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Heritability estimates of tibial dyschondroplasia, valgus-varus, foot-pad dermatitis and hock burn in broiler

Schätzung der Heritabilität von Tibialer Dyschondroplasie, Valgus-Varus-Verdrehung, Fußballenläsionen und Hock Burns bei Broilern

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Introduction

Comparing the performance of broiler strain of 1991 with a strain of 1957 revealed a 420% increase in body weight at 42 days of age (Havenstein et al., 2003a, b). About 85–90% of this improvement was attributed to genetic selection while the rest was achieved by developments in feeding and management. As a consequence of selection for increased broiler performance there has been a correlated increase in the incidence of several metabolic disorders, i.e. leg disorders, sudden death syndrome, and ascites. Furthermore, a very considerable increase in mortality in modern strains has been found, especially in the period from 21 days of age to slaughter (Bradshaw et al., 2002).

Indeed, from the comparison of strains showing different growth characteristics it could be concluded that genetic selection for young fast growing birds has resulted in increased incidence of leg disorders (Wise and Jennings, 1972; Poulos et al., 1978; Ducro and Sørensen, 1992; Kestin et al., 2001; Bradshaw et al., 2002). Due to higher mortality and carcass defects caused by leg abnormalities (Kestin et al., 1999) leg problems are most important reasons of economical loss and welfare issues for poultry industry. For both economical and ethical reasons it is necessary to reduce the incidence of these disorders.

Incidence of leg disorders depends on genetic (Riddell, 1976) and environmental effects (Veltmann and Jensen, 1980; Yalçin et al., 1996). Nowadays, several alternatives are advised to decrease the prevalence of leg disorders as an environmental control program: a) feed restriction during the early period of rearing (Brickett et al., 2007), b) content of Ca, P and vitamin D_3 in the diet (Rennie et al., 1993; Zhang et al., 1997), c) lower stocking densities (Ravindran et al., 2006) and increased activity (Sanotra et al., 2001), d) reduced period of lighting (Moller et al., 1999), e) careful litter management to prevent dermatitis (Bradshaw et al., 2002).

Results from several investigations implied that there was also a genetic basis of leg problem within and between different breeds. Thus, leg abnormalities became selection criteria in modern selection programs to reduce the problems. Although leg problems were high in fast growing broilers, occurrence is independent from body weight (Kiiskinen and Andersson, 1982; Wong-Valle et al., 1993b; Yalçin et al., 1995) and considering leg problems in breeding programs would not affect body weight negatively.

Tibial dyschondroplasia (TD) is a well known leg abnormality for a long time, especially in broiler (Leach and Nesheim, 1965; Siler, 1970; Riddell et al., 1971). Several selection programs were established to decrease the level of TD in the population (Sørensen, 1992). It was reported that heritability estimates for TD were generally moderate to high (0.22 – 0.44) (Ducro and Sørensen, 1992; Wong-Valle et al., 1993a; Zhang et al., 1995; Yalçin et al., 1996;). Sheridan et al. (1978) estimated heritability of TD incidence for four generations as 0.41 ± 0.23, 0.41 ± 0.13, 0.54 ± 0.18 and 0.14 ± 0.09 for male, and 0.40 ± 0.22, 0.80 ± 0.31, 0.64 ± 0.20 and 0.25 ± 0.11 for female broilers, respectively.

However, there is not enough literature on heritability estimates of other leg disorders. Le Bihan-Duval et al. (1996) reported that heritability for valgus-varus was moderate to high (0.16 – 0.40). Heritabilities were estimated to be 0.31 ± 0.12 for foot pad dermatitis and 0.08 ± 0.08 for hock burn by Kjaer et al. (2006).

In the present study, size of additive genetic variance components and heritabilities for leg problems were estimated in a broiler strain. This strain was found to be most sensitive for leg disorders among four commercial strains reared in Turkey (Personal communication, 2008, S. Yalçin, Ege University Faculty of Agriculture Department of Animal Science, Bornova, Izmir Turkey).

Material and Methods

As a commercial base population, 30 males and 240 female Hubbard parents were used. Birds were reared in accordance with management guide of Hubbard breeders (Anonymous, 2002). They were placed to individual cages at 18 weeks of age. Female birds were artificially inseminated with a male/female ratio of 1:8. Pedigreed 1,404 1-d old chicks were produced from three hatches. Average number of individuals per sire family ranged from 20 to 77, except for one sire with only seven progeny. Chicks were wing banded, weighed individually and placed in 48 floor

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pens with a stocking density of 15 birds per m2. Feed and water were provided ad-libitum through the experiment. The birds were fed with standard commercial broiler diets. Lighting was 23 L: 1 D. Room temperature was according to the recommendation for commercial broilers.

Body weights on a weekly basis from 1 to 6 weeks of age were recorded. At 6 weeks, sex was determined and all birds were examined for the occurrence of hock burn, food pad dermatitis (BERG, 2004), and valgus-varus deformities (JULIAN, 1984). At slaughter, left leg was removed from each carcass and tibia was examined for the prevalence of TD (EDWARDS, 1984). A scale from 0 (no problem) to 3 (very severe problem) was used to evaluate the degree of disorders. Since a lower number of individuals were determined in several sub-classes of leg problem in multinomial scale, data were transformed to a binomial scale as 0 (normal) to 1 (abnormal). All statistical analyses on leg problems were carried out using binomial form of the data.

The X^2-test of independence was used to compare sexes for the incidence of leg problems. Effects of sire, sex and hatch on body weights of birds were analyzed using ANOVA. In addition to these effects, leg problems were one by one considered in the model to see the differences of body weights between healthy and diseased birds.

Sire and error variance components were estimated for body weights and leg problems using REML method based on a model including sire, sex and hatch. Heritabilities for the traits were estimated by using half-sib correlation. Estimated heritabilities of leg problems on binomial scale (0 or 1) were transformed to continuous scale using the equation $h^2 = h^2_{01} * \frac{(p * (1-p))}{z^2}$ where p is the mean frequency of affected individuals for the threshold trait, and z is the ordinate of normal distribution at the threshold point (WONG-VALLE et al., 1993a). Standard error of the heritability for a trait was estimated by $\sigma_{h^2_x} = \sqrt{\frac{32 * h^2_x}{N}}$ from half-sib families where N is the total number of observations for the trait (FALCONER, 1989). Statistical analysis was performed using SPSS software (version 13, SPSS Inc., Chicago, Illinois, USA).

Results

While incidence of TD was 7%, average incidence of valgus-varus deformity, hock burns and foot-pad burns were 11%, 71% and 19%, respectively (Table 1).

The differences between sexes in terms of leg problems were significant (Table 1). TD incidence in female (5.2%) was nearly half of the level obtained in male (9.2%). Similar tendency was obtained for valgus-varus deformity. It was 14.4% and 8.8% for male and female, respectively. Although incidence of hock burn was 7.2% higher in male than in female, the differences between sexes for TD and valgus-varus deformity were 4.0% and 5.6%, respectively. On the contrary to other leg problems considered, incidence of foot-pad burns was 7.3% higher in female than in male (Table 1).

Variance components for leg problems estimated by REML are given in Table 2. Heritabilities for leg problems estimated in binomial and continuous scales are also presented in Table 2. Heritability estimate of TD was 0.21. Heritabilities of valgus-varus deformity, hock burns and foot-pad burns were 0.72, 0.17 and 0.34, respectively.

Sire effect on body weights was generally significant ($P < 0.05$) except for the body weights at 5 and 6 wk of age (Table 3). The differences between sexes for body weights in all ages were significant ($P \leq 0.011$) as expected (Table 3). Body weight of male was higher than the body weight of female. The body weight difference between sexes was 81 g at 3 wk and reached 407 g at 6 wk of age. Body weights of birds with TD were not significantly different from those without TD (Table 3). After 3 wk of age body weight of birds with TD was mathematically higher than that without TD. The highest but not significant difference between birds with and without TD was obtained at 6 wk of age as 20 g (Table 3). Body weights at 1, 2 and 6 wk of age were significantly ($P < 0.05$) lower for birds with valgus-varus deformity as compared to those without valgus-varus deformity (Table 3). The body weight difference between these groups at 6 wk of age was 60 g. The body weights of birds with hock burns were significantly higher than those without hock burns for all ages except for hatch weight (Table 3). Body weight differences between these groups were increased by age and reached to 84 g at 6 wk of age. When the body weights of birds with foot-pad burns were compared to those without foot-pad burns, only body weight difference at 3 wk of age was significant (Table 3). In tendency, mean body weight of birds without foot-pad burns tended to be higher.

Variance components and heritability estimates for body weights are given in Table 4. Heritability for body weights obtained at different ages varried between 0.03 and 0.17.

Table 1. Average incidence of leg problems (%) overall and within sexes, and results of chi-square test of distribution over sexes

Durchschnittliche Häufigkeit an Beinschäden insgesamt und innerhalb der Geschlechter sowie X^2-Test der Verteilung über die Geschlechter

		TD	Valgus-varus deformity	Hock burns	Foot-pad burns
Sex	Male	9.2	14.4	78.8	16.3
	Female	5.2	8.8	71.6	23.6
	X^2	5.9	10.1	9.3	10.7
	P	.016	.000	.002	.000
Overall	N	997	1404	1404	1404
	Average	7.0	10.7	71.0	18.9

Discussion

Average levels of leg problems considered in this study were within the levels reported in literature except for

Table 2. Variance components and heritability estimates in binomial (h^2_{01}) and continuous (h^2) scales

Schätzwerte der Varianzkomponenten und Heritabilitäten auf der Basis binomialer (h^2_{01}) und kontinuierlicher (h^2) Verteilung

Component	TD	Valgus-varus deformity	Hock burns	Foot-pad burns
Sire	.001	.006	.004	.006
Error	.064	.087	.176	.133
h^2_{01}	.06 ± .04	.26 ± .08	.09 ± .05	.17 ± .06
h^2	.21 ± .08	.72 ± .13	.17 ± .06	.34 ± .09

Table 3. Significance level of factors on body weights and changes of body weights according to sexes and sub-class of leg problems
Durchschnittliches Körpergewicht über die Versuchsdauer in Abhängigkeit von Geschlecht und Einstufungsklasse der Beinschäden sowie Signifikanzniveaus der Einflussfaktoren

Effect	Levels	BW0	BW1	BW2	BW3	BW4	BW5	BW6
Sex	Male	44.7 ± .2	132 ± 0.8	351 ± 2	720 ± 4	1203 ± 7	1774 ± 9	2334 ± 12
	Female	45.2 ± .2	128 ± 0.7	338 ± 2	639 ± 4	1031 ± 6	1483 ± 9	1927 ± 12
TD	0	45.4 ± .2	130 ± 0.8	346 ± 2	690 ± 4	1126 ± 7	1638 ± 9	2147 ± 12
	1	44.9 ± .5	126 ± 2.2	342 ± 6	695 ± 12	1142 ± 19	1655 ± 27	2167 ± 35
Valgus-Varus	0	45.5 ± .1	130 ± 0.6	345 ± 2	681 ± 3	1120 ± 5	1632 ± 7	2137 ± 10
	1	45.1 ± .3	128 ± 1.5	335 ± 4	668 ± 9	1098 ± 14	1598 ± 19	2077 ± 25
Hock Burns	0	45.0 ± .2	127 ± 1.0	334 ± 3	662 ± 6	1092 ± 9	1578 ± 13	2068 ± 17
	1	45.5 ± .1	130 ± 0.6	347 ± 2	686 ± 4	1126 ± 6	1645 ± 8	2152 ± 10
Food-pad Burns	0	45.4 ± .1	130 ± 0.6	345 ± 2	683 ± 4	1121 ± 6	1631 ± 8	2135 ± 10
	1	45.5 ± .3	129 ± 1.2	341 ± 3	667 ± 7	1103 ± 10	1618 ± 15	2111 ± 19
Source of variation		Significance level of factors on body weights						
Sire		.000	.000	.000	.000	.001	.067	.176
Sex		.011	.000	.000	.000	.000	.000	.000
Hatch		.000	.000	.000	.000	.000	.000	.000
TD*		.323	.074	.557	.699	.418	.554	.568
Valgus-varus deformity*		.328	.048	.016	.153	.130	.098	.025
Hock burns*		.059	.013	.000	.000	.001	.000	.000
Foot-pad burns*		.836	.846	.232	.033	.124	.440	.253

* One of the leg problems in each analysis was included

Table 4. Variance components and heritability estimates for body weights
Schätzwerte der Varianzkomponenten und Heritabilitäten für die Körpergewichte in den einzelnen Mastwochen

	BW0	BW1	BW2	BW3	BW4	BW5	BW6
Sire	.417	11.705	95.270	257.071	517.469	484.346	585.138
Error	13.083	282.667	2132.465	9361.033	22534.99	44532.18	78635.227
h^2	0.12	0.16	0.17	0.11	0.09	0.04	0.03

hock burns. Incidence of TD was 7% while average incidence of valgus-varus deformity and foot-pad burns were 11% and 19%. Incidence of hock burns was highly greater than the average levels of the other leg problems and it was 71%. TD incidence obtained in this study was lower than the average value of 59% reported by YALÇIN et al. (1996) and also lower than the reported values of 41%, 56.8% and 32.5% for several strains by YALÇIN and AKBAŞ (2001).

In the present study, apart from foot-pad burns, average incidences of other three leg problems in male were higher than in female. This may be correlated with higher body weight and growth rate in male. Although there were no significant sex differences in the studies reported in literature (RIDDELL, 1976; YALÇIN et al., 1996; KUHLERS and MCDANIEL, 1996; YALÇIN and AKBAŞ, 2001), average leg problems in male were marginally higher than in female.

Males and females differed in TD incidence (LEACH and NESHEIM, 1965; SHERIDAN, 1974; SHERIDAN et al., 1976). WONG-VALLE et al. (1993a) reported that there was a significant difference between two sexes in TD for all generations. It was reported that incidence of foot-pad burns was more frequent in females (KJAER et al., 2006; HARMS et al., 1977) while there are contradicting results also available in literature (HARMS and SIMPSON, 1975; BERG, 2004).

In general perspective, heritability estimates for leg problems from several studies were between 0.10 and 0.64 due to different genetic background of the traits (VELTMANN and JENSEN, 1980; SHERIDAN et al., 1978). Heritability estimates for TD and hock burns were moderate-low, but for foot pad burns and valgus-varus they were moderate-high. The estimates of heritability for TD incidence varried from 0.2 to 0.3 (SHERIDAN et al., 1978; BURTON et al., 1981).

In the present study, heritability for TD was lower than the estimates from SHERIDAN et al. (1978) and DUCRO and SØRENSEN (1992) which may be due to lack of enough genetic variation for TD among sires. The heritability estimate for TD (0.21) in this study was equal to the estimate obtained by Yalçin and Akbaş (2001) by using animal model. Sire effect on other leg problems except TD may explain available genetic variation in the population.

Kjaer et al. (2006) estimated heritability for foot pad burn of 0.31. This estimate was very close to 0.34 obtained in this study for the same trait.

Muir and Aggrey (2003) reported that heritabilities at 6 weeks for two lines of broiler chickens ranged from 0.16 to 0.40 for valgus angulation and from 0.21 to 0.30 for varus angulation. Heritability of valgus varus deformity (0.72) obtained in this study is highly greater than the values reported by Muir and Aggrey (2003).

Heritability estimates for body weights in this study were exceptionally lower than the previous estimates for the same body weights in literature. This means that there was not enough genetic variation for body weights, even though sire effect on body weights at different age was generally significant ($P < 0.05$) except for the body weights at 5 and 6 wk of age. This shows that variation among sires in terms of their offspring's body weight diminished after 4 wk of age.

The heritabilities for leg problems showed that all these traits have a genetic basis and selection for these characters would be effective in reducing the problems in the population since heritability is the single most important parameter in determining appropriate animal evaluation and selection methods and mating systems. In this viewpoint, TD was more popular leg problem and studied more detailed. Early selection experiments for TD in broiler showed that individual selection was effective to change TD incidence of progeny (Leach and Nesheim, 1965, 1972; Sheridan, 1974; Riddell, 1976; Sheridan et al., 1976). Therefore, Riddell (1976) used individual selection to develop strains for high and low incidence of TD while Leach and Nesheim (1965, 1972) applied family selection for the same purpose. These selection studies showed that incidence of TD can be decreased by selection. Leach and Nesheim (1965, 1972) obtained 41% and 16% incidence in high and low TD lines, respectively. On the other hand, Riddell (1976) developed low and high lines for TD and reached to 0% and 51% incidence, respectively. After four generation of selection, incidence of TD at 7 wk was 61.9%, 16.1% and 3.5% for the high, control and low lines, respectively (Wong-Valle et al., 1993a).

The magnitude of heritability estimates was considerably influenced by statistical methods used. In this study heritabilities were estimated by using half-sib correlation. In other studies, information from sire and dam (Zhang et al., 1995; Yalçin et al., 1996) or sire/maternal-grandsire or dam components (Le Bihan-Duval et al., 1996) were also used for the estimation while animal model approach was applied in recent years (Yalçin and Akbaş, 2001; Kuhlers and McDaniel, 1996). Ducro and Sørensen (1992) estimated heritability of TD using a threshold model including sire, dam and sire + dam components. Sheridan et al. (1978) reported that heritability of TD from dam-component was considerably larger than the corresponding sire-component heritability estimate, and therefore indicate the presence of substantial maternal or dominance effects or both. If heritability is affected largely from maternal component, it indicates that female parent line can influence substantially the incidence of leg problems. Somes (1969) suggested that an autosomal recessive gene with a penetrance of about 70% might be the cause of leg abnormalities in chickens. Sheridan et al. (1978) concluded that the inheritance of TD was influenced by a major sex-linked gene, the recessive allele of which is associated with an increased incidence of TD.

Consequently, in practice, consideration should be given firstly to environmental conditions as age, nutrition, management conditions when there is an outbreak of leg problem. Secondly, genetic selection against leg problem appears to be a most effective way of preventing non-infectious skeletal disorders as decreasing the incidence of TD successfully using genetic selection in recent years. Genetic selection for leg problem must be combined with good management strategies as well.

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Summary

This study was carried out to estimate variance components and heritability for tibial dyschondroplasia, valgus-varus deformity, hock burns and foot-pad burns. A total of 1,404 1-d old Hubbard chickens were used. Individual weekly body weights, sex and the leg disorders were recorded. At slaughter, left leg was removed from each carcass and tibia was examined for the prevalence of tibial dyschondroplasia. All statistical analyses on leg problems were carried out using binomial form of the data. Sire and error variance components were estimated using REML based on a model including sire, sex and hatch.

Estimated heritabilities of leg problems were 0.21, 0.72, 0.17 and 0.34 for tibial dyschondroplasia, valgus-varus deformity, hock burns and foot-pad burns, respectively. Estimated heritabilities for leg problems show that genetic selection appears to be a most effective way of preventing non-infectious skeletal disorders as indicated by the decreased incidence of tibial dyschondroplasia in commercial strains in recent years, most probably accomplished by genetic selection.

Key words

Broiler, heritability, tibial dyschondroplasia, valgus-varus, foot-pad dermatitis, hock burn

Zusammenfassung

Schätzung der Heritabilität von Tibialer Dyschondroplasie, Valgus-Varus-Verdrehung, Fußballenläsionen und Hock Burns bei Broilern

Die Untersuchung wurde durchgeführt, um Varianzkomponenten und Heritabilitäten für Tibiale Dyschondroplasie, Valgus-Varus-Verdrehung, Hock Burns und Fußballenläsionen bei Broilern zu schätzen. Hierzu wurden insgesamt 1404 Eintagsküken der Herkunft Hubbard verwendet. Das Körpergewicht und die Beinschäden wurden wöchentlich erfasst. Ferner wurde das Geschlecht vor der Schlachtung bestimmt. Beim Schlachten wurde das linke Bein von jedem Tier entnommen und die Tibia auf Anzeichen von Tibialer Dyschondroplasie untersucht. Für die Auswertung der Beinschäden wurde eine binomiale Verteilung zu Grunde gelegt. Zur Schätzung der Vater- und Fehlervarianzkomponenten mittels REML wurden Vater, Geschlecht und Schlupf im Modell berücksichtigt.

Für die Tibiale Dyschondroplasie wurde eine Heritabilität von 0,21, für die Valgus-Varus-Verdrehung von 0,72, für

die Hock Burns von 0,17 und für die Fußballenläsionen von 0,34 geschätzt. Die geschätzten Heritabilitäten deuten darauf hin, dass eine Selektion auf geringe Häufigkeit an Beinschäden Erfolg versprechend ist. Dies wird auch durch die in den vergangenen Jahren zurück gegangene Häufigkeit an Tibialer Dyschondroplasie bei den Broilerherkünften belegt, die auf intensive Selektionsmaßnahmen zurück zu führen sein dürfte.

Stichworte

Broiler, Heritabilität, Tibiale Dyschondroplasie, Valgus-Varus-Verdrehung, Fußballenläsionen, Hoch Burns

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Buchbesprechung

Anatomie der Vögel

Horst Erich König, Rüdiger Korbel, Hans-Georg Liebich; Schattauer GmbH – Verlag für Medizin und Naturwissenschaften, Stuttgart und New York, 2. völlig überarbeitete Auflage 2008, 663 überwiegend farbige Abbildungen, diverse Tabellen, 384 Seiten, Preis 129,00 EUR, ISBN-978-3-7945-2578-2

In der veterinärmedizinischen Ausbildung spielt die Vermittlung anatomischer Kenntnisse eine zentrale Rolle. Diese sind Grundlage für das Verständnis der Fortbewegung und des Verhaltens der Vögel in ihrer Umgebung und geben bei Abweichungen Aufschlüsse über mögliche Erkrankungen. Die Vogelanatomie blickt dabei auf eine schon viele Jahrhunderte alte Geschichte zurück. Die Erstauflage des Werkes ‚Anatomie der Vögel' von Horst Erich König und Hans-Georg Liebich erschien vor rund acht Jahren und hat sich in dieser Zeit zu einem äußerst erfolgreichen Lehrbuch entwickelt. Die große Nachfrage und die ständige Zunahme des Wissens auf dem Gebiet der Vogelanatomie hat daher eine überarbeitete Auflage erforderlich gemacht, für die Rüdiger Korbel, ein Spezialist für das Vogelauge, als weiterer Herausgeber gewonnen werden konnte.

Das Buch stellt umfassend die anatomischen Grundlagen der Vogelanatomie (Zier- und Nutzgeflügel) in insgesamt 24 Kapiteln zusammen. Nach einem kurzen geschichtlichen Überblick über die Vogelanatomie werden das Skelettsystem, die Organe, das Immunsystem und das Nervensystem behandelt. Die Darstellung der Fakten wird dabei anschaulich mit vielen ausgezeichneten, farbigen Abbildungen und Farbfotos ergänzt. Zusätzlich sind Informationen auch vergleichend in Tabellen zusammengestellt. Weitere Kapitel befassen sich mit klinischen Untersuchungsmethoden, dem Einsatz von Bild gebenden Verfahren in der Diagnostik, Fixationstechniken, Anästhesieverfahren, Applikations- und Blutentnahmetechniken, Endoskopie und den Grundlagen der Osteosynthese. Ein Sonderkapitel widmet sich der Falknerei und der Greifvogelmedizin. In allen Textteilen werden wichtige Begriffe und Erklärungen hervorgehoben und z.T. in übersichtlichen Infoboxen zusammengefasst. Abgeschlossen wird das Werk durch ein Literaturverzeichnis, ein Verzeichnis anatomischer Schlüsselwörter und einem umfassenden, gut strukturierten Sachverzeichnis. Gegenüber der Erstauflage wurden viele neue makroskopische und histologische Farbfotos sowie Schemazeichnungen nach Originalpräparaten integriert. Neu sind auch die integrierten Scheibenplastinate, viele Röntgen-, MRT- und sonographische Darstellungen.

Das Buch ‚Anatomie der Vögel' von Horst Erich König, Rüdiger Korbel und Hans-Georg Liebich enthält eine umfassende mit zahlreichen, ausgezeichneten Farbabbildungen unterlegte Zusammenstellung des Wissens auf diesem Gebiet. Der Nutzwert des Werkes übersteigt seine Kosten bei weitem. Für Studierende der Veterinärmedizin, insbesondere mit Schwerpunkt Vogelmedizin, ist dieses Lehrbuch ohne Frage ein Muss. Es kann aber auch all denjenigen wärmstens empfohlen werden, die sich im Beruf oder Hobby mit Nutz-, Rasse- oder Ziergeflügel befassen.

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