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Sexual Dimorphism in Body Size and Some Exterior Traits of Pigeon Breed Groups

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Abstract

In this study, sexual dimorphism in pigeons was investigated. Rensch's rule was evaluated across pigeon breeds. Body weight, body length, beak length, wingspan, tail length, and tarsus length were used for the analysis. We have divided the breeds in the five groups (form, frills and owls, tumbler and rollers, homer and highflyer, feral). The allometric relation in the traits between female and male measures were analyzed. The measure of sexual size dimorphism was measured for each trait as a simple male size divided by female size (Sexual Size Index, SSI). On average across traits, male birds have higher values than female birds, both across breed groups and overall. No deviation from isometric allometry can be observed except the tail length. No trends towards logarithmic female values according to the SSI could be identified. According to the results, the rules of Rensch for pigeon breeds are rejected. Sexual dimorphism exists between breeds and traits, mainly in favor of the male birds. In most cases, allometric relationships between breeds change, as do traits.

Introduction

The sex-specific differences, especially in overall size and body parts, are a topic that biology has been dealing with for a long time. It is mostly about evolutionary questions across the species (Kappeler, 1990; Fairbairn, 1997; Teder, 2014; Janicke and Fromonteil, 2021). An earlier hypothesis, known as Rensch's rule, states that sex size dimorphism increases with species size in species in which males are larger and decreases in those in which females are larger (Rensch, 1950). Abouheif et al. (1997) report that Rensch's rule is generally valid across several taxa. Guillermo-Ferreira et al. (2014) confirm this for insects but not for the stoneflies they worked on.

The outstanding difference between wild and domestic animals are the wide variation in size, shape, and color. The variation mentioned is so great that it is not seen between some wild species. The variation between breeds of domestic animals even leads to sexual barriers, which as a factor leads to speciation (Kaneshiro, 1980). Even if there is such a large variation between the breeds of a species, they are all the same species. However, some scientists have attempted to evaluate in particular Rensch's rule on breeds of domestic animals. The motivation for these studies is likely to evaluate the difference in sexual selection between natural conditions and human care. For example, Polak and Frynta (2009) compared sexual dimorphism in wild sheep and goat species with domestic sheep and goat breeds. The authors found greater sexual dimorphism in wild goat and sheep species than in domestic goat and sheep breeds. However, the dimorphism was lowest in non-European chamois, which are also wild species. The authors also conducted a similar study in subfamilies of the *Bovinae* species (Polak and Frynta, 2010). The results of this study state that water buffaloes are less dimorphic than domestic cows, yaks, and wild bovines, and draft breeds are less dimorphic than beef, dual-purpose, and dairy breeds.

In their study entitled “Morphometrics Within Dog Breeds Are Highly Reproducible and Dispute Rensch's Rule” Sutter et al. (2008) found that the differences in height at the withers of female and male dogs are proportionally equal among dog breeds. On the contrary, without the dog breeds specified as monomorphic in the FCI (Federation Cynologique Internationale) standard, Frynta et al. (2012) reported that the withers height in dog breeds confirms Rensch's rule.

Relatively high male dimorphisms were found in the body size of the chickens (live weight), which the jungle chickens showed to be extreme with an average difference of 68% (Remeš, Szekely, 2010). Geibel et al. (2016) found also great differences in favor of rosters in various chicken breed groups. In modern breeding programs that select for economically important traits, sex variation in traits is eliminated prior to selection. It can be assumed that in this way sexual selection loses its meaning. Since the mating decision is also made by humans when breeding domestic animals outside of breeding programs, sexual selection presumably plays a subordinate role here as well. The fact that dimorphism is more pronounced in draft cattle breeds reinforces these statements. Although the physical difference in females and males is smaller in domestic animals, artificial selection has not yet been able to eliminate physical sex dimorphism.

Therefore, in this study, we have investigated the extent to which sexual dimorphism in pigeons exists. We also evaluated Rensch's rule across breeds. How sexual dimorphism behaved in breeds selected for different traits was another question of the study. Furthermore, we investigated the extent to which sexual dimorphism differs in different body traits.

Material and Methods

The averages of female and male pigeons were collected from the literature shown in Table 1. Body weight, body length, beak length, wingspan, tail length, and tarsus length existed in most studies. Therefore, we used these traits for the analysis. We have grouped the breeds for analysis (Table 2). The grouping of the pigeon breeds was based on the grouping of the Association of German Show Pigeon Breeders. However, the "Homer and Highflyer" and "Feral" groups were created based on breed characteristics. Most are well-known breeds among international pigeon fanciers. However, some are local breeds but clearly defined in the literature. For some, on the other hand, only a small amount of open information can be obtained. If we briefly touch on these local pigeon breeds in the study, Denizli Azman pigeons are natives breed to the city of Denizli in western Anatolia. The breeding goals are primarily their shape, form, and color patterns and secondly their ability to fly. Halfbreed Baska is kept in and around Istanbul. This breed developed from a cross between Baska and Mısıri, which main keeping area is also Istanbul. Again, a breed bred for its shape, form, and color pattern and originating from the prince’s city of Manisa is the Manisa Azman Breed. A small breed known with a very short beak and large eyes is the Mısıri Pigeon, which originated from Istanbul. The Turkish "Fleet pigeons" on the other hand are not a breed but rather a group of relatively large pigeons with good flight and navigation ability. Especially in Southeastern Anatolia, these birds are flown in large flocks, consisting of males. Driving the flocks is about attracting and catching as many "stranger" birds as possible from other flocks.

Firstly, the allometric relation in the traits (live weight, body length, beak length, wingspan, tail length, and tarsus length) between female and male measures were analyzed. Allometry, better known as growth allometry, is basically an equation that shows the exponential change of a dependent variable with respect to the independent variable. The allometric equation expressing a remarkable scaling symmetry is $y=\alpha+x^b$. It can also be expressed as:

$$\log y = \log \alpha + b \log x$$

which is again a simple regression between the logarithmic forms of the variables. In addition to the general allometric relation between females and males, we have also used it separately for the breed groups. The differences between the regression coefficients of the breed groups were tested using contrast in PROC GLM (SAS, 2002). A simple contrast (c) is the difference between two means

$$(H_0: \bar{x}_1 = \bar{x}_2;\ c_1 = 1,\ c_2 = -1)$$

Complex contrast can test differences between multiple means, between a single mean and combined means, or between combined means and other combined means. We know that contrast is essentially a difference between regression coefficients. It can be estimate sample contrast by using the means. We can test significance via an F-statistic calculated by dividing MS_c by MS_{error}. SS_c is also a mean square (MS) since all contrasts have 1 degree of freedom.

$$(SS_c = \frac{n \sum c_i \overline{x_i}}{\sum c_i^2})$$

For the regression, the mean for each value of the predictor is estimated as the corresponding point on the line, and the deviations from the line are used as the sum of the squared deviations. To test the difference of the slopes to 1 we created a dummy variable with b=1 and R^2=1. Then the contrast to this dummy variable was determined.

The measure of sexual size dimorphism, discussed at length in Lovich and Gibbons (1992), was measured for each trait as a simple male size divided by female size (Sexual Size Index, SSI). To see how SSI is related to trait size, we regressed SSI to female size, for overall and for the groups separately. The differences between the regression coefficients of the groups were tested using contrast in PROC GLM as described above.

Table 1. Origin of the data by breed

Breeds	Source
Rock Buhara Bombay Hungarian Giant Indian Fantail Indian Lotan Indigenous Koka Lahore Mookee Homer Turkish Clap Tumbler 1	Parés-Casanova, P. M., Kabir, A. (2020)
Turkish Clap Tumbler 2	Atasoy, F., Erdem, E., Hacan, Ö. G. (2013)
Scanderoon	Yıldırım, H., Doğan, U., Cımrın, T. (2018)
Crested Edremit Kelebek Non-Crested Edremit Kelebek	Erdem H, Konyalı, C, Savaş T., (2018)
Adana Dewlap	Özbaşer, F. T., Alaşahan, S., Narinç, D., Gündüz, Ö., Özkul, B. Y. (2018)
Bursa Roller	Balcı, F., Ardıçlı, S., Alpay, F., Dinçel, D., Soyudal, B., Mehlika, E. R. (2018)
Alabadem Roller	Erdem, E., Özbaşer, F. T., Gürcan, E. K., Soysal, M. İ. (2021)
Fleet Pigeons	Özbaşer, F. T., Atasoy, F., Erdem, E., Güngör, İ. (2016)
Turkish Clap tumbler 3	Özçelik, U. C. (2019)
Jalali	Bhowmik, N., M., M. M., Rahman, M. A., (2014)
White Galatz Roller Blue Bar Pied Galatz Roller	Ionescu, H., Oroian, T. E., Botha, M. (2015)
Turkish Donek	Özbaşer, F. T., Erdem, E., Gürcan, E. K., Soysal, M. İ. (2021)
Trace Roller	Soysal, M. İ., Gürcan, E. K., Alter, K., Akar, T., Genç, S. (2011)
Feral 1 (Blue Bar) Feral 2 (Checker) Feral 3 (Dark Checker)	Hetmański, T., Jarosiewicz, A. (2008)
Kendari	Harapin H, Napirah, A., Wanci, S., 2017
Hünkari (Old Fashioned Oriental Frill)	Turkish Official Journal, (2020). Breed description in Türkeş and Gündüz (2021)
Manisa Azman	Data collected by "Salihli Pigeon" (Serkan GÜNDÜZ) in Salihli/Manisa-Turkey for the registry report
Denizli Azman	Data collected by "Pigeon House Society" (İskender DAMGACI) in Denizli for the registry report
Halfbred Baska English Tippler	Unpublished data from the project "Studies on Side Effects of Traits Created or Conserved as a Result of Artificial Selection in Animals: Effects of Short Beak on Pigeon Biology"
Mısıri (Istanbul Owl)	Data collected by the "Committee of Mısıri, Turkish Pigeon Association" (Mehmet CEYLAN) in Istanbul for the registry report

Table 2. Breed by groups

Form	Frills and Owls	Tumbler and Rollers	Homer and Highflyer	Feral
Bombay	Denizli Azman	Alabadem Roller	Adana Dewlap	Feral 1 (Blue Bar)
Buhara	Hünkari (Old Fashioned Oriental Frill)	Blue Bar Pied Galatz Roller	English Tippler	Feral 2 (Checker)
Hungarian Giant	Halfbred Baska	Bursa Roller	Turkish Fleet	Feral 3 (Dark Checker)
Indian Fantail	Manisa Azman	Crested Edremit Kelebek	Homer	Rock
Kendari	Mısıri (Istanbul Owl)	Edremit Kelebek	Indian Indigenous	
Lahore		Indian Lotan	Jalali	
Scanderoon		Mookee	Kokah	
		Trace Roller		
		Turkish Clap tumbler 1		
		Turkish Clap tumbler 1		
		Turkish Clap tumbler 1		
		Turkish Donek		
		White Galatz Roller		

Results

The descriptive statistics of the traits by sex and breed groups are summarized in Table 3. On average across traits, male birds have higher values than female birds, both across breed groups and overall. However, this does not mean that in all breeds the female birds have lower average values. Not in all breed groups, but overall, across the traits, there are breeds where the female birds have higher values on average. Looking at the SSI in Table 3, while males are on average 8% heavier than females, other traits are between 2% to 8% higher in males on average. The average relative sexual size dimorphism varies also between breed groups. The largest body weight difference is observed in the form pigeons and the lowest in the feral birds. Body length could only be considered in the frills and owls and, tumbler and rollers breed groups, where in both groups the male birds are 2% larger than female birds on average. The males of the form, frills and owls, tumblers and rollers, homers and highflyer pigeons have 4%, 2%, 1% and 6% longer beaks than the female birds, respectively. A difference of 2% between the sexes in favor of the males can be observed for the wingspan, also only considered in two groups, frills, and owls as well as tumblers and rollers. While the form pigeons show no difference between the sexes in the length of the tail, it is 3% in favor of the male pigeons in the frills and owls as well as the tumblers and rollers. The cocks of the form pigeons have 11% longer tarsus than the hens. In addition, the tarsus of male birds is in the frills and owls 4%, and tumblers and rollers 3% longer. Figure 1 shows the allometric relationship of the male values to the female values in all traits. A clear deviation from the isometric relationship to positive allometry was observed in tail length ($P<0.0435$). No deviation from isometric allometry can be observed in other traits ($P\geq0.1291$). The regression coefficients of SSI to logarithmic values of female birds can be shown in figure 2. No trends towards logarithmic female values according to the SSI could be identified ($P>0.05$). The results shown in Figure 2 clearly reject Rensch's rule for the pigeon breeds. Interesting results are presented in Table 4 for female-to-male allometry by trait and breed groups. Except for tail and tarsus length, there were no significant differences in the slopes between the breed groups for other traits. While isometry between body weights of the sexes can be observed in form pigeons as well as homer and highflyer pigeons, frills and owls showed negative allometry, feral pigeons positive allometry. In contrast, no relation between the sexes is observed in body weights of tumblers and rollers pigeons. In body length, where only two groups could form, show negative allometry between males and females in frill and owl birds, while the slope for the group of tumbler and roller birds are not different from 1. Significant but not significantly different slopes from 1 were observed for all groups in beak length. Another trait, the wingspan, for which only two groups could form, no trend can be observed in frills and owls.

However, the slope in tumblers and rollers birds shows a highly significant isometry. In tail length, a highly significant positive allometry was observed for the slope of female to male values in form pigeons, negative allometry in frills and owls, and an isometry in tumblers and rollers. The slope of female to male values in tarsus length shows also positive allometry in form pigeons. However, no trend can be observed in frills and owls. Furthermore, the female to male slope for tarsus length

Table 3. Descriptive statistics of the traits by sex and breed groups

Groups	$\bar{x}$ ± SD (min-max)	Live Weight (g)	Body Length (cm)	Beak Length (mm)	Wingspan (cm)	Tail Length (cm)	Tarsus Length (mm)
Form	Female	432.51±114.782 (310.0-680.0)	-	21.46±5.095 (17.0-31.2)	-	12.68±2.066 (9.9-16.4)	25.83±5.672 (22.0-29.0)
	Male	481.00±119.315 (330-690)	-	22.12±5.104 (16.0-31.9)	-	12.86±2.925 (8.7-17.4)	28.83±5.67 (22.0-39.0)
	SSI	1.12±0.113 (1.01-1.32)	-	1.04±0.097 (0.92-1.20)	-	1.00±0.083 (0.88-1.08)	1.11±0.125 (1.0-1.3)
	n	7	-	7	-	7	6
Frills and Owls	Female	288.15±29.137 (244.4-312.4)	30.84±0.898 (29.6-31.7)	12.83±2.400 (9.7-15.1)	60.31±1.14 (59.0-61.8)	11.30±0.458 (10.7-11.8)	26.54±0.491 (26.1-27.1)
	Male	306.14±21.61 (275.6-327.8)	31.59±0.376 (31.1-32.0)	13.09±2.514 (9.9-15.5)	61.76±0.386 (61.3-62.1)	11.65±0.201 (11.4-11.8)	27.65±0.694 (26.9-28.3)
	SSI	1.06±0.038 (1.00-1.03)	1.02±0.018 (1.01-1.05)	1.02±0.014 (1.00-1.06)	1.02±0.016 (1.01-1.04)	1.03±0.024 (1.00-1.06)	1.04±0.024 (1.02-1.06)
	n	5	4	5	4	4	3
Tumblers and Rollers	Female	319.46±22.198 (296.3-369.6)	33.29±2.821 (26.2-35.2)	18.82±4.034 (12.3-26.2)	64.39±2.953 (58.9-68.2)	12.51±1.448 (10.0-14.4)	24.24±3.564 (19.5-31.9)
	Male	343.68±31.612 (280.0-420.0)	33.98±2.817 (27.2-36.3)	18.9±4.002 (11.9-25.7)	65.46±3.395 (59.2-69.5)	12.85±1.569 (10.0-14.7)	24.81±3.213 (20.1-31.7)
	SSI	1.08±0.113 (0.90-1.40)	1.02±0.030 (0.94-1.05)	1.01±0.030 (0.95-1.06)	1.02±0.015 (0.98-1.04)	1.03±0.0216 (1.00-1.06)	1.03±0.058 (0.93-1.14)
	n	13	10	13	10	11	10
Homer and Highflyer	Female	384.17±125.457 (241.3-600.0)	-	19.37±1.119 (17.9-20.3)	-	-	-
	Male	409.88±112.041 (261.7-550.0)	-	20.50±2.304 (16.9-24.0)	-	-	-
	SSI	1.08±0.111 (0.92-1.29)	-	1.06±0.089 (0.95-1.20)	-	-	-
	n	7	-	6	-	-	-
Feral	Female	362.25±28.826 (320.0-385.0)	-	-	-	-	-
	Male	379.00±46.224 (310.0-407.0)	-	-	-	-	-
	SSI	1.04±0.051 (0.97-1.08)	-	-	-	-	-
	n	4	-	-	-	-	-
Overall	Female	354.43±89.224 (261.7-690.0)	33.22±3.043 (26.2-39.5)	18.60±4.437 (9.7-31.2)	63.87±3.405 (58.9-70.2)	11.97±1.806 (8.0-16.4)	24.77±2.997 (19.5-31.9)
	Male	381.96±92.048 (241.3-680.0)	33.99±3.079 (27.2-41.1)	19.07±4.617 (9.9-31.9)	65.16±3.685 (59.2-72.6)	12.44±1.877 (8.7-17.4)	26.59±4.154 (20.1-39.0)
	SSI	1.08±0.098 (0.90-1.40)	1.02±0.026 (0.94-1.06)	1.03±0.062 (0.92-1.20)	1.02±0.015 (0.98-1.04)	1.04±0.082 (0.88-1.31)	1.08±0.142 (0.93-1.60)
	n	36	17	32	17	26	22

Single-breed groups were excluded from the analyses. However, not in the analysis as overall. n: Number of Breeds in groups.

shows slightly negative allometry in tumblers and rollers. Table 5 shows the regression of female logarithmic values to SSI by traits and breed groups. No trend in the above values could be observed (*P*<0.05), except for form pigeons in tail and tarsus length. While the relationship between female logarithmic tail length in form pigeons is almost one-to-one, in tarsus length, the SSI value increases about twice than the logarithmic female value. Since the slopes of the frills and owls and tumblers and rollers do not deviate significantly from zero, the significant differences between the groups' slopes in the tail and tarsus length have practically no meaning.

Discussion

As expected, the form pigeons are the heaviest breed group on average (Table 3). Form pigeons are followed by homer and highflyer pigeons, feral pigeons, tumbler and roller pigeons, and frill and owl pigeons, in order. The biggest difference between hens and cocks in body size can also be seen in form pigeons (SSI=1.12). SSI ranges from 1.04 to 1.08 in other breed groups. Although few, female biased dimorphism is also found in the data collected from the pigeon literature. This female-biased dimorphism can be based on small sample sizes.

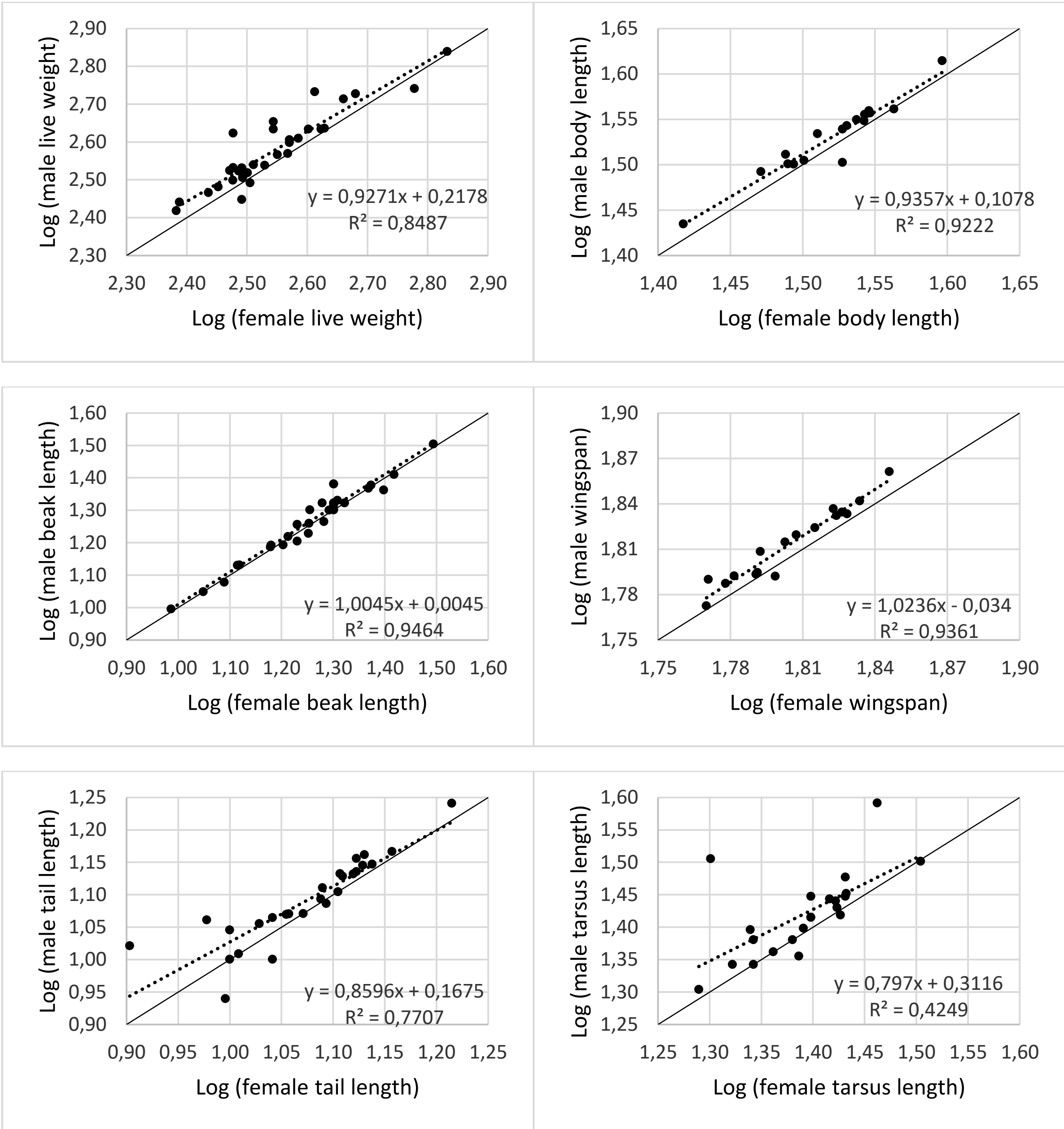

Figure 1. Allometric relations between male and female traits (all slopes were significant different from 0 by P<0.05; no significant differences were between the slopes of the traits (P>0.05). The straight line with a slope of 1.0 defines isometry, a size ratio of 1.0)

Therefore, the results must be viewed with caution. Fairbairn (1997) reported an SSI range between 3% and 128% in male-biased bird species, in which the smallest was in Passerines and the highest in Galliformes. In contrast to domesticated chicken breeds, sexual dimorphism is modest in the pigeon breeds in our study (Remeš and Szekely, 2010; Geibel et al., 2016). It is known that Galliformes are polygamous, but most of the Passerines are monogamous, also the Columbidae. Male sexual competition is expected to be fiercer in polygamous species than in monogamous species. This probably explains the low dimorphism in body size of the pigeons in contrast to the chickens.

It is no wonder that in pigeon breeds with larger cocks, hens are also larger (Figure 1). This does not change for other traits, and there are also no significant differences between the slopes of the traits. The slight differences in the slopes could probably be considered as measurement errors. Also, the distances between the slopes and b=1 of the traits are not significant, except for the tail length. This means that the characteristics of females and males of the breeds increase in a ratio of 1:1, i.e., there is an isometric relationship. However, when it comes to tail length, the ratio is hypoallometric (negative allometry).

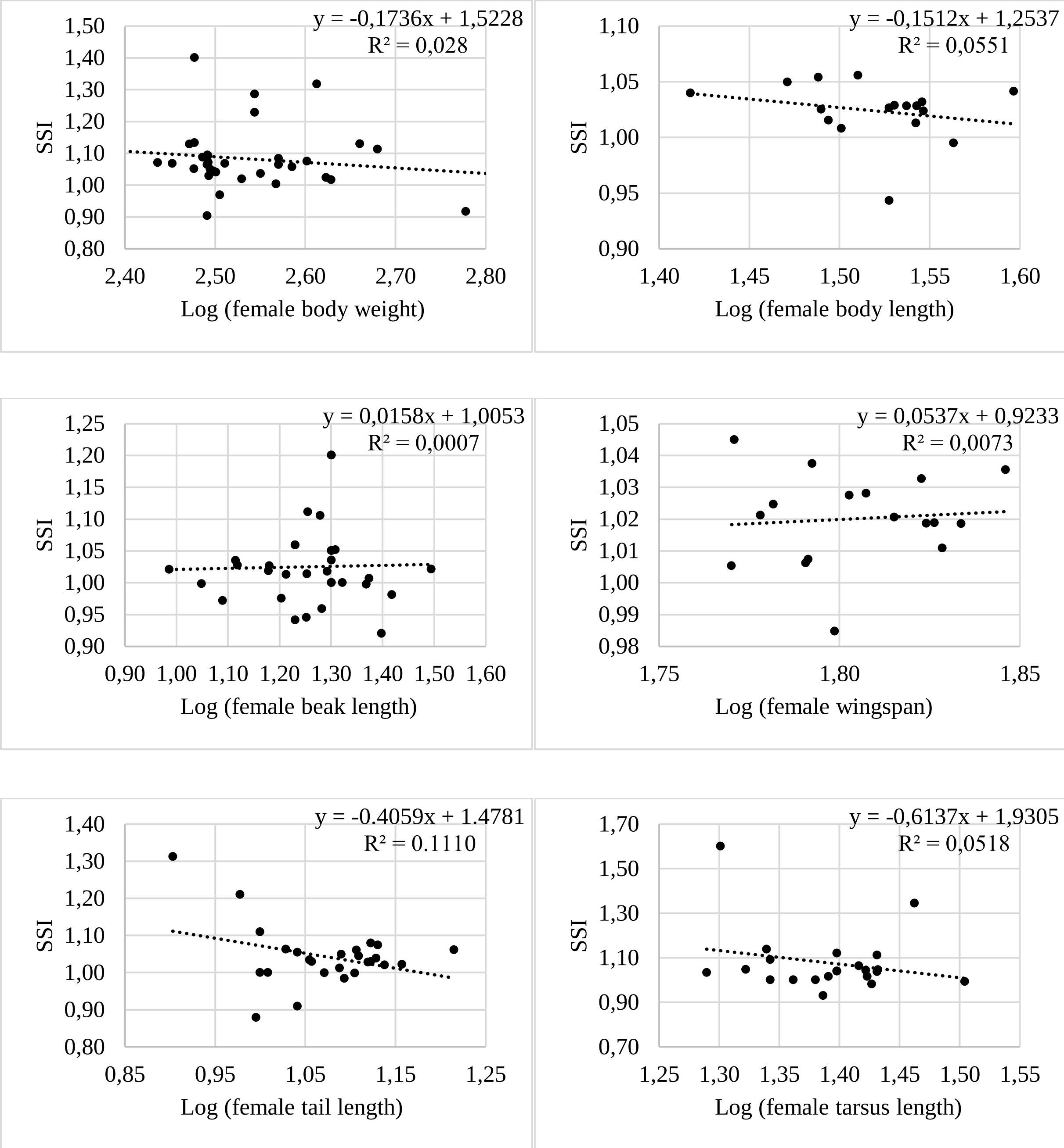

Figure 2. Relation between logarithmic female trait measures and sexual size dimorphism index (SSI) (P>0.05).

Parés-Casanova and Kabir (2020) also found hypoallometry in body mass, neck thickness, and wing length in pigeons. But the sample size is relatively small, the results should be viewed with caution. The authors further stated that the slopes in other morphological traits were not significantly different from 1. According to Sutter et al. (2008), the sex ratios of dog breeds do not differ in terms of withers height and body length. In contrast, Polak and Frynta (2010) reports that the significant positive allometric slopes for body mass in domestic cows change almost to isometry at the wither height. The results summarized in Figure 2 refute Rensch's rule for the pigeon breeds used in this study (Rensch, 1950).

Corroborate of Rensch's rule has been reported in domestic cattle as well as in domestic sheep and goats (Polak and Frynta, 2009, 2010). In studies conducted on dog breeds, on the other hand, no clear results can be seen with regard to Rensch's rule (Sutter, 2008; Frynta et al., 2012). In rare studies with domestic avian species, for example chicken, geese, and pigeons, Rensch's rule is usually refuted (Remeš and Szekely, 2010; Parés-Casanova, 2014; Parés-Casanova and Kabir, 2020). However, Remeš and Szekely (2010) found agreement with Rensch's rule in wild Galliformes. Perhaps a one-to-one comparison of wild gallinaceous birds and domestic breeds is not entirely correct. Ultimately, one deals with the variation between species while the other deals with

Table 4. Regression coefficients (b), their standard errors (SE), and *P* values between logarithmic male to logarithmic female values by traits and breed groups

Groups	Traits	Body Weight	Body Length	Beak Length	Wingspan	Tail Length	Tarsus Length
Form	b	0.86	-	0.92	-	1.44[a]	1.84[a]
	SE	0.117	-	0.130	-	0.092	0.263
	P[1]	<0.0001	-	<0.0001	-	<0.0001	0.0001
	P[2]	0.2697	-	0.5308	-	0.0007	0.0131
Frills and Owls	b	0.68	0.40	1.03	0.22	0.40[b]	0.62[ab]
	SE	0.038	0.030	0.026	0.124	0.072	0.856
	P[1]	<0.0001	0.0002	<0.0001	0.1558	0.0052	0.5438
	P[2]	0.0002	<0.0001	0.3725	0.0033	0.0011	0.7012
Tumblers and Rollers	b	0.34	0.91	1.00	1.09	1.06[b]	0.81[b]
	SE	0.280	0.077	0.028	0.078	0.038	0.088
	P[1]	0.2363	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	P[2]	0.0277	0.2729	0.8724	0.2548	0.1618	0.0512
Homer and Highflyer	b	0.85	-	1.39	-	-	-
	SE	0.089	-	0.481	-	-	-
	P[1]	<0.0001	-	0.0209	-	-	-
	P[2]	0.1257	-	0.4516	-	-	-
Feral	b	1.56	-	-	-	-	-
	SE	0.111	-	-	-	-	-
	P[1]	<0.0001	-	-	-	-	-
	P[2]	0.0071	-	-	-	-	-

[1] H_0: b=0; [2] H_0: b=1 [ab] The regression coefficients of the breed groups according to traits denoted by different letters differ significantly

Table 5. Regression coefficients (b), their standard errors (SE), and *P* values between logarithmic female trait measures to sexual size dimorphism index (SSI)

Groups	Traits	Body Weight	Body Length	Beak Length	Wing-span	Tail Length	Tarsus Length
Form	b	-0.35	-	-0.21	-	0.99[a]	2.22[a]
	SE	0.374	-	0.285	-	0.190	0.739
	P	0.3623	-	0.4780	-	<0.0001	0.0101
Frills and Owls	b	-0.80	-1.42	0.06	-1.85	-1.43[b]	-0.92[ab]
	SE	1.08	1.216	0.396	0.996	1.055	6.006
	P	0.4675	0.2703	0.8834	0.0933	0.1947	0.8800
Tumbler and Rollers	b	-1.74	-0.21	-0.01	0.21	0.13[b]	-0.44[b]
	SE	0.976	0.224	0.201	0.235	0.194	0.369
	P	0.0859	0.3753	0.9541	0.3842	0.5119	0.2507
Homer, Highflyer and Wattle	b	-0.35	-	0.90	-	-	-
	SE	0.291	-	1.165	-	-	-
	P	0.2431	-	0.4502	-	-	-
Feral	b	1.32	-	-	-	-	-
	SE	1.586	-	-	-	-	-
	P	0.4137	-	-	-	-	-

[ab] The regression coefficients of the breed groups according to traits denoted by different letters differ significantly

the variation within a species. It is expected that the difference in biology between species belonging to the same order or family is much greater than that of intraspecific breeds.

The breed groups differ strongly in terms of breeding characteristics. This difference is reflected in the sex allometry between groups and traits partially (Table 4). But no significant differences were found between the slopes of breed groups within the traits. This is probably due to the relatively small sample sizes of the individual groups. On the other hand, the largest group tumblers and rollers show no trend in body weight. Possibly it is the result that in this group one breed has a very high dimorphism (SSI=1.40), whereas in another breed the female is larger (SSI=0.90). In the case of the feral pigeons, the dimorphism is not large (in one breed even the hen is larger than the cock), but a trend towards positive allometry (hyperallometric) can be observed. In this breed group, it seems that Rensch's rule applies. However, the relatively small sample does not allow a clear statement. As with body mass, body length shows negative allometry (hypoallometric) in frills and owls. So, in this group sexual dimorphism in relatively larger breeds decreases. This group includes the smallest breeds (Table 3). Smaller breeds are known to have reduced dimorphism or non (Sutter et al., 2008; Frynta et al., 2012). The hen and cock allometry in beak length does not deviate from 1 in all groups. While frills and owls have short beaks, the beaks of form pigeons appear to be enormously large (Table 3). However, a proportional consideration of beak length to body mass shows that the beak is slightly larger in tumbler and roller pigeons. The slope of wingspan in frills and owls no differ from 0. Therefore, the significant deviation of the slopes from 1 has no meaning. There is simply no connection to allometry. On the other hand, there is clear isometric allometry in the tumblers and rollers group. In the tail length of the three breed groups, the allometric relationships of the sexes behave differently. While the allometric relationship of the sexes is positive in the form pigeon breeds, it is negative in the frills and owls. The tumblers and rollers pigeons, on the other hand, show isometric allometry. What can be responsible for this? Although the difference between average tail lengths between breed groups is not large, the variation within breed groups differs. The form pigeons show the greatest variation, the smallest can be seen in the frills and owls. The variation in tail length in the tumblers and rollers pigeons is between the other two groups. It is questionable whether the positive allometry in the form pigeons can be interpreted as a confirmation of Rensch's rule. In some breeds, such as the Indian Fantail, there is targeted breeding for an impressive tail, which could lead to the lengthening of the tail, which is not the case with other breeds. Furthermore, probably because of the shape-oriented breeding, there are also relatively large female-biased breeds. Probably, from tail lengths of larger in females to larger in males led to the positive allometric slope. As with tail length, allometry from female to male for tarsus length is similar in form and tumblers and rollers. It seems possible to explain this situation in a similar way. On the other hand, female-to-male allometry has no meaning in frills and owls.

The regression coefficients of the logarithmic measures for female traits to SSI show no significance in all groups, except for tail and tarsus length in form pigeons (table 5). Since the regression coefficients of the other groups are not significant, a discussion of the significant differences in regression coefficients between the groups in tail and tarsal length is omitted. The significant slopes between log female values to SSI in the tail and tarsus length support the results presented in Table 4.

Conclusion

The results can be concluded in 3 articles. First, according to the overall analysis, there is sexual dimorphism between breeds and traits, mainly in favor of the male birds. Secondly, even if there seems to be a connection to Rensch's rule for some breed groups and characteristics, it is rejected in general consideration of the results. Third, in most cases, allometric relationships between breeds change, as do traits.

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