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Research Note—

Bumblefoot and Lack of Exercise Among Wild and Captive-Bred Falcons Tested in the United Arab Emirates

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SUMMARY. In the 1990s, bumblefoot posed a major health problem to the falcons in the United Arab Emirates. This retrospective study based on statistical field research showed that in captivity wild falcons need a training frequency of twice a day to reduce the bumblefoot morbidity rate. In this context, they responded very well to free flight in aviaries during the molting season. In contrast, captive-bred falcons did not show a highly significant difference regarding training frequencies. Wild falcons tested fed with pigeons, bustards, and ducks suffered significantly less from bumblefoot compared with those fed a diet of quail. Apart from the disease-reducing impact of beef and mice, captive-bred falcons tested did not show any significant difference regarding the influence of diet on the bumblefoot occurrence.

RESUMEN. *Nota de Investigación*—Hinchazón de la almohadilla plantar y falta de ejercicio en halcones silvestres y en cruces de halcones cautivos examinados en los Emiratos Arabes Unidos.

En 1990, la hinchazón de la almohadilla plantar fue un problema de salud significativo en los halcones de los Emiratos Arabes Unidos. Este estudio retrospectivo basado en una investigación estadística de campo, mostró que los halcones silvestres en cautiverio necesitan entrenamiento con una frecuencia de dos veces al día para reducir el porcentaje de morbilidad de la hinchazón de la almohadilla plantar. De esta manera los halcones responden muy bien al vuelo libre en las jaulas durante la estación de muda forzada. En contraste, los cruces de halcones en cautiverio no mostraron diferencias altamente significantes con respecto a la frecuencia de entrenamiento. Los halcones silvestres examinados alimentados con dieta de palomas, abutardas y patos, sufrieron significativamente menos de la hinchazón de la almohadilla plantar comparados con aquellos alimentados con dietas de codornices. Fuera del impacto en la reducción de la enfermedad en ganado y ratones, los cruces de halcones cautivos examinados no mostraron ninguna diferencia significativa en cuanto a la dieta sobre la ocurrencia de la inflamación de la almohadilla plantar.

Key words: United Arab Emirates, falcon in captivity, bumblefoot, husbandry, statistics, training frequency, management, diet

Abbreviations: UAE = United Arab Emirates; w bf = with bumblefoot; w/o bf = without bumblefoot

Bumblefoot, a necrotic inflammation of toes and foot pads that can spread to joints and tendon sheaths (10), was one of the most frequent diseases affecting falcons living in captivity in the United Arab Emirates (UAE) during the 1990s. This disease, dating back to the 8th century (1), seemed to affect wild falcons more than captive-bred falcons (13). Therefore, a Ph.D. study was started at Munich University

to establish if there was a connection between husbandry and the occurrence of bumblefoot in 338 wild falcons and 181 captive-bred falcons tested in the UAE.

MATERIALS AND METHODS

From November 5 to December 20, 1996 and from March 2 to April 15, 1997, the husbandry con-

Table 1. Bumblefoot morbidity rate correlated with management during molting season in wild and captive-bred falcons.

Management during molting season	Wild falcons tested		Captive-bred falcons tested	
	w bf ^a	w/o bf ^b	w bf	w/o bf
Tethered on blocks	58.0%	42.0%	11.9%	88.1%
Free flight in aviaries	21.9%	78.1%	18.7%	81.3%

^aw bf = with bumblefoot.

^bw/o bf = without bumblefoot.

ditions of 549 falcons tested (508 females, 11 males, 30 without information) had been anamnestically recorded at the Emirates Falcon Hospital, Dubai, and at the National Veterinary Hospital, Abu Dhabi. Of the 549 falcons tested, 338 were wild falcons (115 [34.0%] with bumblefoot [w bf], 223 [66.0%] without bumblefoot [w/o bf]) and 181 were captive-bred falcons (28 [15.5%] w bf, 153 [84.5%] w/o bf). The data gathered were statistically evaluated with the χ^2 test method for relative frequency of independent variables with the computer programs SPSS Release 6.1 and SAS at the Institut für Tierzucht of Munich University (13). This χ^2 test evaluation led to significant result at $P \leq 0.050$.

RESULTS

In the scientific literature of the 20th century, there still does not exist any binding definition of bumblefoot. However, various symptom-related classifications have been established throughout this century, often contradicting each other by terms and disease severity grades (13). Although inactivity after the hunting season (8) and lack of exercise (10,11), thus resulting in circulatory disorders (4), have been discussed as major pathogenic factors, the difference between wild and captive-bred falcons have so far not been taken into consideration. In addition, diet may have a significant influence on the incidence of bumblefoot. Although vitamin deficiencies (3,7), especially vitamin A, and one-sided protein-containing food (14) have been described as predisposing factors for the incidence of bumblefoot, the type of food may also be regarded as an important factor. In respect of a possible connection between diet and the development of bumblefoot in falcons, there has not existed any explicit scientific study yet. However, it has been mentioned in scientific publications covering falcons and falconry that natural diet may help to prevent the out-

break of diseases (6), especially of bumblefoot (12,15).

Management during molting. The molting season takes place from March to August/September of each year. In the UAE, there have been two different types of management during this season: tethered housing and free-flight aviaries. Tethered housing in this context means that the falcons tested were placed in a closed air-conditioned room with glass windows. There they were pegged down on block perches with the help of an approximately 30–50-cm-long rope. The other group of falcons tested spent their molting season flying freely in aviaries of sizes ranging from 12 m² to ≥ 1000 m². These aviaries were surrounded by wire netting with fixed date-palm leaves protecting the falcons against strong sun impact.

Among all wild falcons tested, a significant ($P = 0.001$) case reduction has been observed in the case of falcons flying freely in aviaries compared with those kept tethered on perches throughout the molting period. The data of the captive-bred falcons tested have not resulted in a statistical significance between falcons in aviaries and those tethered (Table 1).

Exercise and training. During the hunting season from September to March, the falcons tested were trained by their falconers with the help of dummy birds fixed at long ropes to hunt in the desert of the UAE. These training units usually consisted of 5–15-min-long flights. In the wild, falcons undergo extensive and often unsuccessful flights in order to catch their prey, thus resulting in better circulatory conditions (14). The wild falcons tested living in captivity have shown a significantly higher susceptibility to bumblefoot than their captive-bred counterparts. Captive-bred falcons sit on perches for long periods of time (6) and receive only a few training flights per day. This means

Table 2. Relationship between training frequency and bumblefoot morbidity rate in wild and captive-bred falcons.

Training frequency	Wild falcons tested		Captive-bred falcons tested	
	w bf ^a	w/o bf ^b	w bf	w/o bf
Once a day	54.9%	45.1%	16.2%	83.8%
Twice a day	21.1%	78.9%	16.7%	83.3%

^aw bf = with bumblefoot.

^bw/o bf = without bumblefoot.

that they have not experienced flying as much and as often as their wild counterparts. In this context, captive-bred falcons tested showed a significantly reduced bumblefoot morbidity rate (Table 2). One to two training units per day correlated with a significant reduction of bumblefoot in wild falcons tested ($P = 0.001$). In captive-bred falcons, there was no significance in the χ^2 test evaluation.

Diet. The falcons tested were fed a variety of food consisting of beef, bustards, chickens, ducks, egg yolks, goats, mice, pigeons, quail, rats, and small wild birds as their major regular daily diet. Within this range of diet, chickens, small wild birds, goats, rats, and egg yolks have not resulted in any statistical significance in the captive-bred and wild falcons tested (13). However, wild falcons showed a significantly reduced number of bumblefoot cases if fed with pigeons ($P = 0.039$), bustards ($P = 0.001$), and ducks ($P = 0.002$) compared with those wild falcons not fed with this diet. In contrast, those wild falcons tested that were fed quail suffered significantly more often from bumblefoot ($P = 0.013$) than those wild falcons that were not fed quail (Table 3).

Pigeons, bustards, ducks, and quail did not show any significant results in the captive-bred falcons tested. However, in the case of captive-bred falcons tested, beef led to a significantly reduced bumblefoot morbidity rate ($P = 0.008$) in comparison with those captive-bred falcons not fed beef. Captive-bred falcons tested eating mice were significantly less affected with bumblefoot ($P = 0.047$) than those captive-bred falcons whose diet did not contain mice (Table 4). Both beef and mice did not result in any significance in the wild falcons tested (13).

Apart from bustards (no data available), the nutrient component evaluation (2,5,9) shows

Table 3. Influence of diet on the bumblefoot morbidity rate in wild falcons.

Diet	Fed		Not fed	
	w bf ^a	w/o bf ^b	w bf	w/o bf
Quail	44.2%	55.8%	12.5%	87.5%
Pigeon	39.0%	61.0%	54.7%	45.3%
Bustard	20.7%	79.3%	52.3%	47.7%
Duck	10.0%	90.0%	45.0%	55.0%

^aw bf = with bumblefoot.

^bw/o bf = without bumblefoot.

that the energy, protein, fat, and water content (Table 5) as well as vitamins (Table 6) do not differ to a great extent in the case of quail and beef. Both contain low energy and fat but high water levels compared with pigeons, ducks, and mice.

DISCUSSION

The research data indicate that the wild falcons tested respond to the conditions of captivity in a different way than their captive-bred counterparts. Whether genetics play a decisive role in this context cannot be determined yet and further research will be needed. However, the current stage of research does not imply genetic involvement in the development of bumblefoot.

In regard to exercise and training, wild falcons tested need a higher training frequency per day than captive-bred falcons tested. This need may derive from the fact that falcons in the wild need more flights for catching their prey and therefore have more exercise leading to a high level in their circulatory condition. Wild falcons tested that live in captivity have only a very limited amount of daily training time, which inevitably leads to a reduced circulatory condition. Therefore, the wild falcons tested reacted sensitively to reduced exercise opportu-

Table 4. Influence of diet on the bumblefoot morbidity rate in captive-bred falcons.

Diet	Fed		Not fed	
	w bf ^a	w/o bf ^b	w bf	w/o bf
Beef	6.4%	93.6%	78.0%	22.0%
Mice	0.0%	100.0%	18.3%	81.7%

^aw bf = with bumblefoot.

^bw/o bf = without bumblefoot.

Table 5. Nutrient components of the diet with significant results in the falcons tested.

Nutrient components (as fed per 100 g)	Quail ^A	Pigeon ^A	Duck ^A	Beef ^A	Mice ^B
Energy (kcal/100 g)	120.0	230.0	430.0	106.0	142.0
Protein (%)	22.4	27.8	11.3	21.2	18.8
Fat (%)	2.3	13.2	42.5	2.4	7.0
H ₂ O (%)	75.8	57.0	44.0	75.3	— ^C

^ASee Hesecker and Hesecker (9).^BSee Fowler (5).^C— = no data available.

nities and were significantly more prone to bumblefoot because this disease is due to microcirculatory disorders caused by captivity-related inactivity and lack of exercise. In contrast, captive-bred falcons tested seem to adjust much better to the circumstances of limited exercise and training time and frequency. Although these living conditions do not seem to affect the captive-bred falcons tested to such an extent as they affect wild falcons tested, exercise twice a day should be regarded as a necessary tool in the fight against bumblefoot. In the molting season, during which no training flights are performed, free flight in aviaries resulted in significantly less bumblefoot cases. Therefore, it cannot be stressed enough that spending the molting season in free-flight aviaries is a very important prophylactic measure to prevent the occurrence of bumblefoot both in captive-bred falcons and especially in wild falcons living in captivity.

Additionally, diet shows a significant influence on the occurrence of bumblefoot. Especially the wild falcons tested showed a reduced morbidity rate when fed pigeons, bustards, and ducks, which resemble their usual prey. Therefore, this high-energy diet is part of the natural nutrition of wild-living falcons. Low-energy

food like quail led to an increased bumblefoot morbidity rate. In contrast to this, captive-bred falcons are often fed with low-energy food like beef as part of their nutrition plan, resulting in a significant decrease of bumblefoot cases. This discrepancy in metabolizing low-energy food by captive-bred falcons and wild falcons tested might be an indication that wild falcons possess a much higher turnover of energy because of an increased exercise and circulation level than their captive-bred counterparts. It also indicates that the high metabolism of wild falcons living in captivity cannot adjust to the much lower metabolic turnover that a sudden and prolonging reduction of natural exercise would require. Captive-bred falcons do not show this demand for high-energy food, indicating an originally lower metabolism. Further research on the effect of nutrition on metabolism in raptors would be desirable.

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Table 6. Nutrient components of the diet with significant results in the falcons tested.

Nutrient components (as fed per 100 g)	Quail ^A	Pigeon ^A	Duck ^A	Beef ^A	Mice
Vitamin A (µg)	17	8	50	15	— ^B
Vitamin E (mg)	0.6	0.5	0.5	0.5	—
Thiamine (mg)	0.13	0.10	0.14	0.23	—
Riboflavin (mg)	0.17	0.28	0.30	0.26	—
Vitamin B ₆ (mg)	0.67	0.82	0.33	0.40	—
Folic acid (µg)	8	8	8	15	—

^ASee Hesecker and Hesecker (9).^B— = no data available.

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