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INTERPRETATION OF THE RELATIONSHIP BETWEEN THE EFFECTS OF DIFFERENT COLORS WAVELENGTH LIGHT APPLICATION AND SOUND FREQUENCY IN JAPANESE QUAILS BY SPECTRAL ANALYSIS

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ABSTRACT

In this study, taking into account the responses of living things to the wavelength of light; Among the poultry species, which are more sensitive to green and red light wavelengths than humans, Japanese quails were used as model animals. In the study, the effects of red and green light wavelengths on gender and the responses of model animals of the same sex were examined. In the study, in the light application, the sound signals were taken in a specially isolated insulated environment. The recordings were analysed in frequency and time period using spectral analysis methods in the Matlab program. The maximum, minimum, average value, variance, dynamic range (Hz), peak frequency and autocorrelation time (S) values of the signal were found. These values, multiple comparison tests of male, female and male-female groups were performed in the study. While there were significant differences between the groups in the study; the red light application was estimated to be close to each other between the minimum and maximum values in the 1st and 7th weeks, variance, peak frequency and autocorrelation time (S) values. The reason for this is that poultry is more sensitive to green and red light wavelengths. It is an indication of the adapted adaptation for red light application (~ 625-740 nm, ~ 480-405 THz). In addition, in the control and green light applied groups, the data give statistically significant results; it is an indication that the wavelength of light has an effect on the frequency of sound. According to the results of the multiple comparison tests, a statistically significant difference was found between the groups (P = 0.05). Since there is no study on this subject, it is aimed to be a source of literature for other studies and to be the subject of scientific studies.

1. INTRODUCTION

It is evolutionarily known that living things have an effect on learning by creating a biological response to perceived colors [1, 2]. While colors allow animals to survive by adapting to their habitats, they also influence the behavior by creating a signal function [3]. It is known that colors associate with various messages, concepts, emotions, learned and their emotional contexts, cognitive and psychological functions in the formation of various behaviors [4; 5, 6, 7, 8, 9, 10, 11, 13]. In addition, depending on psychological functions; Intuitive emotional connections, trial and error, remembering, and various physiological changes in the body are stated to be caused by the perception of colors [5; 10; 14, 15]. It has been stated that there is a relationship between the color red in living species, danger, fear, aggression, courage, an act of strength and a sense of competition [9, 16, 17, 18, 19, 20, 23, 24, 25, 26].
Also; It is also stated that the color red has an aggressive effect on testosterone secretion in men [26, 28, 29, 31]. Studies conducted by Feltman ve Elliot (2011), Ten Velden et al. (2012) the color red creates a fearful, threatening, aggressive and strong perception, it was stated that men have a higher heart rate, higher testosterone and higher performance. But; it is stated that blue and green colors bring feelings such as calmness, meekness, happiness and confidence in living things [33, 34, 35]. Also; it has been observed that there are positive effects on yield and performance on animals. In a sample study examined, it was revealed that broiler chickens raised under blue and green light showed higher body weight gain without affecting feed efficiency and mortality rates [33, 34, 35, 36, 37, 38, 39]. In another study, Halevy et al. (1998) reported that blue and green light accelerated the development of poultry. Suggested that this situation was caused by the decrease in the

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wavelength of the light, causing the muscle satellite cells (new cells) to proliferate more rapidly. But; each living thing's response to the wavelength of light is different. For example; while poultry can detect colors in the 350-700 nm wavelength range, humans are sensitive to light in the 450-650 nm range. In poultry, long wavelengths are more likely to reach the hypothalamus than shorter wavelengths. For example, in poultry species; it is stated that ducks reach the hypothalamus at a speed 36 times faster than short wavelengths, and 80-120 times faster than quails [36, 37, 38, 39, 40, 41, 43, 44, 45]. In this study, Japanese quails, which are among the poultry species that are more sensitive to blue, green and red light wavelengths than humans, were used as model animals. In the study, whether the wavelength of red and green light has an effect on gender and the responses of model animals of the same sex were examined.

1.1. Some Studies

1.2. Light applications in the embryonic period

In a study on the broiler, they examined the effects of monochromatic green light application on embryonic growth, incubation time, output power performance and chick incubation weight [46]. At the end of the study, they stated that the application of monochromatic green light significantly increased hatching efficiency compared to the eggs in the control group. They examined the effects of green light on embryo development and post-emergence development for both species [43, 47]. At the end of the study, they revealed that they had positive effects for both species.

1.3. Light applications in the breeding period

In this study, they found that the application of green monochromatic light during brooding of broiler chickens accelerates embryogenesis, increases embryo weight and chest muscle weight after exit [48]. In the study, which they consider as morphological and molecular, broiler eggs were pre-weighed and randomly selected and experimented [49]. In the study, dark group (control group) and monochromatic green light group (560 nm) used a monochromatic lighting system. Light-emitting diode lamps were set at the level of the eggshell at a density of 15 lx. At the end of the study, light effects during embryogenesis had no effect on incubation time, incubation weight and chick death. However, compared to the dark condition, live weight gain, 7-day-old chicks incubated under green light, were found to have significantly higher pectoral muscle weight and myofiber cross-sectional areas [48]. They found that while the highest number of eggs were obtained in the red light application group during the yield period, the eggs in the blue and green light applications were consistently heavier than the red light applications [50]. They also reported that in a green light application, eggshell strength was significantly higher quality than in other lights. In the study, investigated the effect of different light wavelengths, red blue and green, on the Hy-Brown line between 19 and 52 weeks [51]. At the end of the study, egg weight was lower in red light application than in other light applications, egg length and egg width were shortened in the blue light application and egg width was shorter with age in the red light application; they reported that it improved egg quality in the green light application. They investigated the relationship between the performance of light applications and plasma triiodothyronine concentration in the study conducted by [52]. It has been reported that it encourages the growth of chicks at early ages in green color applications, and the transition to a different light environment at the ages of 10 and 20 days is more effective. For this reason, it has been suggested that opsin receptors that perceive green color, which is very active in hatching, are suppressed by opines that perceive red color at the age of 9 days. They reported in another study that green light positively affected the yield characteristics 1 of broiler chickens in the early stages of the fattening period [53].

1.4. Effects of light applications on behavior

In this study, investigated the effect of different monochromatic light colors on behavior and fear reactions in broiler chickens [54]. In their first experiment, it was reported that walking behavior was significantly increased in sitting and standing behaviors and wavelengths were observed in eight different light applications in red and red-yellow mixed. In the short-wavelength (blue, green-blue) application, the chicks were observed to spend more time sitting and standing than the long-wavelength (red, red-yellow). In their second experiment, they examined five different age groups and six different light colors [54]. They stated that the green light application decreased significantly in walking, and in the application of red and red-yellow light, the broiler chickens spend a much longer time and stimulate fear reactions. He stated that sitting and standing behavior increased under blue light and had a positive effect on young people. In addition, ground pecking and wing stretching behavior have been reported to be affected by the wavelength of light. They, in their study, examined the behavior and fear responses of chickens of different monochromatic light colors [55]. In Experiment 1, eight different light applications, in experiment 2, six different light colors with five different age groups were considered. In Experiment 1, it was stated that using a red and red-yellow mixed-light significantly increased walking behavior. As a result, it was found that sitting and standing behaviors were dependent on the wavelength and that the chickens applied in short-wavelength (blue, green-blue) spent more time sitting and standing than the long-wavelength (red, red-yellow). In Experiment 2, in the green light application of broilers, they stated that they spent more time than other applications and that the walking behavior decreased significantly. They concluded that sitting and standing behavior increases in the blue light application and affects behaviors depending on age (more active in young and older groups). They also observed that ground pecking and wing stretching behavior was affected by the wavelength of light and that they spent longer in tonic immobility in red and red-yellow light applications. As a result, they found that red and red-yellow light stimulate broiler movement and fear reactions, the blue and green-blue movement decreases, and they spend more time sitting. They observed that there is a relationship between light wavelength and poultry and that the aggressiveness and fighting behavior of chickens raised in blue light are less than those raised under white and red light [56].

1.5. Some Sound Analysis

They used the algorithm wavelet decomposition method to recognize the sounds of poultry species in their study [57]. In their study, they conducted a study to identify and distinguish poultry species. In their study, time and frequency domain analysis techniques were used to implement. Also, they have implemented the time-frequency domain feature extraction method [58].

2. EXPERIMENTAL AND METHODS

In this study, considering the effects of green and red color, control group (dark), green and red monochromatic light was applied. The reason for using monochromatic lighting in the study, it is the lighting with the lowest stress effect. Three different gender groups, male, female and male-female, were used to determine whether the application had an effect on gender. In these groups, Japanese quails at the 1st and 7th week ages were determined as animal material. Each Japanese quail has its own number, and their sensitivity to the experimental groups at week 1 and 7 has been observed. The first weeks of Japanese quail development period are known as the maturity age of the 6th and 7th weeks, that is, the yield period. During the development and yield period, the audio signals were recorded for 60 seconds from the female, male and female-male Japanese quail groups in green and red light applications.

In the study, specially designed compartments were used considering the dimensions of 40 cm length, 50 cm width, 40 cm width in order to exhibit species-specific behaviors such as easy movement, wing flapping, pecking, considering the animal welfare. In the study, analysis of Japanese quail sound signals time and frequency was done using the Matlab program. The differences between the sound signals of the female, male and female-male Japanese quail groups, which were applied control, green and red light, were compared by drawing a time-amplitude graph. The Fourier transform has been applied to the audio signals. Thus, the transition from the time domain to the frequency domain has been achieved. The formula for the Fourier transform used to study a signal in the frequency domain is given in (1).

$$F(\omega) = \int_{-\infty}^{\infty} f(t)\, e^{j\omega t}\, dt \tag{1}$$

In the Fourier transform, time information is lost as the time passes from the domain to the frequency domain. To obtain time and frequency domain information, a short-time Fourier transform has been applied. The three-dimensional graph of time, frequency and power spectral density are drawn with the spectrogram method. As a result, power, frequency, and time information are displayed on a single graph.

Welch method was used to obtain, which shows the frequency components and power spectral density of the signal. As shown in Eq. 2 the welch method is calculated by taking the average of the periodograms [59]. While L indicates the length of the signal; Pxx (f) is used to express the periodogram.

$$P_{XX}^{W}(f) = \frac{1}{L}\sum_{i=0}^{L-1} P_{XX}^{i}(f) \tag{2}$$

Properties such as mean absolute value, variance, mean frequency, median frequency, square root mean (RMS) are used to examine the signals. As a result, provides information to be obtained in the time and frequency domain. In the study, RMS (Root Mean Square), MV (Mean Value), Variance, standard deviation (STD) are calculated using the formulas given in Eq.3-Eq. 6. While the lowest value among N values is Minimum Value; for the maximum value, N is the highest value of the value [60].

Minimum Value; for the maximum value, N is the highest value of the value [60].

$$MV = \frac{1}{N}\sum_{1}^{N} Xn \tag{3}$$

$$VAR = \frac{1}{N-1}\sum_{1}^{N}(Xn^2) \tag{4}$$

$$\mathrm{STD} = \sqrt{\frac{1}{N-1}\sum_{1}^{N}(Xn^2)} \tag{5}$$

$$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Xi)^2} \quad (6)$$

2.1. Statistical analysis

In the statistical analysis of the numerical data obtained from the study, the variance analysis technique was used for the variables that met the parametric test assumptions, and for the variables that did not meet the assumptions, there was a 0.05 significance level with the Kruskal Wallis test. In order to determine the statistical difference between the groups, Duncan multiple comparisons test was used for the parametric test and the Mann-Whitney U test was used for the non-parametric test. In the statistical analysis of the discrete data to be obtained from the study, the generalized variance analysis technique with Logit function was used, and the Tukey-Kramer test technique was used as a multiple comparison test. All statistical analyses were performed using SAS 9.3 statistical software.

3. RESULTS

Power spectrum distributions of male-female group Japanese quails recorded in green, red and control (dark) environments were obtained using signal processing methods, and the peak frequency value at which the signal had the maximum power density was obtained. When green light is applied to Japanese quails in female-male groups, the peak frequency value of the power spectrum distributions is 311.985 Hz, while the power value is 13.9 dB, when red light is applied, the peak frequency value is 182.548 Hz, the power value is 11.1 dB, the peak frequency of the power spectrum density in the dark, which is preferred as the control color. While the value is 770.149 Hz, the power value is calculated as 19.1 dB.

Green color, red color and control color peak frequency of female-male group Japanese quail 1st week sound signal are given in Figure 1.

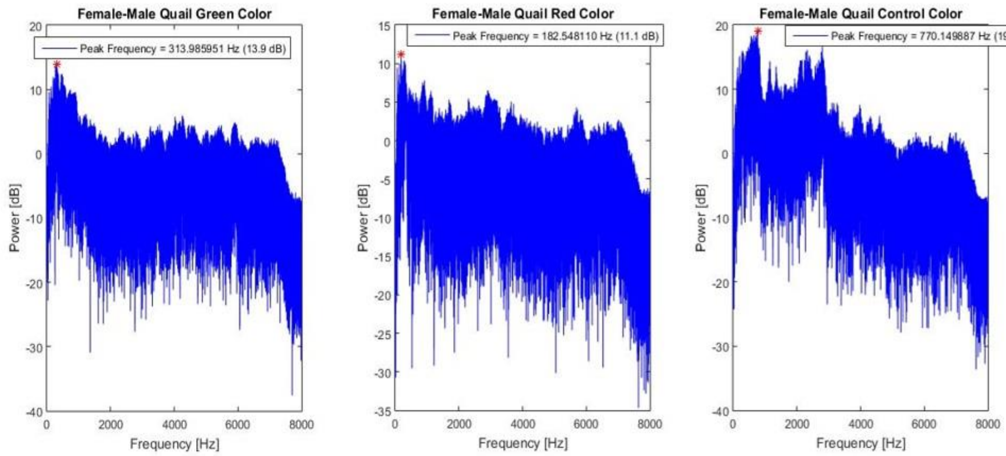

Fig 1. Green color, red color and control color peak frequency of female-male group Japanese Quail 1st week sound signal.

Green color female-male group Japanese quail 1st week sound signal in the time domain and spectrogram are given in Figure2.

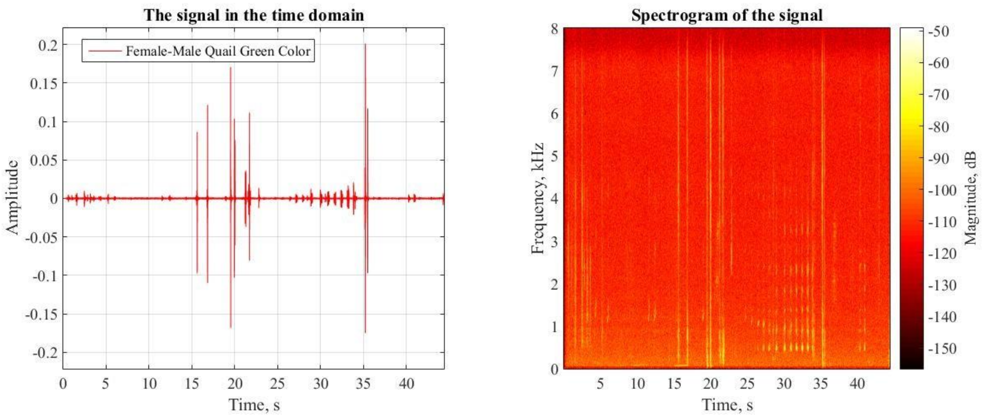

Fig 2. Green color female-male group Japanese quail 1st week sound signal in the time domain and spectrogram.

Red color female-male group Japanese quail 1st week sound signal in the time domain and spectrogram are given in Figure3.

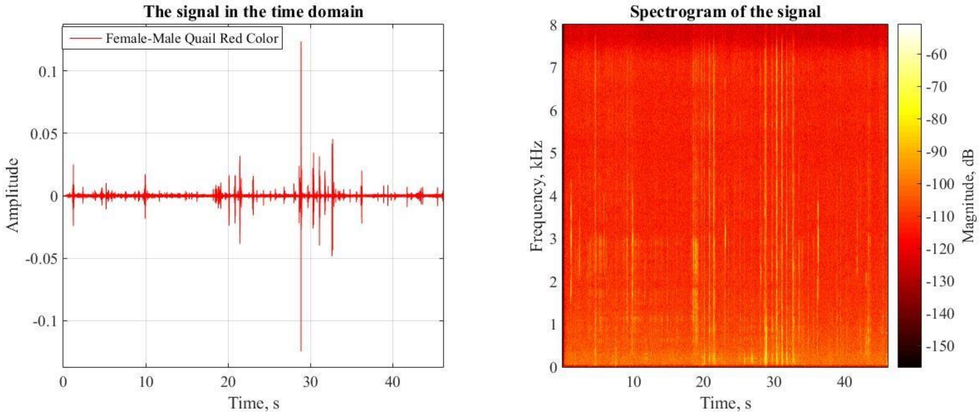

Fig 3. Red color female-male group Japanese quail 1st week sound signal in the time domain and spectrogram.

Control color female-male group Japanese quail 1st week sound signal in the time domain and spectrogram are given in Figure 4.

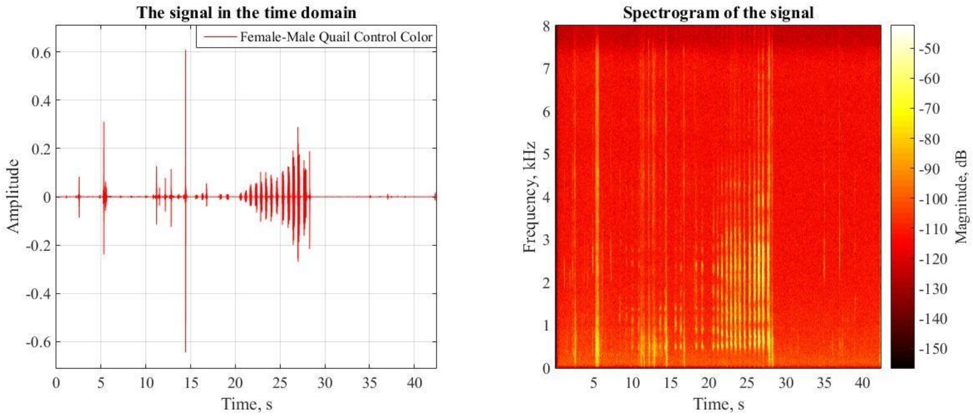

Fig 4. Control color female male group Japanese quail 1st week sound signal in the time domain and spectrogram.

Green color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram are given in Figure 5.

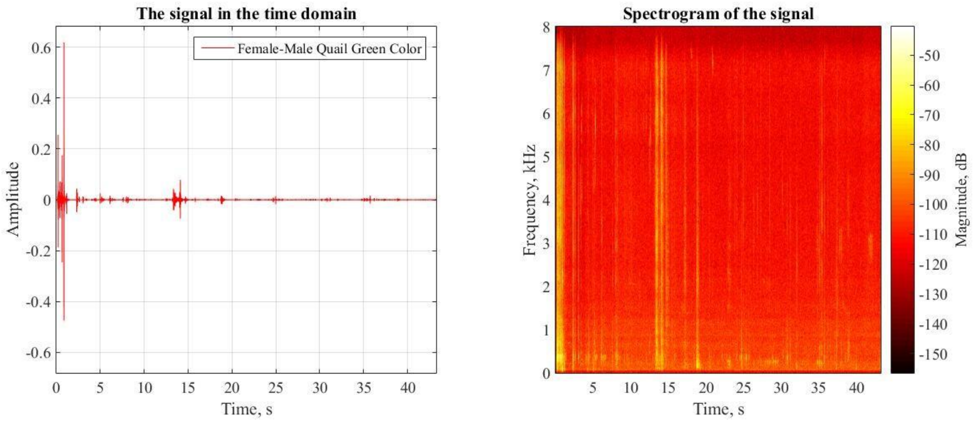

Fig 5. Green color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram.

Red color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram are given in Figure 6.

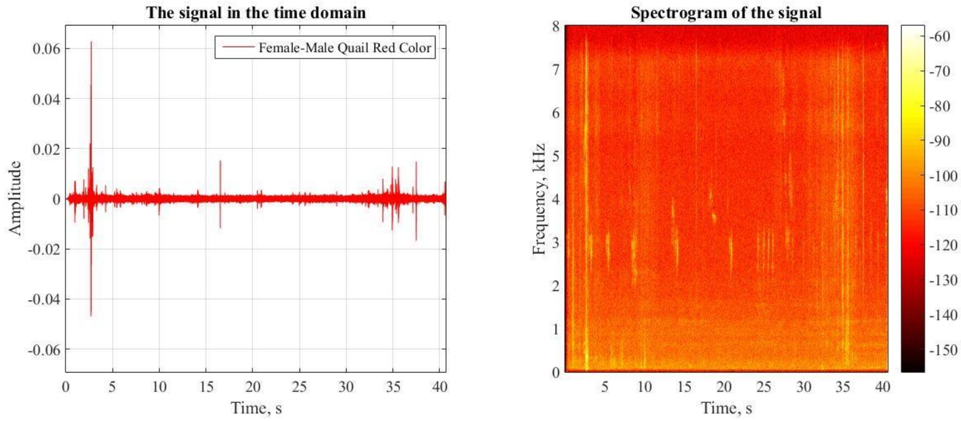

Fig 6. Red color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram.

Control color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram are given in Figure 7.

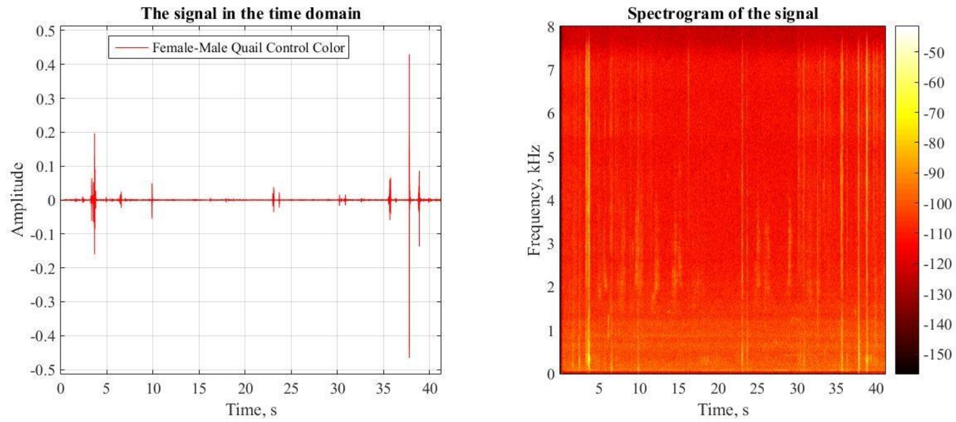

Fig 7. Control color female-male group Japanese quail 7th week sound signal in the time domain and spectrogram.

When the female group was examined in the first week in the study, there was no significant difference between the variance and peak frequencies of the red and control groups; the lowest (-3.03 and 351.090 Hz) variance and peak frequency value belong to the group with green light application. When Autocorrelation time (S) was examined, no statistically significant difference was found between the groups (P = 0.05). However, the lowest (15.429) Autocorrelation time (S) value was found to be in the group with green light application. When the female group variances of the seventh week were examined, a significant difference was found between the control group and the application of red light. While the highest (1.01) variance value belongs to the group with red light; the lowest (-1.98)) variance value belongs to the control group. When peak frequency is examined, there is no difference between the groups where control and red light are applied; the lowest (185.540 Hz) value was estimated to belong to the group with green light application. While the female group's Autocorrelation time (S) for the seventh week showed significant differences between the groups; the lowest (1.846) value belongs to the control group, while the highest (26.143) value belongs to the group with red light application. When the estimated values of the 1st and 7th weeks were examined in the study, the results obtained in the groups in which the red light was applied were the same; statistically significant differences were observed between the control and green light groups. Green color female group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 8.

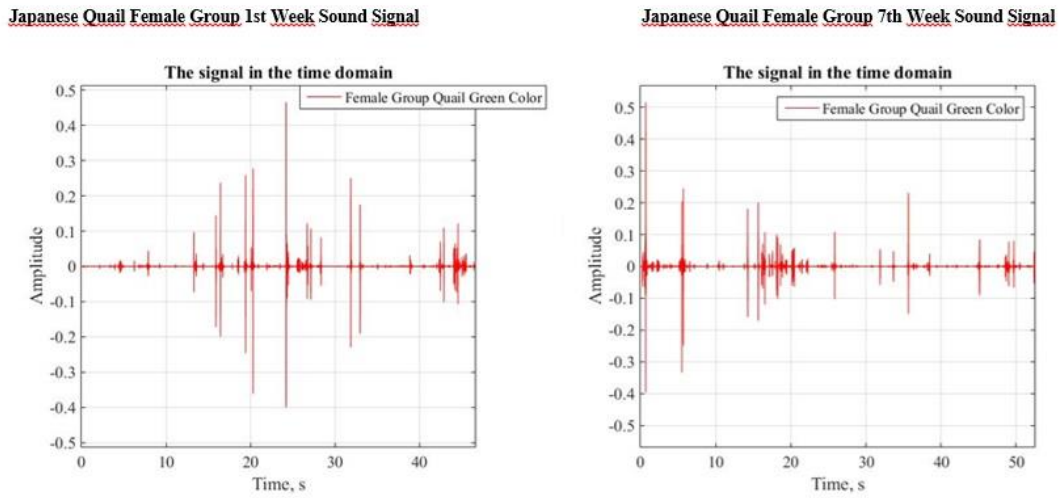

Fig 8. Green color female group Japanese quail 1st week and 7th week sound signal in the time domain.

Red color female group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 9.

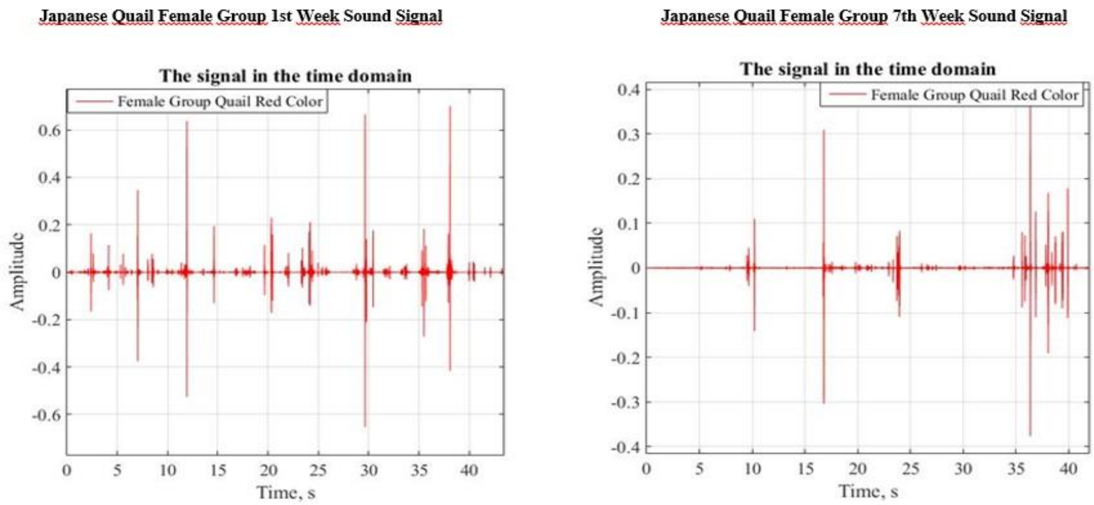

Fig 9. Red color female group Japanese quail 1st week and 7th week sound signal in the time domain.

Control color female group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 10.

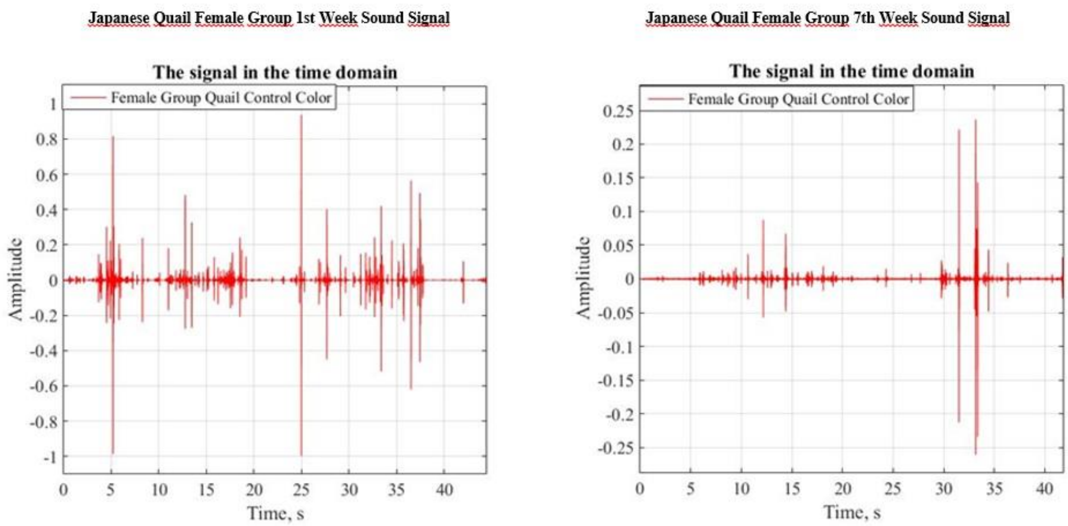

Fig 1. Control color female group Japanese quail 1st week and 7th week sound signal in the time domain.

In the study, it was observed that the highest (-1.08, 4.65) mean values and variance in the control group for the 1st-week male group. The group with the lowest (-8.12, 1.99) mean values and variance was determined as the group with red light application. When peak frequency is examined, the lowest and highest (299.950, 301.136) estimation value; It was observed that it was in the group under the control group and green light. Autocorrelation time (S) value is the lowest (0.010 (S)) in the green light application; the highest was found in the application of red. When the groups are examined, it is estimated that there is a statistical difference between them (P = 0.05). The mean values (-8.98) for the male group in the seventh week belonged to the control group; mean values are the highest (-1.15) value belongs to the group applied red light. While the highest (8.63) variation value was observed to be the control group; the lowest (1.02) value was found in the group with green light application. In the seventh week, it was observed that the peak frequency value was highest in the male group (2290.837 Hz) in the control group; the lowest (298.584 Hz) value was estimated to be in the red light application. While the autocorrelation time (S) value is the lowest (0.060 (S)) value; the highest value (24.746 (S)) was found in the red light application. A statistically significant difference was found between the groups for the seventh week (P = 0.05).In the study, it was estimated that there were significant differences between the groups in the 1st and 7th weeks.
Green color male group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 11.

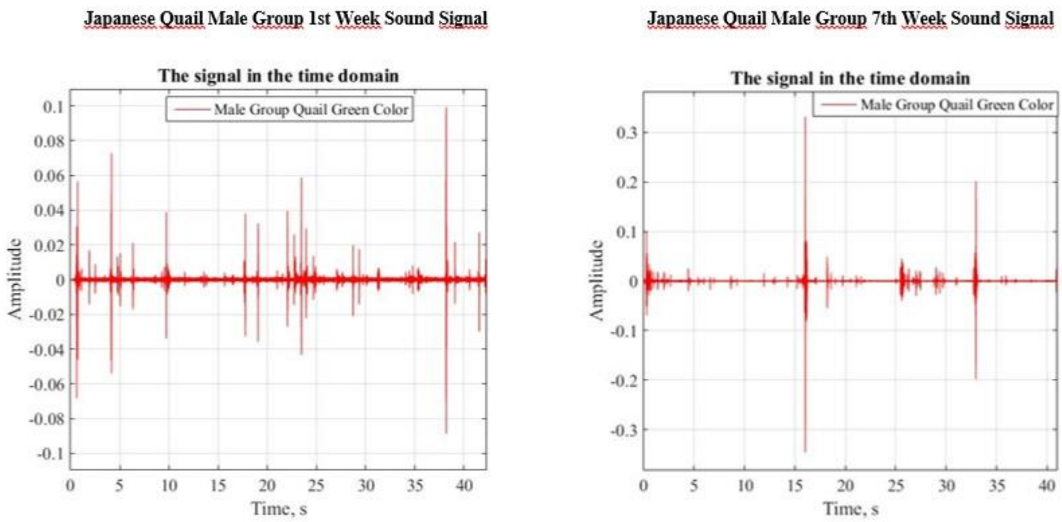

Fig 2. Green color male group Japanese quail 1st week and 7th week sound signal in the time domain.

Red color male group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 12.

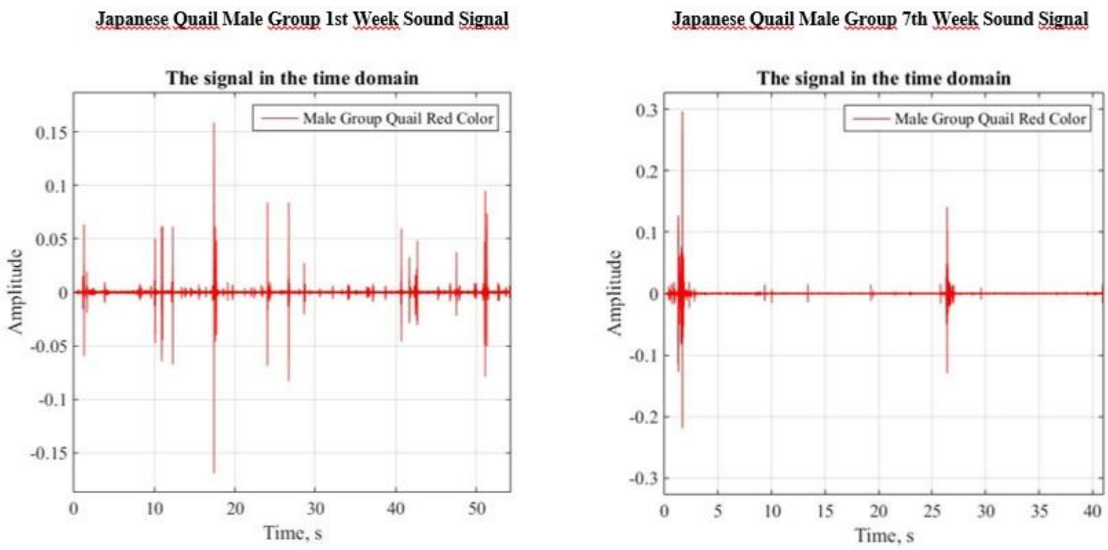

Fig 3. Red color male group Japanese quail 1st week and 7th week sound signal in the time domain.

Control color male group Japanese quail 1st week and 7th week sound signal in the time domain are given in Figure 13.

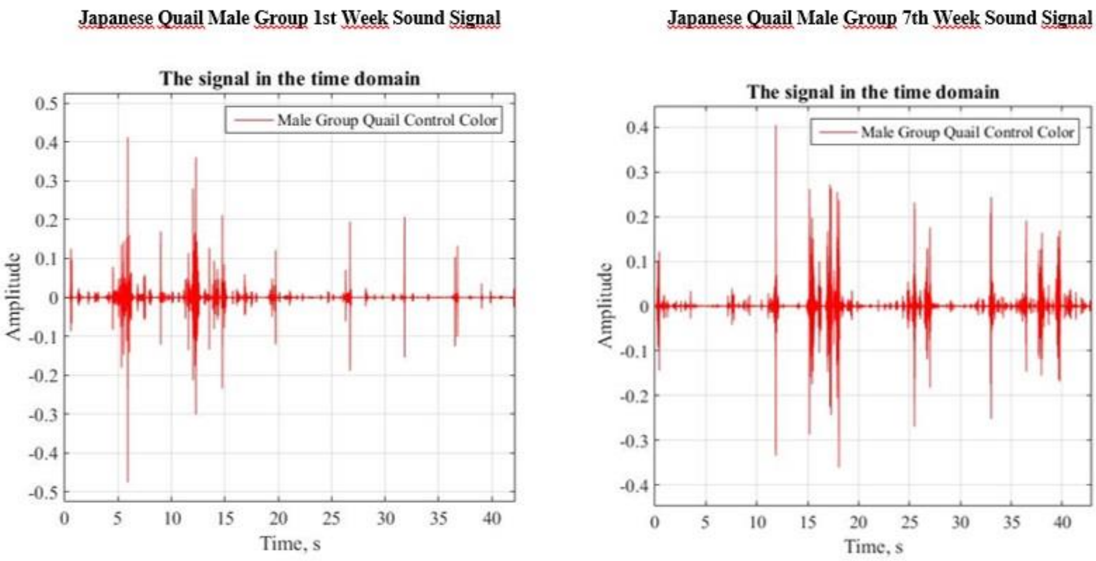

Fig 4. Control color male group Japanese quail 1st week and 7th week sound signal in the time domain.

4. CONCLUSION

In the study, the sound signals of the female quail, the male group, and the female-male group of Japanese quails at Week 1 and Week 7 were analysed. Spectral analysis of the signals was made and variance, mean value, autocorrelation time and peak frequency values with the highest power in the signal were obtained. The mean value of the data received in the first and seventh weeks is between 6.38 (1st-week female-male red) and -8.12 (7th-week female red). When the Peak frequency values for the first and seventh weeks are examined, the lowest value (179.61 Hz) for each group belongs to the red light application. When peak frequency values are examined in the light application, the control (darkness) is between 2290.837 Hz-294.219 Hz (max-min peak frequency), while the green light application is between 388.861- 185.540; the red light application was found as 312.661 Hz-179.601 Hz. In the study, the group with the highest peak frequencies in the 1st and 7th weeks for the experimental groups is the group in which red light is applied. When Autocorrelation time (S) was examined, a significant difference was observed in the control and green light application for the 1st and 7th weeks. When the experiment groups were examined, it was estimated that males and females had higher autocorrelation time (S) in red light compared to the mixed-gender groups. In the study, the autocorrelation time (S) value changed 34.062-9.028 (max-min) in the red light application at the 1st and 7th weeks, meaning less difference than the other groups. In the study, it was determined that there is the least difference between min and max values in the red light application. It is stated that it recognizes the colors as soon as they are perceived by the photoreceptors, as in the studies conducted, and provides adaptation when encountered in the next process. In this study, it was observed that red light application (~ 625-740 nm, ~ 480-405 THz) provided acquired adaptation and learned behaviour in terms of animal psychology. In the control and green light groups, the data are not statistically significant. This is an indication that it is related to a relationship between color wavelength and frequency. According to the results of the multiple comparison tests, there was a statistically significant difference between the groups (P = 0.05).

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