ИССЛЕДОВАНИЯ

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SOME ANOMALIES OF THE PHENOLOGICAL WINTER 2019-2020 IN THE EUROPEAN TERRITORY OF RUSSIA

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Abstract. During the 2019-2020 winter period, peak positive temperature anomalies were recorded in most of the European part of Russia (ER) according to Yu. A. Izrael Institute of Global Climate and Ecology. The authors analyzed the meteorological characteristics of the winter season (34 parameters) and phenological data for 9 animal species (first occurrence) and 13 plant species (onset of sap ascent, onset of leaf flushing, onset of the flowering) for thirty years (1990-2019) in environmental monitoring in six State Nature Reserves: Voronezhsky, Prioksko-Terrasny, Tsentral'nolesnoy, Nurgush, Pinezhsky and Laplandsky. The data of meteorological parameters and phenomena obtained in 2020 were compared with the norm for 1990-2019 years through the normalized deviation indicator n. It is calculated as the ratio of the difference between the parameter value of the current year and the multiyear value to the standard deviation. In the reserves of the southern and central regions of the ER (Voronezhsky, Prioksko-Terrasny, Tsentral'nolesnoy, Nurgush), weather anomalies were revealed that caused an earlier onset of seasonal phenomena in the spring of 2020 in all observed plant and animal species. For example, onset of *Betula* sp., *Corylus avellana*, *Alnus glutinosa (A. incana)*, *Tussilago farfara*,

Scilla siberica, *Hepatica nobilis*, *Corydalis solida*, *Pulmonaria obscura*, *Anemonoides ranunculoides (A. nemorosa)*, *Salix caprea*, *Daphne mezereum*, *Pulsatilla patens* flowering was registered in record time. The winter season peculiarities in the Reserves of the northern taiga subzone (Pinezhsky and Laplandsky) were higher temperatures, precipitation abundance and longer periods with a stable snow cover, short periods with temperatures below -10°C. Average daily temperatures above -5°C and maximum above 0°C were established early. Some phenomena in Pinezhsky Reserve began earlier than multi-year terms (onset of *Betula* sp. sap ascent and of *Alnus incana* and *Tussilago farfara* flowering). The first spring phenomena in animals and 13 plants occurred at the usual time or later in Laplandsky Reserve. The use of the normalized deviation as a criterion for the "norm" made it possible to quantify the features of the early development of biota in different territories of Russia.

Keywords. Climate change, long-term data, Nature calendar, nature reserve, phenology, phenological date, phenological indicators, steady temperature transition, weather anomalies.

Introduction

In the last two decades, climate change and the redistribution of the Earth's heat balance are considered by experts as the dominant factor determining biodiversity indicators, as well as the shift in the time of occurrence of biological events (Minin, 2000; Kozharinov, Minin, 2001; Gruza, Ran'kova, 2012; Review…,2018; Report..., 2020; Sherry et al., 2007; Mann et al., 2017). The biota response is evaluated by the extent of the deviation of the time of manifestation of phenological phenomena from the chosen norms (Minin, 2000; Cleland et al., 2007). In general, there is an ambiguous response of ecosystem components to changes in the global climate system (Minin et al., 2016, 2017; Cleland et al., 2007; Parmesan, 2007; Mann et al., 2017; Ovaskainen et al., 2013, 2020), which can be significantly transformed at the local level. There are long-term meteorological and phenological series (Nature calendar) in Protected Areas that are of scientific interest for climate research and prediction of biota response to environmental conditions changes (Kokorin, Minin, 2001; Kozharinov, Minin, 2001). In recent years, important results have been obtained for many individual areas, but generalized conclusions are available for a few regions of Russia (Minin, 2000; Solov'yov, 2005; Gordienko, Minin, 2006; Minin et al., 2016, 2017; Ovaskainen et al., 2020). The authors resumed the traditions of Russian 20th century phenological analysis between regions, which were interrupted for some last decades. The research of regional features of the biota response to climate fluctuations continues to be an important task of our time.

During the 2019-2020 winter period, peak positive temperature anomalies were recorded in most locations of the European part of Russia (ER) according to Yu.A. Izrael Institute of Global Climate and Ecology. The purpose of this research was a mathematical analysis of the meteorological parameters of the winter seasons and long-term series of seasonal development of some animals and plants in these

Nature Protected Areas over 1990-2019 thirty-year period, and the identification of the biota's response to weather anomalies. The data of meteorological parameters and phenomena obtained in 2020 were compared with the 1990-2019 years norm through the normalized deviation indicator.

Materials and methods

Environmental monitoring data of six state reserved areas located in various natural zones of the European part of Russia (ER) were taken for analysis (fig. 1).

The Voronezh Biosphere Reserve (Voronezh Reserve) is located on the border of the Voronezh region and the Lipetsk region in the northern part of the Usman Forest, in a subzone of typical forest-steppe. Meteorological data were obtained from the gauging station and meteorological station of the reserve of departmental significance of the II category (Bazil'skaya, Starodubtseva, 2012).

The Prioksko-Terrasny Biosphere Reserve (Prioksko-Terrasny Reserve) is located in the Moscow region in the inhabited locality of Danki along the left bank of the Oka River, covered with pine and mixed forests (a subzone of coniferous-deciduous forests). Meteorological data were obtained from the background monitoring station, a separate division of the Federal state budgetary institution «Central AHEM».

The Tsentral'nolesnoy Biosphere Reserve (Central Forest Reserve) is located in the Tver region on the main Caspian-Baltic watershed of the Russian plain of the Volga and Western Dvina river basins in the southwestern part of the Valday upland in the southern taiga subzone. Meteorological data were obtained from the Tver Center of hydrometeorology and monitoring of environment «Lesnoy Zapovednik» meteorological station located on the «Centralnaya usadba» («Central Estate») of the Nature Reserve.

The Nature Reserve «Nurgush» (Nurgush Reserve) is located in the Kirov region in the wide right-bank floodplain of the Vyatka river in the southern taiga subzone with intrazonal biocenoses of floodplain coniferous-deciduous forests. Meteorological data were taken from the Kotelnich meteorological station, located 40 km north of the Nature Reserve.

The Pinezhsky Nature Reserve (Pinega Reserve) is located in the Arkhangelsk region on the right bank of the Pinega river in the area of its sub-latitude bend, in the northern taiga subzone with typical dark coniferous forests and a unique array of larch forests preserved on the eastern edge of Belomorsko-Kuloyskoe plateau. Meteorological data were obtained from the Pinega meteorological station, located 8 km to the east.

The Laplandsky Biosphere Reserve (Lapland Reserve) is located in the western mountainous part of the Murmansk region (Kola Peninsula) in the subzone of the northern rare-forest taiga, the border of which with the plain tundra runs 70-90 km from the northern border of the Nature reserve; the southern border runs 120-130 km north of the Arctic Circle. Meteorological data were obtained from the Monchegorsk meteorological station.

Figure 1. Map of the location of some Nature Protected Areas of the European part of Russia

The climate of all the Nature Protected Areas is moderately continental. According to B.P. Alisov's classification (1954), Voronezh, Prioksko-Terrasny, Central Forest and Nurgush Reserves are located in the Atlantic-continental region, while Pinega and Lapland Reserves are located in the area of Atlantic-Arctic influence. All territories of nature reserves are affected to varying degrees by the North Atlantic current.

The reports by the Russian Hydrometeorological Service (Roshydromet) refer to the calendar winter, which includes December, January and February. In our research, we consider a phenological winter that has different time limits in

different Protected Areas, but is equally characterized by the main criteria: trees and shrubs are leafless, most birds are flown away, and amphibians are in hibernation (Schultz, 1981). Another criterion for the winter season is permanent snow cover (PSC). This winter, according to Roshydromet, in the center, in the west and in the south of the ER, the formation of PSC did not occur. However, according to the data of Protected Areas, PSC with a lower height of the cover was noted, its terms were significantly reduced in comparison with the average long-term temperature by 65-100 days. In the north-west of the ER, on the contrary, the occurrence of PSC lasted longer than usual for 13-18 days due to April temperature below the average long-term temperature by 0.6-0.7°C.

The boundaries of the winter season in different Protected Areas are determined by different temperature criteria. For the beginning of the season in Voronezh, Prioksko-Terrasny, Central Forest and Nurgush Reserves is accepted to be a steady transition of daily average air temperature (Td) through 0°C downward, as for the end of winter and beginning of spring, it is a steady transition of Td through 0°C upwards. In Pinega Reserve, the boundaries of the winter season is determined by the period when a steady transition of the daily maximal air temperature (Tmax) through 0°C to the downward direction and back occurs. In Lapland Reserve, the beginning of the season is considered to be a steady transition of average Td through 0°C downward, and as for the beginning of spring, it is a steady transition Tmax through 0°C upwards.

In these Nature Reserves, steady transitions over certain thermal boundaries (0, -5, -10°C) were calculated on a consistent basis according to the Calculation rule adopted in the Guidance document of Roshydromet (2010). The base period, with which the current climate changes are compared with, is the period of 1961-1990. In this article, the average long-term dates and indicators are calculated for the period of 1990-2019 (from the winter of 1989-1990 to the winter of 2019-2020), because a 30-year period of time is considered to be optimal for determining the climate norm (Kozharinov, Minin, 2001).

To analyze and compare the phenomena of such different categories (meteorological data, abiotic factors, dates of the onset of seasonal phenomena in plants and animals), which differ significantly in variances, as well as in units of measurement (days, degrees, mm), the issue widely uses the normalized deviation **n**, calculated as the ratio of the difference between the value of the parameter of the current year and the long-term value (**M** is the arithmetic mean) to the standard deviation (σ). Most of the analyzed meteorological and phenomenal events have a normal distribution or, using mathematical transformations, it can be reduced to normal. In distributions close to normal, the range of deviations of dates from **M** is usually equal to 3σ in both directions. Therefore, it is believed that all possible deviations of the parameter from its true value will lie within ± 3σ. In the interval of the norm, between **M** - σ and **M** + σ, 68.27% of all variants, or sample dates are located. Between **M** - 2σ and M + 2σ lies 95.45% of total volume dates, and in the interval **M** - 3σ and **M** + 3σ lies 99.73% of the normally distributed population total volume. The use of a normalized indicator is suitable both for long-term series with a normal distribution and for another type of distribution (Zaitsev, 1984).

The following intervals for expert assessment of the date or parameter of the current year were chosen: “typical, normal” (| **n** | <1.0), early, later (1.0 ≤ | **n** | ≤ 3.0), anomalous (| **n** |> 3.0).

The "-" sign in front of the numerical expression of the normalized deviation indicates an advanced nature of the phenodata onset, the "+" sign shows a delay.

Discussions will show phenomena deviations in the range of -5.8> **n** > -3.0, which is outside the normal distribution. In our opinion, such "anomalies" indicate the biological plasticity of the studied objects, the possibility of shifting the rate of development to an earlier date with stable climate change.

The names of hydro-meteorological and phenological phenomena are given in the manuscript by Minin et al. (2020). The nomenclature of Latin names of plant species is given in accordance with the international taxonomic database Plants of the World Online (POWO, 2020). The nomenclature of animals is based on the taxonomy of the Global Biodiversity Information Facility (GBIF, 2019).

Results and discussion

Abiotic data

The winter of 2019-2020 has become the warmest in Russia over the entire 130-year history of regular meteorological observations since 1891. The absolute maximum of the average winter temperature has been reached in both the European and Asian territories. Last winter has become the warmest in history in the North-Western, Central, Volga, Ural and Siberian Federal Districts (meteoinfo.ru, 05.03.2020).

Our data confirms these facts. Almost all deviations from long-term data have been positive since November 2019. Starting from December, the normalized deviations of air temperatures indicate that the typical values of temperature parameters for all Protected Areas, except for Lapland Reserve, have been exceeded (table 1). In the Far North, this winter has not been a record warm one, because there have been five warmer winters for the previous 30 years. For five nature reserves, the average winter temperature was even more anomalous: **n** takes values from 2.4 to 3.1.

The duration of the period with a Td below 0°C in the center and the south of the ER was 28-38 days shorter than the long-term average and amounted 87-88 days. The winter season started at the usual time (**n** from -0.9 to 0.2), and ended early (**n** from -1.0 to -2.4) (table 2). There was no period with Tmax steady below 0°C in these areas, herewith the average duration is 88-92 days.

December and January were marked by frequent thaws, even in the northern Protected Areas. In the east of Central Russia (Nurgush) and in the North, the period with Td below 0°C was almost normal (+3 days), and in the Far North it was longer by 23 days. The period without thawing occurred only in the eastern and northern parts of the ER. In Nurgush it was 34 days shorter than the average, and in the north of the ER it ended earlier by 15-17 days, but the total duration of the period met the norm.

Table 1. Deviations of meteorological indicators during the winter season 2019-2020 in Protected Areas of the European part of Russia

Protected Areas	**Voronezh 51°52′31″ N 39°39′10″ E**		**Prioksko-Terrasny 54°54′53″ N 37°34′19″ E**		**Central Forest 56°30′ N 32°55′ E**		**Nurgush 58°00′44″ N 48°27′24″ E**		**Pinega 64°40′36″ N 43°11′57″ E**		**Lapland 67°49′00″ N 32°28′10″ E**	
Parameter	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n
Daily average Td the winter season. ºC	**-1.4** -5.9 ± 1.6 *-3.4/2012-13*	**2.8**	**-1.3** -6.0 ± 1.6	**2.9**	**-0.5** -5.5 ± 1.6 *-3.1/2007-08*	**3.1**	**-3.3** -8.5 ± 1.8 *-5.6/2003-04*	**2.8**	**-5.8** -10.5 ± 2.0 *-7.5/2007-08*	**2.4**	**-6.8** -8.4 ± 1.4 -5.7/1991-92 *1994-95*	**1.1**
Amount of precipitation during the winter season. mm	**99.5** 181 ± 50 *69/2002-03*	**-1.6**	**93** 175 ± 49	**-1.7**	**200** 229 ± 47 *154/1995-96*	-0.6	**326** 205 ± 53 *310/2014-15*	**2.3**	**212.5** 165 ± 33 *221/1992-93*	**1.4**	**280** 161 ± 30 *209/1999-00*	**4.0**
Average T in November. ºC	**0.8** -0.5 ± 2.9 *4.5/2010*	0.5	**0.9** -1.1 ± 3.0 3.9/2013	0.7	**1.5** -1.3 ± 2.9 *3.3/1996*	1.0	**-3.4** -3.6 ± 3.1 *1.6/2013*	**0.1**	**-4.5** -5.6 ± 3.7 *1.7/2005*	0.3	**-6.8** -5.0 ± 6.0 *0.0/2005*	-0.3
Average T in December. ºC	**-0.2** -4.9 ± 3.4 *1.1/2017*	**1.4**	**0.2** -5.2 ± 3.7 *0.8/2006*	**1.5**	**0.5** -5.2 ± 3.7 *1.3/2006*	**1.5**	**-4.1** -9.8 ± 4.5 *-4.4/2003.17*	**1.3**	**-3.7** -9.7 ± 4.3 *-2.3/2011*	**1.4**	**-5.6** -8.5 ± 7.1 *-2.0/2007*	0.4
Average T in January. ºC	**-0.7** -6.8 ± 3.3 *-1.0/2007*	**1.9**	**-0.5** -7.1 ± 3.0 *-2.0/2007*	**2.2**	**-0.2** -6.9 ± 2.8 *-2.7/2007*	**2.4**	**-4.1** -12.0± 3.2 *-5.4/2007*	**2.5**	**-8.4** -13.4± 4.0 *-6.9/2018*	**1.3**	**-9.9** -11.5 ± 8.2 *-5.4/2001*	0.2
Average T in February. ºC	**-1.4** -6.3 ± 3.6 *0.0/1990*	**1.3**	**-1.3** -6.5 ± 4.2 *0.0/1990*	**1.2**	**-0.9** -6.5 ± 3.9 *0.3/1990*	**1.4**	**-3.7** -10.7± 4.6 *-3.6/1995*	**1.5**	**-6.5** -11.6± 5.0 *-2.4/1990*	**1.0**	**-6.7** -10.9 ± 7.7 *-2.4/1990*	0.5
Average T in March. ºC	**4.2** -1.1 ± 2.9 *3.3/1990*	**1.8**	**3.3** -1.2 ± 2.9 *4.1/2007*	**1.6**	**1.3** -1.9 ± 2.5 3.2/2007	**1.3**	**0.7** -4.2 ± 2.9 *-0.5/2007*	**1.7**	**-2.1** -6.2 ± 3.7 *-0.2/2007*	**1.1**	**-4.9** -6.8 ± 6.0 *-1.3/2007*	0.3
Amount of precipitation in November. mm	**28** 52 ± 18.3	**-1.3**	**20** 46 ± 22.3	**-1.2**	**73** 62 ± 29.4	0.4	**76** 52 ± 16.7	**1.4**	**57** 47 ± 16.6	0.6	**40** 34 ± 14.6	0.4
Amount of precipitation in December. mm	**23** 53 ± 23.1	**-1.3**	**23** 44 ± 20.0	**-1.1**	**70** 60 ± 26.2	0.4	**77** 50 ± 14.4	**1.9**	**78** 44 ± 16.0	**2.1**	**77** 35 ± 14.6	**2.9**
Amount of precipitation in January. mm	**30** 54 ± 20.5	**-1.2**	**43** 44 ± 16.1	0.0	**59** 59 ± 21.3	0.0	**41** 45 ± 14.6	-0.2	**35** 38 ± 12.0	-0.2	**39** 33 ± 14.1	0.4
Amount of precipitation in February. mm	**69** 42 ± 18.3	**1.5**	**30** 40 ± 15.4	-0.6	**59** 45 ± 19.7	0.7	**63** 35 ± 15.8	**1.8**	**37** 31 ± 16.6	0.4	**64** 28 ± 13.5	**2.6**
Amount of precipitation in March. mm	**17** 41 ± 23.1	-1.0	**33** 38 ± 17.0	-0.3	**73** 45 ± 17.9	**1.6**	**57** 30 ± 14.9	**1.8**	**34** 32 ± 12.6	0.2	**47** 26 ± 13.3	**1.6**

In addition to the thermal limit of 0°C, the limits of -5°C and -10°C were considered (the latter is for the northern territories). It turned out that this winter in the ER only beyond the Arctic circle a steady period with a Td below -5°C lasted for more than three months, in the North-west and East it was 21% of the average long-term duration, and in the center and south of the ER it was not.

A steady period with Td below -10°C was observed only in the Far North. In the winter of 2020 it was two weeks shorter than the average (table 2).

Table 2. Deviations in the duration of phenological periods with stable meteorological parameters

Protected Areas	**Voronezh** 51°52′31″ N 39°39′10″ E	**Prioksko-Terrasny** 54°54′53″ N 37°34′19″ E	**Central Forest** 56°30′ N 32°55′ E	**Nurgush** 58°00′44″ N 48°27′24″ E	**Pinega** 64°40′36″ N 43°11′57″ E	**Lapland** 67°49′00″ N 32°28′10″ E
Parameter	**2019-2020** M	**2019-2020** M	**2019-2020** M	**2019-2020** M	**2019-2020** M	**2019-2020** M
Duration of the period with daily T below 0ºC, days	**87** 115	**88** 123	**87** 125	**148** 145	**169** 166	**199** 176
Duration of the period with daily T below -5ºC, days	**was not observed** 62	**was not observed** 64	**was not observed** 66	**21** 100	**24** 116	**131** 116
Duration of the period with daily T below -10ºC, days	it does not happen	it does not happen	it does not happen	**was not observed** 57	15 66	47 61
Duration of the permanent snow-covered period, days	**54** 119	**49** 130	**27** 127	**128** 150	**198** 185	**223** 205
Duration of the winter season, days	**87** 115	**88** 123	**87** 125	**148** 145	**130** 136	**158** 162

The amount of precipitation during the winter season fell less than the average in the south and center of the ER, and exceeded the norm in the north-west and east of Central Russia. The winter was very snowy in the Far North (table 1). A formation of the permanent snow cover in the south and in the center of ER was significantly delayed and occurred at a late date (**n** from 1.8 to 2.6). In the eastern part of the center of the ER and in the North, snow cover was formed at the usual time. On the contrary, the destruction of the snow cover in the southern regions occurred at a record early time (**n** from -2.4 to -3.8). The process of active and early snowmelt was confirmed by observations of thawed patches on open sites and thawed ring patches around trees (**n** from -2.3 to -2.6) (table 3).

Due to extremely warm weather in the winter of 2020, the process of ice formation on most rivers in the south, west and center of the ER was uneven and intermittent. Definitive ice formation on the water body was observed only on small rivers, lakes and ponds. In the north-west of the ER and in the Far North, ice cover was observed longer than usual (table 3).

Table 3. Deviations in hydrometeorological phenomena during the winter season 2019-2020 in Protected Areas of the European part of Russia

Protected Areas	**Voronezh 51°52′31″ N 39°39′10″ E**		**Prioksko-Terrasny 54°54′53″ N 37°34′19″ E**		**Central Forest 56°30′ N 32°55′ E**		**Nurgush 58°00′44″ N 48°27′24″ E**		**Pinega 64°40′36″ N 43°11′57″ E**		**Lapland 67°49′00″ N 32°28′10″ E**	
Phenomenon	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n	**2019-2020** M ± σ *extremum*	n
Transition of daily average air T below 0ºC – steady	**21.11** 23.11 ± 17 *04.01.2018***	-0,1	**21.11** 16.11± 21 *19.12.2006***	0,2	**21.11** 17.11 ± 16 *27.12.2015***	0,2	**29.10** 08.11 ± 12 *12.12.2008***	-0,9	**27.10** 28.10 ± 14 *27.11.1996***	-0,1	**16.10** 26.10 ± 11 *17.11.1989***	-0,9
Transition of daily maximal air T below 0ºC – steady	**was not observed** 01.12 ± 18 *27.01.2007***		**was not observed** 29.11± 20 *23.01.2007***		**was not observed** 29.11 ± 21 *23.01.2007***		**20.11** 14.11 ± 14 *19.12.2006***	0,4	**28.10** 08.11 ± 14 *11.12.1996***	-0,8	**23.10** 05.11 ± 12 *26.11.1996***	**-1,1**
Formation of the permanent snow cover	**12.01** 02.12 ± 18 15.01.2018**	**2,3**	**31.12** 25.11± 58 *20.01.2007***	0,6	**22.01** 25.11 ± 22 *21.01.2007***	**2,6**	**20.11** 12.11 ± 9 *26.11.2015***	0,9	**02.11** 01.11 ± 13 *27.11.1996***	0,1	**19.10** 27.10 ± 15 *24.11.1996***	-0,5
Definitive ice formation on the water body	**22.11** 26.11 ± 15 *08.01.2018***	-0,3	**21.11** 04.11± NDA		**24.11** 03.12 ± 24 *27.01.2007***	-0,4	**27.12** 02.12 ± 16 *31.12.2006***	**1,6**	**10.11** 17.11 ± 14 *18.12.2008***	-0,5	**29.10** 10.11 ± 10 *27.11.2005***	**-1,2**
Transition of daily average air T below -5°C – steady	**was not observed** 18.12 ± 22 *29.01.2007***		**was not observed** 13.12± 23 *24.01.2007***		**was not observed** 19.12 ± 24 *25.01.2005***		**26.01** 30.11 ± 19 *14.01.2014***	**2,9**	**17.01** 23.11 ± 22 *11.01.2018***	**2,5**	**27.10** 02.12 ± 21 *01.01.2008***	**-1,7**
Transition of daily average air T below -10 °C – steady	**was not observed**		**was not observed**		**was not observed**		**was not observed** 19.12 ± 24 *10.02.2018***		**25.01** 18.12 ± 23 *31.01.2018***	**1,7**	**18.01** 01.01 ± 25 *14.02.2005***	**2,8**
The transition of daily average air T above -10°C – steady	**was not observed**		**was not observed**		**was not observed**		**was not observed** 13.02 ± 19 *05.01.2000**		**09.02** 22.02 ± 18 *26.01.1990**	-0,7	**05.03** 03.03 ± 20 *27.01.2016**	0,0
Transition of daily average air T above -5°C – steady	**was not observed** 18.02 ± 21 10.01.1993, *2002**		**was not observed** 15.02 ± 26 *05.12.2015**		**was not observed** 23.02 ± 21 *09.01.2002**		**16.02** 10.03 ± 18 *31.01.2016**	**-1,2**	**10.02** 19.03 ± 17 *02.02.1990**	**-2,2**	**06.03** 28.03 ± 18 *17.02.2015**	**-1,2**

Table 3 continuation

Protected Areas	Voronezh 51°52′31″ N 39°39′10″ E		Prioksko-Terrasny 54°54′53″ N 37°34′19″ E		Central Forest 56°30′ N 32°55′ E		Nurgush 58°00′44″ N 48°27′24″ E		Pinega 64°40′36″ N 43°11′57″ E		Lapland 67°49′00″ N 32°28′10″ E	
Transition of daily maximal air T above 0ºC – steady	**was not observed** 27.02 ± 19 *12.01.1993**		**was not observed** 24.02 ± 18 *18.01.1990**		**was not observed** 01.03 ± 15 *27.01.2016**		**16.02** 16.03 ± 14 *06.02.2002**	**-2,0**	**06.03** 24.03 ± 13 *20.02.2015**	**-1,3**	**22.03** 04.04 ± 13 *25.02.2015**	-1,0
First thawed patches on open sites	NDA		NDA		**12.02** 21.03± 15 *24.02.2014**	**-2,6**	**14.03** 04.04 ± 8 *22.03.2002,2004*	**-2,5**	**20.04** 12.04 ± 9 *19.03.2015**	1,0	NDA	
First thawed ring patches around tree trunks	NDA		NDA		**12.02** 21.03 ± 14 *28.02.2014**	**-2,6**	**03.02** 10.03 ± 15 *07.02.2016**	**-2,3**	**16.04** 09.04 ± 11 *04.05.1993***	0,7	**18.05** 19.04 ± 8 *03.05.1997***	**3,6**
Transition of daily average air T above 0ºC – steady	**16.02** 18.03 ± 14 *18.02.2002, 2017**	**-2,1**	**17.02** 19.03 ± 17 *04.02.2002**	**-1,7**	**16.02** 22.03 ± 14 *21.02.1990**	**-2,4**	**25.03** 02.04 ± 8 *20.03.2007**	-1,0	**14.04** 13.04 ± 9 *27.03.2016**	0,1	**02.05** 20.04 ± 14 *27.03.2016**	0,9
Breaking up of ice on the water body	**08.03** 22.03 ± 12 *28.02.1990**	**-1,1**	NDA		NDA		**27.03** 14.04 ± 6 *01.04.2007**	**-2,9**	NDA		**03.06** 28.05 ± 7 *16.05.2016**	0,9
Destruction of permanent snow cover	**06.03** 30.03 ± 11 *06.03.2016**	**-2,4**	**18.02** 04.04± 12 *12.03.1995**	**-3,8**	**18.02** 01.04± 14 *06.03.1995**	**-3,8**	**26.03** 11.04 ± 7 *31.03.2007**	**-2,4**	**18.05** 05.05 ± 9 *14.04.1994**	**1,6**	**29.05** 20.05 ± 7 *08.05.2001/16**	**1,2**
Disappearance of snow cover on open sites	**07.03** 03.04±10,5 *07.03.2016**	**-2,6**	**20.02** 13.04± 10 *24.03.1990**	**-5,2**	**08.03** 05.04± 12 *10.03.1995**	**-2,3**	**14.04** 14.04 ± 6 *04.04.2007**	0,0	NDA		NDA	
Disappearance of snow cover in the forest	**04.03** 04.04±10,5 *08.03.2016**	**-3,0**	**27.02** NDA		**02.03** 19.04± 11 *20.03.2007**	**-4,4**	**02.05** 30.04 ± 9 *19.04.2010**	0,2	**29.05** 19.05 ± 9 *30.04.1999**	**1,2**	**08.06** 30.05 ± 6 *19.05.2016**	**1,5**
Total clearing of the water body from ice	**11.03** 05.04 ± 9,5 *16.03.2016**	**-2,6**	**17.03** NDA		**23.03** NDA		**09.04** 22.04 ± 6 *10.04.2007**	**-2,3**	**07.05** 05.05 ± 6 *25.04.1995**	0,5	**08.06** 01.06 ± 7 *20.05.2016**	1,0

Note. M – average annual value during 1990-2019; σ – standard deviation; NDA – No Data Available; * - earliest date; ** - latest date.

According to the scientific director of the Hydrometeorological Center of Russia R.M. Vilfand, the reason for such significant temperature anomalies of the past winter was the processes in the circulation of the earth's atmosphere in the circumpolar regions. Due to the very high positive phase of the Arctic oscillation, cold air masses did not move to the northern and temperate latitudes. Warm air masses from the Atlantic quickly moved from west to east, penetrating far into Siberia and even the Far East.

Biota

The above reasons created conditions for a very early start of vegetation in the south and center of European Russia. For some wintergreen species – *Carex* sp., *Achilea millifolium* L., *Chelidonium majus* L., *Lamium maculatum* L., etc. these processes were suspended only in short periods with slight frosts. During the long thaw, the seeds of annuals began to sprout, the snow-covered development of perennials was replaced by aboveground development with the early destruction of the snow cover. High temperatures in March activated physiological processes in hardy-shrub species and sap flow began in maples and birches, and buds began to swell in most native species.

In this article, the response of plants is considered in more detail, since it is for this group that the most complete data were obtained at the beginning of the field season in 2020, when the influence of abnormal winter weather was significant.

Onset of sap ascent of **downy** and **common birch** (*Betula* sp.) for all reserves south of 60° north latitude was registered in 2020 before the multiyear period (table 4). The beginning of sap flow in birch is associated with a steady temperature transition through 0°C (Minin, 2000), and the dates of steady transitions over 0°C threshold at these points are also among the earliest in the last 30 years (table 3).

Onset of the flowering of **hazel** (*Corylus avellana* L.) is presented for Voronezh, Prioksko-Terrasny and Central Forest Reserves, the dates of the phenomenon (pollinating of male catkins) are almost a month ahead of the long-term terms and **n** takes values from -2.3 to -3.4 (table 4). Flowering of the species is one of the first possible due to the peculiarities of biology: all the main organs are laid in the kidneys from the previous year until the onset of the main autumn frosts (Aksenova, Vakhrameeva, 1975). Observations of hazel trees in Voronezh Reserve in the warm winter of 2006-2007 showed that at high positive daytime temperatures, the stigmas of pistils move out of the female buds at the end of January and the male inflorescences (catkins) loosen. In 2020 already on February 3, in Voronezh Reserve, on hazel bushes with dense male inflorescences, it was possible to observe the beginning of the extension of maroon stigmas from female buds. These facts confirm that the period of deep dormancy in hazel is quite short, and the plant actively reacts to the steady arrival of heat in winter.

The synchronicity of the beginning of hazel dusting in 2020 in the above-mentioned Protected Areas is amazing, with different average annual dates and latitudinal location of observation points. The reasons, apparently, are as follows: the progressive movement of heat from January to end of March, the absence of the

maximum air temperature crossing 0°C threshold in the winter season 2019-2020, and the early destruction of snow cover.

Onset of the flowering of **common alder** (*Alnus glutinosa* (L.) Gaertn.) and **grey alder** (*Alnus incana* (L.) Moench) are given for all Protected Areas (table 4). Common alder or black alder, native to bottomland forests of the southern and central parts of the considered territory, is replaced to the north by grey alder. In this study common and grey alders are examined together as there is a similarity in seasonal development of the related species. Alder and hazel are some of the first to open the flowering calendar of the year. Pollinating of alder was extremely early for most Protected Areas, except for the Lapland Reserve, where flowering passed in regular time a little bit later the long-term date, what matched well the meteorological particularities of the year in the region.

Onset of the flowering of **coltsfoot** *(Tussilago farfara* L.*)* in all Protected Areas began ahead of the long-term date, especially the anomaly occurred in Nurgush Reserve (**n** = -3.0) (table 4). Development of generative organs in buds of the species almost entirely completes by autumn, winter months can be regarded as a period of relative dormancy, growth of the flower parts in buds increases sharply in the end of winter and in the beginning of spring (Gubanov, 1974). Therefore in anomalously warm winters, when the abiotic conditions are similar, the plant flowering starts earlier. The geographical particularities of the beginning of the coltsfoot flowering were considered and it was found that for all Protected Areas the time was negatively anomalous. For Central Forest and Nurgush Reserves it was the earliest time of the flowering start over the last 30 years. In Voronezh Reserve the species flowering was observed in regular time because of the particularities of the species habitat.

Onset of the flowering of **Siberian squill** (*Scilla siberica* Andrews), **liverleaf** (*Hepatica nobilis* Mill.), **fumewort** *(Corydalis solida* (L.) Clairv.) and other bulbous and tuberous perennials started anomalously ahead of the long-term date everywhere, where the species sprout (table 4). The very warm December and lack of snow cover in Voronezh region promoted all round underground growth of the perennials, partially sprout of their seeds, beginning of growth on the ground surface. Mass flowering of the Siberian squill was observed in the green area of Voronezh, in a park oak grove, from 10th to 24th of December 2019. It was reported by Mikhail Gluschenko, the manager of the project «Neskuchnyy den. Puteshestviya iz Voronezha» («Fun day. Trip from Voronezh»). There were more than a hundred sprouts of Siberian squill and a few dozen flowering plants with buds and half-opened whisks. A few dozen specimens of the liverleaf were reported flowering in the middle of November in Central Forest Reserve.

Table 4. Features of the seasonal development of biota at the beginning of 2020 in Protected Areas of the European part of Russia

Protected Areas	**Voronezh** 51°52′31″ N 39°39′10″ E		**Prioksko-Terrasny** 54°54′53″ N 37°34′19″ E		**Central Forest** 56°30′ N 32°55′ E		**Nurgush** 58°00′44″ N 48°27′24″ E		**Pinega** 64°40′36″ N 43°11′57″ E		**Lapland** 67°49′00″ N 32°28′10″ E	
Phenomenon	**Date of 2020** M ± σ *the earliest date*	n days	**Date of 2020** M ± σ *the earliest date*	n days	**Date of 2020** M ± σ *the earliest date*	n days	**Date of 2020** M ± σ *the earliest date*	n days	**Date of 2020** M ± σ *the earliest date*	n days	**Date of 2020** M ± σ *the earliest date*	n days
Sturnus vulgaris, first occurrence	**5.03** 18.03 ± 7,5 *4.03.1999*	**-1,8**	**3.03** 23.03 ± 9 *1.03.2008*	**-2,2**	**16.03** 22.03 ± 8,5 *2.03.2014*	-0,7	**26.03** 30.03±6,3 *15.03.2001*	-0,6	**28.03** 4.04 ± 8,7 *17.03.1991*	-0,8		
Alauda arvensis, first occurrence	**6.03** 22.03 ± 6,4 *28.02.2017*	**-1,1**	**7.03** 27.03 ± 9 *4.03.1995*	**-2,2**	**7.03** 24.03 ± 9,1 *8.03.2017*	-0,2	**10.04** 10.04±7,6 *28.03.2007*	0				
Betula sp. onset of sap ascent	**3.03** - -		**11.03** 1.04 ± 10 *11.03.2017*	**-2,1**	**10.03** 29.03 ± 9,5 *12.03.1995/15*	**-1,9**	**26.03** 15.04 ± 7,5 *31.03.2007*	**-2,7**	**17.04** 26.04 ± 7,4 *13.04.1994*	**-1,2**	5.05 1.05± 5,5 *21.04.2006*	0,7
Grus grus, first occurrence	**27.03** 25.03 ± 7,9 *7.03.2017*	0,3	**-** - *1.03.1990*		**25.03** 2.04 ± 7,2 *12.03.2003*	**-1,1**	**06.04** 14.04 ± 4,5 *29.03.2007*	**-1,7**	**28.04** 20.04 ± 4,8 *7.04.2004*	**1,6**		
Buteo buteo, first occurrence	**24.01** 26.03 ± 16 *28.04.2014*	**-3,8**	**18.03** 3.04 ± 16 *9.03.2015*	-1,0							**10.04** 20.04 ± 18 *1.03.2003*	-0,5
The revival of anthills	**11.03** 28.03 ± 9,5 *8.03.2002*	**-1,8**	**23.03** 1.04 ± 10	-0,9					**7.04** 12.04 ± 11,1 *16.03.2015*	-0,5	**18.05** 1.05 ± 10.9 *12.04.2011*	**1,6**
Aglais urticae, first occurrence	**8.03** 29.03 ± 10,3 *9.03.2017*	**-2,0**	**13.03** 4.04 ± 11 *16.03.2002/15*	**-2,0**	**24.03** 30.03 ± 11,4 *6.03.2014*	-0,5	**27.03** 9.04 ± 8,7 *31.03.2007*	**-1,5**	**12.04** 12.04 ± 9,9 *26.03.2007*	0,0		

Table 4 continuation

Gonepteryx rhamni, first occurrence	**8.03** 31.03 ± 11 *10.03.2002*	**-2,1**	*11.03.2002*		**25.03** 4.04 ± 13,2 *9.03.2014*	- 0,8	**29.03** 10.04 ±9,9 *18.03.2015*	**-1,2**				
Corylus avellana, onset of the flowering	**7.03** 2.04 ± 10,0 *8.03.2016*	**-2,7**	**7.03** 10.04 ± 10 *24.03.2008/ 15*	- **3,4**	**11.03** 5.04 ± 10,3 *10.03.2014*	- **2,3**						
*Alnus glutinosa/ Alnus incana**, onset of the flowering	**8.03** 2.04 ± 10,7 *10.03.2016*	**-2,4**	**11.03** 16.04 ± 11 *26.03.2007*	- **3,3**	**11.03*** 3.04 ± 10,6* *9.03.2014**	- **2,2**	**4.04*** 18.04 ± 5,6* *11.04.10/16**	**-2,5**	**19.04*** 28.04 ± 7,2* *15.04.2005**	**-1,3**	**15.05*** 11.05± 7,8* *25.04.2019**	0,5
Tussilago farfara, onset of the flowering	**20.03** 3.04 ± 9,8 *11.03.2016*	**-1,4**	**18.03** 7.04 ± 10 *18.03.1975*	- **2,0**	**19.03** 8.04 ± 8,6 *20.03.2001*	- **2,3**	**27.03** 17.04 ± 7,0 *3.04.2007*	**-3,0**	**13.04** 24.04 ± 6,4 *13.04.2015*	**-1,7**	**18.05** 21.05± 7,2 *8.05.2016*	-0,4
Ursus arctos, first occurrence according to the bear's track					**20.03** NDA		**12.03** 23.04 ± 19,6 *22.03.2002*	**-2,1**	**2.04** 7.04 ± 7,2 *25.03.2007*	-0,7	**15.04** 15.04 ± 8 *1.04.1990*	0,0
First spring occurrence of the wood tick	**5.03** 4.04 ± 11,7 *14.03.2017*	**-2,6**			**4.03**		**28.03** 24.04 ± 6,9 *16.04.2014*	**-3,9**				
Scilla siberica/ Hepatica nobilis onset of the flowering	**9.03** 5.04 ± 8,9 *15.03.2017*	**-3,1**			**10.03*** 5.04 ± 10,8* *12.03.2014**	- **2,4**						
Corydalis solida, onset of the flowering	**20.03** 11.04 ± 6,0 *31.03.2002/ 08*	**-3,7**	**18.03** 14.04 ± 6 *14.03.2015*	- **4,5**								

Table 4 continuation

Pulmonaria obscura, onset of the flowering	**13.03** 12.04 ± 6,8 *28.03.2014*	**-4,4**	**28.03** 18.04 ± 7 *30.03.2007*	**-3**	**04.03** 21.04 ± 7,5 *01.04.2014*	**-3,1**	**29.04** 02.05±4,2 *24.04.2008*	**-1,2**				
*Salix caprea/S. cinerea, S. acutifolia**, onset of the flowering	**26.03/28.03** 13.04 ± 6,6 / 14.04 ± 6,3 *1.04.2002/ 07**	**-3,0** **-2,5**	**8.04** 20.04 ± 7 *13.04.2007* *13.04.2008*	**-1,7**	**12.04** NDA		**5.04*** 22.04 ± 5,4 *13.04.2016*	**-3,2**	**10.05** 6.05 ± 9,6 *17.04.2000*	0,4	**25.05** 24.05 ± 8.0 *5.05.2016*	0,1
Daphne mezereum, onset of the flowering			**28.02** 15.04 ± 9 *3.03.1983*	**-5,8**	**9.03** NDA		**29.04**		**12.05** 9.05 ± 9,0 *25.04.2016*	0,3	**25.05** 22.05± 7,9 *6.05.2006*	0,4
Pulsatilla patens, onset of the flowering	**27.03** 16.04 ± 6,1 *06.04.2017*	**-3,3**	**30.03** 20.04 ± 7 *4.04.2007*	**-3,0**			**04.05** 30.04 ± 9,1 *16.04.1997*	0,4				
*Anemonoides ranunculoides/ A. nemorosa**, onset of the flowering	**20.03** 17.04 ± 6,2 *5.04.2006/08*	**-4,5**	**29.03** 21.04 ± 7 *4.04.2007*	**-3,3**	**28.03*** 15.04 ± 8,4* *25.03.2007**	**-2,2**	3.05*					
Prunus padus, onset of leaf flushing	**3.04 (29.03)** 20.04 ± 7,5 *3.04.1990*	**-2,2**	**18.04** 26.04 ± 9 *23.04.2000*	-0,9	**29.03** 19.04 ± 8,9 *25.03.2014*	**-2,3**	**7.05** 5.05 ± 7 *1.05.2015*	0,3				
Taraxacum campylodes, onset of the flowering	**8.04** 26.04 ± 7,1 *3.04.1990*	**-2,5**	**7.04** 4.05 ± 9 *19.04.2017*	**-3,0**	**3.05** 5.05 ± 7,4 *16.04.2001*	-0,2	**5.05** 8.05 ± 7,5 *27.04.2012*	-0,4	**29.05** 3.06 ± 8,8 *16.05.2016*	-0,6		

Note. M – average annual value during 1990-2019; σ – standard deviation.

Yellow star-of-Bethlehem (*Gagea lutea* (L.) Ker-Gawl.) and **Corydalis marshalliana** (*Corydalis marshalliana* (Pall, ex Willd.) Pers.) flowered extremely early in Voronezh Reserve: 13.03.2020 (**n** = -5.3) and 26.03.2020 (**n** = -2.9) respectively. A reduction of the intervals between flowering of the different species of perennials and a failure in the flowering order were observed, what sometimes manifests itself in the years with early and warm spring after good hibernation. So, the lungwort in Central Forest Reserve flowered earlier than the liverleaf, however the long-term order of these plants flowering is different. In Voronezh Reserve yellow star-of-Bethlehem even overtook Siberian squill on the first phases of growth, however yellow star-of-Bethlehem's development normally lags behind the squill's development for a few days. The reason for such early development of the species is the continuity of underground growth in warm winters and anomalously early establishment of positive daily temperature in the beginning of spring.

Onset of the flowering of **unspotted lungwort** (*Pulmonaria obscura* Dumort.), **yellow anemone** *(Anemonoides ranunculoides* L.*)* and **wood anemone** *(A. nemorosa* L.*)*, was also reported to be extremely early in the species' habitats. The significance of the anomaly for the lungwort was decreasing from south to north, what can be well compared with the later time of flowering in high latitudes and distribution of heat over the ER, which had already changed to that time.

The species of the genus *Salix*, which flower before foliage expansion, such as **goat willow** (*Salix caprea* L.), **grey willow** (*S. cinerea* L.) and **sharp-leaf willow** (*S. acutifolia* Willd.), are indicative among other early flowering hardy-shrub species as the indicators of early spring (table 4). In the habitats, where goat willow does not sprout, the anomalies of grey and sharp-leaf willows can be compared, as their flowering time is close together. It is significant, that willows' flowering was early and extremely early below 60° north and that it started in the third ten-day period of March and in the first ten-day period of April.

Data on *onset of the flowering of* **mezereon** (*Daphne mezereum* L.) were collected from the four Reserves (table 4). This small bush is referred to early-flowering plants. Flowering in the Moscow region environment takes place exactly after snow cover melting. Mezereon is ready for flowering from middle of December, but it remains in the state of enforced dormancy. The plant can flower in the winter period under certain weather conditions (Vakhrameeva, Denisova, 1974). So, the specimen of the plant flowered in the open ground of Botanical Garden on 24th of December in 1949, as it was reported by the staff of the Komarov Botanical Institute of Russian Academy of Sciences. The specimen had been transferred from the vicinity of the town Tikhvin to Garden in September of the same year. Local plants of that species also began to grow, their buds swelled and the bud scales partially opened, but the growth processes were stopped by the fall in temperature (Leontiev, 1950). A more amazing case of mezereon's flowering was reported in Central Forest Reserve on 12th of November 2019. It was promoted by warmth of the first half of the month. In comparison with the above-mentioned cases, flowering of mezereon on 28th of February in Prioksko-Terrasny and on 9th of March in Central Forest Reserves in 2020 is a normal display of the biological features of the seasonal rhythm of the species' development in anomalous for that

time of the year weather conditions. Flowering of that species in Pinega and Lapland Reserves started in regular long-term time. Taking account of the flowering particularities, mezereon can be used as an indicator of warm winter for the Central ER and of early warm spring for the North ER. The phase of the beginning of the species' flowering can be recommended to be included in the main list of Nature Calendars for those Protected Areas, where the species sprouts.

Onset of the flowering of **spreading pasqueflower** (*Pulsatilla patens* (L.) Mill.) on the south of the ER was observed in extremely early time, but in Nurgush Reserve on the east of the Central ER the species' flowering was already in regular for the territory time (table 4). A stable snow cover in Nurgush Reserve broke on 26th of March (11.04 ± 7; **n** = -2.4) (table 1), what was earlier than usual, but a temporary snow cover remained with short intervals till the middle of April.

Onset of leaf flushing of **bird cherry** (*Prunus padus* L.) in three more southern Protected Areas began before the multi-year deadlines. At the same time, an interesting feature of the seasonal development of the species for Voronezh Reserve and Central Forest Reserve was the registration of the appearance of the first young leaves on individual bushes at the end of March. Due to the return of cold weather, the greening process in these territories stopped and began in full force only with the arrival of warm days on April 4th and 10th, respectively (table 4). These facts show how important it is to choose specimens with average development periods in the population for long-term observations. On the other hand, observations of species under different growing conditions allow us to study the possibilities of species biology under abnormal conditions. It is impossible to answer with the help of the available facts why the appearance of leaves of bird cherry in Prioksko-Terrasny Reserve began much later, despite the middle position of the territory between Voronezh and Central Forest Reserves. In Nurgush Reserve, the beginning of bird cherry greening was registered in the usual time frame.

Onset of the flowering of **dandelion** (*Taraxacum campylodes* G.E. Haglund) in this analysis has been chosen because of the particular qualities of the biology of the species. For example, some authors (Ermakova, 1990) indicate that in the Moscow region dandelion inflorescences are laid in the axils of wintering leaves in the summer, often some of them bloom in the same year, but most of them bloom after overwintering from May to early June. That is, to bloom in the usual time after the winter season, the species needs a sufficient amount of heat, since flowering occurs in early May. In 2020 there was an abnormally early start of flowering of individual dandelions in Voronezh and Prioksko-Terrasny Reserves, while in the Voronezh one the beginning of flowering of single dandelion individuals on the central estate was registered in December 2019. In Central Forest, Nurgush and Pinega Reserves, the beginning of dandelion flowering was observed at the usual time.

Among the wildlife objects of other systematic groups, we selected birds that arrive in the first wave, and insects whose first appearance also occurs at the beginning of the spring season.

The first appearance of **starling** (*Sturnus vulgaris* L.) and **sky lark** (*Alauda arvensis* L.) for Voronezh and Prioksko-Terrasny Reserves was recorded at a very early date, in Central Forest and Nurgush Reserves these species were registered

earlier than the long-term date, but within the normal range. The first appearance of **crane** (*Grus grus* L.) in early terms was marked for Central Forest and Nurgush Reserves, the first flocks were able to appear in the central regions with the first strong heat wave, the dates of 2020 were not the earliest in the last 30 years.

The situation is similar with **buzzard** (*Buteo buteo* L.). In mild winters with an abundance of murines flocks of buzzards can roam the entire cold period in the southern regions of the ER, as well as in the vicinity of the city of Voronezh. In other Nature Protected Areas, the first appearance of the species is marked somewhat earlier or at the usual time. Perhaps due to the location of observation points, buzzards also roamed the fields in winter in the vicinity of Prioksko-Terrasny Reserve but were not registered by observers.

Seasonal activity of **invertebrates** depends on local weather conditions, so data on the first appearances of this group are especially interesting for abnormal fluctuations in the temperature regime during the year. All information about the first appearances of invertebrates in 2020 in record early dates was registered only in Voronezh Reserve. The first release of earthworms was recorded early on 12.03 (**n** = -1.9), although the normalized deviation indicator suggests that even earlier dates could be recorded for this event. Further north, the dates of invertebrate encounters are usually earlier than long-term ones, but not record-breaking (table 4). In Central Forest Reserve in the first half of March 2020, there was no early flight of small tortoiseshell as in Voronezh and the Prioksko-Terrasny Reserves, and the first appearance of brimstone and small tortoiseshell was noted only at the end of March. Moreover, for the first time in all the years of research, there were isolated appearances of background species of anglewing and emperor moth in the spring (*oral report by entomologist E. D. Korobov*). Ticks both in the southern and central nature reserves showed activity very early (table. 4).

Winter exits from badger burrows and early appearance of hedgehogs after wintering were registered in Voronezh Reserve and Central Forest Reserve (*oral reports of colleagues-specialists*). The first brown bear track appearance in Pinega Reserve was recorded with negative deviations from long-term dates (table 4), while in Nurgush Reserve the anomaly is significant (**n** = -2.1). 300 km northwest of Nurgush Reserve in the Kirov region, there was a report of a bear coming out of hibernation on February 26 after heavy rains with the usual awakening in late March or early April.

Conclusions

A rapid assessment of the main climatic parameters of the biota response to weather changes in 2020 in the European part of Russia has been given. In the winter of 2019-2020, absolute peaks for a large number of meteorological and phenological parameters of the winter season of the Nature calendar were recorded. Along with expressed positive anomalies in the temperature regime, negative (leading) deviations in the timing of phenological phenomena occurrence from the long-run annual average in a number of species have been recorded. At the same time, in Voronezh, Prioksko-Terrasny and Central Forest Reserves these deviations are very

significant for phenomena that normally occur between March and April. The advance of multiannual terms becomes less expressed or phenological events occur within the normal range for more northern Nature Protected Areas (Nurgush and Pinega Reserves) for the same phenological dates.

It is obvious that an integrated approach to environmental monitoring, which has been preserved and continues to be implemented in Protected Areas, makes it possible to obtain an objective holistic picture of both the features of annual changes in weather conditions and the subsequent reaction of living organisms to these changes.

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НЕКОТОРЫЕ АНОМАЛИИ ФЕНОЛОГИЧЕСКОЙ ЗИМЫ 2019-2020 гг. НА ЕВРОПЕЙСКОЙ ТЕРРИТОРИИ РОССИИ

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Реферат. В зимний период 2019-2020 гг. на бóльшей территории Европейской части России (ЕЧР) были зарегистрированы рекордные положительные аномалии в температурном режиме (по данным ФГБУ «Институт глобального климата и экологии имени академика Ю.А. Израэля»). Авторы провели анализ метеорологических характеристик зимнего сезона (34 параметра) и фенологических данных для 9 видов животных (первая встреча) и 13 видов растений (начало сокодвижения, начало развертывания листьев, начало цветения) за тридцать лет (1990-2019 гг.) в рамках экологического мониторинга в шести государственных природных заповедниках: Воронежский, Приокско-Террасный, Центрально-Лесной, Нургуш, Пинежский и Лапландский. Полученные в 2020 году данные метеопараметров и феноявлений сравнили с нормой для 1990-2019 гг. через показатель «нормированное отклонение n». Он вычисляется как отношение разницы значения параметра текущего года и многолетней величины к стандартному отклонению.

В заповедниках южных и центральных регионов ЕЧР (Воронежский, Приокско-Террасный, Центрально-Лесной, Нургуш) выявлены погодные аномалии, ставшие причиной более раннего наступления сезонных явлений весной 2020 года у всех наблюдаемых видов растений и животных. Например, у *Betula* sp., *Corylus avellana*, *Alnus glutinosa*, *Alnus incana, Tussilago farfara, Scilla siberica, Hepatica nobilis, Corydalis solida, Pulmonaria obscura,*

Anemonoides ranunculoides, A. *nemorosa*, *Salix caprea, Daphne mezereum, Pulsatilla patens* даты начала цветения зарегистрированы в рекордно ранние сроки.

Особенностями зимнего сезона в заповедниках подзоны северной тайги (Пинежский и Лапландский) были более высокая температура, обилие осадков и более длительные периоды с устойчивым снежным покровом, короткие периоды с температурой ниже -10°C. Рано установились среднесуточные температуры выше -5°C и максимальные выше 0°C. Некоторые явления в Пинежском заповеднике наступили раньше многолетних сроков (начало сокодвижения у березы, начало цветения ольхи серой и мать-и-мачехи обыкновенной). В Лапландском заповеднике первые весенние феноявления у животных и растений наступали в обычные сроки или позже.

Использование нормированного отклонения в качестве критерия «нормы» позволило количественно оценить особенности раннего развития биоты на разных территориях России.

Ключевые слова. Заповедник, изменение климата, Календарь природы, многолетние данные, погодные аномалии, устойчивый переход температуры, фенодата, феноиндикаторы, фенология.