*, *Tongoloa*, *Sinocarum*, especially *Trachydium*, and so on).

For the full text of the conspectus, see Pimenov (2017).

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Progress in the knowledge of the *Daucus carota* specific complex in Corsica and description of new taxa

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Key words: Daucus carota, infraspecific taxonomy, Corsica flora

Previous work has shown that the *Daucus carota* specific complex in the southern part of France is organized into a succession of different homogeneous groups restricted to the seashore and a scattered occurrence of a distinct group of inland plants present in meadow, fallow land and roadsides, able to interbreed with the former ones. Since such a situation also exists across Corsica, diverse pluridisciplinary studies were made on the *Daucus carota* specific complex there, mainly on the adult plant and seedling morphologies, and the genetic diversity. The results, mainly based on adult morphology, allowed us to describe 5 new infraspecific taxa: subsp. *caporientalis*, subsp. *corsoccidentalis*, subsp. *fontanesii* var. *meriensis*, subsp. *otaportensis* and subsp. *valeriae*.

Flower structure and development in *Melanophylla* (Torricelliaceae): pseudomonomery, contort petal aestivation and implications for evolution of Apiales

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Key words: Torricelliaceae, flower development, flower anatomy, vasculature, symmetry, corolla, gynoecium

Species-poor families Pennantiaceae, Torricelliaceae and Griseliniaceae form a basal grade in molecular phylogenies of the order Apiales. The flowers in apparently all members of the three families share gynoecia with a single fertile ovule. These gynoecia are interpreted as pseudomonomerous, because of the occurrence of three (or up to five) carpels. Pseudomonomery is traditionally and plausibly viewed as a derived type of gynoecium morphology in angiosperms. Intriguingly, the maximum parsimony approach suggests that this condition may be plesiomorphic within Apiales. All speculations of this sort are hampered, however, by the absence of detailed observations on flower development in any of the early-divergent families of Apiales. In the present study, we are filling this gap with studies of the flower structure and development in one of three genera of Torricelliaceae, *Melanophylla* that is endemic to Madagascar. Fixed material of two species (*M. alnifolia* and *M. aucubifolia*) was collected by PVK, MSN and AAO in natural populations.

Each flower of *Melanophylla* is accompanied by a subtending bract and two bracteoles (these terms are used here for descriptive purposes only). The bracteoles are in an almost transversal position. They are initiated in a rapid sequence. In anthetic flowers, the first initiated bracteole (bracteole 1) is in a somewhat outer position to the succeeding bracteole (bracteole 2), that can be recognized by overlapping of its margins. Flowers possess 5 sepals, 5 petals, 5 stamens and 3 carpels. There is a sepal on the midline of bracteole 1 and a petal on the midline of bracteole 2. Petal aestivation is contort. Both left- and right-handed contortion can be found among flowers of the same synflorescence. The direction of petal contortion correlates with the arrangement of bracteoles 1 and 2. If bracteole 1 is on the left side and bracteole 2 on the right, then petal contortion is left. In the case of their reverse arrangement, the petal contortion is right. The anthers have a wide connective, so that their aestivation can also be recognized in the bud. The aestivation is usually contort. The direction of contortion is opposite to that of the corolla of the same flower. The gynoecium has a syncarpous inferior ovary and free stigmas. The ovary is trilocular. Only one of the three locules is fertile. It contains a pendent ovule attached at cross-zone. Sterile ovules are not found. The fertile carpel is on a radius of a petal and bracteole 2 (i.e. nearly transversal, either left or right). Stigmas are carinate, plicate, with a strand of pollen tube transmitting tissue on the ventral side. These strands unite to form a compitum in the symplicate zone. In *M. alnifolia,* each stigma has a dorsal vascular bundle. In our material of *M. aucubifolia*, the stigma of the fertile carpel has a single bundle whereas the stigmas of the sterile carpels each possess two dorsal bundles. Flower development was studied in *M. alnifolia.* During floral development, a nearly abaxial and a nearly adaxial sepal appear earlier than the three other sepals; they are the largest sepals during subsequent stages of calyx development. The two first formed sepals outlie the median plane; they are closer to bracteole 1. The calyx tube appears due to late congenital fusion. Petals appear simultaneously and very soon after the sepals. The floral apex becomes concave at the time of petal initiation, which could be interpreted as evidence for a weakly pronounced early sympetaly. The contort nature of the corolla is evident before its full closure. Stamens appear simultaneously, long before the closure of the corolla. The carpels appear after the closure of the corolla as three equal depressions at the floral apex. At the stage of young stigmas, one stigma is shorter than two others (only one flower was examined at this stage).

Our data support the view that pseudomonomery is a manifestation of carpel polymorphism that can be expressed at the level of ovary as well as at the level of stigma. Further comparative studies will reveal whether the occurrence of double bundles in two of the three stigmas of *Melanophylla aucubifolia* indicates the actual occurrence of five carpels. As can be expected in flowers with a monosymmetric gynoecium and morphological differentiation between carpels, organ number and position are precisely fixed in flowers of *Melanophylla*.

In contrast to earlier observations (Trifonova, 1998), our data indicate that the symmetry plane of the gynoecium is transversal with respect to the axil of the phyllome commonly interpreted as the flower-subtending bract. In this interpretation, the fertile locule of the gynoecium in non-median. This resembles the pseudomonomerous gynoecium of *Viburnum*, an early divergent member of Dipsacales (which is relatively close to Apiales). On the other hand, the flower of *Melanophylla* can be interpreted as occurring in the axil of bracteole 1. This hypothesis can be tested by studying the gynoecium orientation in flowers of *Aralidium* (Torricelliaceae). Flowers of *Aralidium* are arranged in dichasia. A dichasium develops in an axil of a subtending bract on the main inflorescence axis and bears a terminal flower with two bracteoles and two lateral flowers in the axils of each bracteole. Obviously, a flower of *Melanophylla* with a bract and two bracteoles is homologous to a dichasium in *Aralidium*. If the condition found in *Melanophylla* is derived from that in *Aralidium*, then the flower of *Melanophylla* can be homologous to either a central or a lateral flower in dichasia of *Aralidium*. We hypothesise that the orientation of pseudomonomerous gynoecia relative to the main inflorescence axis in dichasia is different in central and lateral flowers, and this character can be used for homology assessment of flowers of *Melanophylla*.

Our data on contort petal aestivation in *Melanophylla* is the first observation of this phenomenon in Apiales and apparently in the entire campanulid clade (Endress, 2012), which is one of the two major clades of asterids (APG IV, 2016). Endress (1999) concluded that in asterids with contort aestivation, handedness of flowers is fixed at specific and even higher taxonomic levels, whereas it is often labile at species level in rosids. *Melanophylla* with its labile handedness does not fit this pattern.

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Molecular phylogeny of the genus *Pleurospermum* (Apiaceae) inferred from four DNA regions

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Key words: Pleurospermum, Apiaceae, systematics, cladistic phylogeny, molecular phylogeny

The genus *Pleurospermum*, the core group of the tribe Smyrnieae, subfamily Apioideae, Apiaceae, includes about 50 species distributed mainly in north Asia and Eastern Europe, concentrated in the Himalayas and Hengduan mountains ranges. On the basis of extensive field observations, the data from the cladistic analysis based on morphologic characters, and the molecular phylogenetic analysis based on one nuclear sequence and three chloroplast regions, the evolutionary relationships in this genus are discussed and taxonomic suggestions on some taxa made.

Based on morphological traits, an identification key to the 25 species and 1 variety of *Pleurospermum* which were collected during field surveys, was compiled. A cladistic analysis of the genus *Pleurospermum* was carried out through surveying 16 morphologic characters and using UPGMA methods by SPSS16.0. The results showed that all species of *Pleurospermum* were divided into four clades.

The six candidates for constructing a phylogenetic tree include one nuclear sequence (ITS) and three chloroplast regions (*rbc*L, *mat*K and *trn*H-*psb*A). The results showed that the analysis for species discriminating ability to the 25 *Pleurospermum* samples revealed that the tree based on ITS has the highest power, and those based on *rbc*L, *mat*K, and *trn*H-*psb*A respectively are not good enough. The tree based on a combination of all the four regions is pretty ideal.

Considering the results of the cladistic analysis and the molecular phylogenetic analysis, the monophyly of *Pleurospermum* was strongly supported by the cladistic and the molecular data. 25 species of *Plerospermum* can be divided into 2 types and 6 clades: Clade A includes 10 species besides *P. benthamii* and *P. franchetianum*. The main character in these ten species is that their ribs are all sinuolate-winged. Clade B includes 4 species besides *P. nanum* and *P. nubigenum*. Their main characters are that they are dwarf and have the same kind of rays. Clade C includes 4 species besides *P. bicolor* and *P. amabile.* In Clade C, *P. angelicoides* and *P. longicarpum* are in the same branch. They are very similar morphologically to each other, only have different kinds of fruits. Clade D includes *P. yunnanense*, *P. giraldii*, *P. hookeri* and *P.hookeri var. haidongense*. Their main morphologic characters are that they are all dwarf (20–50 cm) and have sinuolate-winged ribs. Clade E includes *P. heracleifolium* and *P. hedinii.* Clade F includes *P. apiolens*, *P. rivulorum* and *P. pilosum.* Trees base on the morphologic characters and the molecular phylogenetic analysis respectively are approximately identical, but differ at some branches. We need further reseach and analysis to establish a reliable taxonomy system.

Secondary woodiness in umbellifer subfamily Apioideae: a preliminary survey

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Key words: secondary woodiness, Apiaceae subfamily Apioideae

Umbellifer subfamily Apioideae comprises ca. 3,000–4,000 species; the majority are herbaceous and only ca. 200 species are to some extent woody. In four clades woodiness is more common. These are (1) southern African and Malagasy tribe Heteromorpheae, (2) the *Lefebvrea* clade in tribe Tordylieae including African endemic genera *Notobubon*, *Nanobubon* and *Dasispermum*, (3) the Mesoamerican *Arracacia* clade in tribe Selineae including *Myrrhidendron*, *Arracacia*, *Coulterophytum*, *Enantiophylla*, *Neonelsonia*, *Prionosciadium*, *Mathiasella* and *Dahliaphyllum*, (4) *Bupleurum* (tribe Bupleureae) including some shrubs and subshrubs in the Mediterranean region and the Far East (although the herbaceous habit prevails in this clade). Other woody umbellifers include endemics of oceanic islands: *Monizia edulis* and *Melanoselinum decipiens* (tribe Scandiceae) from Madeira, two species of *Tornabenea* (tribe Scandiceae) from Cape Verde, *Angelica lignescens* (tribe Selineae) from the Azores, four species of *Pimpinella* (tribe Pimpinelleae) from the Canary Islands, and *Nirarathamnos asarifolius* (tribe Echinophoreae) from Socotra. Woody stems are also characteristic among the desert species of *Deverra* (tribe Apieae). A recent addition is *Xyloselinum* (tribe Selineae) with two species from Vietnam and Laos. Woody representatives of Apioideae therefore represent diverse clades of the phylogenetic tree and are distantly related: Heteromorpheae and Bupleureae represent early diverging lineages while the other tribes are placed in the crown of the tree.

Wood anatomy of *Aralia* L. (Araliaceae): systematic and ecological implications

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Key words: growth form, systematic, herbs, trees

Aralia (Araliaceae) comprises approximately 50–70 species, occurring mainly in the North Hemisphere. This genus shows considerable diversity of habits including trees, shrubs, perennial herbs, and also vines, semishrubs and epiphytes (Wen, 2011). We studied secondary xylem structure in 16 species of different habits representing all six sections of the genus, i.e. *Aralia* (*A. cordata* Thunb., *A. racemosa* L., large herbs with thick short rhizomes), *Dimorphanthus* [shrubs and treelets, *A. armata* (Wall. ex Don) Seem., *A. bipinnata* Blanco, *A. elata* (Miq.) Seem., *A. gintungensis* C.Y.Wu ex K.M.Feng, *A. searelliana* Dunn, *A. thomsonii* Seem. ex C.B.Clarke, *A. vietnamensis* Ha], *Humiles* (*A. humilis* Cav., shrub), *Nanae* (*A. nudicaulis* L., small herb with thin long branching rhizome), *Pentapanax* [shrubs or small trees, *A. gigantea* J.Wen and *A. leschenaultii* (DC.) J.Wen], and *Sciadodendron* [trees, *A. excelsa* (Griseb.) J.Wen, *A. soratensis* Marchal, *A. warmingiana* (Marchal) J.Wen].

Most of the studied species share simple perforation plates, alternative intervessel pits, very thin- to moderately thick-walled septate libriform fibres; scanty paratracheal axial parenchyma with 3–8 cells per strand; heterogenous rays with solitary sheath cells. The shortest vessel elements (average length 212–345 µm) are found in the sections *Nanae* and *Aralia* comprising perennial herbs whereas the longest ones (average length 827–1147 µm) occur in the trees belonging to section *Sciadodendron*. In other woody *Aralia* species, the average vessel element length ranges between 366–674 µm. Apart from the longest vessel elements, the section *Sciadodendron* is distinctive from other species examined by the presence or radial secretory canals. The rays in the members of this section are widest within woody *Aralia* (> 70 µm in width, up to 117 µm in *A. warmingiana*), but they are narrower than in rhizomes of herbaceous species from the section *Aralia*.

The rhizome wood of perennial herbs *A. cordata* and *A. racemosa*, the members of section *Aralia*, shows the alternation of tangential zones of pervasive axial parenchyma with zones composed mostly of libriform fibers, which are not clearly associated with indistinct growth rings. These species are also distinctive from others by the occurrence of scalariform intervessel pitting, and of wide rays (> 120 µm in width, up to 240 µm in *A. cordata*). Unlike them, the axial parenchyma in another perennial herb, *A. nudicaulis*, the only representative of the section *Nanae*, is not abundant. The rhizome of this species resembles the aboveground stems of shrubby members of *Aralia* (including that of its closest relative *A. humilis* from the section *Humiles*) in its wood structure. *Aralia nudicaulis* is distinctive, however, in having the shortest vessel elements and libriform fibers, the smallest vessel diameter and the narrowest rays amongst the species under study.

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A revision of *Lichtensteinia* (tribe Lichtensteinieae, Apiaceae)

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Key words: Umbelliferae, morphology, anatomy, diagnostic characters, geographical distributions

Lichtensteinia is one of the basally divergent genera of the protoapioids that was formerly associated with the subfamily Saniculoideae because of the large rib oil ducts and total absence of vittae (Tilney *et al.*, 2009). This anomalous and phylogenetically interesting genus belongs to the monotypic tribe Lichtensteinieae and is endemic to southern Africa (Van Wyk *et al.*, 2013). A formal taxonomic treatment is in the final stages of preparation. The following seven species are recognized: *L. crassijuga*, *L. globosa*, *L. interrupta*, *L. lacera*, *L. latifolia*, *L. obscura* and *L. trifida*. *Lichtensteinia kolbeana* is considered to be merely a summer rainfall form of *L. interrupta* and is included under the latter species.

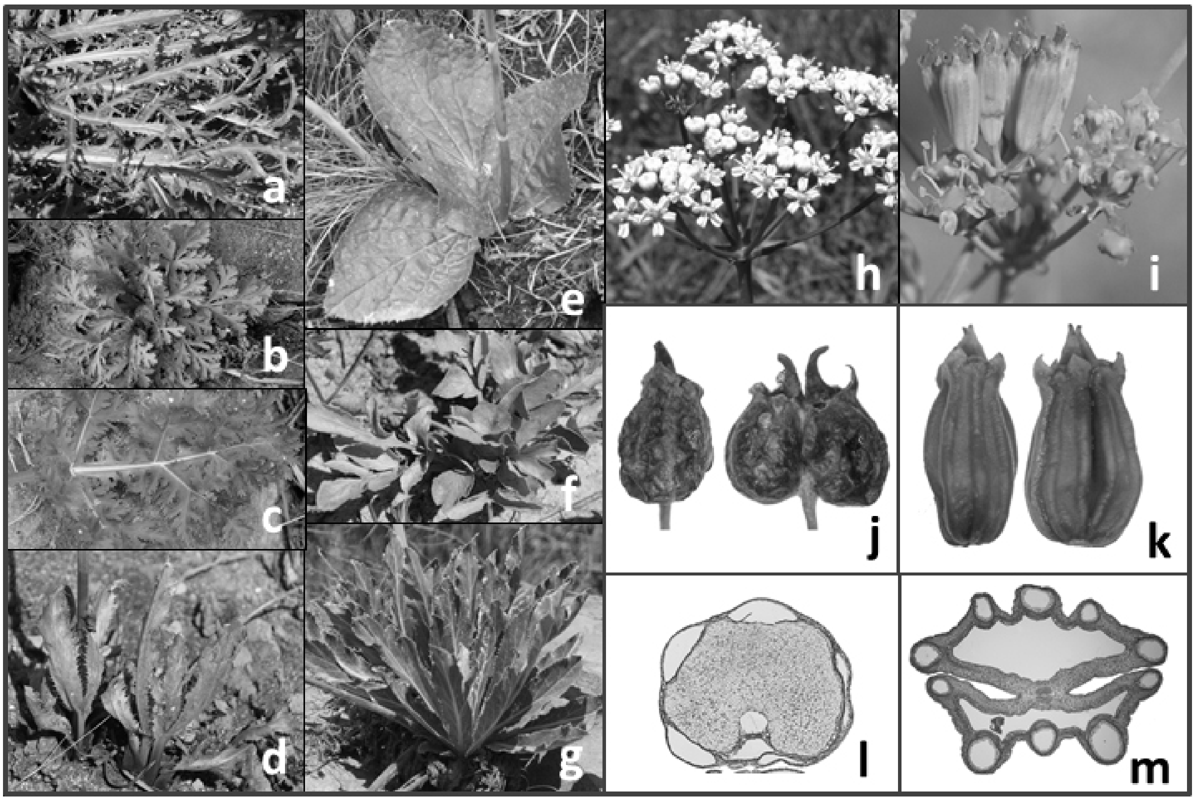

Fig. 1. *Lichtensteinia* species; leaves (a–g), flowers (h–i) and fruits (j–m): a, *L. crassijuga*; b, *L. globosa*; c, *L. interrupta*; d, *L. lacera*; e, *L. latifolia*; f, *L. obscura*; g, *L. trifida*; h, *L. interrupta*; i, *L. trifida*; j, *L. obscura*; k, *L. trifida*; l, *L. obscura*; m, *L. lacera*.

The size and shape of the leaves, together with the nature of their margins, were the main diagnostic characters used to distinguish between the species (Fig. 1). However, the delimitation of species is problematic because of considerable regional variation. A preliminary study of essential oil (Sobiyi, 2017) showed distinct discontinuities and indicated that a comprehensive chemosystematic study may yield useful results. Caryophyllene oxide, for example, appears to be the only compound shared by all three species studied; spathulenol is a major compound in *L. obscura* and *L. trifida* only; β-eudesmol is shared by *L. lacera* and *L. trifida* but appears to be absent from *L. obscura*.

Diagnostic characters are illustrated in Figure 1. *Lichtensteinia crassijuga* (Fig. 1a) can be distinguished by the lacerated leaves and sparsely serrate-dentate margins; *L. globosa* (Fig. 1b) by the small, deeply dissected leaves with marginal serrations often ending in setae, the white flowers and globose, warty fruits (Fig. 1j); *L. interrupta* (Fig. 1c) also has deeply dissected leaves but the marginal serrations lack setae and the fruits are devoid of protuberances; *L. lacera* (Fig. 1d) has coarsely dentate leaf margins with each tooth usually drawn out to form a long, hair-like tip; *L. latifolia* (Fig. 1e) is recognized by the multiple main veins of the leaves and the generally large, simple leaves; *L. obscura* (Fig. 1f) usually has broad leaf segments and yellow flowers but can sometimes be confused with small-leaved forms of the white-flowered *L. interrupta* (Fig. 1h); the latter usually has a larger number of rays per terminal umbel – more than 7); *L. trifida* (Fig. 1g) superficially often resembles *L. lacera* (it has similar yellow flowers, Fig. 1i and similar fruits, Fig. 1k) but the leaf marginal teeth are without setae. The genus can be divided into two groups – three species with ovoid fruits (Fig. j, l) comprising *L. globosa*, *L. interrupta* and *L. obscura,* and four species with oblong fruits (Fig. 1k, m), comprising *L. crassijuga*, *L. lacera*, *L. latifolia* and *L. trifida*.

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Cytotoxic activity of the root and fruit extracts of *Heptaptera anisoptera* (DC.) Tutin

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Key words: Colon cancer, Sesquiterpene coumarins, Apiaceae

The roots and fruits of *Heptaptera anisoptera* (Apiaceae) were collected in the vicinity of Kahramanmaraş in June 2013. Coarsely powdered roots and fruits of the plant were separately and sequentially extracted at room temperature with dichloromethane and methanol. The extracts were individually concentrated in a rotary evaporator under reduced pressure to dryness. Methanol extract was redissolved in a mixture of methanol/water (10:90) and then partitioned with ethyl acetate, the resulting extracts were separately concentrated *in vacuo* to dryness. Cytotoxic activities of the extracts were investigated. The dichloromethane extracts of the roots and fruits exhibited strong inhibitory activity on the colon cancer COLO205 and KM12 cell lines.

The dichloromethane extract of the roots of *H. anisoptera* showed cytotoxic activity with IC_{50} values of 3.1 and 3.9 µg/mL on the colon cancer COLO205 and KM12 cell lines, respectively. Whereas, the dichloromethane extract of the fruits showed cytotoxic activity with IC_{50} values of 5.5 and 4.8 µg/mL on the colon cancer COLO205 and KM12 cell lines, respectively.

Previously, several sesquiterpene coumarins were reported from the chloroform extract of the roots and fruits of *H. anisoptera* collected from the Diyarbakır province of Turkey (Appendino *et al.* 1992a, 1992b, 1993). Cytotoxic activity of certain sesquiterpene coumarins were described earlier (Nezari and Iranshahi, 2011), thus, the cytotoxic compound(s) of the roots and fruits of *H. anisoptera* collected from the vicinity of Kahramanmaraş may be this type of compound(s). Bioactivity guided fractionation of the dichloromethane extracts of the roots and fruits of *H. anisoptera* is planned to isolate and identify their cytotoxic principles. This is the first report on the cytotoxic activity of the roots and fruits of *H. anisoptera.*

Acknowledgements: We thank Dr. John Beutler, Molecular Targets Laboratory, CCR, NCI, Frederick, MD, U.S.A. for the cytotoxic activity testing.

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Potent colon cancer cell line toxicity of the root extracts of *Petroedmondia syriaca*

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Key words: Cytotoxic activity, Coumarins, Apiaceae

Petroedmondia syriaca (Boiss.) Tamamsch. (Apiaceae) is a recently described monotypic genus that has close relation to both genus *Heptaptera* and genus *Smyrniopsis* (Stevens, 1972; Rechinger, 1987). While genus *Heptaptera* is a rich source of sesquiterpenoid coumarins genus *Smyrniopsis* mainly yields furanocoumarin esters (Appendino *et al.*, 1992; Dzhafarov *et al.*, 1992). These compounds have important antibacterial, antiviral, antileishmanial, anti-inflammatory, P-glycoprotein inhibitory and cytotoxic activities (Nazari and Iranshahi, 2011).

The roots of *P. syriaca* were collected from Şanlıurfa province of Turkey in June 2013. Coarsely powdered roots of the plant were sequentially extracted with dichloromethane and methanol at room temperature. The extracts were separately concentrated in a rotary evaporator under reduced pressure to dryness. Methanol extract was redissolved in a mixture of methanol/water (10:90) and then partitioned with ethyl acetate, the resulting extracts were individually concentrated *in vacuo* to dryness. These extracts were subjected to the cytotoxic activity testing. The highest activity was found in the dichloromethane extract of the roots. The dichloromethane extract of the roots showed cytotoxic activity with IC_{50} values of 19.1 and 11.1 µg/mL on the colon cancer COLO205 and KM12 cell lines, respectively. Previously we have reported cytotoxic activity of the roots of *P. syriaca* on MCF-7 cell lines and compounds; scoparone, psoralen, bergapten, marmesin, marmesin acetate, smyrnioridin, 4'-acetyl-3'-isobutyroyloxymarmesin, deltoin, colladonin and 14-acetoxybadrakemin from the active dichloromethane extract (Tosun *et al.*, 2016). Cytotoxic activity testing of these compounds on MCF-7, COLO205 and KM12 cell lines are currently in progress. This is the first report on the cytotoxic activity of the roots of *P. syriaca* on the colon cancer COLO205 and KM12 cell lines.

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Fruit micromorphology in the Apiaceae: study on the example of Russian Far East flora

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Key words: Umbelliferae, taxonomy, identification, morphology

Fruit micromorphological studies in the Umbellifrae cover mostly Europe, North and South Africa, Turkey, Caucasus. There are few publications on East Asia. We studied fruit micromorphology of almost all the species of Russia and present an analysis of species of Russian Far East (Amur, Magadan, Sakhalin regions, Khabarovsk, Primorye and Kamchatka territories and Chukotka Autonomous Okrug). There are 65 native Umbelliferae species here. We compiled a dictionary for characters and character states for the Umbelliferous fruits (Ostroumova *et al*., 2011). Basic points for description of SEM images were published by Barthlot (1981), for cuticular foldings we used, if possible, palynological terminology (Hesse *et al.*, 2009).

Some species have pubescent fruits. Hairs are either thin-walled an smooth (*Heracleum, Glehnia*) or thick-walled with rugulate and tuberculate surface (*Anthriscus, Kitagawia, Magadania, Pachypleurum, Phlojodicarpus, Seseli*). In *Anthriscus sylvestris* and *Magadania olaensis* hairs have multicellular base. The whole spectrum of hair size from tiny sharp projections to usual hairs 50–100 µm long are present in some species of *Magadania, Pachypleurum, Phlojodicarpus, Seseli*. Zoochoric fruits of *Sanicula* and *Torilis* are covered with multicellular hooked emergences.

Cell borders are often inconspicuous. If visible, cells are arranged in rows or at random, cell borders are raised or sunken and always straight in species under discussion. Outer periclinal walls are concave, flat, convex domed, with small papilla, with sharp or blunt projection. In *Glehnia, Halosciastrum, Ligusticum, Magadania, Ostericum, Pleurospermum, Tilingia* exocarp cells are large, >30 µm. Conspicuous, solid, convex exocarp cells are atrribute of some genera: *Ostericum, Pleurospermum, Tilingia* and also *Aulacospermum*, *Taeniopetalum* and *Hansenia* (incl. *Nothopterygium*) from other regions. Cuticular foldings often correlate with wall shape: flat of concave walls are striate, convex walls are rugulate, sharp projections are striato-knotted. On *Anthriscus sylvestris* friuts (also in *Scandix* and *Geocaryum* from another regions) cell borders are indistinct and there are rows of semispherical projections. It was noted (e.g. Yurtseva, 2007) that one cell can have several projections and that projections can stand on cell borders and in the middle of a cell.

Epicuticular secretions (“wax”) is often absent and cuticulas sculpture is clearly visible. Wax layer sometimes masks cuticula. In many *Bupleurum* species and in *Glehnia* wax has the form of tiny scales. Organic solvents and hot water removes the wax from *Bupleurum* fruits and some other species, but we could not remove the wax from *Anthriscus sylvestris* mericarps. Wax structure depends probably on its chemical composition.

SEM images give an opportunity to interpret our observation with a light stereomicroscope and find new data for plant identification and taxonomic work.

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Endemic species of *Semenovia* (Umbelliferae-Apioideae) from northern Pamir-Alay: a taxonomic revision based on morphological and molecular data

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Key words: Kyrgyzstan, Tadzhikistan, Tordylieae, distribution ranges, rare species

The genus *Semenovia* includes about 30 species distributed only in Asia (from Iran in the west to China in the east). The center of genus diversity is situated in the mountains of Middle Asia (Ukrainskaja, 2011; Ukrainskaja *et al*., 2013). Fifteen species of *Semenovia* can be observed in the Pamir-Alay mountain system. Among them, *S. dasycarpa*, is widely distributed in Middle Asia mountains whereas three species, *S. zaprjagaevii*, *S. alaica* and *S. vaginata*, can be found in Kyrgyzstan and Tadzhikistan on the Alay and Turkestan mountain ridges in the Northern Pamir-Alay. The ranges of two endemic species, *S. zaprjagaevii* and *S. alaica*, are represented by a few isolated populations. As for *S. vaginata*, only samples from its typical location can be considered, based on the incomplete herbarium material collected at an early flowering stage. All these species are very similar in their habits and leaf dissection. In addition, the distribution ranges of these species overlap, making them difficult to distinguish. The objective of our study was a detailed revision of *Semenovia* species in the Northern Pamir-Alay using morphological and molecular methods.

A comparative anatomical, morphological and molecular study of three critical species of *Semenovia* (*S. alaica*, *S.vaginata* and *S. zaprjagaevii*), distributed in the Northern Pamir-Alay in Kyrgyzstan and Tadzhikistan, was carried out. Herbarium samples from LE, MW, TAK, TAD, FRU and material collected in nature were used in this study. For molecular-phylogenetic analysis, ITS sequences of four species from the database GenBank were included in the analysis. DNA isolation and amplification along with sequencing of the nrDNA area (ITS 1,2) were performed in accordance with the technique described by Valiejo-Roman *et al*. (2006). All ITS sequences of the analyzed species were aligned using the program MUSCLE (Edgar, 2004). Scanning of the results of nucleotide sequence aligning and the subsequent manual processing were performed in the program BioEdit version 5.0.9 (Hall, 1999). A set from 18 aligned ITS 1,2 nrDNA sequences contains 438 positions, 345 of which are conservative, 43 parsimonious-informative and 50 parsimonious-non-informative. Molecular-phylogenetic trees were built with ITS sequences using two methods, including that of Mr. Bayes 3.1 (Ronquist and Huelsenbeck, 2003) and that of maximum saving of PAUP* 4.0b8 (Swofford, 2003). The obtained variants of tree topology are not identical, but congruous in main joints. When launching Markov chains, 100,000 generations were set, the number of simultaneously generated chains being 4. In the obtained molecular trees, samples of critical species of the genus *Semenovia* (*S. alaica* and *S.vaginata*) form two well-supported subclades (A and B) in clade I, with *S. zaprjagaevii* forming a separate, well supported clade II. It confirms the independence of species *S. alaica*, *S. vaginata* and *S. zaprjagaevii*.

Pair comparison of nrDNA ITS-sequences of the species belonging to subclade “B” demonstrated that the species are close to each other and have a rather low level of divergence of sequences (0.05%). The obtained data suggest that 4 samples (*Semenovia* sp. 96 - Kyrgyzstan, Osh Region, the northern slope of the Turkestan Range, suburbs of settlement Andigen, Sary-Yaz hole, July 15, 1969, № 1183a, Pimenov, Boryayev; *Semenovia* sp. 99 - Kyrgyzstan, the northern slope of the Turkestan Range, the Andigen River , Sary-Yaz hole, September 08, 2016, №5-15, Klujkov, Ukrainskaya; *Semenovia* sp. *49* - Kyrgyzstan, the Turkestan Range, 70 km western from settlement Lyailyak, September 25, 2011, Lazkov; *Pastinacopsis* sp. - Tadzhikistan, the southern macroslope of the Alay Range, valley of the Kyzyl-Emme River, basin of the Kyzyl-Su, August 12, 1981, Ikonnikov, Ladygina) with indistinct morphological features can be referred to *S. alaica* (isotype) that in this clade is a reference species. After inclusion of these samples in this species, its distribution range extends southwards and westwards.

Subclade "A" includes *S. vaginata* (type), sample *S.bucharica* as well as two samples earlier determined as *Seseli tragioides*. A sample of *Seseli tragioide*s 845 (Tadzhikistan, the southern slope of the Zarafshan Range, basin of the Sarbog River, Gazny hole, August 22, 1966, № 4129, Strizhova) is characterized with a sequence identical to that of *S. vaginata* (type), and sample 822 (type of *Seseli tragioides*: Tadzhikistan, the Karategin Range, Valley of the Komarou River, July 03, 1988, № 244, Pimenov *et al*.) has a sequence identical to that of *S.bucharica*. This suggests that subclade "A" includes two separate species, *S. vaginata and S. bucharica. Seseli tragioide*s is considered synonymous to *S.bucharica*. With the inclusion of the samples into these species, the distribution area of *S. vaginata* is extended southwards and the species is known from two locations; the area of *S.bucharica* has expanded north-eastwards. All samples of clade II taken from different places are represented by the species *S. zaprjagaevii* and have identical nucleotide sequences. A comparison of ITS sequences of clade II and clade I samples revealed some group-specific (synapomorphic) changes (three changes T→C, one change C→T and one change A→T) marking species of clade II, which confirms its distinct isolation. The obtained molecular-phylogenetic data correlate well with those of anatomical-morphological studies of critical species of the genus *Semenovia.*

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The early radiation of the Asian Palmate group (Araliaceae) as inferred from phylogenomic data

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Key words: Paleocene deep radiation, SE Asian generic diversification, temperate vs. tropical lineages, Eastern Asia - Western North America disjunction

The Asian Palmate group is one of the main clades of the Araliaceae. It gathers more than 75% of the diversity of the family with 21 generic-lineages and nearly 1,500 species. The diversity center of the group has been located in SE Asia, with 19 generic lineages occurring in Asia (13 in SE Asia) plus three in the neotropics. Phylogenetic studies have failed to reconstruct a fully resolved and well-supported tree for the backbone of the group (Wen *et al.*, 2001; Plunkett *et al.,* 2004; Mitchel *et al.*, 2012; Valcárcel *et al.*, 2014; Li and Wen, 2016). This lack of resolution has been attributed to an ancient rapid radiation combined with multiple events of inter-lineages hybridization (Valcárcel *et al.*, 2014). However, the first phylogenomic approach conducted in the group (5 taxa, Li *et al.*, 2013) provided a well-resolved tree suggesting the analysis of the whole plastid genome might help disentangling its evolutionary history. In this study we analyzed the complete plastomes of 29 species of Araliaceae (17 plastomes newly sequenced). Representatives of all the generic lineages of the Asian Palmate group except for *Sinopanax* were included to test whether the lack of resolution at the base of the tree is a methodological artifact or the evolutionary footprint of a true radiation. The final goal is to disentangle early evolutionary history that led to the divergence of the main generic lineages of the Asian Palmate group. The analysis of the plastomes helps clarify the early steps in the evolution of the group and provide high support for the basalmost placement of the small eastern Asian – Northwestern North American disjunct genus *Oplopanax*. The *Tetrapanax*-*Heteropanax*-Asian *Schefflera* clade as sister to the rest of the Asian Palmate group (Asian Palmate core). However, low resolution is obtained for the backbone of the Asian Palmate core due to the scarcity of informative characters. This low resolution at the base of the core is coupled to the occurrence of short branches adjacent to long external branches. This phylogenetic signal points to a typical scenario of ancient radiation. Our biogeographic and divergence age analyses set the origin of the Asian Palmate group in Asia during the Paleocene - late Cretaceous. Interestingly, the colonization of the Americas seems to have occurred before the Paleocene/Eocene transition due to the placement of the New World *Schefflera* clade within the Asian Palmate core (as already reported in Li and Wen, 2016), as sister to a large diverse clade of at least 13 genera. This relationship represents an interesting case of old trans-Beringian migration.

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Chemosystematic studies of African Apiaceae (Umbelliferae)

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Key words: chemotaxonomy, essential oils, coumarins, phenylpropanoids, organic acids

In recent years, molecular systematic studies have clarified the relationships amongst almost all African Apiaceae (Magee *et al.*, 2011; Van Wyk *et al.*, 2013). Several genera have remained poorly known and provided a new perspective on the relationships amongst basally divergent lineages (the so-called protoapioids) of the subfamily Apioideae. As a result, a modified classification system has been proposed, including a new circumscription of the subfamily Apioideae (now including the Saniculoideae as a tribe, the Saniculeae) and several new tribes of protoapioids. The clarification of relationships and the new tribal circumscriptions provide new opportunities to explore chemical patterns and to reinterpret available evidence (Sobiyi, 2017). Asiaticoside and other triterpenoids, as well as dicaffeoylquinic acids are common in *Centella* species and appear to be chemosystematic markers for subfamily Mackinlayoideae. Diterpenes seem to be of diagnostic value for the subfamily Azorelloideae. The presence of diterpenes (*cis*- and *trans*-communic acid) in *Hermas* is therefore of interest, as it is the only African genus associated with the Azorelloideae. The subfamily Apioideae is chemically diverse but comparative data are still lacking. Most genera produce essential oil but the pattern is conservative (Sobiyi *et al.*, 2017), with no clear discontinuities at tribal level. The occurrence of phenylpropanoids and coumarins, however, seems to be worthy of further detailed studies. Of special interest is the fact that all members of the tribe Annesorhizeae thus far studied had high levels of dillapiole and other phenylpropanoids. Coumarins are absent, suggesting that the ability to synthesize phototoxic coumarins evolved later (amongst euapioids, such as the tribe Tordylieae). Phenolic acids (e.g. rosmarinic acid) seem to be chemical markers for the tribe Saniculeae. A rigorous comparative study, using standardised methods of extraction and analysis, will be necessary to record the presence or absence of selected classes of compounds and to reinterpret the overall pattern of secondary metabolites in the family.

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The study on variations under species and systematic evolution of *Cryptotaenia japonica* (Apiaceae)

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Key words: *Cryptotaenia japonica*, variations under species, leaf architecture, ddRAD, populations

There are 5–8 species through the world in genus *Cryptotaenia*. *Cryptotaenia japonica* Hassk. (Apiaceae) is one of the two intercontinental distribution species in North America and eastern Asia, which have analogous distribution pattern. It is the exceptional member of a small genus native to eastern Asia including China. Although, *C. japonica* Hassk. has been reported that it has reputed applied value, the others are lack of reported. It is a geographical ecoytpe with much morphological variations.The taxonomic case is unclear because of differences in taxonomic treatment between *C. japonica* Hassk. and its variations, which is the appropriate material to study intercontinental distribution and taxonomy and systematic evolution in Apiaceae. It is significant important between the evolution under species and the sustainable utilization of resources by gaining a clear idea of the problems.

Through the research, the fractal dimension, rectangularity, leaf type coefficient and vertical and horizontal axis ratio of the leaf profile were rich in populations, In the leaf shape, the leaf fractal dimension value is closer to some extent, but it is different from the deep-rooted. The linear correlation between the squareness and the coefficient of leaf shape is consistent with the distribution of the two parameters in the tested materials. The clustering analysis of fractal dimension values showed that, according to the zigzag and leaf petiole of the leaf edge (the degree of leaf self-similarity) clustered into three types: high, middle and low fractal dimension, The fractal dimension was close to the populations, which indicated that *C. canadensis* (L.) DC. had a closer leaf shape than the deep-rooted. There was a negative correlation between the fractal dimension of the leaf profile and the longitude and latitude. There was a negative correlation between the leaf rectangularity and the leaf type coefficient between latitude and longitude. There was a negative correlation between leaf aspect ratio and longitude, and there was a positive correlation between altitude and leaf area.

A simplified genome sequencing technique was performed, and an average of 3,881,709 reads were obtained for each germplasm resource. And 8,526,656 Tag tags were obtained. A total of 1,293,180 ddRAD markers were obtained, and a total of 53,222 SNPs were detected. Based on the SNP results, 158 samples were analyzed for genetic composition and structure, and evolutionary analysis was performed to obtain the PCA bitmap, population structure analysis and evolution analysis. *Cryptotaenia japonica* was divided into two major clades, and the cluster analysis showed that they could be further divided into 15 clades.

Fruits of *Pittosporum* and related genera (Pittosporaceae) in relation to their dispersal

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Key words: Auranticarpa, Hymenosporum, fruit anatomy, secretory canals, phragmocarpous gynoecium

The position of Pittosporaceae in the order Apiales (Plunkett *et al*., 2004) is not in complete accordance with morphological data and therefore, studies of this taxon are of utmost importance. Thus, fruits of Pittosporaceae in general and the genus *Pittosporum* in particular are superior, deriving from paracarpous (in some cases, secondarily syncarpous or phragmocarpous) gynoecium, while in the vast majority of Apiales the fruits are inferior, derived from syncarpous gynoecium (Konstantinova and Nilova, 2014). Pittosporaceae are known for completely different pericarp histology of their usually dehiscent (but not cremocarp-type, as in other Apiales) fruits. Our investigation is focused on the comparison of morphological and anatomical traits of fruits in 8 species of *Pittosporum*, *Auranticarpa rhombifolia* and *Hymenosporum flavum*.

Pittosporum fruits are fleshy loculicidal capsules, derived from superior 2–3- (rarely 5-) carpellate paracarpous (phragmocarpous in *P. angustifolium*) gynoecium and dehiscent by longitudinal grooves, very well seen from the outside, at maturity. Well-developed placentae (as many as carpels) deeply invaginate into the only (two in *P. angustifolium*) locule bearing large seeds. Since, differently from all other Apiales, the fruits of Pittosporaceae are dehiscent, the seed coat in studied *Pittosporum* species is much better developed, multi-layered and usually well-differentiated. The seeds are submerged into resin-like substance, freely excreting from a cut fruit, and possibly serving to protect from bacterial or fungal infections. Probably, this substance also prevents the seeds with underdeveloped embryo (Cayzer *et al.*, 2000) which are unable to germinate, from prematurely falling off the already dehiscent fruit, thus being constantly pecked on by birds and therefore dispersed for longer distances. Even though sclereids in the pericarp are not common in Apiales (excluding *Delarbrea*), in *Pittosporum* they serve to provide physical strength and are found extensively throughout the outer fruit part. The pyrene, composed of fibers and surrounding the seed cavity, developed in other Apiales to a certain extent, is missing in *Pittosporum*. The inner part of the pericarp lacks vascular bundles and secretory canals and consists of peculiar homogenous non-lignified parenchyma. Vascular bundles mostly form a single circle, with the deepest position near the placentae (*P. undulatum*); the canals may occur both separately from or in association with the bundles; they possess well-developed multi-layered lining.

Anatomically, fruits of *P. angustifolium* and *P. multiflorum* show the greatest deviation from the typical paracarpous fruit, found in most species studied. *P. angustifolium* is known to have a dimeric fruit based on phragmocarpous gynoecium; it resembles other *Pittosporum* species by the sclereid location pattern, complete lack of lignifications in the outer pericarp layers, etc. *P. multiflorum* had earlier been placed in the genus *Citriobatus* and was included in *Pittosporum* not so long ago (Cayzer *at al.*, 2000). Thin pericarp of this species appears to have sclereids of different type and location; its mesocarp cells are also different and pronounced placentae and dehiscence lines are absent.

A closely related genus *Auranticarpa* (6 species), with the type *A. rhombifolia*, which previously was treated as *Pittosporum rhombifolium*, has fleshy phragmocarpous capsules with 2 unequal locules and large solitary seeds in them. The overall pericarp histology pattern is similar to that of *Pittosporum*, yet the mesocarpic canals in *Auranticarpa* are larger and more numerous, moreover, they are closely associated with the vascular bundles (contrary to many *Pittosporum* species). Mature fruits of *A. rhombifolia* also lack the sticky resin-like substance in the locules.

As earlier investigators pointed out, the genus *Hymenosporum* is rather isolated within the family (Nilova and Oskolski, 2010) demonstrating more resemblance to *Auranticarpa* than to *Pittosporum* (Cayzer *et al*., 2000), and this is reflected in the fruit anatomy. Thus, fruits of *Hymenosporum* can also be called “fleshy phragmocarpous capsules” (lacking pericarp lignification), but, unlike those of *Auranticarpa*, they possess multiple stacked seeds, winged and adapted to anemochory. Vestigial seeds have also been recorded. Pericarp secretory canals are found to be definitely associated with vascular bundles which is a common trait in *Auranticarpa*, but does not occur in most *Pittosporum* species studied by us. The overall structural pattern of *Hymenosporum* is quite similar to that of *Auranticarpa*, too, e.g., the dehiscence fissure, running through both locules and the false septum of the phragmocarpous gynoeceum/fruit, is very well seen. Due to phragmocarpous gynoecium, the placentation in *Auranticarpa* and *Hymenosporum* should better be treated as modified parietal one (typical for the phragmocarpous gynoecium) and not the truly axillary, as Cayzer *at al.* (2000) defined it. No resin-like substance was found and its presence would have lacked any feasible explanation in this case of obvious anemochory. One more trait of resemblance of *Auranticarpa* and *Hymenosporum* was noticed for the first time (Konstantinova, original data) – complete embedding of abortive ovules and their long funicles into the ovary (subsequently – the fruit) wall, with tissues of the commissural zone of the pericarp growing over them.

Thus, our study has demonstrated the overall resemblance of various *Pittosporum* species in terms of fruit anatomy, excluding the set-apart *P. angustifolium* and *P. multiflorum*. Anatomical resemblance of *A. rhombifolia* and *H. flavum* has also been shown while these species do differ since they are adapted to different dispersal agents (presumably endo- and epiornithochory in *A. rhombifolia* and anemochory in *H. flavum*).

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Comparative analysis on the micromorphological characteristics of leaf and fruit epidermis of *Ostericum* (Apiaceae)

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Key words: epidermis, micromorphology, *Ostericum*, SEM, waxy ornamentations

According to molecular and morphological studies, *Ostericum* Hoffm., a small genus in Apiaceae subfamily Apioideae, showed a relatively complete intrageneric variation and prominent interspecific differences (Vasil'eva and Pimenov, 1991; Qin *et al*., 1995; Pan *et al*., 1997; She *et al*. 1997; Xue *et al*., 2007; Liao *et al*., 2012). Recently, micromorphological characteristics have been concerned as an important reference for the taxonomy of Apiaceae, especially these of fruit surface (Özcan, 2004; Pu and Liu, 2006, 2008; Deng *et al*., 2009; Gao *et al*., 2011; Ma *et al*., 2010; Liao *et al*., 2015). In this study, the morphological characteristics of leaf and fruit epidermis of 8 species and 2 variants of *Ostericum* were investigated and compared, focusing on their diversity and correlation at different levels. **The result suggested that the leaf adaxial epidermis exhibited rich micromorphological characteristics and a low correlation with fruit micromorphologies.** Despite the homologue of leaf and fruit epidermis cells, the visibility, the shapes and sizes of them seemed not to be correlated for each species respectively. For example, the outlines of fruit epidermis cells of all species were visible, yet those of leaf epidermis cells of some species were unclear and covered or disturbed by thick and complicated ornamentations. Also the shapes and sizes of the epidermis cells of leaf and fruit varied greatly, for instance, the leaf and fruit epidermis cells of *O. citriodorum* and *O.viridiflorum* were in polygon shape, while for *O. maximowiczii* they were irregular and rectangle shaped respectively. The average square of visible cells of leaf adaxial epidermis was similar for most species (1700–2500 μm^2), whereas the average square of fruit epidermis cells was little smaller than leaf cells for most species except for *O. citriodorum*. The primary waxy ornamentations of leaf epidermis were usually lineate and sparsely or densely arranged, also indicating a low relationship with fruit epidermis ornamentations. For epidermis accessory structures, granular appendages could be found on both leaf and fruit surface, however, filiform appendages appeared more common on fruit, but they were quite rare on leaf epidermis. Totally, the leaf adaxial epidermis provided rarious information compared with fuirt micromorphologies and could be considered as new complement to taxomic and evolutionary research probably.

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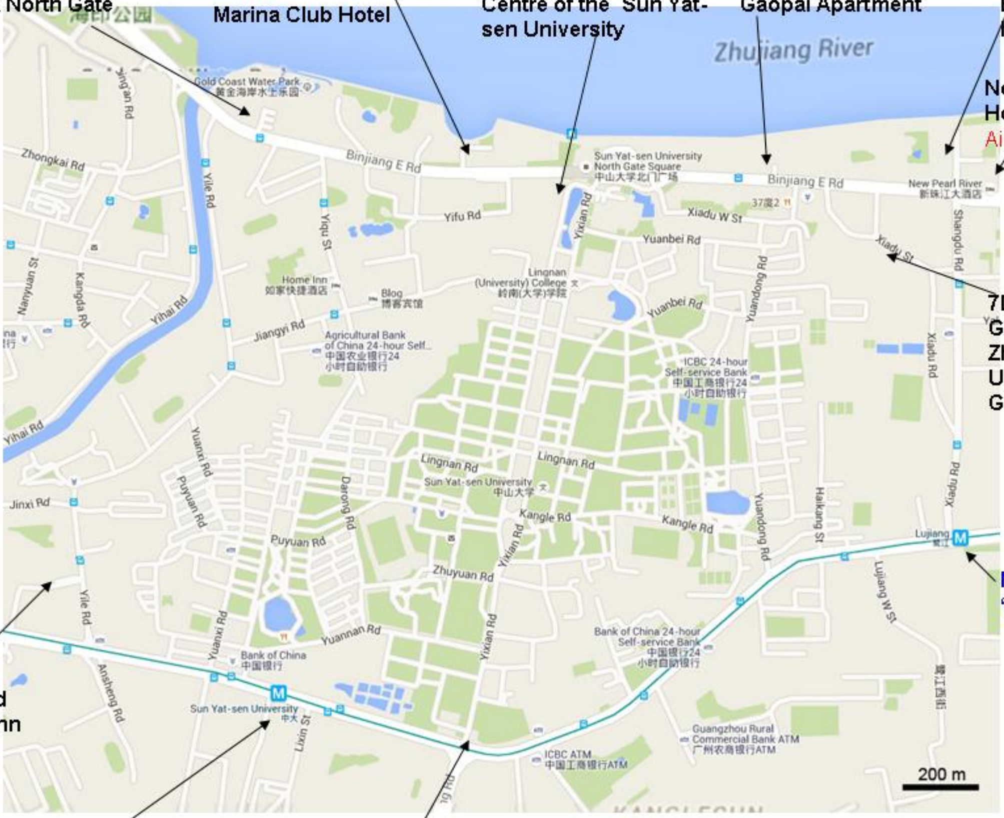

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