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LITERATURE CITED

BRENSING, D. 1977. Nahrungsökologische Untersuchungen an Zugvögelen in einem südwesdeutschen Durchzugsgebiet während des Wegzuges. Vogelwarte 29:44–56.

FORD, H. A., N. FORDE, AND S. HARRINGTON. 1982. Non-destructive methods to determine the diets of birds. Corella 6:6–10.

HESS, C. A. AND F. C. JAMES. Diet of the red-cockaded woodpecker in the Apalachicola National Forest. J. Wildl. Manag. (in press).

JACKSON, J. A. 1982. Capturing woodpecker nestling with a noose—a technique and its limitations. North American Bird Bander 7:90–92.

JAMES, F. C., C. A. HESS, AND D. KUFRIN. 1997. Species-centered environmental analysis: indirect effects of recent history of fire on the red-cockaded woodpecker. Ecol. Applic. 7:118–129.

JENNI, L., P. REUTIMAN, AND S. JENNI-EIERMANN. 1990. Recognizability of different food types, feces, and alimentary flushes of *Sylvia* warblers. Ibis 132:445–453.

LIGON, J. D. 1970. Behavior and breeding biology of the Red-cockaded Woodpecker. Auk 87:255–278.

MOODY, D. T. 1970. A method for obtaining food samples from insectivorous birds. Auk 87:579.

ROSENBERG, K. V. AND R. J. COOPER. 1990. Approaches to avian diet analysis. Pp. 80–90. *in* Avian foraging: theory, methodology and applications. Studies in Avian Biology, No. 13 (Morrison, M. L., C. J. Ralph, J. Verner, and J. P. Jehl, Jr., eds.) Cooper Ornithol. Soc., San Diego, California.

SNEDECOR, G. W. AND W. G. COOPER. 1980. Statistical methods, 7th ed. The Iowa State University Press, Ames, Iowa.

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Morphological differences among populations of House Sparrows from different altitudes in Saudi Arabia.—The House Sparrow (*Passer domesticus*) is widely distributed throughout the world, both as a result of introduction and natural spread from Africa (Summers-Smith 1988, 1990). Johnston and Selander (1973) examined geographical variation in House Sparrow populations from both North America and Europe and found that the degree of geographical variation within North America is less than in Europe. This is presumably because sparrows have relatively recently become established in North America. In this paper we study differences between two populations of House Sparrows (*P. d. indicus*) separated by only 150 km, and which are close to the center of their ancient range (Summers-Smith 1988).

Study area and methods.—We examined morphology of sparrows at two different locations in Saudi Arabia. The first is at Taif (21°04′N, 40°16′E, elevation 1900 m) and the second at King Abdul-Aziz University campus in Jeddah (21°30′N, 39°12′E) on the Red

TABLE 1

MEAN ± ONE SE FOR SEVEN MORPHOLOGICAL CHARACTERS FOR *PASSER DOMESTICUS INDICUS* IN SAUDI ARABIA[a]

	Males		Females	
	Jeddah (16)	Taif (34)	Jeddah (18)	Taif (26)
Mass	18.00 ± 0.39	23.54 ± 0.59	18.25 ± 0.25	19.46 ± 0.61
Wing length	73.13 ± 0.52	74.71 ± 0.46	71.22 ± 0.38	71.96 ± 0.39
Tail length	58.72 ± 0.79	55.09 ± 0.73	56.06 ± 0.59	52.65 ± 1.04
Tarsus length	18.78 ± 0.28	18.59 ± 0.22	18.81 ± 0.19	17.79 ± 0.38
Bill length	9.50 ± 0.12	9.81 ± 0.07	9.44 ± 0.12	9.69 ± 0.13
Bill depth	6.63 ± 0.20	6.28 ± 0.16	6.67 ± 0.10	5.60 ± 0.20
Bill width	6.06 ± 0.13	5.37 ± 0.09	6.11 ± 0.14	5.14 ± 0.09

[a] Mass in g; all other measurements are in mm. All values are means ± SE. Sample sizes are in parentheses.

Sea coast. The two locations, beside being separated altitudinally, are about 150 km apart. The habitat of the upland site in Taif is mainly a rural area, mostly arable farmland, whereas Jeddah is mainly suburban. Taif has a moderate climate, varying from 30°C in summer to 10°C in winter. Rain falls mostly in winter and late spring (ca 30 cm per year). Jeddah is about 10°C hotter, and rain falls mostly in winter (ca 5 cm per year).

We captured birds in mist nets at these sites throughout the years 1993–1995. Most trapping effort (76%) was in the month of November (out of the breeding season). We measured mass, wing length, tail length, tarsus length, beak length (distance from the foremost feathers of the forehead to the tip of the upper mandible), beak depth, and beak width (both at the base of the bill). We analyzed both geographical and sex differences.

To compare our results with those of other studies, we used results on published studies of the same subspecies (Gavrilov 1965, Gavrilov and Korelov 1968, Summers-Smith 1988, Saini et al. 1989). We also used unpublished data on this subspecies collected by T. D. Price in the Eastern Ghats of India (17°40′N, 82°30′E, elevation ca 850 m). In this study, sparrows were captured in the village of Lammasinghi, as part of a study investigating competition between the House and Tree Sparrow (*P. montanus,* Price 1979). We extracted morphological data from the literature on House Sparrows of other subspecies from Europe (Grimm 1954, Niethammer 1953, Löhrl and Böhringer 1957) and North America (Packard 1967a). From these latter papers, we also estimated geographical distance between locations for a sample of populations. Distances between four locations in Germany (Stuttgart, Leipzig, Bonn, Nordheim) were calculated for mass and wing length comparisons. In Kansas and Colorado, distances between six locations were calculated for weight comparisons, and distances between eight locations were used for wing-length comparisons.

Results.—We captured 94 House Sparrows in Saudi Arabia. Sixty were from Taif and 34 from Jeddah (Table 1). There were significant differences both between populations and sexes (Table 2). When sexes were combined, birds from Taif were about 3 g heavier and had longer wings and bills, whereas birds from Jeddah had longer tails, and deeper and wider bills. Other traits, which are less subject to diurnal and seasonal fluctuations, showed differences varying up to maximum of 12% (in bill width). Males are larger than females at both sites, especially in wing length, but all the geographical patterns are seen when each sex is analyzed separately (Table 1). The only significant sex by region interaction is in body weight.

TABLE 2

TESTS FOR DIFFERENCES BETWEEN SEXES AND REGION OF HOUSE SPARROWS FROM TAIF AND JEDDAH IN SAUDI ARABIA[a]

	Sex	Region	Sex × region
Mass	10.353**	32.168***	13.231***
Wing length	23.497***	5.857*	0.771
Tail length	8.076**	15.369***	0.016
Tarsus length	1.636	3.985*	1.848
Bill length	0.574	6.003*	0.072
Bill depth	2.952	14.749***	3.894
Bill width	0.655	53.767***	1.527

[a] *F*-values from two-way analyses of variance are presented, N = 94 birds. $*P < 0.05$; $**P < 0.01$; $***P < 0.001$.

When compared with locations outside Saudi Arabia, sparrows from Jeddah are of strikingly low mass (Table 3). The heaviest birds are found in the locations further north, in Punjab, India (Saini et al. 1989), and in Kazakhstan (Gavrilov 1965). Differences between Jeddah and Taif populations are comparable to those among those of Kazakhstan, north India, and south India. The large differences between Jeddah and Taif are further illustrated in plots of geographical distance against weight and wing length (males only) for North America and Germany (Fig. 1). Populations in Germany show stronger differentiation than North America, but the Jeddah-Taif difference is a conspicuous outlier.

Discussion.—Vaurie (1956) divided House Sparrow populations into two groups: the Palearctic group with six races, and the Oriental group with another six races. *Passer domesticus indicus* is a member of the oriental group extending from the Red Sea in Saudi Arabia to Burma in the east (Summers-Smith 1988). Johnston and Selander (1964, 1973), in their studies of North American and European populations, showed that wing length increases with latitude and altitude in a pattern which matches that seen in Saudi Arabia. There have only been a few studies on *P.d. indicus,* all from central Asia and the Indian sub-continent (Gavrilov 1965, Gavrilov and Korelov 1968, Saini et al. 1989).

The differences we find between populations in Saudi Arabia are much larger than dif-

TABLE 3

MEAN MASSES (G) AND WING-LENGTHS (MM) OF SOME POPULATIONS OF *P. D. INDICUS*

	Males			Females		
	N	Mass	Wing length	N	Mass	Wing length
South India[a]	37	22.03	73.11	26	22.70	71.54
North-west India[b]	135	23.61	76.17	90	23.68	72.97
Kazakhastan[c]	70	24.80	76.80	—	—	—
Unknown[d]	—	27.50	74.50	—	—	76.80

[a] Price (unpublished).
[b] Saini et al. (1989).
[c] Gavrilov 1964 (data are for males and females).
[d] Summers-Smith 1988 (no location and sample size are given).

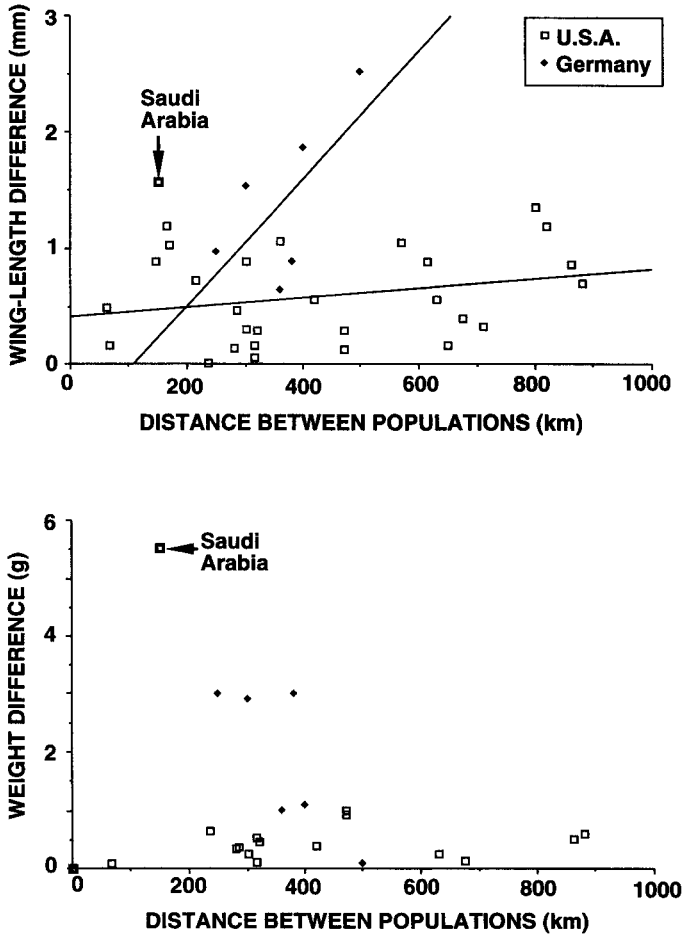

FIG. 1. Plots of differences in male wing length (above) and male weight (below) against geographical distance for Germany (Grimm 1954, Niethammer 1953, Löhrl and Böhringer 1957), North America (Packard 1967a), and Saudi Arabian populations. For wing length, lines are the least-square regression lines fit separately to the Germany and North America data.

ferences over comparable distances in Germany and the U.S.A. (Fig. 1). The large differences may be explained in two ways. First, altitudinal variation between our two sites in large, and for other species, larger birds have been shown to occur at the higher, colder altitudes (Diamond 1973, Britton 1977). Britton (1977) and Hanmer (1978) have compared weights of birds at high and low altitudes in Kenya and found striking differences among populations. The longer, thinner bills at Taif may reflect the type and availability of food in rural areas (e.g., Davis 1954, Packard 1967b, Selander and Johnston 1967). The slightly shorter tarsi at Taif run opposite to the general pattern of increased size and may reflect

foraging adaptations (Grant 1966). The second reason for the relatively large differences between populations in Saudi Arabia may be the length of time that the species has been established there. In Germany, it must have reinvaded following the last ice age and the spread of agriculture, and in North America sparrows were introduced only last century (Summers-Smith 1988, 1990).

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LITERATURE CITED

BRITTON, P. L. 1977. Weights of birds in western and coastal Kenya, a comparison. Scopus 1:70–73.

DAVIS, J. 1954. Seasonal change in bill length of certain passerine birds. Condor 56:142–149.

DIAMOND, A. W. 1973. Altitudinal variation in a resident and a migrant passerine on Jamaica. Auk 90:610–618.

GAVRILOV, E. I. 1965. On the hybridization of Indian and House sparrows. Bull. Br. Orn. Club. 85:112–114.

——— AND M. N. KORELOV. 1968. The Indian Sparrow as a distinct good species. Byull. Mosk. Obshch. Ispyt. Prir. Otd. Biol. 73:115–122.

GRANT, P. R. 1966. Further information on the relative length of the tarsus in land birds. Postilla 98:1–13.

GRIMM, H. 1954. Biometrische Bemerkungen uber mitteldeutsche und westdeutsche Sperilingspoplationen. J. Orn. 95:306–318.

HANMER, D. B. 1978. The effects of latitude and altitude on birds weights. Scopus 2:35–39.

JOHNSTON, R. F. AND R. K. SELANDER. 1964. House Sparrows: rapid evolution of races in North America. Science 144:548–550.

——— AND ———. 1973. Evolution in the House Sparrow. III. Variation in size and sexual dimorphism in Europe, North America, and South America. Am. Nat. 107:373–390.

LÖHRL, H. AND R. B. BÖHRINGER. 1957. Untersuchungen an einer südwestdeutschen Population des Haussperlings (*Passer d. domesticus*). J. Orn. 98:229–240.

NIETHAMMER, G. 1953. Gewich und Flugellange beim Haussperling (*Passer d. domesticus*). J. Orn. 94:282–289.

PACKARD, G. C. 1967a. House Sparrows: evolution of populations from the Great Plains and Colorado Rockies. Syst. Zool. 16:73–89.

———. 1967b. Seasonal variation in the bill length of House Sparrows. Wilson Bull. 79: 345–346.

PRICE, T. 1979. The seasonality and occurrence of birds in the eastern Ghats of Andhra Pradesh. J. Bombay Nat. Hist. Soc. 76:378–422.

SAINI, H. K., M. S. DHINDSA, AND H. S. TOOR. 1989. Morphometric variation in an Indian population of House Sparrow, *Passer domesticus*. Le Gerfaut 79:69–80.

SELANDER, R. K. AND R. F. JOHNSTON. 1967. Evolution in the House Sparrow. I. Intrapopulation variation in North America. Condor 69:217–258.

SUMMERS-SMITH, J. D. 1988. The sparrows, a study of the genus *Passer*. T. & A. D. Poyser, Calton, England.

———. 1990. Changes in distribution and habitat utilization by members of the genus *Passer*. Pp. 11–29 *in* Granivorous birds in the agricultural landscape (J. Pinowski and J. D. Summers-Smith, eds.). Polish Scientific Publishers, Warszawa, Poland.

VAURIE, C. 1956. Systematic notes on Palearctic birds, No. 24 Ploceidae; the genera *Passer, Petronia,* and *Montifringilla*. Am. Mus. Novit. No. 1814.

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A female Gambel's Quail with partial male plumage.—Gambel's Quail (*Callipepla gambelii*) are sexually dimorphic, with males exhibiting head plumes that are long, wide, and black, a rusty head patch, a black facial bib outlined in white, and a black belly patch. Females have dark brown plumes which are shorter and narrower than males, and do not exhibit the other listed traits (Johnsgard 1973). In the late summer of 1996, we observed a captive female Gambel's Quail molting into partial male plumage. The female was at least two years old and had exhibited only female plumage in previous years.

We compared this female with typical male and female Gambel's quail (Table 1). The head plumes of the aberrant female were long, wide, and black, consistent with male plumes. In addition, the female had developed a striking rusty head patch. The posterior portion of the patch contained a mixture of rust and gray feathers, unlike a typical male. The female had an obvious facial bib composed primarily of beige, rather than black feathers. The white outline of the bib was present on the sides, but did not extend far down the throat. There was no black belly patch, but some black-tipped feathers were scattered throughout the belly region. A typical female has beige belly feathers with some brown streaking.

Many sexually dimorphic galliform birds, best studied in the pheasants (Phasianinae), exhibit estrogen-dependent plumage development (Domm 1939, Witschi 1961, Owens and Short 1995). Dull female plumage is dependent upon the presence of estrogen, while ornamental plumage of males develops in the absence of estrogen. This has been demonstrated experimentally, where ovariectomized females developed full male plumage. Similarly older females, or females with diseased ovaries, molt into partial or full male plumage because they do not produce sufficient estrogen. Therefore, ornamental male plumage is the "default" state in both sexes, and female plumage may be more derived (Owens and Short 1995).

The actual mechanism that disrupted normal estrogen levels in the female Gambel's Quail we observed is unknown. She had experienced no known injuries or disease while in captivity, and acted as healthy and vigorous as other females in her pen. When the female first exhibited partial male plumage, she was at least two years old, which is older than most wild females. Sowls (1960) reported an annual survival rate of only 28–40% for Gambel's Quail. Mean longevity for quail after their first fall is approximately 8–10 months (Johnsgard 1973: Table 21).

Given abnormal estrogen production in the female we observed, partial male plumage development may have occurred in one of two ways. First, feather tracts differ in their sensitivity to estrogen (Juhn et al. 1931). If this female produced low concentrations of estrogen throughout molt, male plumage may have developed in some areas that were highly estrogen sensitive, but not in others. Alternatively, estrogen may have been produced only during a portion of molt. Thus, female feathers developed when estrogen was present, while male feathers developed in the absence of estrogen.

While estrogen-dependent plumage dimorphism has been observed most in Phasianinae (Domm 1939, Witschi 1961, Owens and Short 1995), it has not been well documented in