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Features of the dynamics of the reproductive cycle of female reindeer in the taiga and tundra zones

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Abstract: Reindeer remains one of the least studied animals from the point of view of genetics and reproduction of all animals that are use by humans in economic activities. In Russia, reindeer is use as a farm animal to produce environmentally friendly meat with high nutritional value. Reindeer is also the basis of economic activity for the indigenous peoples of the Arctic. Depending on the climatic zone, there are two methods of breeding reindeer - tundra and taiga. For more effective breeding and planning of reproduction work of this species of animals, it is necessary to have clear knowledge about the features of their reproductive cycle. Reindeer are animals with a pronounced seasonal reproduction; in addition, the timing of calving and rutting season can shift significantly depending on changes in weather conditions. According to researchers, the gestation period of northern females has a very high variability. The aim of this work was to conduct research on the differences in the timing of the beginning and end of the calving and rutting periods, their dynamics, as well as the duration of pregnancy in female reindeer in reindeer herding farms in the taiga and tundra climatic zones. To compare the dynamics and timing of calving and rutting, data were collected on the recording of matings and calvings in reindeer herding farms in the tundra zone of the Arctic regions of the Russian Federation (Taimyr Peninsula and Yamal Peninsula) and in the taiga zone (Buryatia). Because of the research, it was found that not only the timing of the rut, but also the timing of calving have differences in time in the tundra and taiga habitat zones of reindeer, in addition, they can shift even within the same climatic zone depending on weather conditions. The pregnancy period under unfavorable weather conditions can be shorten or extend.

Keywords: *Climatic zones, Rangifer tarandus, Reindeer, Reproduction, Reproductive cycle, Taiga, Tundra.*

1. Introduction

The reindeer (Rangifer tarandus) is one of the few domesticated mammals that has a distinct breeding season, adapting to the extreme conditions of the arctic and subarctic climate. Their reproductive cycle closely linked to changes in photoperiod, which requires optimizing the breeding season in conditions of limited resources. In Russia, reindeer is a farm animal. From time immemorial, this type of animal has been the basis of life and traditional culture for the indigenous peoples of the Far North, such as the Nenets, Dolgans, Nganasans, Evenks and many others. From the 50s to the 90s of the twentieth century, the scientific principles of selection and breeding of animals were introduce into the practice of reindeer husbandry. As a result by the end of the twentieth century in the Arctic regions of Russia (Nenets Autonomous district, Yakutia, Chukotka) four breeds of reindeer were bred and officially registered (Nenets, Even, Evenki and Chukotka).In the Republic of Buryatia, the Tofalar reindeer, which is an brat of the Evenki breed of deer, is widespread. In addition to domestic reindeer,

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the regions of the Far North are home to populations of wild reindeer, which are phenotypically significantly different from domestic reindeer. One of the key points in successful breeding of farm animals is a high level of knowledge about the structure, functioning and regulation of the reproductive function of such animals. The practice of breeding cattle and small cattle, pigs, chickens and other farm animals on an industrial scale all over the world based on a high level of reproduction of the livestock. This level has been achieve thanks to deep knowledge of the structure, functional features and mechanisms of regulation of the reproductive system of the main animal species. Assisted reproductive technologies, such as obtaining and cryopreserving sperm, artificial insemination, and embryo transplantation, are widely used. Assisted reproductive technologies have found especially wide application in large-scale cattle breeding, where artificial insemination has practically displaced natural insemination. Despite the fact that several thousand tons of reindeer meat harvested annually in Russia, the issue of scientifically, based reproduction of the herd remains unresolved. Reindeer reproduction has not been sufficiently studies.

The most significant obstacle to the successful use of reproductive technologies in reindeer herding is the seasonality of reproduction. Seasonality is due to the harsh living conditions of reindeer beyond the Arctic Circle and the lack of practice of keeping animals in specialized stationary premises. The absence of stationary farms with a large number of livestock is due to the peculiarities of the food supply of reindeer. The main food for reindeer is lichens, which are characterize by a high content of carbohydrates. Harvesting such feed is extremely unprofitable economically; they cannot be grown, since they are not angiosperms for which seeds can be harvested and sown over large areas. And the most critical point is that lichens grow extremely slowly, several millimeters per year, so it is impossible to grow them artificially. Therefore, reindeer herding is nomadic livestock farming, since reindeer can only be kept in natural conditions. This significantly affects the absence of changes in the seasonality of reproduction, unlike other domestic productive animals. Reindeer constantly move from pasture to pasture and cover huge distances in the process Figure 1.

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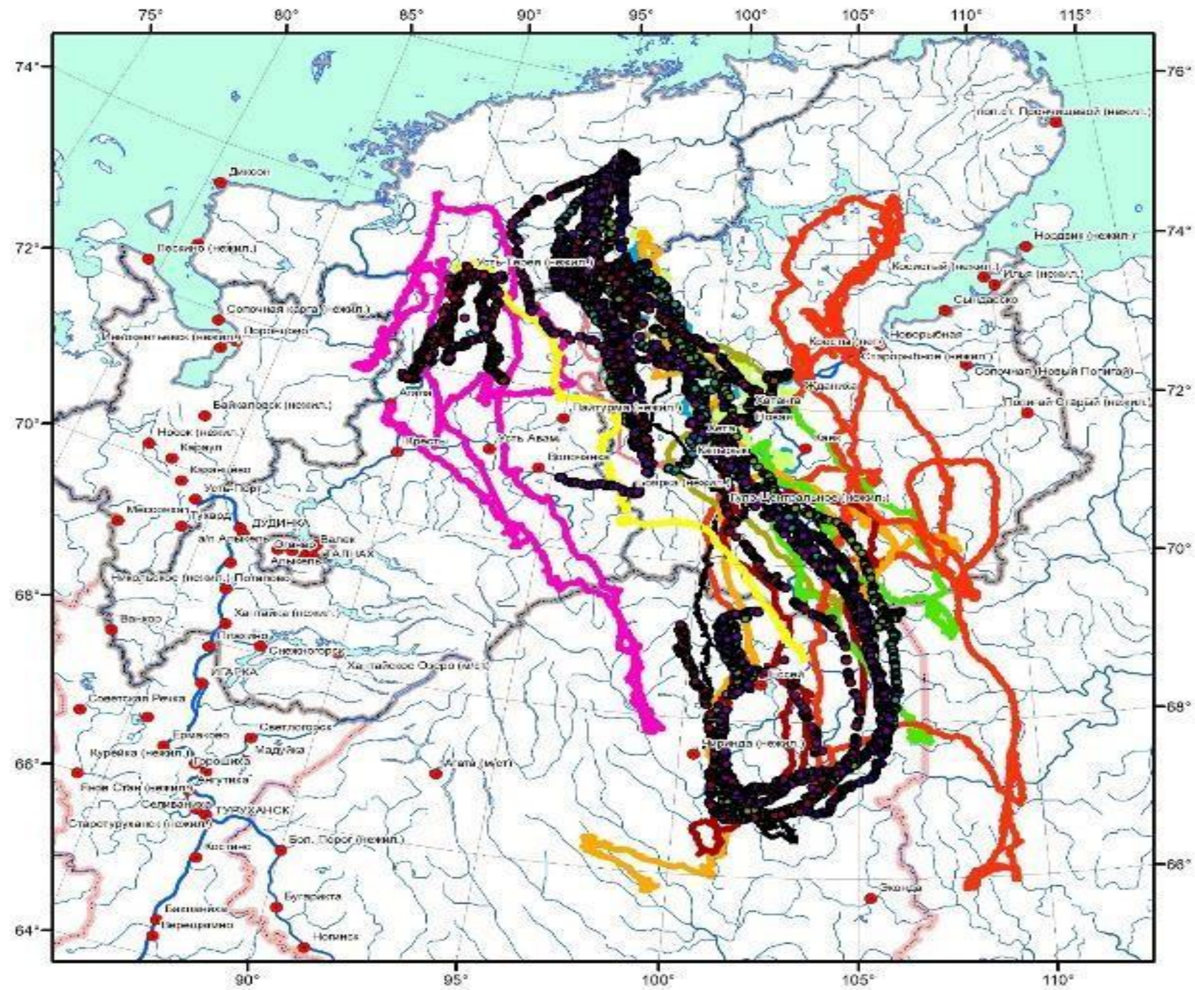

Figure 1.
Tracks of wild reindeer of the Taimyr population, marked with radio beacons (http://zapovedsever.ru/news/details/rezultaty-monitoringa-sostoyaniya-i-territorialnogo-razmeshheniya-tajmyrskoj-populyaczii-dikogo-severnogo-olenya-1-etap-ekspedicziya-xeta-xatanga-2020).

Female reindeer, unlike such types of farm animals as cattle and pigs, have a clearly defined seasonal reproduction and come into sexual heat (rut) only once a year. The severity of the seasonality of reproduction in reindeer is associated with the extreme conditions of their arctic and subarctic range. Their reproductive cycle is primarily closely linked to changes in photoperiod (length of daylight), which allows for the optimization of reproduction in conditions of limited resources [1]. The main trigger for the onset of reproduction in reindeer is the shortening of daylight in autumn. This phenomenon initiates a cascade of endocrine changes that stimulate the sexual cycle in animals. Research shows that a reduction in photoperiod is a key signal for the onset of the mating season in reindeer.

Extreme climatic conditions also play a role in regulating the reproductive cycle. Winter cold and summer abundance of food affect the physical condition of animals, which, in turn, affects their reproductive capacity [2].

Nutrition is also a significant factor in regulating the seasonality of reproduction in reindeer. The availability and quality of food varies greatly throughout the year. The summer period of abundant food allows reindeer to accumulate the necessary energy reserves for successful reproduction and bearing

offspring in winter and spring [3]. Genetic factors also play an important role in the seasonality of reproduction. Genetic differences between reindeer populations can also affect the timing of their reproduction. For example, caribou and reindeer have different seasonal timing of reproductive events [4].

The rut begins in different regions at different times and significantly depends on weather conditions even within the same climate zone. The beginning of the rutting period depends on a whole range of factors. The rutting period can take place in a short period, or it can be extend over time. However, the period of mass rutting occurs for three to four weeks, when the main population of females is inseminate. The main determining factors for the onset of the rut include the temperature regime - the rut begins with the onset of negative temperatures and can be active even at very low temperatures (about -25°C – -35°C).

The main environmental factors that influence the reproductive seasonality of reindeer include photoperiod, climate conditions, food availability and stress levels. Photoperiod is a key factor determining the onset of the mating season in reindeer. The reduction in day length in autumn serves as a signal for the onset of the reproductive cycle. This is because changes in day length affect melatonin levels, which in turn regulates the secretion of gonadotropins and sex hormones. Melatonin is a hormone secreted by the pineal gland that regulates circadian rhythms and responds to changes in daylight hours. When daylight hours are short, melatonin levels increase, stimulating the hypothalamus to secrete gonadotropin-releasing hormone (GnRH) [1]. GnRH stimulates the anterior pituitary gland to secrete luteinizing hormone (LH) and follicle-stimulating hormone (FSH), which play a key role in regulating ovarian and testicular function. Increased levels of LH and FSH stimulate ovulation in females and spermatogenesis in males [5]. Increased levels of estrogen and progesterone in females and testosterone in males are the result of activation of gonadotropins. These hormones regulate the development of the reproductive organs and the body's preparation for reproduction [6]. The endocrine mechanisms that regulate seasonal changes in reindeer are poorly understand. Research suggests that reproductive hormone levels and their interactions with external factors such as photoperiod and nutrition require further study [7].

Another significant factor in the onset of the rut is the level of nutrition of the female by the rut season, which is an indicator of the body's readiness for pregnancy. Seasonal changes in the weight and body condition of female reindeer affect their reproductive capacity [8]. According to researchers, the onset and duration of the rut in reindeer also depends on the abundance of food during the growing pasture period. The more nutritional the females are, the better their condition during the summer period, the earlier the rut begins [5] within the season and weather conditions. The mechanisms of the relationship between seasonal changes in the weight of female reindeer and their reproductive function are not yet fully understood and require further study [8].

Many researchers note a high degree of dependence of the timing of the onset of the rut, pregnancy and calving on changes in climatic conditions in the habitat of reindeer. In particular, studies conducted on semi-domestic reindeer in Northern Finland over 45 years [9] have shown that the start of the calving season has shifted and begins on average 7 days earlier, which is explained by the increase in average annual temperature over the past decades (i.e., global warming), as well as a decrease in the level of snow cover and the amount of precipitation in the reindeer habitat. The timing of the onset of the rut and, accordingly, calving also have annual fluctuations, which is associated with the timing of the onset of positive temperatures, the beginning and duration of the vegetative period of pastures. In addition, the researchers noted an extension of the calving period in the herd, it became more extended in time. Individual variability in the timing of calving could also be affected by improved climatic conditions in autumn and winter, which led to a weakening of the synchronicity of calving within the herd [9]. Climate change may not only directly affect the shift in calving and rutting dates, but also indirectly, for example, by increasing the activity periods of insects that pursue reindeer [10]. It has been noted that Arctic parasitic insects may exacerbate the effects of seasonality on host populations [11], including the timing of the reproductive cycle, reducing the fatness of female reindeer and forcing

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herds to migrate to more northern territories where there are fewer parasitic insects. Despite significant research, our knowledge of the reproductive cycle of female reindeer remains fragmented. In particular, the endocrine mechanisms that regulate seasonal changes in their bodies are insufficiently studied. Research shows that reproductive hormone levels and their interaction with external factors such as photoperiod and nutrition require further study [7].

2. Materials and Methods

Data on the start dates and duration of rutting and calving for two years were obtained from the documentation of economic records of private farms on the Taimyr Peninsula (n=560) and the Yamal Peninsula (n=323) (tundra, Arctic zone), as well as in the reindeer herding on the farm of MAU "Directorate of the Territory of Traditional Natural Resources Management of Soyots" (n=110) (taiga zone, Buryatia). To carry out the analysis, all rutting and calving periods were divide into decades (10 days each). The recorded dates of mating and calving were distribute according to the days of the decades. Females that entered the state of sexual heat (rutting season) were distinguished from other females by characteristic behavioral signs: they stop feeding, behave restlessly, mount other deer and allow the male to mount (Figure 1).

Figure 1.
Cage of a male reindeer (Onot, Buryatia).

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3. Results and Discussions

We have identified three main factors that influence the timing of the start of the rut in reindeer: the climatic zone of habitat, the weather factor (the onset of negative temperatures) and the level of fatness of females. In the tundra and taiga zones, the rut does not occur simultaneously, which is due to differences in climatic conditions. In the taiga zone, the rut begins later, the difference is 15–20 days, and the rut takes place in a shorter period. In the tundra zone, the rut begins on average in the first ten days of September. The initial period lasts approximately until the end of September, the mass rut stage lasts from the beginning of October to the end of the second ten days of October, and the final period stretches from the third ten days of October to almost mid-November. In the taiga zone, the rut begins later - at the very end of September and takes place in a shorter time - on average until the end of November. Thus, the difference in the timing of the beginning of the rut between the tundra and taiga is about three weeks, and in the timing of the end of the rut - about 10 days. The beginning of the rut depends on weather conditions and can also vary within one climate zone. Experienced reindeer herders know that the rut begins when average daily temperatures drop to negative. If the onset of negative temperatures is delay, then the start of the rut is shift to a later period. An important factor in the individual variability of the onset of the rut is the fatness of the females, that is, the body's readiness to bear a pregnancy. The most well fed females come into heat first. If the summer was unfavorable and the females were unable to achieve the necessary body condition, then the rut begins later and extends over time. In both the tundra and taiga regions, the rut of reindeer occurs unevenly and is divide into three stages: initial, mass and final (Fig. 2). The initial stage lasts from 5 to 15 days; at this stage, adult females with good body condition come into heat. At the stage of the mass rut (10–15 days), the bulk of females of all ages come into heat. Moreover, the final stage is the longest and lasts 20 – 25 days. At this stage, all remaining females gradually enter the rutting state. At the initial stage, up to 20% of females are cover, at the stage of mass rutting - up to 65% of females, and at the final stage, the remaining 15% of females are covered.

In the taiga zone, the rut begins later and is characterize by a shorter duration; females come into heat in a shorter period of time Figure 2.

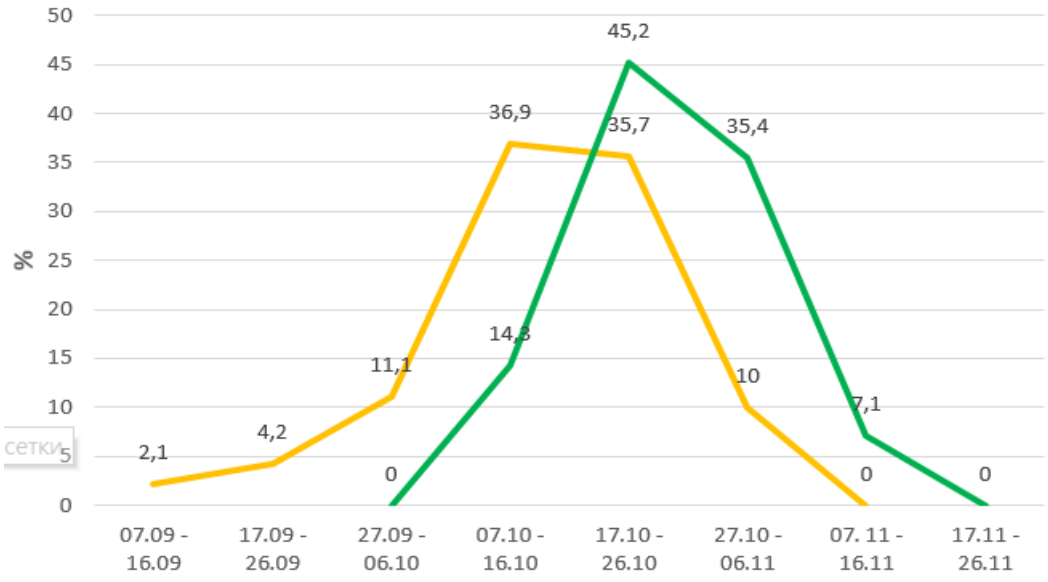

Figure 2.
Dynamics of the reindeer rut in the tundra (Orange) and taiga (Green) zones.

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The initial stage of the rut in the taiga regions begins in late September - early October and lasts until mid-October. The mass rutting stage starts from mid-October and covers the first week of October. The final stage takes place on average from the second week of October to the end of November. In the first phase of the rut, up to 15% of the females are cover, during the mass rut - up to 75%, and in the final phase - about 10% of the females.

Calving is an important period for the population, as it becomes more vulnerable to predators, more dependent on the food supply, and young animals are susceptible to changing weather conditions. Therefore, synchrony in the appearance of offspring reduces risks for the population [12]. This is a significant adaptive feature for populations living in regions of high latitudes with a short growing season. Phenological changes significantly affect the food supply of Arctic ungulates [13]. Trophic mismatch has a negative impact on reindeer reproduction [14]. Calving, as well as the rut, occurs unevenly, but has a fairly narrow period for a herd of 1500 - 2000 heads, where females make up 50 - 60%: in the tundra zone about 55 - 60 days, in the taiga - on average 45 - 50 days. Studies conducted on North American bighorn sheep (*Ovis canadensis ssp.*) also confirm that calving timing is significantly dependent on climatic and weather conditions [15].

Calving in a herd, just like the rut, is divid into stages: initial, mass and final. In the tundra and taiga zones, calving on average begins approximately simultaneously with a difference of several days, in the tundra zone it begins several days earlier. However, in the tundra zone, calving is more extended and ends a about 10 days later than in the taiga zone. Calving begins around mid-April in both the tundra and taiga, but in the tundra, the initial phase of calving is delay until the end of April. In the tundra zone, the mass calving stage lasts from the beginning of May to 20 May and the final stage - from the end of May to mid-June. In the taiga zone, mass calving begins earlier - in the last ten days of April and ends by mid-May. The final stage of calving begins in mid-May and ends in early June (Fig. 2).

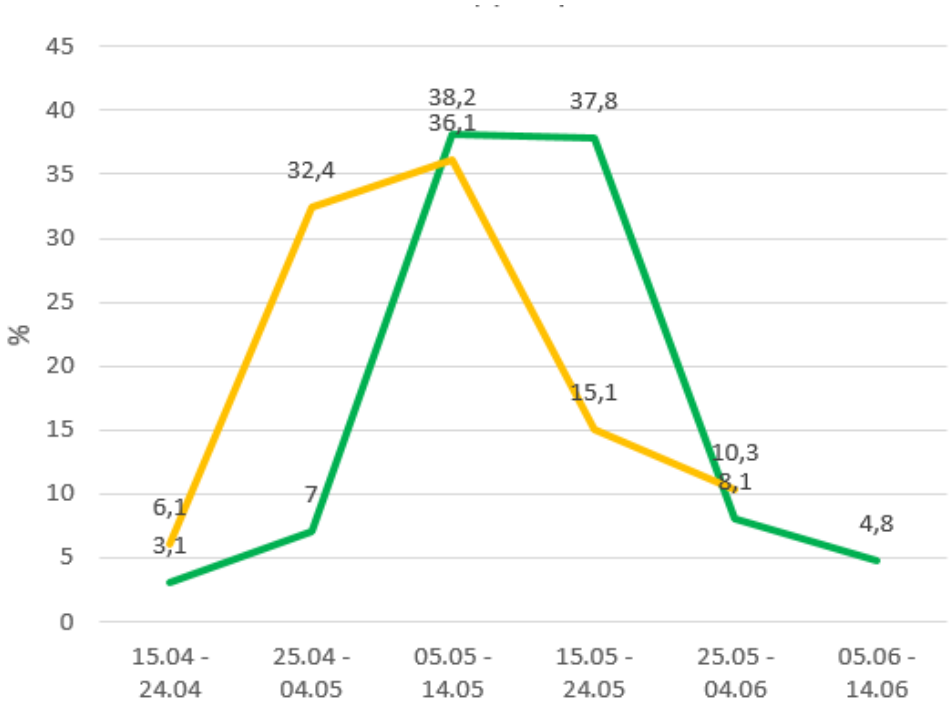

Figure 3.
Calving dynamics of female reindeer in the tundra (green) and taiga (orange) zones.

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The bulk of calving in the tundra zone occurs from mid-May to the first week of June (about 65-70%), and in the taiga zone - from late April to the second half of May (70-75%). Analysis of calving data showed that the start and end dates of calving, as well as its extension, vary from year to year and depend on feeding conditions in the winter-spring period; the less favorable they are, the later calving begins and lasts for a longer period of time. . In addition, the dynamics of calving significantly depend on weather conditions. At the stage of mass calving in the tundra zone, when unfavorable weather conditions occur (lower temperatures, strong winds, snowstorms), calving abruptly stops. Such weather conditions can last from several days to one and a half to two weeks. During this period, calving does not occur (Figure 4).

Calving resumes when favorable weather arrives and is more widespread. Stopping calving when unfavorable weather conditions occur leads to more mass calving when the weather improves. Thus, the regulatory adaptive mechanisms of female reindeer may suspend calving until the onset of favorable weather conditions. This is also, why the gestation period in reindeer is very variable.

An analysis of the scientific literature on the duration of pregnancy in female reindeer showed that there is no consensus among researchers working on this issue and there is a very large scatter in the data regarding the number of days of pregnancy. E.V. Shmit [16] determined that the pregnancy period in female reindeer can range from 219 to 238 days, and also that females inseminated at the beginning of the rut carry the fetus 6-7 days longer than those inseminated at the end of the rut.

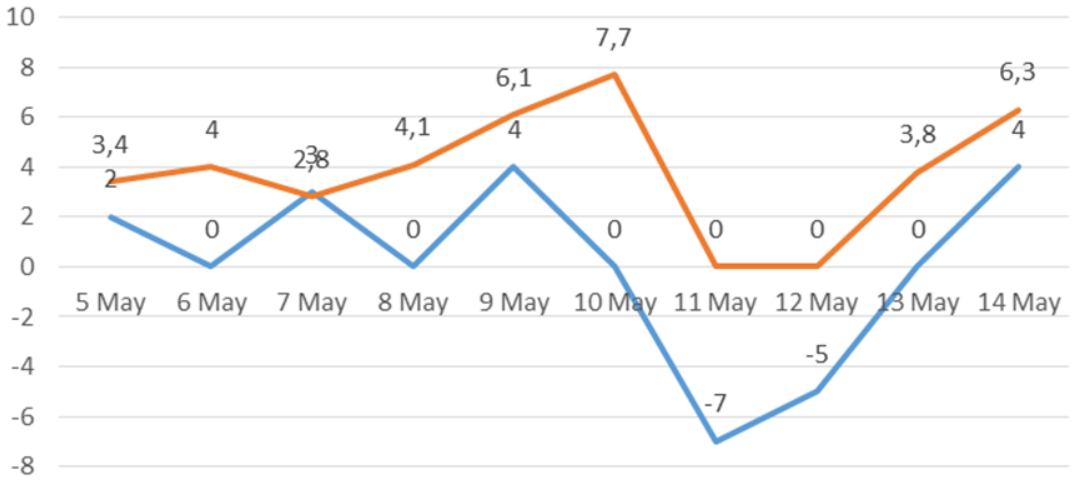

Figure 4.
Dependence of the number of daily calvings in % (red) on fluctuations in ambient temperature at ^{0}C (blue).

E.I. Gorbunov [17] found that the pregnancy period for female reindeer is on average 223 days. The wide range of gestational ages also depends on region, weather conditions and feeding conditions. The importance of a complete food supply during the period of preparation for the rut and during pregnancy for maintaining a high level of reproduction in reindeer herds is give first place in some studies [18]. Our research also confirms that the body condition of female reindeer plays a significant role in their reproductive function, since it is females with good body condition who come into heat first and become mated first. Our further studies on an experimental group of animals will make it possible to clarify the timing of pregnancy in reindeer.

4. Conclusions

The seasonality of reindeer reproduction is a complex and multifaceted process, regulated by a number of external and internal factors. Despite significant advances in the study of these processes, many aspects of the reproductive cycle of female reindeer remain incompletely understood. The

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introduction of reproductive assisted technologies in reindeer husbandry faces numerous difficulties that require further research and adaptation of methods. A better understanding of these processes will help not only to improve the management of domestic reindeer populations, but also to introduce reproductive technologies into reindeer breeding. Despite the fact that humans in agriculture actively use domesticated reindeer, their existence is as close to natural as possible. The human influence on reproductive function is minimal; it is close to the physiological norm as in wild reindeer. This significantly distinguishes reindeer from most other farm animals, which have lost their seasonal reproduction as a result of domestication. The reindeer body is characterize by a high level of adaptation processes that regulate reproductive function in response to changing weather conditions. Adaptation mechanisms also cause a shift in the timing of the rut, pregnancy and calving of reindeer in the tundra and taiga climatic zones relative to each other. Therefore, in the northern tundra regions the rut begins in early September and can last up to a month and a half. In the taiga regions, the rut begins on average three weeks later, in the last ten days of September, and has a shorter period. The clearly expressed seasonality of the sexual cycles of females is an evolutionarily formed adaptation feature to the extreme conditions of the Far North, which makes it possible to obtain offspring in the shortest possible time and the most favorable for feeding, which is limit by a short period of positive temperatures and, accordingly, a short growing season of pastures. Analysis of the dynamics of rutting and calving in the tundra and taiga zones allows us to conclude that the duration of pregnancy of females actually has a high level of individual variability and depends on climatic and weather conditions, as well as the body condition of the female, which is determined by the quality and availability of food supply. The variability of the pregnancy period is also an adaptation mechanism aimed at preserving offspring in the extreme conditions of the Far North.

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