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CHANGES IN THE DYNAMICS OF WEATHER CONDITIONS AND BEHAVIORAL ACTIVITY OF ANIMALS ON THE DAY OF THE TOTAL SOLAR ECLIPSE OF AUGUST 1, 2008

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According to the observations of the total solar eclipse of August 1, 2008 changes in the daily dynamics of air temperature, wind speed and behavioral activity of animals, especially day-time insects were recorded. It was found out that the decline and subsequent recovery of meteorological and biological indicators follow the progress of illumination values with a slight time delay.

Keywords: total solar eclipse, the Earth's surface illumination, violation of photoperiod, weather conditions dynamics, daily activity of animals.

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Introduction. The intensity and duration of solar radiation are important regulators of the processes occurring in the atmosphere and the live shell of the planet. The total solar eclipse can be considered as a kind of natural experiment, comprising of sudden disturbance of the daily planetary dynamics by a sharp reduction of solar radiation level. The study of the natural dynamics of changes in physical and biological processes associated with these rare phenomena, contributes to a better understanding of those processes as well as the Sun-Earth relations. Therefore, the comprehensive monitoring of full solar eclipses, covering not only the space around the Sun, but also areas of the Earth's surface, are of great scientific value.

Status of the current research and goals. A total eclipse of the Sun is a very rare event for a given geographical location, and it is not easy to predict the reaction of animals to such events, thus more data is required, though the volume of literature concerning the topic is growing every year [1-8, 11-13]. However, the literary sources are isolated and do not include even the possible effects in relation to the major natural areas. Not all of the effects observed are expressed in comparable digital values. In addition, quantitative estimates of the connections between the obtained values are absent with rare exceptions [9, 10].

The purpose of this work is to study the changes of the atmosphere state and the daily activity of animals associated with the full solar eclipse of August 1, 2008, including the statistical analysis of the relationship between the values obtained.

On the techniques of observation. Changes of illumination (i) of permanent areas of the Earth's surface were recorded on the scale of the photo exposure meter "Ю-11/4", the temperature (t°C) was measured in the shade at the soil surface, wind speed (v) - at a height of 1.5 m using the inertial areometer "АРИ". Numbers of butterflies (L) and bees (A) flying were assessed on a conventional basis. The correlation coefficients between these parameters were calculated using the Past software.

Observation results:

On the total eclipse pattern. The sky during the eclipse was actually clear and cloudless, visibility – excellent. The solar crown appeared 2-3 seconds before the total phase, together with the observed phenomenon of the so called "diamond ring". During the total phase the locality was in the dark twilight. Illumination was the same as on 31/07 after the sunset (i=5.0). Plain text lines were clearly visible, but some letters and words not recognizable. Alongside with the darkened luminary Venus and Mercury were clearly visible, however, stars were not confidently observed. A glow ring shone in the northern part of the sky, the brightest area was observed 90° to the right of the Sun.

Changes in the atmosphere and behaviour of animals during the eclipse:

Meteorological observations of changes in illumination of the Earth's surface (permanent plots), air temperature and wind speed were performed on August 1, 2008 from the beginning till the end of the eclipse with an interval of 15 min., and as the full phase was approaching – every 2-5 minutes. Contact moments UT: T_1 = 9-41; T_2 = 10-45; T_{max} = 10-46; T_3 = 10-47; T_4 = 11-45. Reference data related to the usual daily dynamics of these indicators were obtained in the 2nd half of the day on July 31, 2008, at the same time monitoring of the daily activity of insects and animals was performed. The observation point: 54°15′8″ N, 83°28′10″ E. The overall results are presented in the Table 1.

Fifteen minutes before the total phase there was a marked reduction of light, air temperature and wind speed. The number of insects in flight reduced, especially noticeable in relation to butterflies and bees (see Table 1). Nine minutes before the total eclipse shadows on subjects began to warp and colour details of the area appeared in grey-silver tones. At the same time there was a rapid flight of a flock of rooks towards the northwest, accompanied by their continuous cawing, which is a feature of the disturbance behaviour. After the rooks a desolate hooded crow appeared in the sky. It changed the direction of flying randomly all the time. Farm animals in the village of Bochkaryovo (2 km from the observation point) subsided, however, 4 min. before the total phase there was a loud response from sheep, and 3 min. – from cows. Simultaneously there was loud barking

Table 1

Indicators of the state of the surface layers of the atmosphere and activity of insects in the ordinary course of daily dynamics and during the solar eclipse, where: i - the illumination of the Earth's surface on the scale of the photometer; t° - temperature, °C; v - wind speed, m/sec.; L - number of butterflies in flight; A - the number of bees in flight (in the sectors of simultaneous visual inspection)

	31/07/2008					*1/08/2008*				
T	**i**	**t°**	**v**	**L**	**A**	**i**	**t°**	**v**	**L**	**A**
16-40	10,5	+31	2,0	8	9	10,5	+29	3,5	8	9
17-00	11,0	+31	2,0	8	9	10,5	+29	3,5	8	9
17-15	11,0	+31	2,0	8	9	10,5	+29	3,5	8	9
17-30	11,0	+30	2,5	8	9	9,5	+27	2,0	6	7
17-40	11,0	+30	2,0	8	9	8,5	+23	1,5	1	5
17-45	11,0	+30	2,0	8	9	6,5	+21	0,5	0	4
17-47	11,0	+30	2,0	8	9	5,0	+20	0,1	0	3
17-50	11,0	+30	2,0	8	9	8,0	+20	0,5	0	3
18-00	10,5	+30	2,0	8	9	9,5	+20	1,5	0	5
18-15	10,4	+29	2,5	8	9	10,2	+21	1,0	2	6
18-30	10,3	+29	2,0	8	9	10,4	+22	1,0	5	7
18-45	10,0	+29	1,5	8	9	10,3	+24	0,5	8	8

of dogs that gradually grew stronger as the full phase approached. In the beginning of the total phase dogs and other domestic animals all went silent at the same time.

Temperatures (with some delay) fell in concordance with the diminishing light; in particular, the minimum temperature during the eclipse occurred at the end of the total phase. At this point the overall drop in air temperature during the eclipse reached 8°C, whereas the usual daily dynamics show a drop of only 1°C over the same period. Wind speed significantly decreased as the full phase approached, but after its completion it recovered its speed, and after that the gradual fall usual for the evening was observed. During the total phase the wind, with one exception of an individual gust, was practically absent. The overall drop in wind speed during the eclipse reached about 3.5 m/sec. The numbers of butterflies and bees in flight significantly decreased as the full phase approached; butterflies completely stopped flying 4 min. before the beginning and returned to this state 23 min. after its completion. As the total phase approached, flight activity of dragonflies, bumblebees, wasps and flies had fallen significantly, but quantitative data on these groups could not be obtained. The distribution and activity of ants on the ground near their nests during the eclipse remained completely unchanged.

Previously the responses of some species of Orthoptera, for which the normal diurnal song patterns are well established, were studied in relation to such events [11-13]. We focused on Bryodema gebleri - a species common in the area of the SW Altai and found in dry and semi-desert grassland habitats around the settlement of Kosh Agach. The singing activity of this grasshopper gradually declined during the eclipse, and stopped completely before the actual start of the total eclipse (Table 2). After a marked delay, the singing activity has suddenly renewed and quickly recovered to its usual level.

Thus, during a total solar eclipse the changing light conditions resulted in (with some delay) alteration of the usual daily dynamics of changes in air temperature, wind speed and activity of certain groups of animals (see Fig. 1 & 2). The data in general fits well with the results of observations of the total solar eclipse in this area on 31/07/1981 [2].

Table 2

Solar eclipse timing and song activity of *Bryodema gebleri* (*Insecta*: *Orthoptera*)

Location, latitude, longitude; date	Kosh Agach: 50°01 N, 88°44 E; 1/08/2008			
Timings	**Moon first touches the Sun**	**Actual start of the totality**	**Actual end of the totality**	**Moon is no longer visible over the Sun**
Local time (hour: minute: second)	17:54	17:55	17:56	18:54
Singing activity (stridulation)	Ceased at 17: 47		Renewed at 18:14	

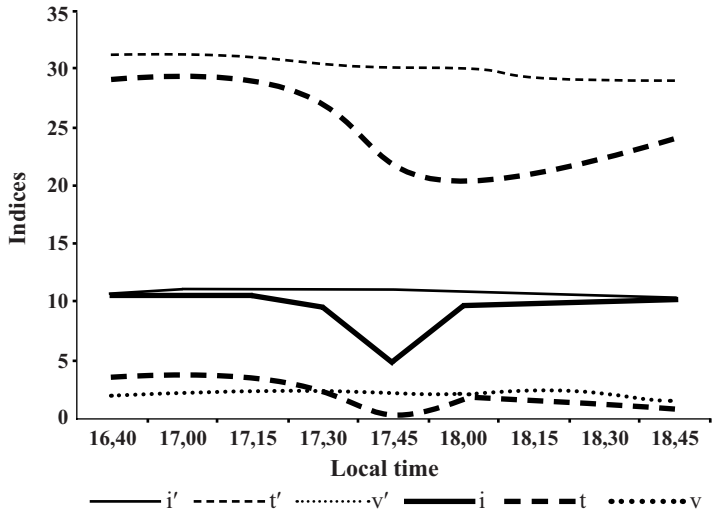

Fig. 1. Indices of environmental features under conditions of solar eclipse and reference observations:

i′ - illumination on the scale of the photometer on the reference day 31/07/2008;
t′ - air temperature (°C) on the reference day 31/07/2008;
v′ - wind speed, m / sec. on the reference day 31/07/2008;
i - illumination of the Earth's surface by the scale of the photometer on the day of the eclipse 01/08/2008;
t - temperature (°C) on the day of the eclipse 1/08/2008

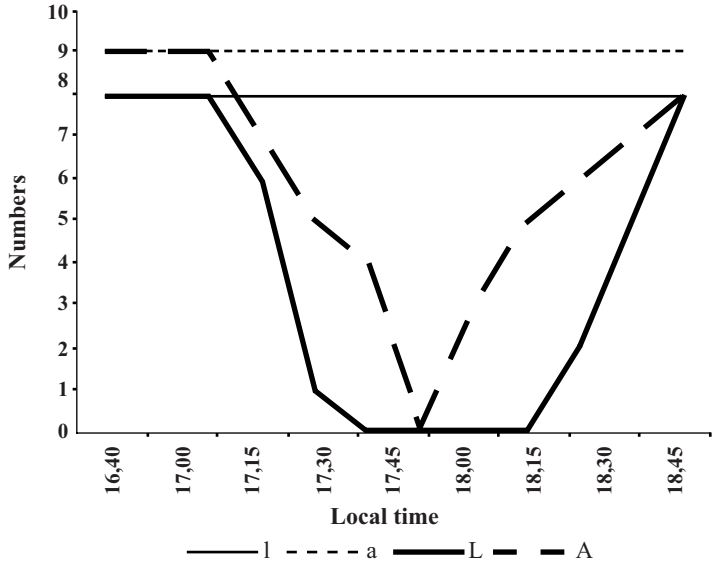

Fig. 2. Dynamics of numbers of butterflies and bees on the reference day and during the solar eclipse:

l - number of butterflies on reference day 31/07/2008;
a - number of bees on the reference day 31/07/2008;
L - number of butterflies on the day of eclipse 1/8/2008;
A - number of bees on the day of eclipse 1/8/2008

Table 3

Correlation coefficients between the physical and biological parameters during the total solar eclipse of 1/08/2008

	i	t°	v	L	A
i		0,59	0,62	0,73	0,84
t°	0,59		0,90	0,88	0,88
v	0,62	0,90		0,70	0,79
L	0,73	0,88	0,70		0.96
A	0,84	0,88	0,79	0.96	

The most noticeable changes in animal behaviour were manifested by day-time animals, primarily butterflies, *Hymenoptera*, dragonflies and birds. For instance during the eclipse of 01/08, butterflies and dragonflies almost ceased their flight under the recorded illumination of i=8,5, which happens when they retreat for the night, as in the reference observation carried out before on the 31/07 – 1 hour 20 min. before sunset (i=8,1). Fischer [11] suggests that light intensity is the main parameter controlling the diurnal song pattern in the species of orthopterans he studied, and obviously overrides any internal rhythm. This notion that may be true for *Bryodema gebleri*.

Bees, wasps and flies on the reference day of 31/07 disappeared from sight 20 min. before the sunset at about the level of illumination of i=6,0, which was observed at around the same level the next day before the full phase of the eclipse. Reference observations (carried out beforehand on the 31/07) showed that species of the local fauna of *Orthoptera*, which continued to stridulate during the total solar eclipse, maintained their sound activity at night. Night activities are also observed in ants. It should be noted that specific twilight and nocturnal species probably do not have time to activate within the short period of the total phase. For example, the mosquitoes that were active on 31/07 1 hour 10 min. before the sunset (when i=8,0), did not appear during the eclipse. Neither any hedgehogs nor bats were seen. The correlation coefficients (level of significance <0.05) between the investigated parameters are shown in the Table 3.

The highest correlation coefficients were between the number of bees and butterflies in the air, which indirectly indicates the similarity of their behaviour, and between air temperature and wind speed.

Conclusions. Quite similar changes in the atmospheric state, first of all the air temperature drop, as well as the weakened daily activity of the animals, especially insects and birds, were observed during other full eclipses: 6/30/1954 [1], 7/31/1981 [2-7], 11/08/1999 [8-10, 13]. Some authors also indicated changes in the shape of

the flowers of some plants [1, 7]. All observers notice that during the total phase the wind subsided, animal activity decreased and peace was establishment.

Illumination changes that took place during the total solar eclipse of 01/08/2008, caused significant changes in the usual daily dynamics of air temperature, wind speed and behavioural activity of animals – especially insects active in the day-time. The drop and subsequent recovery of meteorological and biological parameters following the changes in the level of illumination occurs with a certain time lag. Significant changes in daily dynamics of the surface layer of the atmosphere and behaviour of animals observed during the eclipse were recorded in the span of 15-20 min. before the total phase and 40-50 min. after its end.

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