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The improvement of the volumetric monitoring system to raise the analysis accuracy for the allergic pollen found in the city atmosphere

Abstract. *The number of patients sensitive to the allergenic pollen from different plant species has been constantly increasing. The severe cases of pollen allergy (pollinosis) can lead to the asthma development. The bronchial asthma is common pollinosis aggravation. It is one of the most widely spread chronic diseases typical both of children and of adults [4,8,9]. So, it is very important to analyze the pollen obtained from the allergic plants and to study the time changes in the levels of its concentration in the atmospheric air. To solve the above task, we should monitor the factors that influence the pollen emission and its spread in the air. On the bases of the study we can build the regression model for conducting such an analysis and for forming the prognosis.*

Streszczenie*. Liczba pacjentów wrażliwych na alergeny pyłku z różnych gatunków roślin, stale wzrasta. Poważne przypadki alergii na pyłki (Pyłkowica) może prowadzić do rozwoju astmy. Astma oskrzelowa jest najczęstszym ostrym następstwem pyłkowicy. Jest to jedna z najbardziej rozpowszechnionych chorób przewlekłych typowych zarówno dla dzieci i dorosłych. Jest więc bardzo ważne, aby analizować pyłek otrzymany z roślin alergennych i badać zmiany jego stężenia w czasie w powietrzu atmosferycznym. W celu rozwiązania powyższego zadania należy monitorować czynniki mające wpływ na emisję pyłku i jego rozprzestrzenianie się w powietrzu. Na bazie badań możemy zbudować model regresji dla przeprowadzenia takiej analizy i formowania prognoz. (****Poprawa systemu monitorowania na podstawie podniesienia dokładności analizy dla alergicznego pyłku znalezionego w atmosferze miasta.****).*

Keywords: pollinosis, pollen allergens, atmosphere, health
Słowa kluczowe: pyłkowica, alergeny pyłków, atmosfera, zdrowie

Introduction

The number of patients sensitive to the allergenic pollen from different plant species has been constantly increasing. The severe cases of pollen allergy (pollinosis) can lead to the asthma development. The bronchial asthma is common pollinosis aggravation. It is one of the most widely spread chronic diseases typical both of children and of adults [4, 8, 9]. According to the World Health Organization, about 300 million people suffer from the bronchial asthma worldwide. The experts estimate that 250 000 people die of it every year. The Ministry of Healthcare of Ukraine states that in 2012 about 0.5% of the Ukrainian population suffered from the bronchial asthma, the world statistics reports that this figure constitutes from 5 till 11% of the world population. The situation has deteriorated even more recently, the incidence of the disease and its severity has increased. In accordance with some data, the amount of the patients suffering from the bronchial asthma has doubled during the last 25 years. At the very beginning of the XXI century the death rate has increased more than 9 times in comparison with the 1990s [4].

Another complaint, which is commonly caused by the plant pollen, is seasonal allergic rhinitis. The number of the individuals affected by it has increased in the world too. In order to prevent the pollinosis attacks it is important to predict the periods of high pollen concentrations and let the allergy-sufferers avoid the contact with the causal allergen.
So, it is very important to analyze the pollen obtained from the allergic plants and to study the time changes in the levels of its concentration in the atmospheric air, especially within cities and towns. It will raise the efficiency of the research related both to the pollen spread time and to its trajectories within urban areas; besides it will improve the prognosis for the disease risks with the vulnerable people and will promote the development of the measures needed to reduce these risks [2, 7]. To solve the above task, we should monitor the factors that influence the pollen emission and its spread in the air. On the bases of the study we can build the regression model for conducting such an analysis and for forming the prognosis.

Urgency of the research

Pollinosis is provoked by the pollen allergens spread by the blooming plants. The allergy on grass and trees pollen arises only at the time of their blossom that is why there are seasonal disease peaks for every region. Taking into the consideration the conducted research [4] it has been stated that the wave of the summer and autumn blossom is of special importance for Ukraine, as at this period high concentrations of pollen from cereals, artemisia and ambrosia can be found in the atmosphere. The first signs of the disease appear at the period of the grass blossom especially if it is windy, and disappear after the plant pollination stops. The duration and the character of the yearly aggravation depend on the weather conditions and local flora. So, the pollinosis disease incidence is the current problem of health protection both in Ukraine and in other countries of the world.

The data monitoring is done by the Laboratory for Aero Allergenic Research Methods which operates on the basis of the Vinnytsia National Pirogov Memorial Medical University. The laboratory also researches and analyses the reasons and the sources of the pollen appearance in the air of the Vinnytsia city. It should be noted that Vinnytsia is one of the three Ukrainian cities which conduct the constant pollen monitoring, the results of which are shown on the special European Aeroallergen network (European Aeroallergen network, EAN, polleninfo.org) and on the basis of which the relevant researches can be done. The application of the simulation and some amount of the empirical data of other cities allows to make prognosis for the patients suffering from the allergy including those living in other regions of Ukraine.

The study of the changes in the pollen concentration from the allergic plants on the territory of the city is performed with the help of the Hirst's sampler Burkard (Burkard trap). To perform the complex analysis of the reasons of the pollen changes in the city air and to provide the opportunity to predict its composition on the basis of the multifactorial regression model, it is necessary to compare the data related to the pollen presence collected with the help of this device with the meteorological data during the definite period of time and the data about the habitats of the

allergic plants. Of course, we can use the meteorological information provided by the Ukrainian Hydrometeorological Center, but it may be not enough accurate. For example, there is no stationary meteorological post within the territory of Vinnytsia city, it is located in the suburbs not far from the local airfield. But in order to raise the accuracy of the analysis and to predict the value changes, the measurement of the output data should be done at the place where the Burkard trap is located. In spite of the fact that this idea is not new and is successfully implemented in Europe [10], it is important not just to read the meteorological parameters at the place of the pollen collection, but to develop the information measuring system (IMS) which will measure the preset parameters at the preset place within the preset periodicity and according to the preset factors. Hence, the task of the improvement of the monitoring system working on the bases of the Burkard trap with the purpose of performing the accurate analysis for the pollen contents obtained from the allergic plants in the atmospheric air is really important. The solution of this task will make possible to raise the efficiency of the prognosis for the disease risks for the population and to develop the methods for lowering the risks of such a disease.

Objective of the research

The objective of the research is to improve the monitoring system developed on the bases of the bullet-type sampler Burkard in order to raise the efficiency of the accuracy rate for the pollen contents obtained from the allergic plants in the atmospheric air of the cities which will in turn make it possible to raise the efficiency of the prognosis for the disease risks among people and to develop the ways for reducing the risks of the disease.

Solution

Sample probes for the allergic pollen in the air have been done at the Laboratory of the Air Allergic Research Methods working on the basis of the Vinnytsia National Pirogov Memorial Medical University (VNMU) under the aegis of the pharmaceutical firm Merck Sharp and Doum (MSD) and the Immunological Reseach Institute of New England (the USA) since 2010.

The air sampling is done with the ordinary volumetric method and with the help of the bullet-type sampler Burkard. (Fig. 1). The Burkard Spore Trap (Burkard) is a volumetric air sampler, it is one of the standard devices for monitoring airborne pollen and spores. It is widely used by the allergy community and also by the plant pathology community.

Fig.1. Burkard Spore Trap on the roof of the Chemistry Building of the Vinnytsia National Pirogov Memorial Medical University

A preset number of the air samples is inserted on the drum with the Melinex tape which is controlled by the clockwork. Before the sampling has been done, the Melinex tape is covered with the sticky substance on the basis of gelatin-glycerin with the addition of some phenol. After the sampling has been completed, the sampling drum is sealed into the metal case and is brought into the laboratory for the primary processing. At the Laboratory of the Aero allergenic Research Methods (VNMU) the tape which has been taken off the drum is separated into the preset amount of equal parts, each of which corresponds to one observation day. One microscopic sample is obtained from each fragment; it is stained with the basic fuchsine fixed on the slide with the help of the gelatin. The application of the basic fuchsine as an indicator and the addition of a special paint for the plant material which paints the biological tissue randomly, simplifies the identification of the pollen grains and their calculation.

The research of the pollen contents and the level of its concentration in the atmospheric air is conducted on the system of the digital image analyzing VIDAS-386 (Kontron Elektronik, Germany) along with the application of the Axioscop microscope (Zeiss, Germany) which is equipped with the highly sensitive microphotographic camera COHU-7922. 400 times magnification is usually applied for the pollen analysis and calculation. The calculation of the pollen grains contained on the surface of the whole slide can take much time so in order to obtain the factual information quickly a certain fraction of the sample area is usually analyzed. In accordance with the demands of the workgroup from the European Aerobiological Society (EAS), which has worked out the general demands concerning the quality control of the aerobiological research, the chosen area to be identified constitutes at least 10% of the microslide surface. The pollen grains identification is done with the help of the method of twelve vertical transections, it allows to get aeroallergic concentration changes with the interval of every two hours. It corresponds to 13.00, 15.00, 17.00, 19.00, 21.00, 23.00, 1.00, 3.00, 5.00, 7.00, 9.00, 11.00 o'clock of every day observation. (Fig. 2).

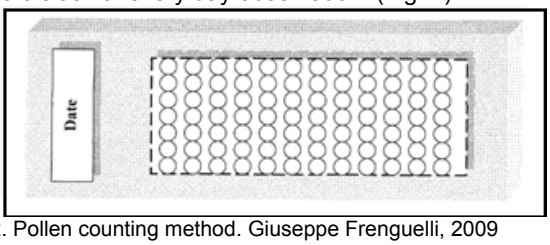

Fig.2. Pollen counting method. Giuseppe Frenguelli, 2009

Pollen and spores identification takes place according to the air allergen manual published by the National Allergy Bureau of the American Academy of Allergy, Asthma & Immunology (AAAAI) and is also based on the program Pollen Identification Key from the French National Aerobiology Network (RNSA) which specifies the level of the pollen allergenic capacity [6,1]. Taking into account the similarity of the morphological composition of the pollen grains from the same biological genus, pollen is mostly identified according to the taxonomical category of the genus.

To compare the data which show the changes in the pollen concentration we have used the information from the Ukrainian Hydrometeorological Center and the results of the weather monitoring found at the site http://rp5.ua/Weather_archive_in_Vinnytsia.

It should be noted that this site contains information about 28 parameters found in Vinnytsia. The analysis of these parameters has determined the most formalized of them and also stated those which have been observed for a long time:

DD – wind direction (cardinal directions) at the altitude of 10-12 meters above the ground surface, which has been averaged for the last 10 minutes;

Po – is the atmospheric pressure measured at the level of the station (millimeter of mercury);

RRR – the amount of precipitations (millimeters);

Td – the temperature of the dew point measured at the altitude of 2 meters above the ground surface (degrees of Celsius);
U – relative humidity (%) at the altitude of 2 meters above the ground surface;
Ff – wind speed at the altitude of 10-12 meters above the ground surface, which has been averaged for the last 10 minutes that preceded the observation duration (meters per second);
T – air temperature (degrees of Celsius) at the altitude of 2 meters above the ground surface.

The greater part of the data becomes available every 3 hours. The amount of precipitations is measured every 6-12 hours.

The analysis of the ragweed pollen contents in the atmospheric air of Vinnytsia in 2013 (the data obtained from March till October was taken into account) was conducted with the application of the programming language R. The meteorological information and the natural habitat of this allergic plant were also considered.

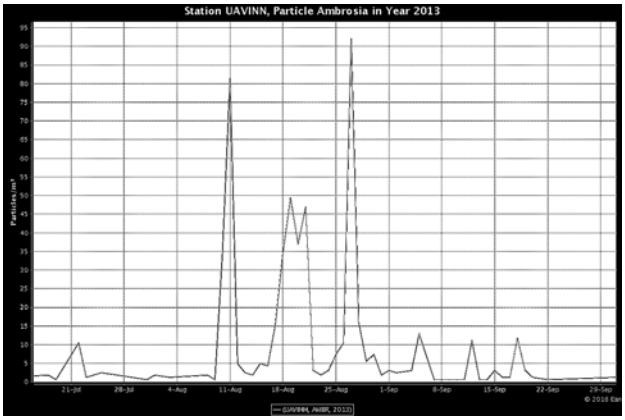

Fig.3. Daily ragweed pollen count in Vinnitsa city for 2013

The analysis was carried out in 3 stages. During the first stage the data related to the ragweed pollen contents in the atmospheric air of the city (Fig. 3) were compared with the meteorological information collected with the smallest possible intervals: pollen (AMBR) – every 2 hours, the majority of the weather data (DD, Po, RRR, Td, U, Tm, Ff, T) – every 3 hours. This common approach used technology formalization and processing of spatial-temporal data [8].

The results of the analysis grounded on these parameters are shown in Fig. 4.

The analysis has shown the connection between the ragweed pollen contents and the wind direction (DD), air temperature (T) and the air humidity (U). However, this connection is rather week. The correlation coefficient (according to the absolute value) is: for DD – 0.25, T – 0.26, U – 0.20, that is there is practically no connection. More profound analysis has shown that the different monitoring intervals have led to the loss of the great amount of data (the interpolation has not been used, only those data have been taken into account which dates and measuring time fully coincide).

As has been stated above, the pollen spread must slow down or stop completely during the precipitation. If ambrosia habitats are rather local, then the identification of the pollen at the place of the device location must depend on the wind direction and the wind force. It means if the wind blows from those habitats, the amount of the pollen grains that are sensed by the device must increase. So, the correlation must be present in these data. And the fact of its non-identification can mean that the data or the ways of their primary processing are imperfect.

To eliminate the detected problem it is suggested to supplement the Burkard trap with the complex of the extra devices for the determination of the meteorological parameters, that is to build the information measuring system, and this device will act as the core sampling element. However, it can turn out to be rather expensive and difficult to duplicate the measurement of all the meteorological factors. Therefore, this task should be narrowed and we have to define which parameters are worth measuring. For this purpose, the second stage of the analysis has been done [11].

During the second stage there have been performed the data comparison related to the ragweed pollen contents in the atmospheric air of the city and the meteorological information which have been integrated during a day: for the majority of the parameters the integration has been conducted by means of averaging. But in case of the precipitation it has been done by performing addition. The identification of the prevailing wind direction has been defined by the expert mode.

The mid-August has been analyzed as this time period had the highest level of the ragweed pollen concentration in the city air in 2013. The period was defined (13-23.08.2013) when both the maximum and the minimum values were observed, and it allows us to evaluate the impact of different factors objectively.

Fig. 5 contains the analysis results according to such parameters as AMBR, DD, Po, RRR, Td, U, Tm, Ff, and T.

The analysis has shown the connection between the ragweed pollen contents and the wind direction (DD), the wind force (Ff), the air humidity (U) and the dew point (Td). It should be noted that this connection is rather strong. The correlation coefficient (according to the absolute value) is: for DD – 0.80, Ff – 0.71, Td – 0.62, U – 0.50, that is the stochastic connection has been found.

The ratio between the value of the ragweed pollen contents and the wind direction deserves our special attention (the directions have been numerically coded – the points of the compass have been clockwise enumerated in the consecutive order (Fig. 6).

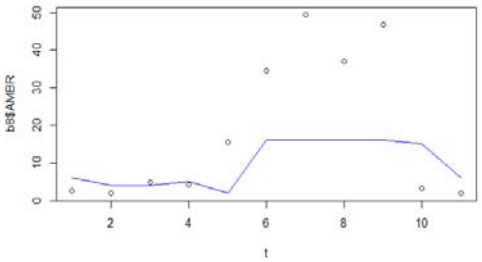

Fig.6. The graph of the averaged daily value for the ragweed pollen contents and the wind direction in Vinnytsia in August 2013

The graph and the above mentioned correlation coefficient of 0.8 shows that the increase of the pollen concentration correlates greatly with the wind direction. Therefore, we can come to the conclusion that the allergic plants are rather concentrated and, regarding the Burkard trap, they are located in the direction from which the wind was blowing during 17-22.08.2013. The analysis has also shown the wind directions. They are: “the wind blowing from the east”, “the wind blowing from the north-east” and “the wind blowing from the east-south-east”. To check the validity of the analysis we should compare the obtained results with the data about the ragweed habitats in Vinnytsia.

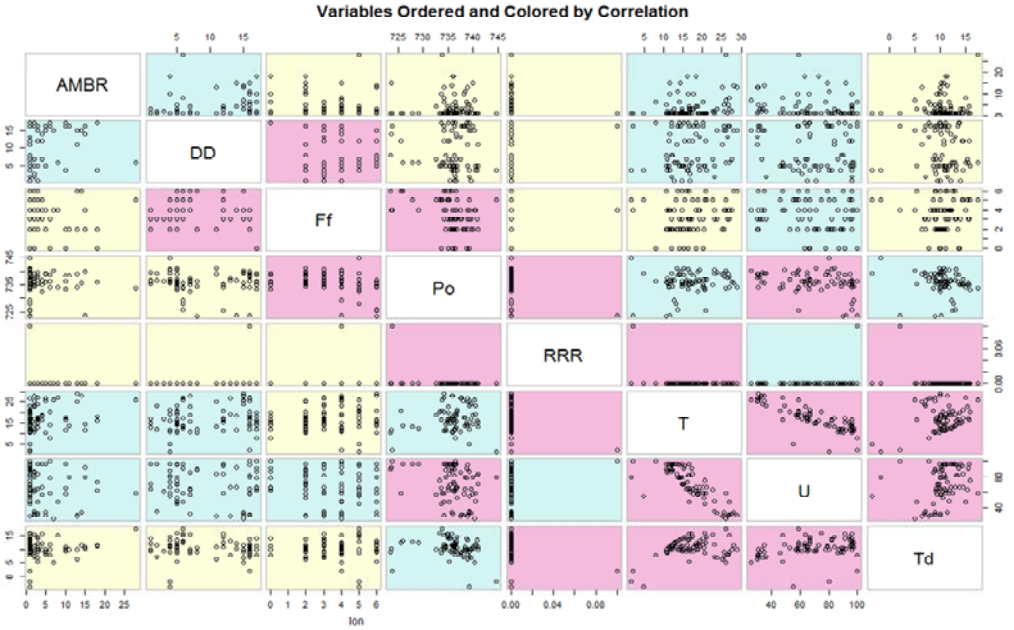

Fig.4. The result of the correlation analysis related to the ragweed pollen contents in the atmospheric air in Vinnytsia in 2013 and the main meteorological data collected with the smallest possible interval (2-3 hours) (the darker cells (rectangles) correspond to the greater correlation values)

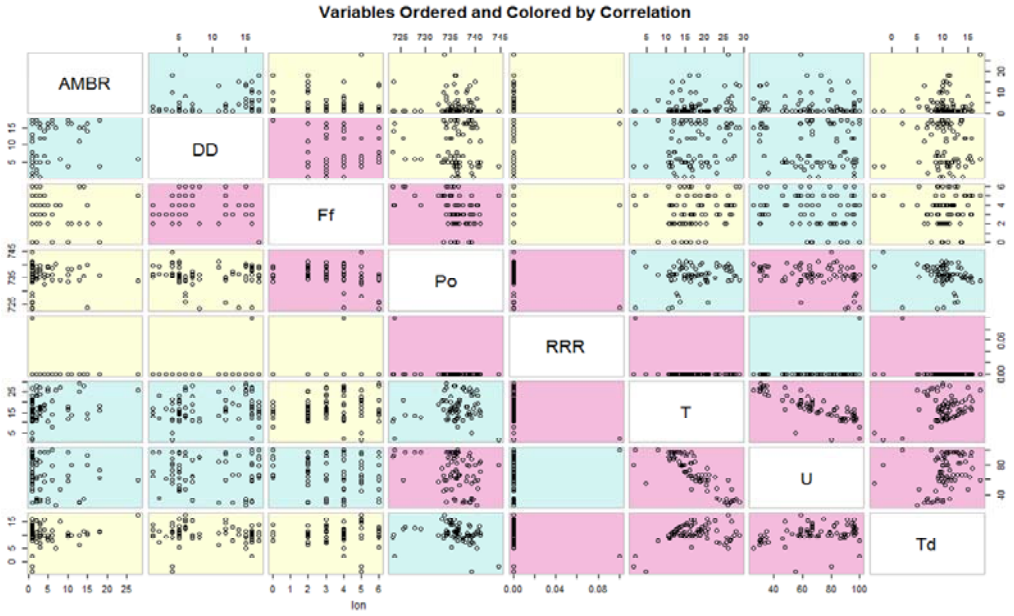

Fig.5. The result of the correlational analysis between the ragweed pollen contents in the atmospheric air in Vinnytsia in 2013 and the main meteorological data, which were averaged during the observation day (the darker cells (rectangles) correspond to the greater correlation values)

So, the conducted research has allowed us to narrow the number of the meteorological factors and parameters which should be measured using the IMS and the Burkard trap: DD – 0.80, Ff – 0.71, Td – 0.62, U – 0.50. Meanwhile, there is no need to measure the amount of precipitations RRR (you can just measure the humidity and the dew point), the air temperature T and the atmospheric pressure Po. The regularity of the measurement must correspond to the regularity of the pollen sampling applying the Burkard trap, that is every 2 hours.

Discussion

The comparison of the monitoring indices for the pollen contents in the atmospheric air of the city, meteorological information (mainly the wind direction) and the data related to the ragweed habitats in Vinnytsia has been performed.

The previously stated results of the research have been used and the Vinnytsia habitats mapping has been performed [2]. Fig. 7 shows the location of the Burkard trap in the city (marked with a rather big circle in the center of the city), the places of the detected ragweed (small circles) in Vinnytsia published at the work [2], and the density isolines of these areas.

The analysis of Fig. 3 proves the validity of the data study and it reveals the existence of certain regularities. The samples collected with the help of the Burkard trap fix the highest values of the ragweed pollen in the atmospheric air in Vinnytsia. According to them, there really exist the scientifically proved habitats for the allergic pollen spread.

On the other hand, the represented data coincides with the results seen in Vinnytsia in the year 2012 when the ragweed pollen was recorded at night while the natural ambrosia peak is associated with the midday [5]. Using the SILAM modelling for Vinnytsia it was shown how ragweed pollen travels to the city from the south-eastern areas 70-110 km away (Fig. 8).

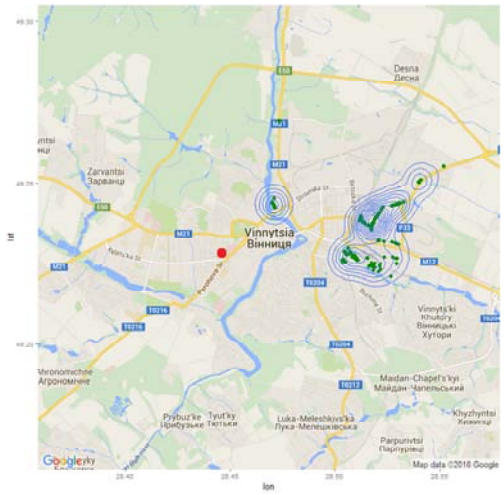

Fig.7. The result of the spatial analysis for the location of the device used to monitor the ragweed contents in the atmospheric air of the city as well as the known places and the density isoclines of the ragweed habitats in Vinnytsia

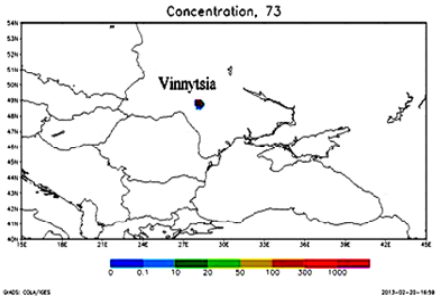

Fig.8. The modelling results for ragweed pollen spread to the city of Vinnytsia from the south-eastern areas 70-110 km away (using the SILAM)

Conclusions

1. The correlation analysis of the monitoring indices for the pollen contents from the allergic plants in the atmospheric air has been carried out on the example of the ambrosia plant and on the ground of the meteorological study of the air condition in Vinnytsia. The technology for such analysis has been worked out, the regularities have been found and the possible reasons for the ragweed pollen appearance in the atmosphere have been stated. The suggested technology has been successfully tested taking into the account the real information.
2. The list of the indices which are to be additionally measured using the information measuring system and the sampler Burkard have been proved and optimized. This will make possible to raise the accuracy of the measurement of the allergic pollen contents in the atmosphere of Vinnytsia; it will also allow to determine the trajectory of the pollen movement and will consequently improve the efficiency for the pollen spread forecast. The pollen forecast accuracy, in turn, determines the efficiency of the seasonal allergy prevention for population. The analysis performed gives also the opportunity to improve the awareness of the sensitive individuals concerning the current pollen situation in the ambient air.
3. The developed technology for the data analysis is the universal one and can be applied both for the spatial and time analyzing and for the parameters optimization; it is suitable for the monitoring of other parameters which can interact both in time and in space.

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