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Light pollution affects body mass and age of the first mating of domestic male birds (study model: Domestic Pigeon)

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Abstract
Urbanization around the world is accompanied by a new and growing phenomenon called artificial light at night or light pollution. Because this pollution disrupts the natural light-dark cycle of the earth, it has many behavioral and physiological effects on living organisms and is a potential threat to biodiversity. We tried to find out the effects of this pollution on male birds by disrupting the dark-light cycle of the domestic pigeon (*Columba livia domestica*). The birds were divided into control and lighting groups. In the light group, birds were exposed to artificial light at night from the time of mating until determining the sex of chickens and reaching the age of first mating. In addition to examining the age of the first mating and body mass, some growth-related traits were also measured. Comparing the mean of the studied traits in the two groups using an independent t-test, we found that the increase in body mass in male chickens exposed to artificial light at night until the end of adulthood was always less than in the control group, male chickens in the light group much faster than Male chicks in the dark group reached the age of first mating, but no significant differences were observed in the traits of nesting age, flight age, wing length, tip length, and tarsus length. This study demonstrates the importance of biological cycles in birds and we hope that will be a reason for further studies on light pollution, which is one of the reasons for the disruption of these cycles.
Keywords: Artificial light at night, darkness-light cycle, body mass

Introduction

The darkness-light cycle is one of the most important factors in the growth and survival of the planet's creatures. All organisms on Earth, from the smallest to the largest, have evolved and grown according to this cycle, so most of the behaviors and physiological processes of these organisms are in harmony with this cycle. By disrupting the natural cycle of the darkness-light, artificial light at night has created a new type of pollution called light pollution, and it has changed the night environment in many parts of the world, according to Koen et al. (2018) the rate of this pollution has almost doubled in the last 30 years in areas with good biodiversity (Koen et al., 2018). Since the natural light cycles allow living things to predict environmental changes (Gaston & Bennie, 2014), artificial light at night can cause many disturbances in the behaviors and activity patterns of living things by altering these natural light cycles, in fish, for example, it changes their communities (Becker et al., 2013), the effect on migration and motor activity (Lowe, 1952; Vowels and Kemp, 2021; Riley et al., 2012; Juell & Fosseidengen, 2004), a disorder of melatonin secretion (Bruning et al., 2015), effect on reproduction (Fobert et al., 2019; Bruning et al., 2010) Changing predator-prey interactions (Bolton et al., 2017; Mazur & Beauchamp, 2006), and habitat change (Bolton et al., 2017). In insects, its effects in the form of attraction to light sources (Altermatt et al., 2009; Wakefield et al., 2016; Eisenbeis, 2006), reproduction reduction, and disruption of related practices and behaviors to that (McLay et al., 2017; Firebaugh & Hynes, 2016; Botha et al., 2017; Van Geffen et al; 2015a; Bird & Parker, 2014; Van Geffen et al., 2015b), change in larval growth time (Van Geffen et al., 2014), effect on predator-prey interactions (Stone et al., 2015; Warren, 1990), disruption and changes in movement patterns, (Duarte et al., 2019; Shi et al., 2017) changes in foraging behavior (van Langevelde et al., 2017), disruption of orientation (Dack et al., 2013) and population decline (Lewis et al., 2020) appear. In reptiles, it influences the pattern of food search timing (Garber, 1978), patterns of activity (Maurer et al., 2019) and orientation (Bourgeois et al., 2008). On the behavior of foraging (Bird et al., 2004; Shier et al., 2020; Spoelstra et al., 2015., Zhang et al., 2020) patterns of activity (Stone et al., 2012; Haffmann et al., 2018), reproduction (Rabert et al., 2015), melatonin secretion (Dimowski & Robert., 2018) and immune function (Zhang et al., 2020) affects mammal. In amphibians on movement pattern (Baker and Richardson, 2006; May et al., 2019), reproduction (Touzot et al., 2020; May et al., 2019) and activity (Touzot et al., 2019) affect. And in birds due to living in diverse habitats (De jong et al,. 2016) and the visuals of these creatures (Goldsmit, 1990) as a result of their sensitivity to light, we can explicitly say that these creatures are greatly affected by artificial light at night. The effects of artificial light on birds at night can be attributed to the effect on singing behavior (Da silva et al., 2016; Miller, 2006), activity (de Jong et al ,. 2016; Schlicht et al., 2014), feeding behavior (Santos et al., 2010), sleep (Aulsebrook et al., 2020), reproduction (de jong et al., 2015; Dominoni & Partecke., 2015; de Molenaar et al., 2006), migration and orientation (Rowan, 1925; Horton et al., 2019), absorption of artificial light at night (Rodriguez et al., 2015; Rebke et al., 2019), disorder of melatonin secretion (Moaraf et al., 2019) and even the impact on the choice of migratory bird resting place (McLaren et al., 2018) can be mentioned. Although several different studies have been performed in birds, it can be said that the effects of this pollution on the sex of birds have not been studied separately. Here we focus on the effect of artificial light at night on male birds.

Martial and methods

In the present study, 50 adult pigeons were examined. The birds were released into the natural environment during the day and had sufficient access to water and grain throughout the day. At night, they were divided into two groups, with 25 birds in the dark group and 25 birds in the light group. The birds were monitored at night in two chambers, one completely dark for the control group and the other chamber equipped with LED lights to obtain samples of the lighting group. The lighting group was affected by night light from the time the birds mated until the chicks reached the age of first mating. The lights were turned on at sunset and off at sunrise.

After hatching, the weights of the chicks were measured at all stages of development (from birth to the age of flight chicks) at intervals of twice a week with a digital scale (100 g accuracy). Around the fourth week, the chicks were examined daily to record the exact time of their departure from the nest. With the growth and completion of feathers and wings, the chicks were kept at a height of about 1 meter and 30 cm above the ground. If flying about 5 meters, maintaining balance when sitting on the ground, the age of flight, and the number of chickens to fly received. On the same day, the flight length of the tip (from below the mandible to the end of the tip), the wing (from the wing protrusion to the end of the first remex), and the tarsus (from the outer bend of the joint to the base of the toes) were measured. In order to obtain the time of the first mating, the chicks were regularly examined and observed, and by observing them mating, the desired time was recorded.
After collecting data, the first independent t-test in SPSS 23 software was used to examine the differences between the variables of darkness and light. Multiple regression analysis was used to quantify the response of weight changes between the two groups on different days and the corresponding chart was drawn in the Excel program. It should be noted that the type of regression and its order were determined based on the value Coefficient of Determination (R2).

Results

Regression equation of weight changes of male chickens in two groups

The regression equation for changes in the weight of male chicks (Figure 1) shows that the response of male chicks to artificial light at night is to gain less weight than male chicks in the dark group. This difference in weight gain between the chickens of the two groups started slowly from the end of the second week, but at the age of 21 days, this difference reaches its peak and from the age of 24 days until the chicks arrive, this difference in weight gain remains constant.

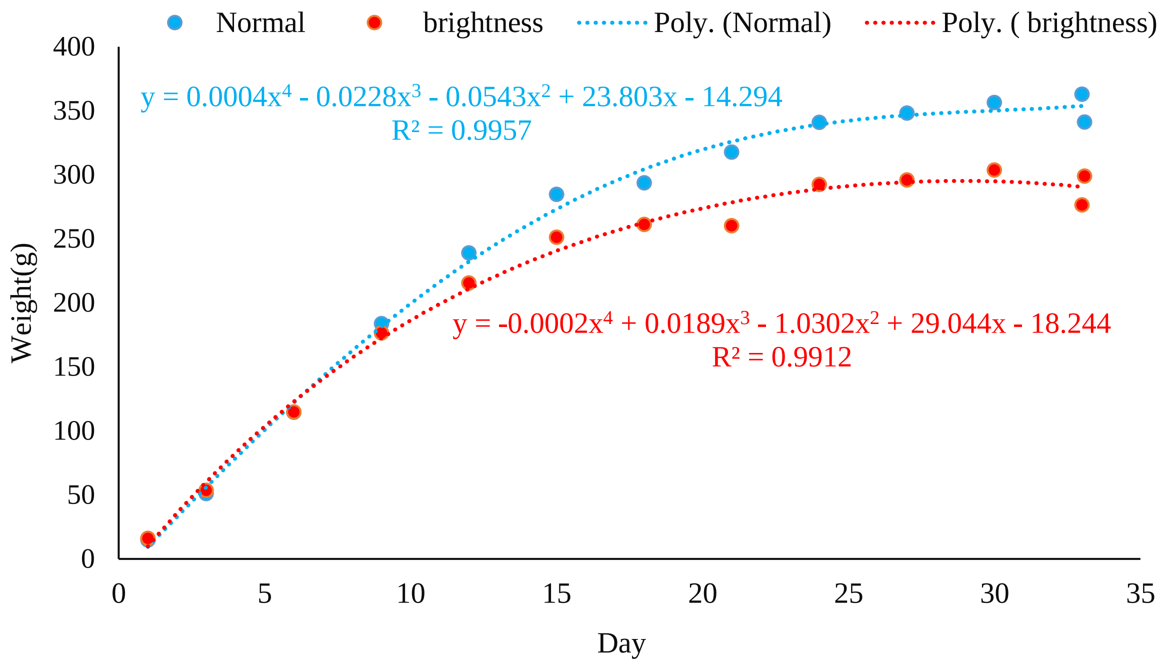

Figure 1. Regression equation Response of weight changes of male chickens in each group during growth to different days

The age of leaving the nest of male chickens in the two groups of normal and light

The age of leaving the nest of male chickens in the normal group and the light-affected group is not different because the significance level of this trait is more than 0.05. The range of changes in this trait is between 27-36 days. The higher average of 32.58 belongs to the lighting group and the lower average of 31.18 belongs to the normal group.

Table 1. Descriptive Statistics of nest leaving age in male chickens of normal and light and Independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
Time to leave the nest	Darkness	29	34	31.18	1.72	2.96	-1.599	0.125	21
	Brightness	27	36	32.58	2.39	5.72			

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

Flying age of male chickens in normal and light groups

The flight age of male chickens does not differ between the two groups. The minimum flight age is 28 days and belongs to the lighting group and the maximum flight age of 37 days belongs to the same group. The lower mean of this trait between the two groups, ie 32.64, is related to the normal group and the higher mean, 33.50, is related to the group with light at night.

Table 2. Descriptive statistics of flight age trait in chickens of normal and light groups and independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
flight age	Darkness	30	35	32.64	1.96	3.86	-0.914	0.371	21
	Brightness	28	37	33.50	2.50	6.27			

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

The wingspan of male chickens is normal and light

Wing length in male chickens of the two groups does not differ. The range of variation of this trait is between 22-25.5 cm.

Table 3. Descriptive statistics of wing length in chickens of normal and light groups and independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
Wing length	Darkness	22.60	25.50	24.15	0.89	0.76	1.078	0.050	21
	Brightness	22.00	25	23.38	0.85	0.75			

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

The tip length of male chickens is normal and light

According to Table 4 the length of the tip of male chickens between normal and light groups are not significantly different and the significance level of this trait is more than 0.05. The range of variation of this trait in male chickens of these two groups is between 1.40-2.10 cm. The average of the group affected by light is more and 1.74 and the average of the normal group is lower and 1.66.

Table 4. Descriptive statistics of tip length trait in chickens of normal and light groups and independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
Tip length	Darkness	1.40	1.80	1.66	0.14	0.02	-1.150	0.263	21
	Brightness	1.50	2.10	1.74	0.18	0.03			

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

Tarsus length of male chickens in normal and light groups

The length of the tarsus in male chickens is not different between the normal group and the light group. The means are almost equal and the range of variations of this trait is between 3.00-3.60 cm, which is the shortest tarsal length of 3.00 cm and belongs to the lighting group and the longest tarsus length of 3.60 cm also belongs to this group.

Table 5. Descriptive statistics of Tarsus length trait in chickens of normal and light groups and independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
Tarsus length	Darkness Brightness	3.20 3.00	3.50 3.60	3.45 3.37	0.09 0.20	0.01 0.04	1.219	0.241	21

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

Age of first mating in male chickens of normal and light groups

The age of the first mating in male chicks of the two groups is very different because it has a significance level of less than 0.05 and the difference between the means is very large. The highest average is 100.45 and belongs to the normal group and the lowest average of 67.17 days belongs to the lighting group.

Table 6. Descriptive statistics of the age of the first mating in male chickens of normal and light groups and independent t-test between them

Adjective	Group	Min	Max	Mean	SD	Var	T independent	P-Value	Sample size
Age of first mating	Darkness Brightness	60 42	167 91	100.45 67.17	29.26 14.65	855.87 214.70	3.497	0.002	21

Min: Minimum, Max: Maximum, SD: Standard deviation, Var: Variance

Discussion

The results of the present study showed that the disappearance of natural night darkness by artificial light has a significant effect on the weight of male chickens during growth. Males under the influence of light had less weight gain than male chicks raised under completely normal conditions, and until the time the chicks reached the age of flight, this weight difference was quite evident. In this regard, Bhardwaj SK, Anushi (2006), stated that male house sparrows under the influence of 20 hours of light and 4 hours of darkness had less body mass than male sparrows under the influence of 13 hours of light and 11 hours of darkness and male sparrows in the control group. Therefore, considering that the male chickens in our study were exposed to artificial light all night, and according to Bhardwaj SK, Anushi's study, increasing the time of exposure to artificial light may have reduced body mass. Also, Bhardwaj & Kumar (2004), showed that exposure of Brahmi enamel chickens to 16 hours of light and 8 hours of darkness in birds that had previously been exposed to light periods reduced body mass in this bird. Our results are also consistent with the results of Cianchetti-Benedetti et al. (2018) but different from the results of Malek & Haim (2019), which can be attributed to differences in the species studied, the duration of exposure to artificial light at night, and also mentioned different feeding times. Finally, it can be said that the effect of artificial light at night may vary according to the type of species, the duration of exposure to artificial light at night and the intensity of light and color of light, and it is suggested that in future studies by manipulating light-related factors and Duration of exposure to artificial light at night The effects of this pollution should be further investigated and also the effect of artificial light at night on female birds should be studied.

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