The Effect of Environmental Factors on the Morphological Variation of the Common Pheasant, *Phasianus colchicus* in China

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**ABSTRACT**

This study aims to assess morphological variation of the ring-necked or common pheasant *Phasianus colchicus* across mainland China in response to environmental factors. We collected 399 pheasant and divided them into two groups: high altitude (>1500m) and low altitude (<1500m). The results showed that all morphological size measures of males were significantly higher than those of females (*P*<0.05). Most measures of size at low altitude significantly greater than those at high altitudes, including body weight, body length, wing length and tail length for males (*P*<0.05), and body weight and wing length for females. The results showed that males and females are different in response to environmental factors. The body weight, wing length, tarsus, skull length and interorbital distance in males were significantly correlated with atmospheric pressure (*P*<0.05), along with body weight, body length, rictus, wing length, tarsus and skull length in males (*P*<0.05). A significant positive correlation was observed between wing length of males and wind speed (*P*=0.017). Conversely, body weight, body length, wing length and tail length in males were significantly negatively correlated with air temperature (*P*<0.05). Many measures of body size (wing length and tail length for males; tail length for females) increased with latitude after controlling for altitude, indicating that the body size of this species, especially in males, is significantly larger at high latitudes. It is the common pheasant’s adaptability to considerable environmental change that has facilitated the vast distribution of this species.

**INTRODUCTION**

Geographic variation in morphology is a common occurrence in species of birds, and widespread patterns are often explained within an adaptive framework (Healy and Price, 2008). Intraspecific geographic variation in body size is assumed to reflect adaptation to local environmental conditions, such as altitude, latitude and ambient temperature (Millien et al., 2006; Yom-Tov and Geffen, 2011; Sun et al., 2017). Altitudinal variation in body size has been well-documented (Blackburn et al., 2001; Bulgarella et al., 2007; Zhao et al., 2013; Sun et al., 2017). For instance, animals inhabiting higher altitudes generally have higher energy demands for cold surroundings (Storz, 2007; Storz et al., 2010). The body size is significantly negatively correlated with altitude (*P*<0.01) in tree sparrow (Lan et al., 2018). Although latitudinal and altitudinal gradients show similar trends in temperature decline (Ashton and Feldman, 2003), some climate factors, such as solar radiation and lower temperatures, are often accompanied by decreased atmospheric pressure and constant, strong wind. Thus, these climatic components are more strongly associated with variation in altitude than latitude (Liao et al., 2006, 2010; Körner, 2007). Similarly, limited oxygen availability may decrease digestive efficiency, thus eliciting a negative effect on body size; the mechanism of which has been demonstrated in geographic size variation in some lizards and mammals (Liao et al., 2006; Jin et al., 2007). Previous studies have demonstrated a positive relationship between body size and latitude in some species of birds and mammals (Ashton, 2002; Meiri and Dayan, 2003; Gardner et al., 2009; Olson et al., 2009). Associated morphological adaptations in birds and mammals are known to include variations related to body
size (Blackburn et al., 1999; Blackburn and Ruggiero, 2001).

The common pheasant (Phasianus colchicus) belongs to the genus Phasianus of the family Phasianidae, under the order Galliformes. A significant degree of sexual dimorphism exists in this species, which ranges across most of China (Zheng, 2011). Therefore, it is an ideal species to understand morphological variation in different geographical locations. The study of this species has largely been focused on phylogeography (Qu et al., 2009; Liu et al., 2010; Zhang et al., 2014), distribution of subspecies (Braasch et al., 2011), physiology and biochemistry (dos Santos Schmidt et al., 2007; Kececi et al., 2011), heavy metal accumulation in tissues (Dzugan et al., 2012), as well as breeding ecology (Musil et al., 2009; Kayvanfar et al., 2014). However, the morphological variation of this species in response and adaptation to environmental factors is unknown. In this study, we collected 399 samples both from male and female common pheasants, across differing altitudinal and samples sites distributions in mainland China. Our objectives are to determine: 1) the difference in response to environmental effects between male and female conspecifics; 2) whether there is significant difference in morphology along the altitudinal gradient; and 3) the environmental factors which significantly affect the morphological size, by analyzing the relationship between size and environmental factors.

MATERIALS AND METHODS

A total of 399 individuals were obtained from: the Institute of Zoology, Chinese Academy of Sciences (CAS); the Kunming Institute of Zoology, CAS; the South China Institute for Endangered Animals; or collected from the wild. We used a Vernier caliper (0.1mm) to measure the morphological size of males and females, including: body length, tail length, culmen, rictus, wing length, tarsus, skull length, skull width, interorbital distance and so forth. Body mass was measured by an electric balance (0.1g). The sample sites were situated from 76.17°E - 129.17°E, while the region’s altitude spanned from 2m - 4472m (Tables I, II). Two populations were devised from the sample sites according to altitude: a high altitude population (>1500m) and a low altitude population (<1500m). The high altitude population consisted of 130 males and 65 females, while 136 males and 68 females comprised the low altitude population. We analyzed the correlation between environmental factors and morphological size of both males and females using the principal component analysis method, respectively. Twenty one environmental factors included: longitude, latitude, altitude, extreme minimum atmospheric pressure, extreme maximum atmospheric pressure, average atmospheric pressure, extreme minimum wind speed, average wind speed, extreme maximum wind speed, extreme maximum air temperature, extreme minimum air temperature, average air temperature, average maximum temperature, average minimum temperature, precipitation, average vapour pressure, average relative humidity, daily precipitation, maximum daily precipitation, sunshine duration, and percentage of sunshine. All the meteorological data was obtained from national meteorological data center of China. We used the independent sample T-test method, and analysis of the morphological differences between males and females, and high altitude and low altitude populations for male and female, respectively. All data were analyzed in SPSS 20.0 software.

RESULTS

Sexual size dimorphism

The results of the independent sample T-test illustrated that all the morphological size measures of males were significantly greater than those of females (P<0.05) (Table III).

Relationship with environmental factors

From principal component analysis, four principal components were obtained: PC1 (-0.966) (atmospheric pressure factor), PC2 (0.927) (precipitation factor), PC3 (0.916) (air temperature factor), and PC4 (0.887) (wind speed factor). The four principal components can explain 92% of the total variance in 21 environmental factors analyzed. Based on analysis of environmental factors and morphological characteristics, the results indicated that body weight, wing length, tarsus, skull length and interorbital distance had significant positive correlations with the atmospheric pressure factor in females (P<0.05). There was no significant correlation observed between any measure of morphological size and the wind speed factor neither in females, nor for female morphological size and the precipitation factor (P>0.05) (Table IV). Following the analysis of environmental components and morphological traits in males, the results illustrated that body weight, body length, rictus, wing length, tarsus and skull length had a significant positive correlation with the atmospheric pressure factor (P<0.05). Conversely, body weight, body length, wing length and tail length had significant negative correlations with the air temperature factor (P<0.05). Additionally, a significant positive correlation between wing length and the wind speed factor was revealed, while no significant correlation was observed between any morphological size measure and the precipitation factor for males (P>0.05) (Table IV).
Table I. Sampling sites of males of *Phasianus colchicus*.

| Sites                | Gender | Date       | Sampling size | Longitude | Latitude | Altitude (m) |
|----------------------|--------|------------|---------------|-----------|----------|--------------|
| Wuhu, Anhui          | ♂      | 1908       | 1             | 118.43    | 31.35    | 11           |
| Yuexi, Anhui         | ♂      | 2013       | 8             | 116.36    | 30.85    | 694          |
| Beijing              | ♂      | 1932/1966/ | 8             | 116.41    | 39.90    | 48           |
| Dangchang, Gansu     | ♂      | 2013       | 2             | 104.39    | 34.05    | 2350         |
| Minqin, Gansu        | ♂      | 2013       | 6             | 102.99    | 38.58    | 1384         |
| Minxian, Gansu       | ♂      | 2013       | 9             | 104.04    | 37.93    | 1537         |
| Pingliang, Gansu     | ♂      | 2013       | 9             | 106.65    | 35.22    | 1580         |
| Wuwei, Gansu         | ♂      | 2013       | 8             | 102.64    | 37.93    | 48           |
| Zhangxian, Gansu     | ♂      | 2013       | 5             | 104.47    | 34.85    | 2034         |
| Lianyang, Guangdong  | ♂      | 1959       | 3             | 111.18    | 23.72    | 372          |
| Shaoqun, Guangdong   | ♂      | 2013       | 2             | 113.04    | 24.69    | 722          |
| Anshun, Guizhong     | ♂      | -          | 1             | 105.89    | 25.99    | 1398         |
| Tongren, Guizhong    | ♂      | -          | 2             | 109.05    | 25.83    | 425          |
| Chengde, Hebei       | ♂      | 1927/1932/ | 9             | 117.91    | 40.95    | 338          |
| Dongling, Hebei      | ♂      | 1929/1930/ | 14            | 117.66    | 40.18    | 108          |
| Harbin, Heilongjiang | ♂      | 1922/1952/ | 4             | 129.21    | 48.24    | 370          |
| Jishou, Hunan        | ♂      | 1955/1956/ | 2             | 109.70    | 28.26    | 378          |
| Yizhang, Hunan       | ♂      | 1955/1956/ | 5             | 113.02    | 28.21    | 38           |
| Xianghai, Jilin      | ♂      | 2013       | 2             | 122.35    | 45.03    | 162          |
| Nanjing, Jiangsu     | ♂      | 1960/1929/ | 3             | 120.44    | 32.07    | 4            |
| Nanchang, Jiangxi    | ♂      | 1960       | 1             | 115.86    | 28.68    | 21           |
| Aohan Banner, Inner Mongolia | ♂ | 2013 | 8 | 120.39 | 42.13 | 601 |
| Haggin Banner, Inner Mongolia | ♂ | 2013 | 5 | 108.74 | 39.83 | 1394 |
| Wuhai, Inner Mongolia | ♂ | 1960 | 9 | 106.80 | 39.66 | 1093 |
| Jingyuan, Ningxia    | ♂      | 2013       | 3             | 106.33    | 35.50    | 1935         |
| Longde, Ningxia      | ♂      | 2013       | 15            | 106.11    | 35.63    | 2106         |
| Guide, Qinghai       | ♂      | 2013       | 6             | 101.43    | 36.04    | 2301         |
| Huzhu, Qinghai       | ♂      | 2013       | 7             | 101.96    | 36.84    | 2762         |
| Menyuan, Qinghai     | ♂      | 1960       | 6             | 101.62    | 37.36    | 3435         |

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Table II. Sampling sites of females of *Phasianus colchicus*.

| Sites           | Gender | Date   | Sampling size | Longitude | Latitude | Altitude (m) |
|-----------------|--------|--------|---------------|-----------|----------|--------------|
| Yuexi, Anhui    | ♀      | 2013   | 8             | 116.36    | 30.85    | 694          |
| Beijing         | ♀      | 1965/1966 | 4         | 116.41    | 39.90    | 48           |
| Dangchang, Gansu| ♀      | 2013   | 4             | 102.99    | 34.44    | 2428         |
| Minqin, Gansu   | ♀      | 2013   | 4             | 102.64    | 37.93    | 1537         |
| Minxian, Gansu  | ♀      | 2013   | 4             | 104.04    | 34.44    | 2428         |
| Pingliang, Gansu| ♀      | 2013   | 3             | 106.65    | 35.22    | 1580         |
| Wuwei, Gansu    | ♀      | 2013   | 4             | 102.64    | 37.93    | 1537         |
| Zhangxian, Gansu| ♀      | 2013   | 5             | 104.47    | 34.85    | 2034         |
| Lianyang, Guangdong | ♀      | 1959 | 2              | 111.18    | 23.72    | 372          |
| Shaoguan, Guangdong | ♀      | 2013 | 4              | 113.04    | 24.69    | 722          |
| Anshun, Guizhou | ♀      | -     | 1             | 105.89    | 25.99    | 1398         |
| Qianxi, Guizhou | ♀      | -     | 1             | 104.90    | 25.09    | 1353         |
| Chengde, Hebei  | ♀      | 1960/1974 | 2         | 117.91    | 40.95    | 338          |
| Dongling, Hebei | ♀      | 1935   | 4             | 117.66    | 40.18    | 108          |
| Harbin, Heilongjiang | ♀   | 1960 | 2              | 129.21    | 48.24    | 370          |
| Yichang, Hunan  | ♀      | 1959   | 1              | 113.02    | 28.21    | 38           |
| Xianghai, Jilin | ♀      | 2013   | 3              | 122.35    | 45.03    | 162          |
| Nanchang, Jiangxi | ♀      | 1960  | 1              | 115.86    | 28.68    | 21           |
| Aohan Banner, Inner Mongolia | ♀      | 2013 | 8              | 120.39    | 42.13    | 601          |
| Haggin Banner, Inner Mongolia | ♀      | 2013 | 5              | 108.74    | 39.83    | 1394         |
| Wuhai, Inner Mongolia | ♀      | 1963/1964 | 3         | 106.80    | 39.66    | 1093         |
| Longde, Ningxia | ♀      | 2013   | 14             | 106.11    | 35.63    | 2106         |
| Guide, Qinghai  | ♀      | 2013   | 6              | 101.43    | 36.04    | 2301         |
| Guinan, Qinghai | ♀      | 1959   | 2              | 100.75    | 35.58    | 3412         |
| Menyuan, Qinghai| ♀      | 1959   | 1              | 101.62    | 37.36    | 3435         |
| Tongren, Qinghai| ♀      | 1960   | 3              | 102.02    | 35.52    | 2549         |
| Xining, Qinghai | ♀      | 1959   | 4              | 101.78    | 36.62    | 2270         |
| Qixia, Shandong | ♀      | 1964   | 1              | 112.07    | 37.19    | 216          |
| Qinshui, Shanxi | ♀      | 1962   | 1              | 112.19    | 35.69    | 856          |
| Yicheng, Shanxi | ♀      | 1962   | 2              | 111.72    | 35.74    | 623          |
| Foping, Shaanxi | ♀      | 1957   | 1              | 107.99    | 33.52    | 1008         |

Table III. Sexual size dimorphism in common pheasant, *Phasianus colchicus*.

| Sites          | Gender | Date   | Sampling size | Longitude | Latitude | Altitude (m) |
|----------------|--------|--------|---------------|-----------|----------|--------------|
| Xi’an, Shaanxi | ♀      | 1957   | 2             | 108.94    | 34.34    | 383          |
| Yangxian, Shanxi | ♀      | 1957 | 1             | 107.55    | 33.22    | 482          |
| Batang, Sichuan | ♀      | 1960   | 1             | 99.11     | 30.00    | 4687         |
| Hongyuan, Sichuan | ♀      | 1961 | 2             | 102.46    | 32.51    | 3612         |
| Muli, Sichuan  | ♀      | 1959   | 2             | 101.28    | 27.93    | 3461         |
| Pingwu, Sichuan | ♀      | 1969   | 1             | 104.53    | 32.41    | 1209         |
| Wanyuan, Sichuan | ♀   | 1958 | 1             | 108.03    | 32.08    | 1033         |
| Mangkang, Tibet | ♀      | 1976   | 1             | 98.59     | 29.68    | 4283         |
| Aksu, Xinjiang | ♀      | 1958   | 1             | 80.26     | 41.17    | 1108         |
| Kunming, Yunnan | ♀      | 1962 | 3             | 102.61    | 25.06    | 2166         |
| Lijiang, Yunnan | ♀      | 1960   | 2             | 100.23    | 26.86    | 2405         |
| Yuxi, Yunnan   | ♀      | 1957   | 2             | 102.41    | 24.17    | 1642         |
| Zhaotong, Yunnan | ♀      | 1962 | 1             | 103.72    | 27.34    | 1921         |
| Zhongdian, Yunnan | ♀      | - | 1             | 103.23    | 25.23    | 1799         |
| Haiyan, Zhejiang | ♀      | 1925 | 3             | 120.95    | 30.53    | 5            |

Note: Bold font represents a statistically significant size difference between male and female pheasants at the significance level of 0.001.

Furthermore, we analyzed the relationship between morphological size and latitude after controlling for altitude, as well as the relationship between morphological size and altitude after controlling for latitude. The results showed that female tail length had a significant positive correlation with latitude when controlling for altitude (P<0.05), while female body weight and skull length had significant negative correlation with altitude when controlling...
Table IV. The correlation of principal environmental factors with morphology of *Phasianus colchicus* of male and female.

| Statistical parameters | Body weight | Body length | Culmen | Rictus | Wing length | Tail length | Tarsus | Skull length | Skull width | Interorbital distance |
|------------------------|-------------|-------------|--------|--------|-------------|-------------|--------|--------------|-------------|----------------------|
| Female PC1 r           | 0.515       | 0.222       | -0.156 | 0.067  | 0.324       | 0.135       | 0.367  | 0.451        | -0.047      | 0.341                |
| df                     | 37          | 46          | 46     | 46     | 46          | 45          | 46     | 46           | 34          | 34                   |
| P                      | 0.001       | 0.138       | 0.301  | 0.656  | 0.028       | 0.377       | 0.012  | 0.007        | 0.792       | 0.048                |
| PC2 r                  | -0.026      | -0.160      | 0.231  | -0.127 | -0.034      | -0.228      | 0.174  | 0.014        | -0.274      | 0.128                |
| df                     | 37          | 46          | 46     | 46     | 46          | 45          | 46     | 46           | 34          | 34                   |
| P                      | 0.878       | 0.289       | 0.122  | 0.400  | 0.824       | 0.132       | 0.247  | 0.939        | 0.116       | 0.472                |
| PC3 r                  | 0.299       | -0.167      | 0.024  | -0.107 | -0.184      | -0.479      | 0.042  | -0.161       | 0.089       | -0.314               |
| df                     | 37          | 46          | 46     | 46     | 46          | 45          | 46     | 46           | 34          | 34                   |
| P                      | 0.072       | 0.269       | 0.877  | 0.479  | 0.221       | <0.001      | 0.781  | 0.362        | 0.616       | 0.070                |
| PC4 r                  | 0.202       | 0.109       | 0.079  | -0.027 | 0.081       | -0.066      | 0.152  | -0.216       | 0.082       | -0.023               |
| df                     | 37          | 46          | 46     | 46     | 46          | 45          | 46     | 46           | 34          | 34                   |
| P                      | 0.231       | 0.471       | 0.6002 | 0.859  | 0.591       | 0.669       | 0.312  | 0.219        | 0.643       | 0.895                |
| Male PC1 r             | 0.395       | 0.260       | 0.033  | 0.259  | 0.293       | 0.215       | 0.598  | 0.407        | 0.129       | 0.136                |
| df                     | 49          | 64          | 65     | 59     | 64          | 60          | 65     | 49           | 49          | 49                   |
| P                      | 0.005       | 0.038       | 0.797  | 0.048  | 0.019       | 0.098       | <0.001 | 0.004        | 0.376       | 0.350                |
| PC2 r                  | 0.123       | -0.001      | 0.141  | -0.197 | -0.129      | -0.046      | 0.008  | 0.253        | 0.164       | -0.038               |
| df                     | 49          | 64          | 65     | 59     | 64          | 60          | 65     | 49           | 49          | 49                   |
| P                      | 0.399       | 0.991       | 0.262  | 0.134  | 0.309       | 0.729       | 0.949  | 0.080        | 0.260       | 0.798                |
| PC3 r                  | -0.437      | -0.407      | 0.196  | -0.252 | -0.256      | -0.500      | -0.177 | -0.039       | -0.110      | -0.163               |
| df                     | 49          | 64          | 65     | 59     | 64          | 60          | 65     | 49           | 49          | 49                   |
| P                      | 0.002       | -0.001      | 0.117  | 0.055  | 0.041       | <0.001      | 0.159  | 0.791        | 0.454       | 0.263                |
| PC4 r                  | 0.098       | -0.047      | 0.042  | -0.073 | 0.297       | -0.100      | 0.027  | -0.059       | -0.134      | 0.029                |
| df                     | 49          | 64          | 65     | 59     | 64          | 60          | 65     | 49           | 49          | 49                   |
| P                      | 0.503       | 0.71        | 0.7409 | 0.582  | 0.017       | 0.449       | 0.833  | 0.686        | 0.359       | 0.845                |

Note: PC1: atmospheric pressure factor; PC2: precipitation factor; PC3: air temperature factor; PC4: wind speed factor. Bold font represents a statistically significant correlation between the environmental factor and the size of the trait measured, at the significance level of 0.05.

for latitude (P<0.05) (Table V). Our analysis also showed that male body weight, rictus, wing length and tail length had significant positive correlations with latitude when controlling for altitude (P<0.05). Conversely, male tarsus and skull length had significant negative correlations with altitude when controlling for latitude (P<0.05) (Table V).

Variation of morphology with altitude

The results indicated that most measures of morphological size at low altitude sites were significantly greater than those at high altitude sites, including body weight, body length, culmen, rictus, wing length, tarsus, and skull length for males (P<0.05), as well as body weight, wing length, tarsus, and skull length for females (Fig. 1, Table VI).

DISCUSSION

Sexual selection is one of the evolutionary motive forces, and the selection pressures affecting mating opportunities and mating competitiveness have led to sexual dimorphism in animals (Williams, 1992; Andersson, 1994). Our study indicates that body size is greater in males than females. It is common that pheasant family exhibits significant sexual dimorphism. It also performs a feature that male body size is greater than female. The morphology size is the weapons or reliable signals of male quality directed both to females and rivals in pheasants (Mateos, 1998). The superior body condition of males ensures better offspring viability in birds, such as barn swallow *Hirundo rustica* (Møller, 1994; Petrie, 1994; Sheldon et al., 1997). Therefore, we believe that this characteristic is
Table V. The partial correlation analysis of altitude and latitude with morphology of *Phasianus colchicus* of male and female.

| Control variable | Variable | Body weight | Body length | Culmen | Rictus | Wing length | Tail length | Tarsus | Skull length | Skull width | Interorbital distance |
|------------------|----------|-------------|-------------|--------|--------|-------------|-------------|--------|--------------|-------------|----------------------|
| Altitude (F)     | r        | -0.04       | 0.3         | -0.291 | -0.157 | 0.212       | 0.638       | -0.05  | 0.219        | 0.082       | 0.193                |
| Latitude         | df       | 23          | 23          | 23     | 23     | 23          | 23          | 23     | 23           | 23          | 23                   |
| P                |          | 0.85        | 0.145       | 0.159  | 0.455  | 0.308       | 0.001       | 0.811  | 0.293        | 0.696       | 0.356                |
| Latitude (M)     | r        | -0.546      | 0.111       | -0.028 | -0.256 | -0.142      | 0.248       | -0.295 | -0.435       | -0.076      | -0.241               |
| Altitude         | df       | 23          | 23          | 23     | 23     | 23          | 23          | 23     | 23           | 23          | 23                   |
| P                |          | 0.005       | 0.599       | 0.893  | 0.216  | 0.497       | 0.232       | 0.153  | 0.03         | 0.718       | 0.246                |
| Altitude (M)     | r        | 0.339       | 0.212       | -0.089 | 0.528  | 0.44        | 0.336       | 0.286  | -0.109       | -0.123      | 0.189                |
| Latitude         | df       | 37          | 37          | 37     | 37     | 37          | 37          | 37     | 37           | 37          | 37                   |
| P                |          | 0.035       | 0.196       | 0.59   | 0.001  | 0.005       | 0.037       | 0.078  | 0.51         | 0.457       | 0.248                |
| Latitude (M)     | r        | -0.216      | -0.177      | -0.274 | -0.274 | -0.27       | 0.012       | -0.649 | -0.481       | -0.195      | -0.136               |
| Altitude         | df       | 37          | 37          | 37     | 37     | 37          | 37          | 37     | 37           | 37          | 37                   |
| P                |          | 0.187       | 0.282       | 0.091  | 0.092  | 0.096       | 0.944       | <0.001 | 0.002        | 0.234       | 0.41                 |

Note: Bold font indicates a significant correlation between altitude or latitude and the morphological measure in question, at the significance level of 0.05. F: female, M: male.

Table VI. Morphological variations between high and low altitude regions for male and female pheasants of *Phasianus colchicus*.

|                  | Body weight/g | Body length/cm | Culmen/cm | Rictus/cm | Wing length/cm | Tail length/cm | Tarsus/cm | Skull length/cm | Skull width/cm | Interorbital distance/cm |
|------------------|---------------|----------------|-----------|-----------|----------------|----------------|-----------|-----------------|----------------|------------------------|
| **Female**       |               |                |           |           |                |                |           |                 |                 |                        |
| Low Altitude     | 824.90±       | 54.82±         | 2.91±     | 2.89±     | 21.18±         | 26.17±         | 5.94±     | 3.73±           | 2.60±          | 2.05±                  |
| t                | 3.30          | 1.14           | 1.16      | 0.05      | 0.37           | 0.13           | 0.07      | 0.04            | 0.04           | 0.05                   |
| df               | 35.00         | 24.19          | 44.00     | 44.00     | 44.00          | 44.12          | 44.00     | 32.00           | 32.00          | 32.00                  |
| P                | 0.002         | 0.266          | 0.181     | 0.964     | 0.002          | 0.898          | 0.034     | 0.031           | 0.704          | 0.154                  |
| **Male**         |               |                |           |           |                |                |           |                 |                 |                        |
| Low Altitude     | 1094.63±      | 79.00±         | 3.39±     | 3.33±     | 23.71±         | 45.25±         | 6.66±     | 4.16±           | 2.81±          | 2.38±                  |
| t                | 2.99          | 1.54           | 1.09      | 0.04      | 0.16           | 1.28           | 0.07      | 0.05            | 0.06           | 0.05                   |
| df               | 47.00         | 61.76          | 63.00     | 57.00     | 61.32          | 58.00          | 63.00     | 47.00           | 47.00          | 47.00                  |
| P                | 0.004         | 0.041          | 0.005     | 0.041     | 0.002          | 0.180          | 0.001     | 0.009           | 0.477          | 0.788                  |

Note: Bold font indicates a statistically significant difference in size at the significance level of 0.05.

an important result of its wide distribution in evolutionary adaptation.

The most measures of morphological size are significantly greater at low altitudes than at high altitudes both for male and female common pheasants. Some researchers have shown that in the *Galerida*, body size does not increase with altitude in *G. cristata* (Alban et al., 2008). Also, Lu et al. (2009) reported two sympatric *Montifringilla* snow finch species (*M. taczanowskii* and *M. ruficollis*) in a higher altitude region, and compared the data with those of their lower altitude conspecifics. Their results indicated that relative to their lower altitude conspecifics, the higher altitude snow finches had smaller body sizes. Similarly, in some mammal species, such as the Daurian pika (*Ochotona daurica*), skull size is negatively correlated with altitude (Liao et al., 2006). The body size of avian fauna is affected by the availability of food and interspecific competition (Scholander, 1955; McNab, 1971).
Fig. 1. Sexual size dimorphism and variation of morphology of *Phasianus colchicus* compared at differing altitudes. Note: Black circles represent the lower altitude population (<1500m); while black triangles represent the higher altitude population (>1500m); Additionally, * represents statistical significance at a 0.05 significance level; while statistical significance at the level of 0.01 is represented by **.

Individual size is significantly positively correlated with the degree of primary productivity in any environment (Rosenzweig, 1968). Although latitudinal and altitudinal gradients show similar temperature decline trends (Ashton and Feldman, 2003), some climate factors such as solar radiation and lower temperatures, which are often accompanied by decreased atmospheric pressure and constant strong wind are more strongly associated with variation in altitude than latitude (Liao et al., 2006, 2010; Körner, 2007; Scholander, 1955; McNab, 1971). The body size patterns observed may be attributed to constraints on individual growth by climate severity, food scarcity and hypoxia at higher altitudes (Lu et al., 2009). The body size of avian could be affected on food available and interspecies competition (Scholander, 1955). The primary productivity is positively correlated with body size in any environments (McNab, 1971; Rosenzweig, 1968). The body size, such as body weight, wing length and tarsus, could be significantly smaller at higher altitude areas due to lower level of primary productivity and few air (P<0.01) (Lan et al., 2018). We argue that body size tends to decrease with altitude in common pheasant due to the harsh conditions brought forth by environmental factors at high altitudes.

The results indicated that the atmospheric pressure factor and the air temperature factor had significant effects on both male and female body size. Atmospheric pressure and temperature are often associated with a significant decrease with rising elevation; for every additional 100m above sea level, temperature drops by 0.6°C, while atmospheric pressure is reduced by 0.67 KPa. However,
male body weight, body length, wing length and tail length had significant negative correlations with the air temperature factor ($P<0.05$). Usually, air temperature decreases with rising altitude and latitude. The overall pheasant body size (such as weight, wings length, etc.) is larger with increasing latitude. Essentially, the body size of the common pheasant is significantly larger at high latitudes in colder regions than at low latitudes of warmer regions (Table VI). Conversely, some measures of body size, such as skull length, decrease as the altitude rises. That is to say that the body size of the common pheasant is significantly smaller at high altitudes than at low altitudes (Table VI). Therefore, altitude is the primary factor of morphological variation in different areas, as compared to latitude. Furthermore, the wind speed factor had a significant effect on male wing length ($P=0.017$) (Table IV), thus indicating that the greater the wind speed in a given area, the longer the wing length of male common pheasants situated in said region. Longer wings have increased flight ability (Sun et al., 2016) and allow for easier acclimation to the environment, in order to survive. Therefore, geographic variation in body size is assumed to reflect adaptation to local environmental conditions for conspecifics (Mayr, 1956; Millien et al., 2006; Yom-Tov and Geffen, 2011). It is the common pheasant’s adaptability in response to environmental changes that has facilitated the vast distribution of this species.

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Statement of conflict of interest

The authors declare that “there is no conflict of interests regarding the publication of this article”.

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