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ANALYSES OF TRAITS RELATED TO HIP AND ELBOW DYSPLASIA IN GERMAN SHEPHERD DOGS

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ABSTRACT

The group of German shepherd dogs which are representatives of populations from Russia, Ukraine, Belarus, Lithuania, Estonia, and Latvia was analyzed. Traits of hip and elbow dysplasia were estimated at the veterinary center certified by SV (Verein für Deutsche Schäferhunde (SV) e.V.). It is shown that the ratio of dogs with varying degrees of degenerative changes in the elbow and hip was changed from 2011 to 2018, taking into account the gender of the dogs, color, and type of coat and inbreeding coefficient. Significant correlations were found between the level of elbow and hip dysplasia in the parents and the appearance of pathological changes in the elbow and hip of their offspring. It was also discovered that increasing the average mean of the inbreeding coefficient for the whole breed or part of the breed can cause an increase in the proportion of dogs with signs of joint dysplasia. Significance of differences between intercluster averages for 12 main characteristics for two groups of German shepherds has been obtained: the first group consists of dogs from Russia, Latvia, and Belarus, and the second one is formed by dogs from Lithuania, Ukraine, and Estonia.

Disciplinary: Animal Science (Animal Breeding), Veterinary Science.

1. INTRODUCTION

It is becoming more and more important to reduce the frequency of joint dysplasia in the populations of dogs of utility breeds that perform serious functions in the relevant sectors of the state services because this pathology has a significant impact on their working abilities.

German shepherd id one of the utility breeds, which is widely used for different services all over the world. That is why the improvement of the health of representatives of this breed is one of the priority tasks of dog breeding. In this context, the research aimed at determining the type of inheritance of joint dysplasia in a German shepherd dog breed and the development of methods to reduce the incidence of this anomaly are highly relevant. Monitoring the frequency of the incidence

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of anomalies, identification of the carriers, and determining selection strategies are the basis for successful breedings of dogs of this breed (Christensen and Lund, 2010).

However, to achieve this goal, it is necessary to understand the structure of diversity and the correlation of characters that are used to determine the degree of dysplasia of the hip and elbow, since the incorrect selection of signs can affect the efficiency of breeding work with the certain breed (Baers, et al, 2019).

At present, a lot of research related to finding methods for predicting hip dysplasia in dogs during their selection is conducted for the Labrador Retriever, Rottweiler, Golden Retriever, German Shepherd dogs (Beuing, et al, 2000; Malm, et al, 2008; Hou, et al, 2010; Kirberger, 2017). Most of these studies are based on characterizing the proportion of animals with varying degrees of joint dysplasia in dog populations of different breeds and identifying the genes that can control this disease (Maki, et al, 2002; Bartolomé, et al, 2015). The number of studies related to the use of correlation indicators between the degree of dysplasia in animals of different generations, different joints, the inbreeding coefficient to change the breeding strategy with the breed is very limited (Lewis, et al, 2011; Wilson, et al, 2013; Oberbauer, et al, 2017).

The purpose of this study was to establish correlations between different signs characterizing the manifestation of the elbow and hip dysplasia, with several other characteristics in German shepherd dogs.

2. MATERIAL AND METHODS

The material used for the study was the data on 736 German shepherd dogs examined at the Jakov Veterinary Center in Lithuania from 2011 to 2018.

The following features were included in the analysis for each of the dogs examined: date of birth; age of examination; country of origin of the dog; the degree of hip dysplasia (HD) according to SV (Verein für Deutsche Schäferhunde (SV) e.V.) classification, assigned to a dog based on x-ray analysis and Norberg angle values for left and right hips separately (HD-L and HD-R); the degree of elbow dysplasia (ED), including its individual characteristics: ununited anconeal process (UAP), medial compartment disease (MCD), radiographic degree of osteoarthritis (OA) and incongruity (INC) of left and right joints (Hazewinkel, 2007). HD и ED degrees have been evaluated by both the animal and its parents (HD-F and ED-F – for father, HD-M, and ED-M – for mother). The inbreeding coefficient, color, and type of coat were determined for each dog.

To assess the normality of the distribution of continuously varying signs (Norberg angle value and inbreeding coefficient), the Kolmogorov-Smirnov criterion was used (d-statistics), Lilliefors correction factor, and Shapiro-Wilk test (w-statistics). Since the distribution of these signs does not correspond to normal (Table 1), in the future to analyze these signs, non-parametric statistical methods were applied.

The median was taken as a measure of the average level of dysplasia according to the SV classification (*Me*), and a measure of the variation in the sign values is 25% and 75% percentiles (1 and 3 quartiles), characterizing the lower and upper quarters of the distribution, and also non-parametric methods of statistical data analysis were applied.

To assess the statistical correlation between the analyzed characteristics, taking into account the nature of the data distribution and the fact that the samples contained many coincident values, a nonparametric correlation analysis was applied using the Gamma criterion (Gamma statistics).

To identify similarities and differences in the degree of dysplasia of manifestation German

shepherd dogs from these countries, Ward's method of cluster analysis was carried out. To implement this, medians (*Me*) of 12 signs were used (Norberg angle values for left and right hips, UAP, MCD, OCD, INC, and OA for left and right elbows).

Statistical analysis of data was carried out using a software package STATISTICA (StatSoft, Inc. (2011), STATISTICA10. www.statsoft.com). For statistical procedures used in the study, a significance level is established $p=0.05$.

3. RESULTS

The dynamics of individual signs values in a population over years can illustrate or indicate the presence or absence of certain processes in which breeding traits are involved. Therefore, the first step in our study was to characterize the distribution of males and females with varying degrees of the elbow and hip dysplasia over the years (Figure 1).

It was found that in 2016 the number of German shepherd dogs, whose hips were evaluated, had doubled compared with 2011. Over the past three years (2016-2018), this number has practically not increased and remained at the same level. Probably, this is the result of the fact that the maximum number of dogs that this clinic can examine, together with the number of owners who can visit this clinic due to its geographical location and material capacities, has been reached.

It seems that such a significant increase in the number of dogs passed the HD and ED tests by 2016 is as being due to the increasing, first of all, requirements of national clubs and the umbrella organization (SV) for the admission of German Shepherd dogs to breeding usage: for example, the introduction of mandatory diagnostics of not only the hips but also the elbows could be one of the driving factors.

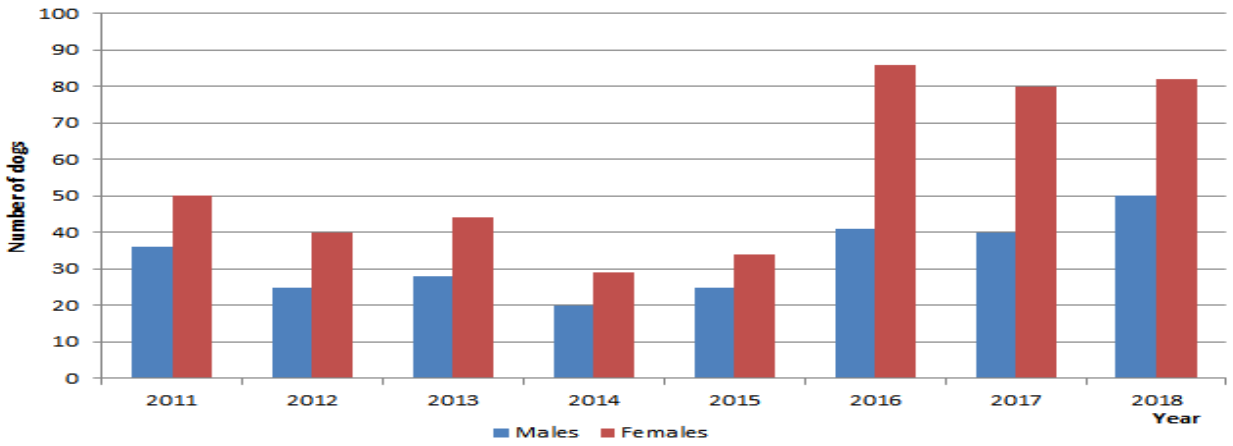

Figure 1: Distribution of German shepherd dogs, passed the HD and ED tests, by years.

The requirement of the Association of German Shepherd Dog Owners in Germany also played a role: it became necessary for foreign dogs, whom it is planned to participate in German national events for, to have a conclusion on radiographic studies conducted by specialists accredited by the SV. Clinic «Jakov veterinary center» is one of the few clinics which are situated closer to borders of Russia and in which dog owners from Russia and neighboring countries can receive such documents.

We also underline that in all years, and the last three years especially, the number of females who have been examined is significantly higher than males. It was also found that the relative growth rate of the number of examined females was considerably higher compared to males (48.5% versus 32.6%). The reason for this lies possibly in the fact that breeders are trying to use for breeding

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purposes all dams, whose ratings on the exterior, working qualities, and health allow this to be done. So, as a result, if at least one litter is received from each female for the entire period of her life, then not every male is used as a sire throughout his life.

Figure 2 presents data on changes in the proportion of animals with varying degrees of hip dysplasia for the entire study period.

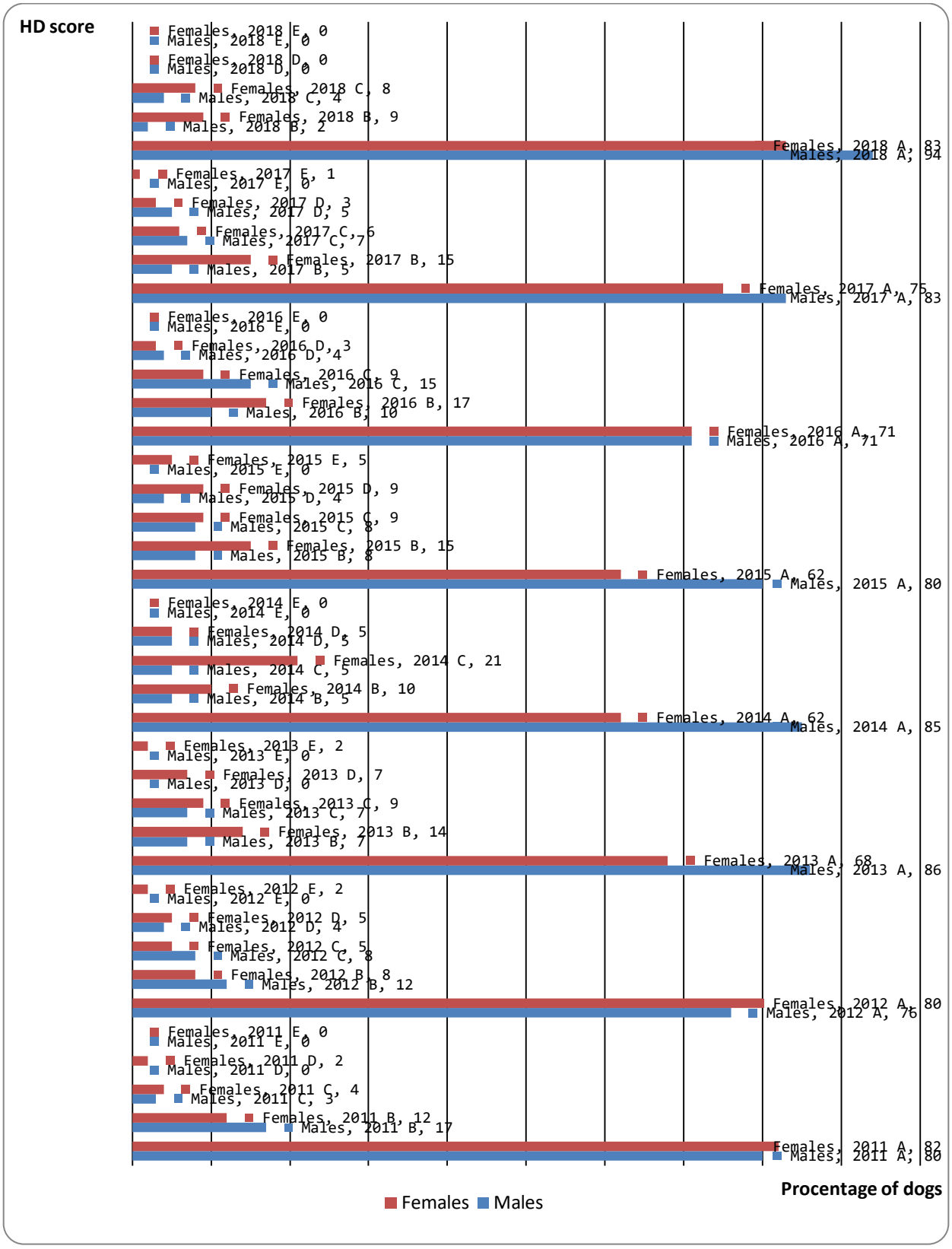

Figure 2: Distribution of German shepherds with different levels of HD by years.

It is noteworthy that among males in all years, no animals were found with an extreme degree of

destructive changes in the hip joints (E). This means, possibly, that the owners do not carry out a radiographic diagnosis of the dog when obvious symptoms of dysplasia are observed since such individuals will not be allowed to be used as a sire.

The proportion of males with changes corresponding to degree D was in the range of 4-5%, and in some years (2011, 2013, 2018) it was zero.

As for the distribution of males with the allowed degree of hip dysplasia (A, B and C), since 2016, there has been a clear change in the ratio between the proportion of animals without the pathological structure of the joints (grade A) and the proportions of animals with different but slight, degree of change (B). The proportion of males with grade A increased from 80% in 2011 to 94% by 2018, the proportion of males with grade B fell to 2% from 17%, respectively.

The proportion of males with a C degree of dysplasia was subjected to the greatest fluctuations: 3% in 2011, then an increase to 15% in 2016, and a subsequent decrease to 4% in 2018. Most likely, the reason for such fluctuations lies in the fact that in some years, the breeders and the Association of Owners of the German Shepherd Dogs were more loyal to the possibility of using dogs with border, but an acceptable degree of dysplasia (C). Further, the requirements for the quality of the hips, and, consequently, the selection on this trait, again became more stringent, which led to a decrease in the proportion of dogs with this degree of hip dysplasia.

It should be noted that with a general similar tendency to change the ratios of dogs with different degrees of dysplasia by years, the proportion of dogs with the normal joint structure in 2013-2015 and in 2017-2018 significantly higher (φ *method*) than the proportion of females. This is additional evidence that the intensity of males' selection for this trait is higher. This conclusion also confirms by the presence of a small, but constant in all years, the percentage of females with a D degree, and even E degree of dysplasia. This leads to the conclusion that it is necessary to approach the selection of sires and dams with equal requirements to reduce the proportion of dogs with a high degree of hip dysplasia in the next generation, regardless of the involvement in the breeding process and the intensity of use of dogs of different sexes.

As a result of cluster analysis, all studied German shepherds were clearly divided into two clusters. Both groups are shown in Figure 3.

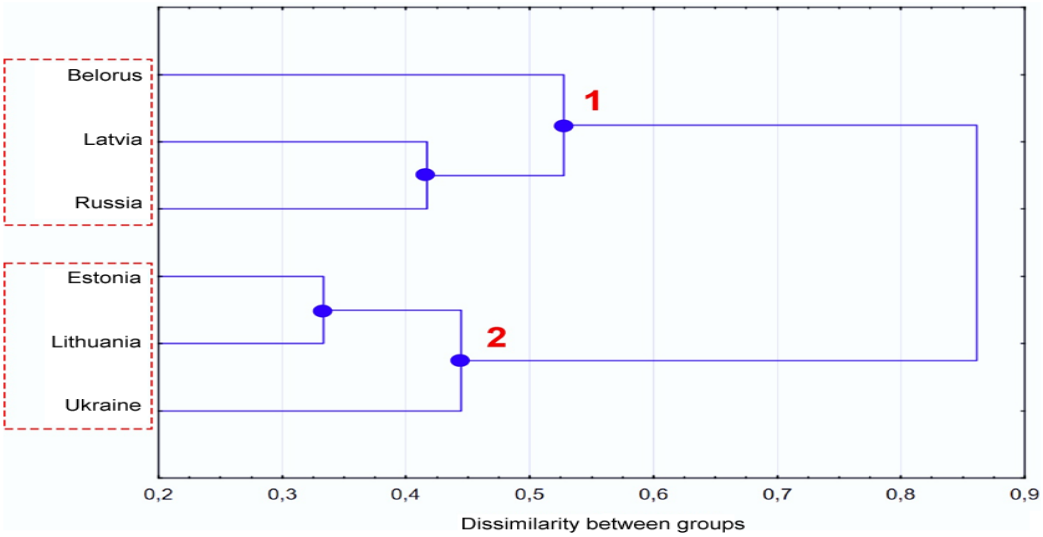

Figure 3: Cluster analyses dendrogram.

The first cluster included dogs from the following countries: Belarus, Latvia, and Russia, the second one - from Estonia, Lithuania, Ukraine. One-way analysis of variance using the McKean

k-means algorithm showed significant differences in intercluster averages ($p < 0.01$).

Such a division into clusters can be attributed, at least, to two factors.

As the first factor, we assume differences in approaches to the admission for German shepherds to the breeding use in these countries. Many breeders point out that in Estonia, Ukraine, and Lithuania, much earlier than in neighboring countries, they began to tighten the requirements for the condition of elbows and hips in German shepherds. As the second factor, we can consider the relative proximity of geo-cultural ties between individual countries in recent decades, which may affect the level of subdivision of the German shepherd population and the direction of gene flow in it.

For a more correct and accurate interpretation of the result, it is necessary to perform further analyses of the data, but collected in a larger volume and more detailed.

Before calculating the correlations between the traits we estimated compliance with the normal distribution for each trait studied. Previously, we excluded those signs whose distribution a priori could not correspond to the normal one. Like the rest, only inbreeding coefficient, HD R and HD L were considered (Table 1). Since the distribution of that signs (like all other signs) does not correspond to the normal one, we used nonparametric statistical methods for their analysis, in particular, gamma correlation. Table 2 shows the only reliable values of the correlation coefficients.

Table 1: Normality tests for HD R, HD L and inbreeding coefficient.

Traits	Test				
	Kolmogorov-Smirnov		Lilliefors	Shapiro-Wilk	
	Statistic	Sig.		Statistic	Sig.
HD R	0.495	<0.01	<0.01	0.491	0.00001
HD L	0.495	<0.01	<0.01	0.491	0.00001
Inbreeding coefficient	0.297	<0.01	<0.01	0.579	0.00001

Table 2: Gamma correlation between various traits

Traits	N	Gamma
HD – Sex	736	0.22
HD – Coat type	736	0.16
HD – HD-F	736	0.27
HD – HD-M	736	0.21
HD – ED-F	736	0.23
HD – ED-M	736	0.22
ED – Sex	736	-0.14
ED – Coat colour	736	0.14
ED – HD-M	736	0.12
Inbreeding coeff. – HD-F	541	0.17
Inbreeding coeff. – HD-M	541	0.09
HDL – Coat type	141	0.29
UAP_R – HD-F	735	-0.70
UAP_R – ED-F	735	-0.71
MCD_R – Sex	736	-0.46
MCD_R – ED-M	736	-0.61
MCD_L – Sex	736	-0.37
MCD_L – HD-F	736	-0.70
MCD_L – ED-F	736	-0.71
MCD_L – ED-M	736	-0.74
OA_L – Sex	736	-0.51
OA_L – HD-F	736	-0.70

A negative, but middle in strength, the correlation was found between the total degree of hip and elbow dysplasia of the dog's parents and almost all indicators characterizing changes in its elbows of the dog itself (from -0.67 to -0.74), except for incongruence value. It means that if destructive

changes in the hips and elbows are found in the parents of the dog, then it can be assumed that their offspring may have some deviations in the elbow structure.

Interestingly, a weak positive relationship between the inbreeding coefficient and the degree of the elbow and hip dysplasia was found (17 and 9%, respectively). We can assume that an increase in the average value of the inbreeding coefficient in a population will entail an increase in the probability to produce animals with destructive changes in the joints. Therefore, one of the measures to reduce the manifestation of elbow and hip dysplasia should be considered centralized monitoring of the frequency and degree of inbreeding mating in the controlled part of the population.

Special attention should be paid to the fact that the average negative and weak positive correlations of some dysplasia indicators with the sex of dogs were found. However, the data calculated require additional theoretical conceptualization and analysis to understand what is the reason (physiological, organizational, genetic, or other) for such statistical linkages creation.

4. CONCLUSION

The research studies German shepherd dogs populations obtained from Russia, Ukraine, Belarus, Lithuania, Estonia, and Latvia. After analyzing traits of hip and elbow dysplasia, it found that the ratio of dogs with varying degrees of degenerative changes in the elbow and hip was changed from 2011 to 2018, taking into account the gender of the dogs, color, and type of coat and inbreeding coefficient. Significant correlations were found between the level of elbow and hip dysplasia in the parents and the appearance of pathological changes in the elbow and hip of their offspring. It was also discovered that increasing the average mean of the inbreeding coefficient for the whole breed or part of the breed can cause an increase in the proportion of dogs with signs of joint dysplasia. Significance of differences between intercluster averages for 12 main characteristics for two groups of German shepherds has been obtained: the first group consists of dogs from Russia, Latvia, and Belarus, and the second one is formed by dogs from Lithuania, Ukraine, and Estonia.

The understanding and assertion that conducting a mandatory assessment of the degree of the elbow and hip dysplasia simultaneously using the results obtained for parents of dogs will increase the accuracy of the breeding value evaluation of individual dogs and, therefore, the effectiveness of breeding scheme with the breed as a whole. To reduce progressively the proportion of animals with joint dysplasia, it is also necessary to compile selection index for ranking dogs according to their breeding value, using the calculated correlation coefficients between the signs of hip and elbow dysplasia and in different generations.

5. AVAILABILITY OF DATA AND MATERIAL

Information about this study can be made available by contacting the corresponding author.

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