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ACER L. BEE POLLEN MORPHOLOGICAL FEATURES

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Abstract. *Purpose: Considering the significant biodiversity of polliniferous plants in natural-climatic zones of Ukraine, the purpose of our research was to define morphological characteristics monofloral bee pollen of Acer L. common species in Ukraine. Methods: The measurements were performed in laboratory of Institute of Biodiversity Conservation and Biosafety, Slovak University of Agriculture in Nitra. We were used the method of pollen analysis, weighing (on the scales 100C), method of constructing a Lab color model. Software Ascension Waves Vision, microscope Zeiss SteREO Discovery V20, Nicolet 6700 FT-IR, spectrometer and Lovibond SP62 S/N 044929 were used. Results: In our researches we have established spectrometric and morphological parameters for monofloral bee pollen lumps, which were obtained from A. platanoides L. (length 3.07 ± 0.048 mm, width 2.49 ± 0.055 mm, weight 8.04 ± 0.314 mg; indicators of spectrometry, units: L* 57.94 ± 0.131, a* 3.52 ± 0.057, b* 23.07 ± 0.157, C* 23.34 ± 0.157, h° 81.30 ± 0.140); from A. negundo L. (length 2.85 ± 0.046 mm, width 2.40 ± 0.051 mm, weight 5.73 ± 0.207 mg; indicators of spectrometry, units: L* 60.47 ± 0.119, a* 7.80 ± 0.062, b* 30.72 ± 0.145, C* 31.69 ± 0.145, h°75.74 ± 0.109); from A. tataricum L. (length 3.87 ± 0.062 mm, width 3.35 ± 0.071 mm, weight 10.88 ± 0.41 mg; indicators of spectrometry, units: L* 63.96 ± 0.119, a* 2.69 ± 0.023, b* 23.98 ± 0.081, C* 24.13 ± 0.082, h° 83.59 ± 0.053); from A. campestre L. (length 3.54 ± 0.061 mm, width 2.94 ± 0.067 mm, weight 9.78 ± 0.334 mg; indicators of spectrometry, units: L* 64.34 ± 0.093, a* 2.95 ± 0.034, b* 23.81 ± 0.128, C* 23.99 ± 0.126, h° 82.93 ± 0.096). Discussion: All parameters of bee pollen from different Acer L. species were determined by spectrometry and a low variability was characterized. The most stable indicators were h° (C_v in the range from 0.201% to 0.547%) and L.* (C_v in the range from 0.461% to 0.715%). Obtained results suggest about possibility to apply these parameters for pollen identification the certain types of Acer L. family with use the Lab color space.*

Key words: bee pollen, pollen lump, weight, morphological parameters, spectrometry, Acer L.

Introduction. Bee pollen is one of the products of beekeeping industry, which has a plant-animal origin and due to its broad range of properties and composition. It is main source of protein feed for bees and brood. The lack or absence of pollen in nature can lead to protein degeneration bees, slowing the development of family and death. Production technology of bee pollen envisages sampling of bees by using pollen traps, removing of impurities and primary processing for long-term storage [3]. The value of this product is for people in its preventive and therapeutic, dietary, diabetic, immune properties. This effect is caused by complex of biochemical composition. Bee pollen contains the essential amino acids, macro- and micronutrients, vitamins, plant hormones, pheromones and other valuable substances for the human body [11].

However, the properties of bee pollen aren't constant. They depend from nature, climatic and environmental conditions, harvesting period, and the greatest caused by botanical type of plant, from which bees collected pollen [1]. Significant honey-polliniferous resources and climate of Ukraine contribute for obtaining bee pollen at industrial level. Now, an increase in production monophlal bee pollen that is one, that comes from one plant species. Monofloral types of bee pollen characterize by relatively stable biochemical composition, and thus the impact on the human body. So nowadays, scientists are actual in-depth study of technological, biochemical and morphological characteristics of monofloral bee pollen.

Analysis of recent research and publications. Scientists [10, 11, 15, 18] have studied biochemical and morphometric features of some species of bee pollen. Moreover, scientists [4, 8] have solved the problem of classification of pollen grains, its morphological features for identification bee pollen. Also, new methods for identifying bee pollen were developed by use the spectrometry [13]. Skrypka and Kasianchuk (2015) determined the content of organochlorine and organophosphorus pesticides in bee pollen of some species [7].

Studies are under antioxidant activity of pollen and bee pollen [16, 17]. Were investigated the quality characteristics of bee pollen, depending on the botanical and territorial origin, production conditions [1, 5]. Pollen productivity *Acer* L. species studied during its pollination by bees and bumble bees [14]. Campana and Moeller (1977) have determined nutritional value of *A. negundo* L. pollen for bees feeding [12]. Batra (1985) explored the role of *A. rubrum* L. in spring bees' nourishment and other insects [9]. Pollen productivity of some *Acer* L. species was studied, which consist to the ecological community [6].

Purpose. Considering the significant biodiversity of polliniferous plants in natural-climatic zones of Ukraine, the purpose of our research was to define the morphological characteristics of monofloral bee pollen of *Acer* L. common species in Ukraine. The purposes of scientific work are by tasks: to collect bee pollen of *Acer* L. common species in Ukraine; to define the botanical origin of bee pollen from particular species with using pollen analysis; to explore morphometric parameters and bee pollen weight of specific types of *Acer* L.; to carry out spectrometric analysis of bee pollen with specific types of *Acer* L.

Materials and methods. Bee pollen collected by using the hanging pollen traps from the local population of bees from different regions of Ukraine

in April 2016. For further studies were sampled monofloral bee pollen, received from Rokitne and Skvira (Kyiv region) and Donetsk (Donetsk region). Identification of bee pollen carried out by method of pollen analysis [4].

Morphometric measurements were performed in laboratory of Institute of Biodiversity Conservation and Biosafety, Slovak University of Agriculture in Nitra. For the analysis was taken sample of bee pollen with weight of 100 g. The weight of individual lumps of bee pollen was determined on an analytical balance ANG 100C (Axis). The length and width of lumps bee pollen were measured with using software Ascension Waves Vision and have made photos on electron microscope Zeiss SteREO Discovery V20. Pollen color determined by the building Lab color model with using spectrometry devices (Nicolet 6700 FT-IR Spectrometer and Lovibond SP62 S/N 044929). The shape level of lumps of pollen was determined by the method, which was developed at the Department of beekeeping NULES Ukraine [2].

After obtaining numerical data, the statistical research results conducted by computer using Microsoft Office Excel – 2010.

Results. Were explored the general bee pollen from four *Acer* L. species: *A. platanoides* L., *A. negundo* L., *A. tataricum* L., *A. campestre* L. Installed shape level of pollen lumps within 3–5 points. Organoleptic analysis of bee pollen had a rounded shape grayish-beige (*A. negundo*, *A. tataricum*), light brown (*A. platanoides*) and amber colors (*A. campestre*). Pollen lumps of bee pollen had tightly shape, without splits and destruction. The length, width and weight were determined, as a result after measurement of 50 pollen lumps (Tab. 1).

1. Bee pollen morphological parameters of the *Acer* L. species (n=50)

Indicator	Species of *Acer* L.			
	A. platanoides L.	A. negundo L.	A. tataricum L.	A campestre L.
		length, mm		
Min	2.50	2.39	3.23	3.01
Max	3.60	3.28	4.68	4.18
M±m	3.07 ± 0.048	2.85 ± 0.046	3.87 ± 0.062	3.54 ± 0.061
δ	0.26	0.25	0.34	0.33
C_v (%)	8.60	8.84	8.77	9.42
		width, mm		
Min	1.65	1.95	2.61	2.27
Max	3.02	3.19	4.05	3.77
M±m	2.49 ± 0.055	2.40 ± 0.051	3.35 ± 0.071	2.94 ± 0.067
δ	0.30	0.28	0.39	0.37
C_v (%)	12.09	11.60	11.68	12.50
		weight, mg		
Min	4.6	3.3	5.5	1.7
Max	13.0	10.8	19.7	14.5
M±m	8.04 ± 0.314	5.73 ± 0.207	10.88 ± 0.41	9.78 ± 0.334
δ	2.22	1.47	2.92	2.37
C_v (%)	27.60	25.58	26.86	24.19

After defining the length, which is a straight line that connected two distant points. So, the moon hole on pollen clumps was located on the left side, and the most convex part was on the right. The length of the studied bee pollen was in the range from 2.85 ± 0.046 mm to 3.87 ± 0.062 mm depending from species. Thus, the greatest value of parameter length was in *A. tataricum*, which is 20.67%, 26.36% and 8.53% more, than in *A. platanoides*, *A. negundo* and *A. campestre*, respectively. Indicator of length variation of pollen clumps is weak (<10%) and, relatively, stable for all species *Acer* L., which were studied. By defining the width of pollen clumps, it's a straight perpendicular line, which connects two farthest points on the area of bee pollen (Fig.).

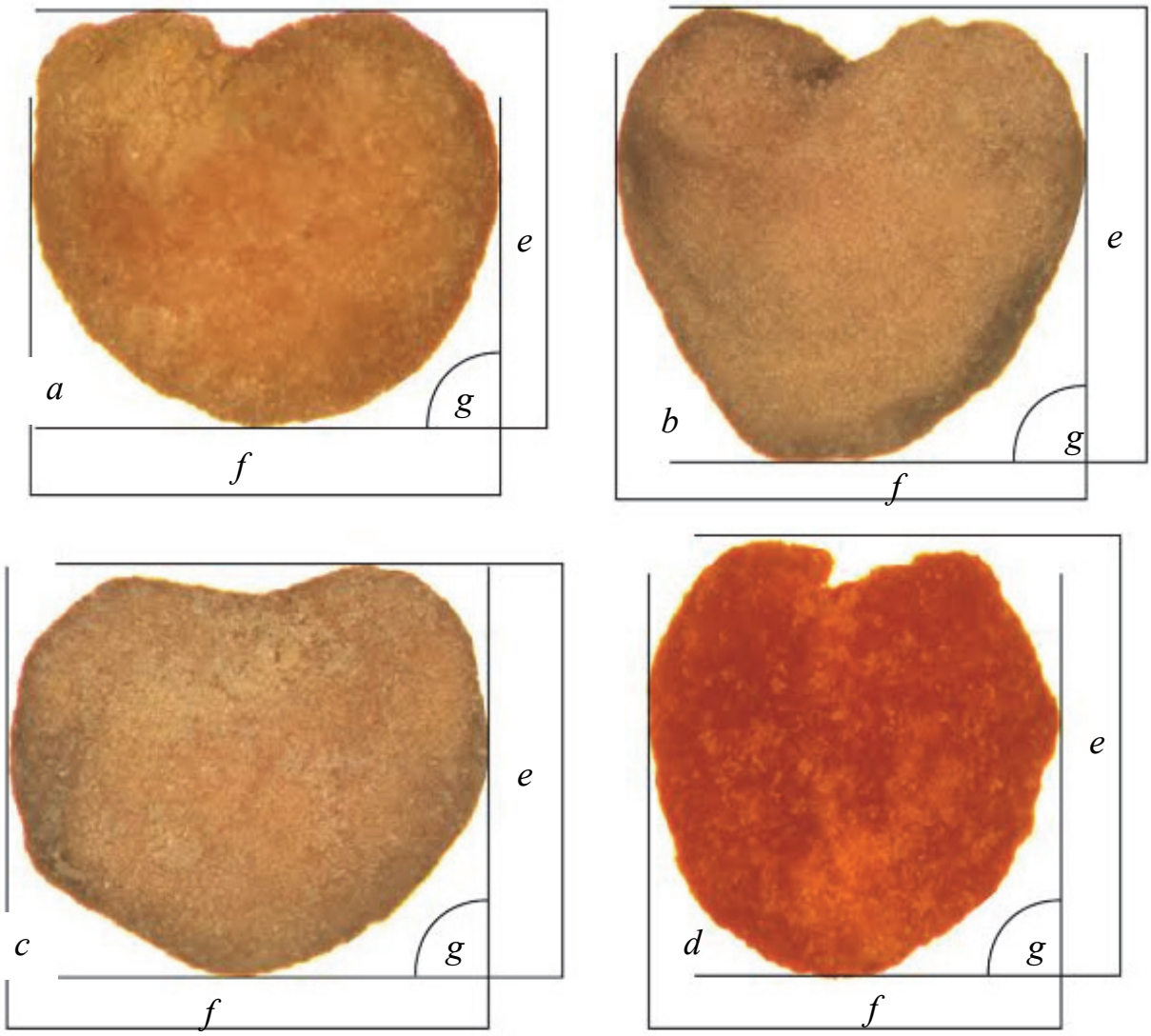

Fig. Bee pollen morphological parameters of Acer L. species:
a – A. platanoides L.; b – A. negundo L.; c – A. tataricum L.;
d – A. campestre L.; e – length measurement; f – measurement the width;
g – perpendicular angle, forming by straight lines of length and width.

Width of bee pollen is in the range from 2.40 ± 0.051 mm to 3.35 ± 0.071 mm depending from the species. Thus, the most important parameter had the *A. tataricum*, which is 25.67%, 28.36% and 12.24% more, than in *A. platanoides*,

A. negundo and *A. campestre,* respectively. The coefficient of variation (Cv, %) was the width of parameter at the middle level and in the range from 11.60% to 12.50%, that characterize this sign as a variable. Weight bee pollen of the *Acer* L. species was in the range from 55.73 ± 0.207 mg to 10.88 ± 0.41 mg. Thus, the most of weight were in the *A. tataricum*, which is 26.10%, 47.33% and 10.11% more, than in *A. platanoides*, *A. negundo* and *A. campestre*.

Variation of weight *A. platanoides*, *A. negundo* and *A. tataricum* bee pollen was large (C_v>25%). This confirms, that bee pollen weight is variable within a single *Acer* L. species, and cannot use as a factor for identification.

High variation in an indicator of bee pollen weight may be due to carbohydrate feed, so bees back into the nest without complete level of shape. The morphological parameters of *A*. *negundo* bee pollen we classified as small and in other studied species – medium size. Were determined, that bee pollen from *Acer* L. species appropriated for identification of morphological features, and the most stable indicator is length of pollen clumps.

Color bee pollen was determined with using system Lab color space in the parameters: lightness (L*); the ratio from green to red color (a*); the ratio from blue to yellow color (b*); relative saturation (C*); hue angle (h°) (Tab. 2).

2. Bee pollen spectrometric parameters of the species of *Acer* L. (n=10)

Indicator	Spectrometric parameter				
	L*	a*	b*	C*	h°
			A. platanoides L.		
Min	57.324	3.228	22.220	22.454	80.581
Max	58.524	3.759	23.719	23.971	81.732
M±m	57.94 ± 0.131	3.52 ± 0.057	23.07 ± 0.157	23.34 ± 0.157	81.30 ± 0.140
δ	0.414	0.182	0.496	0.497	0.445
C_v (%)	0.715	5.176	2.153	2.131	0.547
			A. negundo L.		
Min	59.942	7.445	29.642	30.639	75.345
Max	59.942	8.005	31.300	32.292	76.392
M±m	60.47 ± 0.119	7.80 ± 0.062	30.72 ± 0.145	31.69 ± 0.145	75.74 ± 0.109
δ	0.378	0.197	0.458	0.461	0.346
C_v (%)	0.626	2.535	1.492	1.455	0.457
			A. tataricum L.		
Min	63.431	2.554	23.419	23.562	83.415
Max	64.490	2.791	24.316	24.476	83.969
M±m	63.96 ± 0.119	2.69 ± 0.023	23.98 ± 0.081	24.13 ± 0.082	83.59 ± 0.053
δ	0.376	0.074	0.259	0.260	0.168
C_v (%)	0.588	2.776	1.080	1.078	0.201
			A campestre L.		
Min	64.063	2.703	23.276	23.471	82.603
Max	65.043	3.064	24.419	24.569	83.682
M±m	64.34 ± 0.093	2.95 ± 0.034	23.81 ± 0.128	23.99 ± 0.126	82.93 ± 0.096
δ	0.297	0.109	0.404	0.399	0.304
C_v (%)	0.461	3.719	1.700	1.664	0.366

We defined differences of bee pollen parameters between *Acer* L. species by spectrometry. Lightness is in the range from 57.94 ± 0.131 to 64.34±0.093 units. Thus, the highest ratio of real illumination to image brightness of pollen clumps, characterized bee pollen from *A. campestre*. This indicator was 9.95%, 6.15%, 0.59% and higher, than in of *A. platanoides*, *A. negundo*, *A. tataricum*, respectively. Colorfulness of parameters (a*, b*) is close in value for bee pollen from *A. campestre* and *A. tataricum*. Thus, the ratio levels of green color and red color are component of *A. campestre* bee pollen. It was at 8.81 % higher, than in *A. tataricum*, but at 16.19% and 62.18%, which lowers in *A. platanoides* and *A. negundo*, respectively. The ratio levels of blue color and yellow color were the highest in *A. negundo* bee polen and amounted to 30.72 ± 0.145 units, which are 24.90%, 21.94%, 22.49%. They are higher, than in *A. platanoides* , *A. tataricum* and *A. campestre*, respectively. This significant difference was not noticeable visually. Probably, due to relative saturation parameter (C*), which has a similar meaning. Thus, bee pollen from *A. negundo* was 31.69 ± 0.145 units, which are 26.35%, 23.86%, 24.30%. They are higher, than *A. platanoides*, *A. tataricum* and *A. campestre*, respectively. Hue angle (h°) describes vector direction for color saturation that is an angle of shade. The smallest value was for *A. negundo* and amounted to 75.74 ± 0.109 units, which are 7.34%, 10.36%, 9.49% and higher, than in *A. platanoides*, *A. tataricum* and *A. campestre*, respectively.

In our research were determined all parameters of *Acer* L. bee pollen from different species with using spectrometry. They were characterized by low variability. The most stable indicators were h° (Cv is in the range from 0.201% to 0.547%) and L* (Cv is in the range from 0.461% to 0.715%). However, the variation coefficient from other parameters didn't exceed 3%. Obtained results suggest about possibility to apply these parameters for pollen identification the certain types of *Acer* L. family with use the Lab color space.

Conclusions and prospects. Researched spectrometric and morphological parameters of monofloral bee pollen lumps obtained from *A. platanoides* (length 3.07 ± 0.048 mm; width 2.49 ± 0.055 mm; weight 8.04 ± 0.314 mg; indicators of spectrometry, units: L* 57.94 ± 0.131, a* 3.52 ± 0.057, b* 23.07 ± 0.157, C* 23.34 ± 0.157, h° 81.30 ± 0.140), from *A. negundo* (length 2.85 ± 0.046 mm; width 2.40 ± 0.051 mm; weight 5.73 ± 0.207 mg; indicators of spectrometry, units: L* 60.47 ± 0.119, a* 7.80 ± 0.062, b* 30.72 ± 0.145, C* 31.69 ± 0.145, h°75.74 ± 0.109), from *A. tataricum* (length 3.87 ± 0.062 mm; width 3.35 ± 0.071 mm; weight 10.88 ± 0.41 mg; indicators of spectrometry, units: L* 63.96 ± 0.119, a* 2.69 ± 0.023, b* 23.98 ± 0.081, C* 24.13 ± 0.082, h° 83.59 ± 0.053), from *A. campestre* (length 3.54 ± 0.061 mm; width 2.94 ± 0.067 mm; weight 9.78 ± 0.334 mg; indicators of spectrometry, units: L* 64.34 ± 0.093, a* 2.95 ± 0.034, b* 23.81 ± 0.128, C* 23.99 ± 0.126, h° 82.93 ± 0.096).

Further researches of bee pollen obtained from *Acer* L. species are perspective for biochemical composition, studying the antioxidant activity, microbiological contamination and elements of technogenic pollution.

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МОРФОЛОГІЧНІ ОСОБЛИВОСТІ БДЖОЛИНОГО ОБНІЖЖЯ ОТРИМАНОГО З *ACER* L.

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Анотація. *Зважаючи на значне біорізноманіття пилконосних рослин природо-кліматичних зон України, нами була визначена мета дослідити морфологічні характеристики монофлорного бджолиного обніжжя поширених в Україні видів Acer L. Методи: Вимірювання проводили в лабораторії інституту збереження агробіорізноманіття та біологічної безпеки, при Словацькому аграрному університеті в Нітрі. Застосовували методи пилкового аналізу, зважування (на вагах ANG 100C), метод побудови колірної моделі Lab. Використовували програмне забезпечення Ascension Waves Vision, мікроскоп Zeiss SteREO Discovery V20, Nicolet 6700 FT-IR Spectrometer та Lovibond SP62 S/N 044929. Результати: встановлено спектрометричні та морфологічні параметри для пилкових грудочок монофлорного бджолиного обніжжя, отриманого з A. platanoides L. (довжина 3,07 ± 0,048 мм, ширина 2,49 ± 0,055 мм, маса 8,04 ± 0,314 мг; показники спектрометрі, одиниць: L* 57,94 ± 0,131, a* 3,52 ± 0,057, b* 23,07 ± 0,157, C* 23,34 ± 0,157, h°81,30 ± 0,140); з A. negundo L. (довжина 2,85 ± 0,046 мм, ширина 2,40 ± 0,051 мм, маса 5,73 ± 0,207 мг; показники спектрометрії, одиниць: L* 60,47 ± 0,119, a* 7,80 ± 0,062, b* 30,72 ± 0,145, C* 31,69 ± 0,145, h°75,74 ± 0,109); з A. tataricum L. (довжина 3,87 ± 0,062 мм, ширина 3,35 ± 0,071 мм, маса 10,88 ± 0,41 мг; показники спектрометрії, одиниць: L* 63,96 ± 0,119, a* 2,69 ± 0,023, b* 23,98 ± 0,081, C* 24,13 ± 0,082, h° 83,59 ± 0,053); з A campestre L. (довжина 3,54 ± 0,061 мм, ширина 2,94 ± 0,067 мм, маса 9,78 ± 0,334 мг; показники спектрометрії, одиниць: L* 64,34 ± 0,093, a* 2,95 ± 0,034, b* 23,81 ± 0,128, C* 23,99 ± 0,126, h° 82,93 ± 0,096). Обговорення: визначили, що для всіх параметрів спектрометрії бджолиного обніжжя різних видів Acer L., була характерна низька варіабельність. За цього, найстабільнішим показниками були h° (C_v у межах від 0,201% до 0,547%) та L* (C_v у межах від 0,461% до 0,715%). Отримані результати свідчать про можливість застосування цих параметрів для ідентифікації окремих видів обніжжя родини Acer L., з використанням системи Lab color space.*

Ключові слова: бджолине обніжжя, пилкова грудочка, маса, морфологічні параметри, спектрометрія, Acer L.

МОРФОЛОГИЧЕСКИЕ ОСОБЕННОСТИ ПЧЕЛИНОЙ ОБНОЖКИ ПОЛУЧЕННОЙ ИЗ *ACER* L.

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Аннотация. *Принимая во внимание значительное биоразнообразие пыльценосных растений природно-климатических зон Украины, нами была определена цель, исследовать морфологические характеристики монофлорной пчелиной обножки, распространенных в Украине видов Acer L. Методы: измерения проводили в лаборатории Института сохранения агробиоразнообразия и биологической безопасности, при Словацком аграрном университете в Нитре.*

Применяли методы пыльцевого анализа, взвешивания (на весах ANG 100C), метод построения цветовой модели Lab. Использовали программное обеспечение Ascension Waves Vision, микроскоп Zeiss SteREO Discovery V20, Nicolet 6700 FT-IR Spectrometer ma Lovibond SP62 S/N 044929. Результаты: установлено, спектрометрические и морфологические параметры для пыльцевых комочков монофлорной пчелиной обножки полученной: с A. platanoides L. (длина 3,07 ± 0,048 мм, ширина 2,49 ± 0,055 мм, масса 8,04 ± 0,314 мг; показатели спектрометрии, единиц: L 57,94 ± 0,131, a* 3,52 ± 0,057, b* 23,07 ± 0,157, C* 23,34 ± 0,157, h° 81,30 ± 0,140); з A. negundo L. (длина 2,85 ± 0,046 мм, ширина 2.40 ± 0.051 мм, масса 5,73 ± 0,207 мг; показатели спектрометрии, единиц: L* 60,47 ± 0,119, a* 7,80 ± 0,062, b* 30,72 ± 0,145, C* 31,69 ± 0,145, h°75,74 ± 0,109); з A. tataricum L. (длина 3,87 ± 0,062 мм, ширина 3,35 ± 0,071 мм, масса 10,88 ± 0,41 мг; показатели спектрометрии, единиц: L* 63,96 ± 0,119, a* 2,69 ± 0,023, b* 23,98 ± 0,081, C* 24,13 ± 0,082, h° 83,59 ± 0,053); з A campestre L. (длина 3,54 ± 0,061 мм, ширина 2,94 ± 0,067 мм, масса 9,78 ± 0,334 мг; показатели спектрометрии, единиц: L* 64,34 ± 0,093, a* 2,95 ± 0,034, b* 23,81 ± 0,128, C* 23,99 ± 0,126, h° 82,93 ± 0,096). Обсуждение: определили, что для всех параметров спектрометрии пчелиной обножки различных видов Acer L., была характерна низкая вариабельность. При этом, наиболее стабильными показателями были h° (C_v в пределах от 0,201% до 0,547%) и L* (C_v в пределах от 0,461% до 0,715%). Полученные результаты свидетельствуют о возможности применения этих параметров для идентификации отдельных видов обножки семейства Acer L. с использованием системы Lab color space.*

Ключевые слова: пчелиная обножка, пыльцевые комочки, масса, морфологические параметры, спектрометрия, Acer L.