



Digits Angle and Digits Length Ratio in Japanese Quail (*Coturnix coturnix Japonica*)

İsmail Demircioğlu, Sokol Duro¹, Gülşah Güngören², Om Prakash Choudhary³, Ozan Gündemir⁴, Yasin Demiraslan⁵, Gülsün Pazvant⁴

10.18805/IJAR.B-1326

ABSTRACT

Background: Digit lengths are dimorphic in some other creatures as in humans. In particular, gender analysis can be done using the ratio between the second finger (D2) and the fourth finger (D4). The aim of this study is to examine whether the ratio of foot fingers is related to gender in Japanese quail (*Coturnix coturnix japonica*).

Methods: In this study, 60 adults (30 female and 30 male) Japanese quail foot digit length ratios were examined in relation to gender. The ratios of the lengths of the second finger (D2), the third finger (D3) and the fourth finger (D4) to each other were taken on the computer.

Result: In addition, geometrical analysis of base posture positions between female and male individuals were made and shape differences were revealed. It was observed that the second finger (D2) of male birds was more introverted than in females. It was seen that Principal component analysis (PCA1) explained 53.07% of the total variation between female and male groups. PCA2 explained 17.6% of the total variation and PCA3 announced 11.83%. In statistical morphometric analysis, the difference in shape between the male and female was statistically insignificant. D2:D3, D2:D4 and D3:D4 ratios were higher in males. It was observed that the lateral angle in both genders was higher than medial angle. This difference was statistically significant ($p < 0.001$). While the average of the lateral angle was 50.89% in all individuals, the average of the medial angle was 42.81%. The highest length in all individuals belonged to the third finger. It was observed that the ratio of D2:D4 among females used in the study was 0.867 in females and 0.877 in males.

Key words: Bird, *Coturnix coturnix*, Digit, Geometry morphometry.

INTRODUCTION

Quails (*Coturnix coturnix japonica*) are used in poultry for both, meat and egg production. It belongs to the Phasianidae family. It is difficult to determine gender according to its morphological features at a young age. Sexual maturity varies from four to six weeks (Alkan *et al.*, 2008). After this period, ovulation period comes. After the sixth week, the female birds can be separated due to the larger body structure (Brunström *et al.*, 2009). It has been reported that sex discrimination can be made using features such as wing length, weight and chest width (Rathert *et al.*, 2017).

It has been reported in previous studies that finger lengths are dimorphic in some primates, including humans (Brown *et al.*, 2002; Leoni *et al.*, 2005; McFadden and Shubel, 2002; Saino *et al.*, 2007). In addition to sexual dimorphism, some of its hormones have been shown to be directly related to this ratio (Lutchmaya *et al.*, 2004; Van Anders *et al.*, 2006). This ratio between genders was observed especially between the second digits (D2) and fourth digits (D4) and lengths of the foot (McIntyre *et al.*, 2005; Peters *et al.*, 2002). It has been reported that D2:D3 ratio is higher in female samples exposed to high androgen hormone (Romano *et al.*, 2005). Estradiol is said to decrease the D2:D3 ratio in male (Saino *et al.*, 2007). In addition, asymmetries between the right and left hands were examined using these ratios and it was observed that this asymmetry was larger in male (Williams *et al.*, 2000). Quails as other domesticated birds have four toes. The first toe oriented in a medial and plantar

Department of Anatomy, Faculty of Veterinary Medicine, Harran University, Sanliurfa, Turkey.

¹Faculty of Veterinary Medicine, Agricultural University of Tirana, Tirana, Albania.

²Department of Animal Science, Faculty of Veterinary Medicine, Harran University, Sanliurfa, Turkey.

³Department of Veterinary Anatomy and Histology, College of Veterinary Sciences and Animal Husbandry, Central Agricultural University, Selesih, Aizawl-796 014, Mizoram, India.

⁴Department of Anatomy, Faculty of Veterinary Medicine, Istanbul University-Cerrahpasa, Istanbul, Turkey.

⁵Department of Anatomy, Faculty of Veterinary Medicine, Burdur Mehmet Akif Ersoy University, Burdur, Turkey.

Corresponding Author: Sokol Duro, Faculty of Veterinary Medicine, Agricultural University of Tirana, Tirana, Albania.

Email: durosokol@ubt.edu.al

How to cite this article: Demircioğlu, İ., Duro, S., Güngören, G., Choudhary, O.P., Gündemir, O., Demiraslan, Y. and Pazvant, G. (2022). Digits Angle and Digits Length Ratio in Japanese Quail (*Coturnix coturnix Japonica*). Indian Journal of Animal Research. 56(9): 1105-1109. DOI: 10.18805/IJAR.B-1326.

Submitted: 24-09-2020 **Accepted:** 07-01-2021 **Online:** 26-02-2021

direction while the other three are spread out and points forwards (Nickel *et al.*, 1977) (Fig 1).

Geometric morphometric analysis is made with the data taken from the photograph, unlike normal morphometry. The points on the photo are determined and the positions of these

points relative to each other are examined on the x-y coordinates and the shape variations are revealed. With this method, which is used especially in the field of osteology, the differences of bone shapes are revealed both between sexes and between species (Gündemir *et al.*, 2020; Gürbüz *et al.*, 2020; Şahiner and Yalçın, 2007).

Various anatomic, genetic and breeding studies of this bird species used for breeding are available in reference information (Kumari *et al.*, 2008; Hertamawati *et al.*, 2019; Demiraslan *et al.*, 2014; Demircioglu *et al.*, 2019; Demircioglu *et al.*, 2020; Monika *et al.*, 2020). In this study, we analyzed digits angle and digits length ratio of Japanese quail using geometric morphometric analysis. With this method, we examined whether male-female distinction can be made.

MATERIALS AND METHODS

Samples

In the study, 60 (30 female, 30 male) adult quail (60 days-old) were used. Weights of the samples were taken. The application was carried out in the Harran University Anatomy Laboratory from January 2020 to August 2020. Approval was obtained from the ethics committee of the University of Harran University, Faculty of Veterinary Medicine (approval no: 2020/004). In the study, only the left foot of each bird was used. Os tarsometatarsus was allowed to surface on a thin glass surface at an angle of 90 degrees to obtain foot print pictures of all digits. Then, photographs were taken with the camera prepared 10 cm away on the other side of the glass. Angle and length measurements were made on two-dimensional photographs. Rates were determined from these measurements. At the same time, these photographs were analyzed by geometric morphometric method.

Geometric morphometric analysis

In the first stage, the photographs were converted into a TPS file where the landmarks can be placed using the TpsUtil (version 1.74) program. Photographs taken from 60 samples were used as a single file in tpsDig (version 2.30) program and landmarks were made and their coordinates were determined. Morphoj (version 1.07a) program was used to visually show the changes in the points after geometric analysis. We have used eight landmarks (Fig 1):

- 1: The point between claw and distal phalanx of the second finger.
- 2: The point between claw and distal phalanx of the third finger.
- 3: The point between claw and distal phalanx of the fourth finger.
- 4: The point between claw and distal phalanx of the first finger.
- 5: The midpoint of Tela interdigitalis medialis.
- 6: The midpoint of Tela interdigitalis lateralis (Baumel *et al.*, 1993)
- 7: The point between base of the first finger and torus metatarsalis.
- 8: The most caudal point of torus metatarsalis where the foot is touching the ground (Ghetie, 1976).

Ratio and angle analysis

The measurements of three lengths from the pixel value were taken using Image J (version 1.52a) program on each photograph. Then, using these measurements, ratios between live finger surfaces contacting the ground were obtained (D2:D3 and D3:D4). It was also recorded at angles between the reference points used for lengths taken using this program (Fig 1).

D2: The distance between the first and eighth landmarks.

D3: The distance between the second and eighth landmarks.

D4: The distance between the third and eighth landmarks.

a1: Angle between reference points used for D2 and D3 measurements.

a2: Angle between reference points used for D3 and D4 measurements.

Statistical analysis

Principal component analysis (PCA) was used for geometric morphometric analysis. For this, the PAST program (IBM SPSS for Windows, Ver. 23) was used. The variations obtained in the PCA analysis were determined. ANOVA test was performed to statistically determine whether there are geometric differences between groups with eight landmarks used in the study. SPSS (version 22) program was used to examine the statistical difference between the female and male ratio and angle values taken from the photograph and ANOVA test was performed. In addition, the correlation values between these ratios and angles were examined.

RESULTS AND DISCUSSION

As a result of the geometrical analysis, 16 principal components were obtained using eight landmarks. The geometric difference between genders is shown in Fig 2A. According to this figure, the biggest difference is seen in the landmark number one. It was observed that the second finger (D2) of male birds was more introverted than in females. In Fig 2B, distribution of female and male birds according to PCA1-PCA2 is given as a result of principal component analysis. It was seen that PCA1 explained 53.07% of the total variation between female and male groups. PCA2 announced 17.60% of the total variation and PCA3 announced 11.83%. In the 95% confidence ellipse obtained using PCA1 and PCA2, it was observed that the female and male samples did not separate (Fig 2B). In addition, Anova test result showed that the difference between male and female was statistically insignificant in geometric analysis.

Table 1 gives the ratio and angle values of female and male individuals using finger measurements. Using this ratio and angles, no statistically significant difference was observed between male and female. D2:D3, D2:D4 and D3:D4 ratios were higher in males. It was observed that the lateral angle was higher than medial angle in both genders. This difference was statistically significant ($p < 0.001$). While the average of the lateral angle was 50.89% in all individuals, the average of the medial angle was 42.81%. The lengthiest

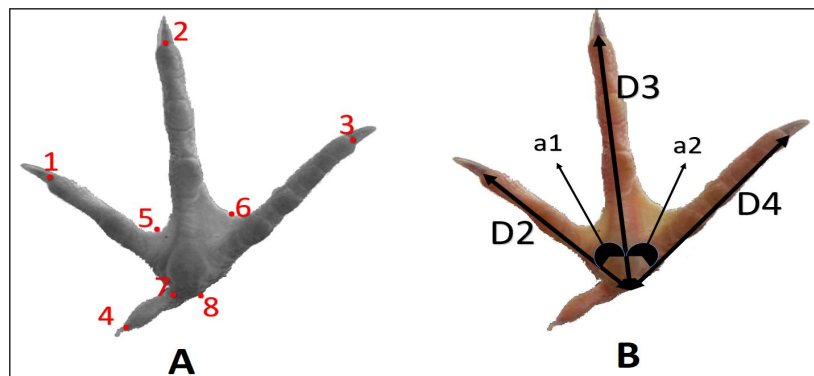


Fig 1: A) Landmarks used for geometric analysis. B) Finger length measurements and angle points used between fingers.

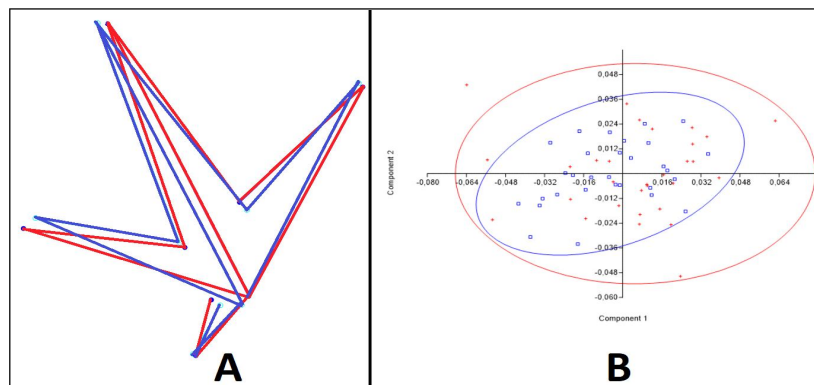


Fig 2: A) Morphoj. B) Graphic of 95% confidence analysis. (PCA1-PCA2) Blue: Female, Red: Male.

in all individuals belonged to the third finger. Then the longest measurement value belonged to the fourth finger.

In Table 2, the correlations of the angle and ratio values related to each other and the weights of the individuals are given. While the D2:D4 ratio was directly related to the D2:D3 and D3:D4 ratio, the correlation between the D2:D3 ratio and the D3:D4 ratio was found to be statistically insignificant. While there was a negative correlation between the finger length ratios of the a1 angle, there was a positive correlation between the finger length ratios of the a2 angle.

We planned to use this measurement method, which can be obtained from radiographic measurements (Leoni *et al.*, 2008) or, from the external appearance of the foot. In this study, no statistically significant difference was found between adult quails D2:D3, D2:D4 and D3:D4 finger length ratios. In the study, only the photos of the normal posture position of the fingers were taken and the proportions were made on these photos. No osteometric or radiological measurements were taken. It has already been said that there is a consistency between these rates taken from both radiological and external appearance (Ruuskanen *et al.*, 2011). However, in the study of Ruuskanen *et al.* (2011), it was observed that the ratio of D2:D3 and D2:D4 is sexually dimorphic and these rates are higher in male than in female.

Finger lengths were previously measured osteometrically in some birds and the D2:D4 ratio between the female and male was examined (Lombardo *et al.*, 2008). In the study by Lombardo *et al.* (2008), the left toe length ratios are house

Table 1: Average values and standard deviations of finger length ratios and angle between fingers for male and female.

| | N | Female | Male | F | p value |
|--------|----|--------------|--------------|--------|---------|
| Weight | 60 | 167.75±19.78 | 148.88±18.63 | 0,017 | 0.898 |
| a1 | 60 | 42.47±3.76 | 43.15±5.10 | 1,026 | 0.315 |
| a2 | 60 | 51.05±4.33 | 50.74±5.37 | 0.988 | 0.324 |
| D2:D4 | 60 | 0.867±0.278 | 0.877±0.033 | 1.842 | 0.180 |
| D2:D3 | 60 | 0.683±0.011 | 0.689±0.018 | 11.396 | 0.001 |
| D3:D4 | 60 | 1.270±0.032 | 1.271±0.035 | 0.010 | 0.921 |

Table 2: Correlation test of weights, finger length ratios and angle between fingers of all individuals.

| | Weight | a1 | a2 | D2:D4 | D2:D3 | D3:D4 |
|--------|--------|--------|-------|---------|---------|---------|
| Weight | 1 | 0.103 | 0.094 | 0.036 | 0.007 | 0.040 |
| a1 | 0.103 | 1 | 0.172 | 0.115 | -0.002 | -0.154 |
| a2 | 0.094 | 0.172 | 1 | 0.096 | 0.014 | 0.117 |
| D2:D4 | 0.036 | -0.115 | 0.096 | 1 | 0.669** | 0.761** |
| D2:D3 | 0.007 | -0.002 | 0.014 | 0.669** | 1 | 0.028 |
| D3:D4 | 0.040 | -0.154 | 0.117 | 0.761** | 0.028 | 1 |

**Correlation is significant at the 0.01 level.

sparrows (male 0.919, female 0.895), tree swallows (male 0.965, female 0.961), budgerigars (male 0.761, female 0.685) and chicken (male 0.869, female 0.853) also taken. However, the D2:D4 ratio difference between the male and female was not statistically significant as in this study.

In this study, the left foot D2:D4 ratio was found to be 0.867 in females and 0.877 in males. It was observed that the D2:D4 ratio was higher in all birds used by Lombardo *et al.* (2008) in his studies, as in this study. In addition, another study reported that males have higher D2:D4 ratios than females (Chang, 2008).

Dimorphism studies were carried out in birds using digit ratio. There are studies suggesting that digits parameters length are related to the hormone level in the body (Romano *et al.*, 2005; Saino *et al.*, 2007). However, in another study, it was stated that androgen hormone was not associated with digit ratio (Ruuskanen *et al.*, 2011). When these differences in results are evaluated, it makes us think that it is important to carry out more studies on this subject. In addition, digit ratio was also examined in terms of right and left foot. The hypothesis of using one particular limb more than another was mentioned (Robins *et al.*, 1998). For example, in a study conducted in White Stork, it was reported that there was no significant difference between the digit ratios between the right and left foot (Kazimirski *et al.*, 2019).

In this study, it was investigated whether there is a shape difference between the genders by using geometrical analysis. Although it is observed that the second finger (D2) looks more inward in males than females, even this difference was found to be statistically insignificant. Geometrical analysis studies on the foot structure of birds have not been encountered. However, there is a geometrical analysis study in cattle (Parés-Casanova *et al.*, 2020) to determine the asymmetries of the fingers. In addition, sexual dimorphism with skull bones was demonstrated in birds using geometrical analysis (Gündemir *et al.*, 2020). In a study conducted in bats, the geometrical analysis of wing shapes was carried out and the shape relationships between the species were examined (Schmieder *et al.*, 2015).

CONCLUSION

Different bird species have been studied with the ratios of finger lengths to each other and differences between the female and male have been tried to be revealed. These rates provide information about the development of the fingers of males and females. As stated in the literature studies using this method, the effect of hormones is said to have a direct effect on this finger morphometry. In this study, in contrast to the literature information, in addition to finger length ratios, geometric analysis of finger shape caused by body mass pressure was performed. We think that the geometrical analysis of the way birds hit the ground can be a helpful analysis in determining the taxonomy of birds in addition to the gender gap.

REFERENCES

Alkan, S., Karabağ, K., Galiç, A., Karslı, T. (2008). Effects of genotype and body weight on egg production and feed consumption in Japanese Quails (*Coturnix coturnix japonica*) in winter season reared in Antalya region. Journal of Lalahan Livestock Research Institute. 48(2): 73-79.

Baumel, J., King, A.S., Breazile, J.E., Evans, H.E., Vanden Berge, J.C. (1993). Handbook of Avian Anatomy: Nomina Anatomica Avium. 2nd ed. Cambridge, Massachusetts. Prepared by the International Committee on Avian Anatomical Nomenclature (ICAAAN).

Brown, W.M., Finn, C.J., Breedlove, S.M. (2002). Sexual dimorphism in digit length ratios of laboratory mice. The Anatomical Record: An Official Publication of the American Association of Anatomists. 267(3): 231-234.

Brunström, B., Axelsson, J., Mattsson, A., Halldin, K. (2009). Effects of estrogens on sex differentiation in Japanese quail and chicken. General and Comparative Endocrinology. 163(1-2): 97-103.

Chang, J.L. (2008). Sexual dimorphism of the second-to-fourth digit length ratio (2D: 4D) in the strawberry poison dart frog (*Oophaga pumilio*) in Costa Rica. Journal of Herpetology. 42(2): 414-416.

Demiraslan, Y., Tufan, T., Sari, M., Akbulut, Y., Dayan, M.O. and Kukurt, A. (2014). The effect of clinoptilolite on long bone morphometry in Japanese quail (*Coturnix coturnix japonica*). Animal and Veterinary Sciences. 2(6): 179-183.

Demircioğlu, I., Yılmaz, B., Filikci, K. and Daş, A. (2019). A morphometric and histometric analysis of the effect of mint oil (*Mentha piperita*) supplementation at different levels to quail (*Coturnix coturnix japonica*) rations on Glandula Uropygialis. Firat Üniversitesi Sağlık Bilimleri Veteriner Dergisi. 33(3): 185-189.

Demircioğlu, I., Yılmaz, B., Filikci, K., Güngören, G. and Bozkaya, F. (2020). Morphometric, histometric and histomorphological investigation of the effects of different ratios safflower (*Chartamus tinctorius* L.) oil supplements on glandula uropygialis in Japanese quails (*Coturnix coturnix japonica*). Eurasian Journal of Veterinary Sciences. 36(1): 42-47.

Ghetie, V. (1976). Anatomical Atlas of Domestic Birds. Editura Academiei Republicii Socialiste Romania, Calea Victoriei 125, Sector I, Bucuresti.

Gündemir, O., Özkan, E., Dayan, M.O., Aydoğdu, S. (2020). Sexual analysis in turkey (*Meleagris gallopavo*) neurocranium using geometric morphometric methods. Turkish Journal of Veterinary and Animal Sciences. 44(3): 681-687.

Gürbüz, İ., Aytekin, A.I., Demiraslan, Y., Onar, V., Özgel, Ö. (2020). Geometric morphometric analysis of cranium of Wolf (*Canis lupus*) and German Shepherd Dog (*Canis lupus familiaris*). Kafkas Üniversitesi Veteriner Fakültesi Dergisi. 26(4): 525-532; DOI: 10.9775/kvfd.2019.23841.

Hertamawati, R.T., Soedjarwo, E. and Sjöfjan, O. (2019). Reproductive performance of Japanese quail hens (*Coturnix coturnix japonica*) fed with feed restriction regimes during growth period. Agricultural Science Digest-A Research Journal. 39(2): 163-166.

Kazimirski, P.P., Kaczmarek, M., Zagalska-Neubauer, M.M., Zolnierowicz, K.M., Tobólka, M. (2019). Absence of sex differences in digit ratio in nestlings of the White Stork *Ciconia ciconia*, a monomorphic bird species. Bird Study. 66(4): 503-509.

Kumari, B.P., Gupta, B.R., Reddy, A. R., Prakash, M.G. and Reddy, K.S. (2008). Genetic and non-genetic factors affecting the carcass characteristics of Japanese quails (*Coturnix coturnix japonica*) 1. Indian Journal of Animal Research. 42(4): 248-252.

- Leoni, B., Canova, L., Saino, N. (2005). Sexual dimorphism in metapodial and phalanges length ratios in the wood mouse. *The Anatomical Record Part A: Discoveries in Molecular, Cellular and Evolutionary Biology: An Official Publication of the American Association of Anatomists.* 286(2): 955-961.
- Leoni, B., Rubolini, D., Romano, M., Di Giancamillo, M., Saino, N. (2008). Avian hind limb digit length ratios measured from radiographs are sexually dimorphic. *Journal of Anatomy.* 213(4): 425-430.
- Lombardo, M.P., Thorpe, P.A., Brown, B.M., Sian, K. (2008). Digit ratio in birds. *The Anatomical Record. Advances in Integrative Anatomy and Evolutionary Biology.* 291(12): 1611-1618.
- Lutchmaya, S., Baron-Cohen, S., Raggatt, P., Knickmeyer, R., Manning, J.T. (2004). 2nd to 4th Digit Ratios, Fetal Testosterone and Estradiol. *Early Human Development.* 77(1-2): 23-28.
- McFadden, D., Shubel, E. (2002). Relative lengths of fingers and toes in human males and females. *Hormones and Behavior.* 42(4): 492-500.
- McIntyre, M.H., Ellison, P.T., Lieberman, D.E., Demerath, E., Towne, B. (2005). The development of sex differences in digital formula from infancy in the Fels Longitudinal Study. *Proceedings of the Royal Society B: Biological Sciences.* 272(1571): 1473-1479.
- Monika, M., Rokade, J.J., Narayan, R., Saxena, V.K., Panda, S. and Gopi, M. (2020). Studies on growth performance and genetic parameters of three varieties of domesticated Japanese Quail. *Indian Journal of Animal Research.* 54(11): 1338-1342.
- Nickel, R., Schummer, A., Seiferle, E. (1977). *Anatomy of the Domestic Birds.* Parey, Berlin, Hamburg, ISBN: 3489554183.
- Parés-Casanova, P.M., Castel-Mas, L., Jones-Capdevila, K.N. (2020). Asymmetries of forelimb digits of young cattle. *Veterinary Sciences.* 7(3): 83. doi:10.3390/vetsci7030083.
- Peters, M., Mackenzie, K., Bryden, P. (2002). Finger length and distal finger extent patterns in humans. *American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists.* 117(3): 209-217.
- Rathert, T.Ç., Güven, İ., Uçkardeş, F. (2017). Sex determination of Japanese quails (*Coturnix coturnix japonica*) using with zoometric measurements. *Turkish Journal of Agriculture Food Science and Technology.* 5(9): 1002-1005.
- Robins, A., Lippolis, G., Bisazza, A., Vallortigara, G., Rogers, L.J. (1998). Lateralized agonistic responses and hindlimb use in toads. *Animal Behaviour.* 56(4): 875-881.
- Romano, M., Rubolini, D., Martinelli, R., Alquati, A.B., Saino, N. (2005). Experimental manipulation of yolk testosterone affects digit length ratios in the ring-necked pheasant (*Phasianus colchicus*). *Hormones and Behavior.* 48(3): 342-346.
- Ruuskanen, S., Helle, S., Ahola, M., Adamczyk, F., Möstl, E., Laaksonen, T. (2011). Digit ratios have poor indicator value in a wild bird population. *Behavioral Ecology and Sociobiology.* 65(5): 983-994.
- Saino, N., Rubolini, D., Romano, M., Boncoraglio, G. (2007). Increased egg estradiol concentration feminizes digit ratios of male pheasants (*Phasianus colchicus*). *Naturwissenschaften.* 94(3): 207-212.
- Schmieder, D.A., Benítez, H.A., Borissov, I.M., Fruciano, C. (2015). Bat species comparisons based on external morphology: a test of traditional versus geometric morphometric approaches. *PloS One.* 10(5). doi.org/10.1371/journal.pone.0127043.
- Şahiner, Y., Yalçın, H. (2007). Erkek ve bayanlarda kafatası kemiğinden geometrik morfometri metoduyla cinsiyet tayini ve ramus flexure. *Atatürk Üniversitesi Veteriner Bilimleri Dergisi.* 2(4): 134-142.
- Van Anders, S.M., Vernon, P.A., Wilbur, C.J. (2006). Finger-length ratios show evidence of prenatal hormone-transfer between opposite-sex twins. *Hormones and Behavior.* 49(3): 315-319.
- Williams, T.J., Pepitone, M.E., Christensen, S.E., Cooke, B.M., Huberman, A.D., Breedlove, N.J., Breedlove, T.J., Jordan, C.L., Breedlove, S.M. (2000). Finger-length ratios and sexual orientation. *Nature.* 30: 404(6777): 455-456. doi: 10.1038/35006555.