UDK 581.144.1

LEAF STRUCTURE OF HERBACEOUS PLANTS, CULTIVARS OF APIOIDEAE DRUDE SUBFAMILY (APIACEAE LINDL.) AS STUDY CASES.

Sergey Yuryevich Naumov

Lugansk National Agricultural University,
91008, the city of Lugansk, LNAU, campus
mr_sun@ramler.ru

Introduction

Leaves are classified into simple and compound. If a leaf contains ony one plate, it is considered simple one. But another situation if one footstalk with common bottom has got several separate plates, sometimes even with own footstalk, this leaf is compound. Development of compound leaf resembles branching in one surface, that can get the second-third order; in this way leaves generate twice and thrice, many times and etc. (4, 11, 21, 28 and etc.). A. Takhtadzhyan notes that in comparison with compound leaf a simple is never divided into separate sharply marked segments, so-called leaflets [3]. Leaflets of typical compound leaves are supplied with joints, that is why such leaves don`t fall whole [16]. This characteristic of compound leaves is typical for arboreal and shruby plants, concerning herbaceous – only some families, among them *Fabaceae* Lindl, possess it [13, 16, 29]. But in some families of herbaceous plants there are leaves that difficult to classify for sure – simple or compound as they are not characterized with separate leaflet fall. Leaves of majority cultivars from *Apioideae* family are in this categoty, as even after total dying they hold on the stem. Publishing materials don`t express common opinion concerning their structure. Most authors tend to consider leaves of this subfamily specimens as simple with various degree of segmentation [14-17, 22], others don`t have any clear point of view and that` why moreoften contradict oneself [1], but there are specialists that consider them compound [10, 23, 26]. In this way purpose of our study was to identify type of leaves based on findings concerning some specimens of Apioideae subfamily.

Objects and methods of the research

Study objects were cultivars of *Apioideae Drude* subfamily. Seeds of *Levisticum officinale* Koch. From All-Russian Institute of plant growing named after N.I. Vavilov, seeds of some cultivated crops belonging to *Apium graveolens* L., *Daucus sativus* (Hoffm.) Roehl., *Foeniculum vulgare* Mill., *Petroselinum crispum* (Mill.) A.W. Hill. were bought. Wild-growing cultivars of *Bupleurum rotundifolium* L., *Conium maculatum* L., *Daucus carota* L. were yielded during botanical expeditions on south-east of Ukraine. On the territory of Nikita Botanica Gardens (NBG), the Crimea, *Bupleurum asperuloides* Heldr., *Bupleurum fruticosum* L. were yielded and investigated. Plants of *Bupleurum woronowii* Manden. were collected during expedition along Chatyr-Dag mountain.

Plant cultivation was conducted either in laboratory of photoculture, or under field conditions. All these plants were regularly observed during their biocycle. Morphological leaf peculiarities of cultivars from *Apiaceae* family and some other herbaceous plants were studied using green and herbarium material. Photography and computer technology were applied to get leaf pictures. But to illustrate this research the author used original photos, processed with Adobe Photoshope, Corel Draw.

Anatomical organization of footstalks was investigated using cross sections. Rosette leaves of virginal specimens were in use. Cross sections of 5-8 multiple repeatability were made in the middle of footstalk of developed leaves, as this very part has got the most constant structure [15]. Material was fixed in Karnua mixture. Serial microtome cross section 10-12 mkm were made applying agreeable method. Section color was created by Erich hematoxylin with tincturing of gentian violet or methylene blue [27]. Footstalk and petiolule structure was investigated applying microscope MBI-3, microphotos were successfully made by camera Olympus SP350 [9].

Results and discussions

Study and classification of any organs or organisms must be implemented if developed completely. It concerns leaves either.

Applying of morphological methods only can`t get definite answers in the field of leaf development study, classification into simple or compound, as on early development stages of simple divided and compound leaves their ontogenesis has similar characteristics due to cell proliferation of costal and intercostal tissue [11, 13, 23, 25, 26]. Recent years intensive investigations of model plants favored to identify certain number of genes, that control growth and development of plants. As a result we found out that compound leaves appear out of developing simple, first-class induction KNOTTED-like genes (KNOXI, as well as genes ARP, FLO, PHAN) [20, 21, 24]. These genes were revealed in *Solanum lycopersicum* L., and they are so active that cause higher division of compound leaves [24]. They were found within specimens of *Apioideae* either and in particular *Pimpinella anisum* L. and *Daucus carota* L. At the same time leaves of *Pimpinella anisum* are classified as simple, developed out of compound primordial; that fact points that other cultivars of *Pimpinella* genus like majority of *Apiaceae* specimens, have got highly divided leaves. That is authors suppose that simple leaves of *Pimpinella anisum* have got repeated origin in spite of compound primordial [19]. Perhaps, they didn`t allow for fact of heterophilia what is typical for anisum and other subspecies of *Apioideae* family. Before we determined that during ontogenesis of *Pimpinella anisum* simple leaves appear first that turn into odd-pinnate compound leaves with 9 leaflets [12].

Different methods (physiognomic, structural, rhythmological, anatomic) in analysis of leaf structure typical for representatives of *Apiaceae* family revealed that study cultivars, belonging to Apioideae subfamily have got majority of leaves, developed in terms of ontogenesis, possess all morphological characteristics of compound leaves. *Bupleurum* genus is exclusion, as leaf ontogenesis is an open case study because this taxon of species has got leaves with both venation netted and parallel. Leaves of most *Apioideae* cultivars bear more than two leaf plates, fixed to rhachis by pronounced petiolule that helps leaflets locate in different surfaces towards light. Rhachises as petiolutes of lateral leaves keep typical structure inherent in footstalk of different cultivars – some of them are rounded others – chanelled. But none of them has got stripes of leaf plates, that`s why we cannot call lateral leaflets as segments of simple leaf. Besides leaf footstalks, petiolules and rhachises of study cases from *Apioideae* family are composed of three types of tissue: integumentary, main and connective; connecting bundles are separated from each other by layers of the main parenchyma (like initial stem structure of some herbaceous plants [18]); notable for radial symmetry, they can be considered as axial structures.

Majority of study cases, as mentioned before, compound leaves development resembles branching, beginning with separation in footstalk and rhachis of connecting bundles and approaching the second-forth order; in this way morphological structure of branching nodes is similar to branching nodes of leaves, obviously compound, branching nodes of tricompound leaves *Melilotus albus* Medik.

In general petioputes have the same structure as footstalks. In particular, *Conium maculatum* has got large petiolules of the first and second orders with the central space what is non-typical for either leaf plate or its central vein, but characterizes petioputes. Space in rhachis and peoputes becomes smaller and turns into white friable parenchymal tissue as reaching the leaf top. Such characteristics of node, footstalks, rhachises and petiolules structures were marked almost for all study case from *Apioideae* subfamily [5, 7, 8].

Representatives of Apioideae subfamily quite often have such a phenomena as dying of leaflets on compound leaves without any damage signs. Leaflets didn`t fall, held on till the very leaf dying. It was fixed for *Apium graveolens, Conium maculatum, Daucus carota, Peucedanum ruthenicum* and others.

Non-allowing for data mentioned before we can suppose if necessary characteristic of compound leaves is their division into leaflets with petiolules, the problem could be solved due to comparison of petioputes and footstalks structure. That is, if a petiolules is cylindrical and its structure resembles footstalk structure, we deal with a compound leaf. Anatomical researches revealed leaflet structure of compound leaves is similar to the first simple leaves in terms of the same cultivar. In particular, petiolules of leaves keep the structure, typical for footstalks, but some cultivars, such as *Apium graveolens* have got even more complicated structure in comparison with footstalk of the first true leaf [fig.1). Comparing with footstalk of the first true leaf (fig.1D) petiopte of lateral leaflet includes five close collateral bundles, three of them are large and two located on ledge of the channel – small (fig.1E). Besides in petiolule opposite connecting bundles there are bands of angular collenchyme, what is non-typical for footstalk. Petiolule isn`t a part of a segment or a leaf plate.

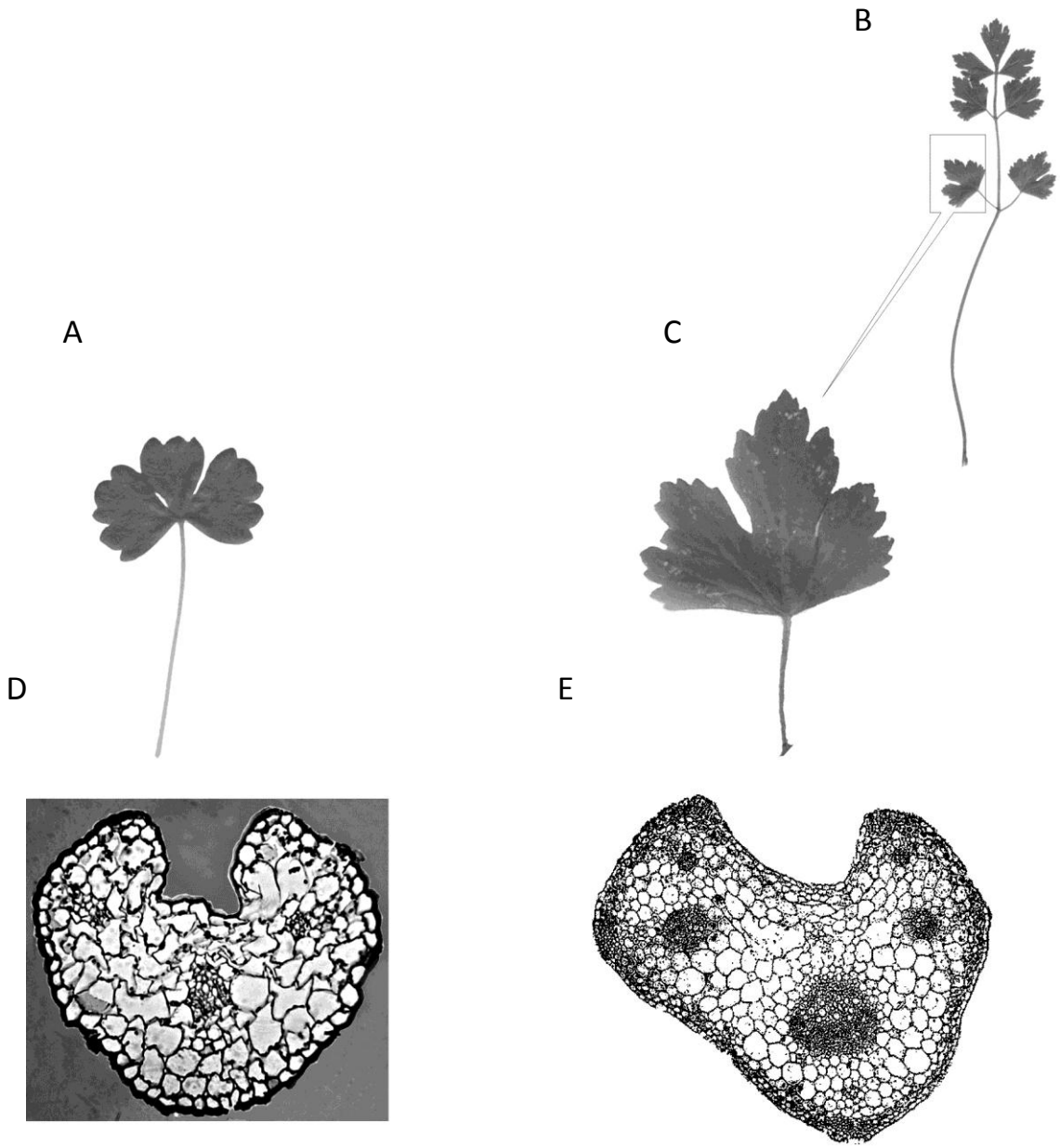

Fig.1 The first true leaf (A), odd-pinnate compound leaf (B) and cut off lateral leaflet (C) *Apium graveolens:* D – footstalk section of the first true leaf (hematoxylin, 20x7); E – petiopute section of lateral leaflet (hematoxylin, 10x10)

The first true leaf of *Petroselinum crispum* is simple, divided into three segments (Fig.2A). The footstalk is long, channeled almost triangular in cross section, covered with one layer of epidermis and two layers of chlorenchyma (fig.2D). Majority of footstalk is filled with oval cells of the main parenchyma which contains three connecting bundles. Tricompound leaf develops after that (*P. Crispum) (*Fig.2 B). Petiolele of the lower pair of lateral leaflets has similarities with structure of the first true leaf footstalk. Difference is that in petiolule opposite connecting bundles under epidermis cells and in ledges of channel there are bands of collenchyme, what is non-typical for footstalks of the first leaves (Fig. 2 E). Besides linear size of footstalks is more than petiolule`s. Such insignificant differences in structure of simple leaves footstalks and compound leaves petiolules in terms of the same cultivars from *Apioideae* subfamily are typical for other study cases as well: *Daucus sativus, D. carota, Foeniculum vulgare* and etc. [5-8].

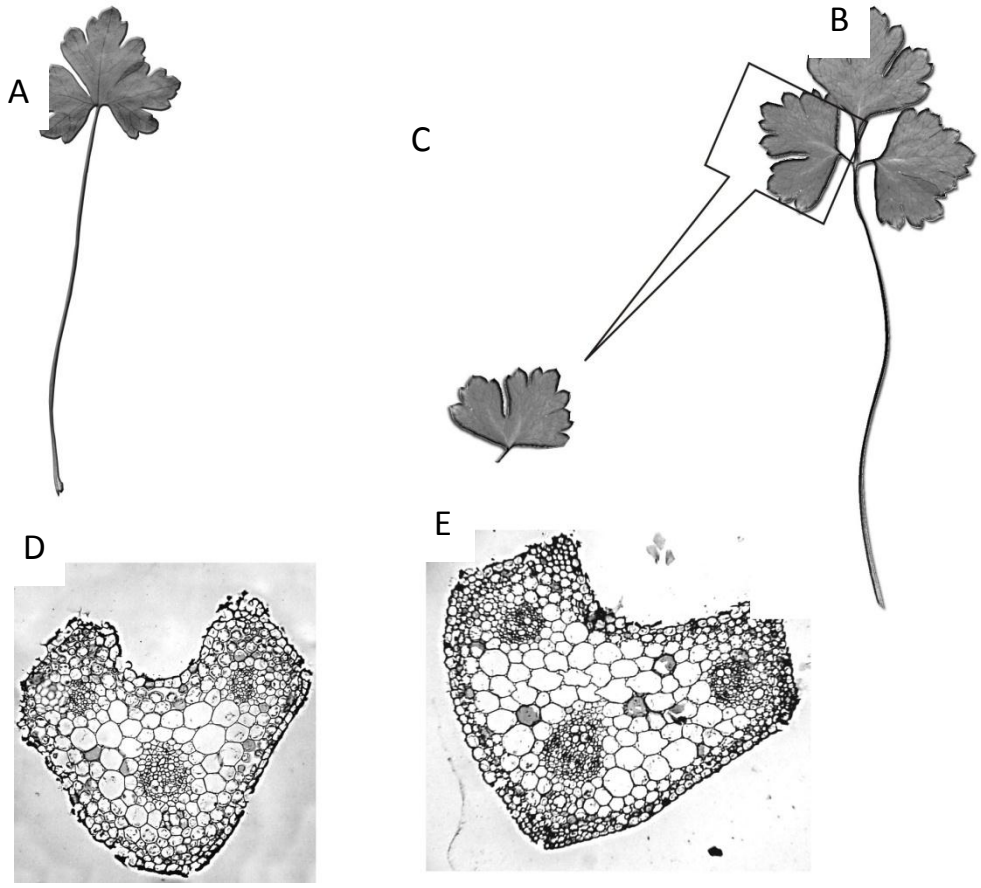

Fig.2 The first true leaf (A), tricompound leaf (B) and cut-off lateral leaflet (C) *Petroselinum crispum:* D – section of the first true leaf footstalk (hematoxylin, 8x7); E – section of lateral leaflet petiopute (hematoxylin, 8x7)

There are two hypotheses, capable to explain homology of simple and compound leaves. The first one was suggested by Sattler R. and Rutishauser R., it equalizes separate leaflets of the compound leaf with simple leaves. The second hypothesis, suggested by Kaplan D., supposes the compound leaf as a simple leaf equivalent [20]. Study findings prove the first hypothesis, as according to anatomic structure leaflets of compound leaf are similar with simple leaves (the same plant), but in mostly they have more complicated structure [5-9].

Conclusions

1. Study leaves of *Apioideae* subfamily are rather compound due to all characteristics revealed in terms of the research. Typical joint in nodes, that allow leaflets of compound leaf to fall, weren`t found. We consider term "joint" for compound leaves isn`t correct, as during setting and development of compound leaves, processes of part joint don`t happen. It`s a well-know fact, that compound leaf develops as a single unit [11, 13, 21, 23, 25, 26 and etc], as it was mentioned before branching of connecting bundles with accompanying elements of strengthening tissue happens in nodes.

2. Based on study results, we suppose that leaves of *Apioideae* specimens consisting of some separate leaf plates should be believed as compound, in spite of type of their falling: either separate falling happens or a leaf dies entirely. In this way, Linney K. [4] classified simple and compound leaves using degree of their disjoint as it is.

Gratitudes

The author is thankful to senior scientist of Botanical Institute named after V.Komarov (St.-Petersburg, Russia), Doctor Oskolsky A.A. for useful consultations and advice discussing the article.

References

1. Botanichesky atlas / Pod obshch.red. B.K. Shyshkina. – M.-L.: Selkhozizdat, 1963. – 504 s.

2. *Gendels T.V.* Osobennosti morphogeneza lista dvudolnyh // botan.zhurnal. – 1988. – T.73, № 11. – S. 1554-1559.

3. Zhyzn rasteny v 6-ti tt. / Pod obshchey red.akad. a.L. Takhtadzhyana. – M.: Prosveshcheniye, 1980. – T. 5. Ch.1. – 430 s.

4. *Linney K.* Philosophiya botaniki. M.: Nauka, 1989. – 456 s.

5. *Naumov S.Yu.* Anatomichni doslidzhnnya lystkiv *Petroselinum crispum* (Mill.) A.W.Hill. // Ukr.botan.zhurn. – 2007. – T. 64, № 6. – S. 901-904.

6. *Naumov S.Yu.* Formoobrazovaniye listyev *Daucus carota* L. v techeniye ontogeneza // Zbirnyk naukovyh prats LNAU. – Lugansk: "Elton-2", 2007a. - № 75 (98). – S. 87-93.

7. *Naumov S.Yu., Bril O.A.* Anatomicheskiye issledovaniya vaskulyarnoy sistemy listyev *Daucus carota* L. // Zbirnyk naukovyh prats Luganskogo NAU. – 2007. - №79 (102). – S. 32-40.

8. *Naumov S.Yu., Zlobina A.A.* Izmeneniye vaskulyarnoy sistemy listyev prikornevoy rozetki *Foeniculum vulgare* Mill. // Zbirnyk naukovyh prats Luganskogo NAU. – 2008. - № 83. – S. 73-80.

9. *Naumov S.Yu., Sokolov I.D.* Dosvid vykorystannya tsyfrovyh prystroyiv u biologii // Naukovy vistnyk Volynskogo derzhavnogo universytetu im.L.Ukrayinky. – 2004. - №4. – S. 76-79.

10. *Satsyperova I.F.* Borshcheviki flory SSSR – noviye kormoviye rasteniya. – L.: Nauka, 1984. – 223 s.

11. *Serebryakov I.G.* Morphologiya vegetativnyh organov vysshyh rasteny. – M.: Gos. Izd-vo "Sov.nauka", 1952. – 391 s.

12. *Sokolov I.D., Naumov S.Yu., Minyayeva I.V., Shelikhov P.V.* Formoobrazovaniye listyev v ontogeneze anisa (*Anisum vulgare* Gaertn.) // Visnyk Donetskogo universitetu. Seriya A. Prirodnychi nauky, 2001. – № 2. – S. 294-297.

13. *Ten A.G.* Rost lista bobovyh rasteny v ontogeneze // Voprosy morphologii, rosta i razvitiya rasteny: Trudy Tselinogradskogo SKhI. – 1973. – T.9, vyp.3. – S. 25-49.

14. *Tikhomirov V.N.* Proiskhozhdeniye, evolutsiya i sistema semeistva zontichnyh (Umbelliferae Juss. – Apiaceae Lindl.): Avtoref.dis.dokt.biol.nauk / MGU im. M. Lomonosova. – M., 1977. – 39 s.

15. *Tikhomirov V.N., Yanitskaya T.O., Pronkina G.A.* Zontichniye Sredney Rossii. Opredelitel po vegetativnym priznakam. – M.: Argus, 1996. – 88 s.

16. *Fyodorov Al.A., Kirpichnikov M.E., Artyushenko Z.T.* Atlas po opisatelnoy morphologii vysshyh rasteny: List. – M.-L.: Izd-vo AN SSSR, 1956. – 302 s.

17. Flora SSSR / red. B.K. Shyshkina. – M.-L.: izd-vo AN SSSR, 1950. – T. XVI. – 648 s.

18. *Ezau K.* Anatomiya semennyh rasteny. – M.: "Myr", 1980. – 558 s.

19. *Bharathan G., Goliber T.E., More C., Kessler Sh., Pham T., Sinha N.R.* Homologies in leaf form inferred from *KNOX1* gene expression during development // Science, 2002. – Vol. 296, N 5574. – P. 1858-1860.

20. *Champagne C., Sinha N.* Compound leaves: equal to the sum of their parts? // Development, 2004. – Vol.131. – P. 4401-4412.

21. *Cronk Q.* The Molecular Organography of Plants.-Oxford: University Press, 2009.-259 p.

22. *De Candolle Aug. P.* Prodromus systematis naturalis regni vegetabilis. – Paris, 1830. – V. 4. – 683 p.

23. *Eberwein R.K.* Bau und ontogenese unkonventioneller Blätter des typs 'unifaziale Phyllome' und deren beitrag zur theorie des spermatophytenblattes: Dis. Doktors der Natur. / Rheinisch-Westfälischen Technischen Hochschule Aachen. Österreich, 1995. – 77 p.

24. *Eckardt* N.A. Evolution of compound leaf development in Legumes: Evidence for overlapping roles of *KNOX1* and *FLO/LFY* genes // Plant cell. – 2007. – Vol.19. – P. 3315-3316.

25. *Gerrath J.M.,* Lacroix, C.R. Heteroblastic sequence and leaf development in *Leea guineensis* // Int. J. Plant Sci., 1997. – Vol. 158 (6). – P. 747-756.

26. *Guedes M.* Leaf morphology in the Umbelliferae: Rachis, unifaciality, stipels and pinna insertion // Phyton. 1984. – Vol. 24. – P. 257-272.

27. *Lillie R.D.* Histopatologic technic and practical histochemistry. New York: 1965. 645 p.

28. *Meyen S.V.* Plant morphology in its nomothetical aspects // Bot. Rev. 1973. – Vol. 39, № 3. – P. 205-260.

29. *Takhtajan A.L.* Diversity and Classification of Flowering Plants. New York: Columbia University Press, 1997. – 643 p.

The article was received at editors 23.12.2015

Naumov S.Yu. Leaf structure of herbaceous plants, cultivars of Apioideae Drude subfamily (Apiaceae Lindl.) as study cases. // Bull. of the State Nikit. Botan. Gard. – 2016. – № 118. – P. 57-63.

In the course of comparative morphological and anatomical researches of leaf ontogeny mechanisms within a number of cultivars belonging to Apioideae subfamily, it was revealed their leaves are truly compound.

Key words: *Apioideae; simple leaf; compound leaf; petiole; petiolule.*