AN ALBINISTIC MARBLED GODWIT: A FIRST RECORD

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Albinism occurs infrequently in the family Scolopacidae as compared to other avian families (Sage 1963, Gross 1965). There are apparently no previous records of albinism for the Marbled Godwit (*Limosa fedoa*) (Ross 1963), although there is one record each for the Hudsonian Godwit (*Limosa haemastica*) (Deanne 1880), and the Bar-tailed Godwit (*Limosa lapponica*) (Sage 1962).

At 15:30 on 9 February 1974 on the east shore of Drake Estero, Point Reyes National Seashore, Inverness, California, I spent approximately 15 min observing an albinistic Marbled Godwit foraging on mudflats among a relatively large flock of godwits. Observations were made from a distance of about 30 m with a 15–60× "zoom" telescope. There were no clouds or wind, and glare was minimal.

A description follows: Bill—flesh colored with black tip, apparently normal; Irides—black, apparently normal; Legs—dark or black, apparently normal; Body and head—entirely or almost entirely diluted to white on all parts except axillae and wing linings, which were heavily tinged cinnamon. The back and the wing coverts retained a distinct pattern of dusky, transverse barring. A less distinct pattern of faint barring was present ventrally on the rectrices.

The coloration of this individual seems to have resulted from extreme dilution of the rufous-brown, and cinnamon pigmentation in most of the plumage and should therefore be considered as a case of "imperfect" albinism (Pettingill 1956).

LITERATURE CITED

DEANNE, R. 1880. Additional cases of albinism and melanism in North American birds. Bull. Nuttall Ornithol. Club 5:25–30.

GROSS, A. O. 1965. The incidence of albinism in North American birds. Bird-Banding 36:67–71.

PETTINGILL, O. S., JR. 1956. A laboratory and field manual of ornithology. Burgess Publ. Co., Minneapolis.

ROSS, C. C. 1963. Albinism among North American birds. Cassinia 47:2–21.

SAGE, B. L. 1962. Albinism and melanism in birds. Brit. Birds 55:201–225.

SAGE, B. L. 1963. The incidence of albinism and melanism in British birds. Brit. Birds 56:409–416.

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MORPHOLOGICAL AND BIOCHEMICAL EVIDENCE OF HYBRIDIZATION BETWEEN CAVE AND BARN SWALLOWS

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A recent breakdown of ecological segregation of the Cave Swallow (*Petrochelidon fulva*) and other hirundinids in central Texas was reported by Martin (1974). Breeding of the Cave Swallow in the United States previously was limited almost entirely to caves and sinkholes, where it nested in isolation from other swallows (Selander and Baker 1957, Wauer and Davis 1972), but it now also nests in highway culverts and other man-made structures, where it is associated with the Barn Swallow (*Hirundo rustica*). Among the potential hazards to both species in this altered situation is failure of premating isolating mechanisms (Martin 1974). We now report the occurrence of two hybrids between these species. The hybrid identity of these individuals was recognized first on the basis of morphological features and subsequently confirmed by an electrophoretic analysis of protein variation.

The ecology of swallows is being studied by Martin along a transect coincident with U.S. Highway 90, lying just south of the Edwards Plateau in central Texas and spanning a distance of 200 km from Hondo, Medina County, to Comstock, Val Verde County. In this area, tributaries of the Nueces River and the Rio Grande draining the Edwards Plateau pass through concrete culverts beneath the highway. The Cave Swallow is absent at either end of the transect, but both Cave and Barn Swallows nest together in most culverts between Uvalde and the Kinney-Val Verde county line. Additionally, single pairs of Cave Swallows have been found nesting in colonies of Barn Swallows in two culverts (numbers 8 and 9) 32 km E of the main area of co-occurrence.

Clutch-size, brood-size, and other data for nests in culverts were recorded twice weekly from 7 April to 15 September 1973. Examination of nest B.5 (in culvert 8, 24.3 km W Hondo) on 23 May indicated that the three large juveniles present were of two phenotypes. One of the nestlings was *H. rustica*-like in plumage color and pattern, whereas the plumages of the other two were intermediate between those of *H. rustica* and *P. fulva*. Repeated observation indicated that both adults attending the nest were phenotypically *H. rustica*. Originally, the nest held five eggs (within normal range of clutch size for both species) that apparently were laid in normal temporal sequence. However, one nestling from this clutch disappeared from the nest in the period from 2 to 4 days after hatching, and another individual was lost either as an egg or as a nestling a day or so after hatching. On 30 May the *H. rustica*-like juvenile flew from the nest as it was being inspected. The two young of intermediate plumage were collected from the nest at night on 1 June, but the adults escaped from the nest and were not collected.

MORPHOLOGICAL EVIDENCE

In the two apparent hybrids the color of most of crown, nape, and back was intermediate between the glossy blue-black of juveniles of *H. rustica* and the duller dark brown of those of *P. fulva*. The breast and abdomen were cinnamon as in *H. rustica*, not

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TABLE 1. Proteins analyzed electrophoretically.

Protein	Tissue	Buffer system (*pH*)[a]	Position on gel
A. *Proteins showing no intra- or interspecific variation*			
Esterase-1	Liver	Lithium hydroxide (8.2)	Anodal
Esterase-2	Heart muscle	Lithium hydroxide (8.2)	Cathodal
Phosphoglucomutase	Heart muscle	Tris-citrate (8.0)	Anodal
Phosphoglucose isomerase	Breast muscle	Phosphate (6.7)	Cathodal
Malate dehydrogenase-1	Breast muscle	Tris-citrate (6.7)	Anodal
Malate dehydrogenase-2	Breast muscle	Tris-citrate (6.7)	Cathodal
Isocitrate dehydrogenase-2	Breast muscle	Tris-citrate (6.7)	Cathodal
Glutamate oxalacetate transaminase-1	Heart muscle	Tris-citrate (8.0)	Anodal
Glutamate oxalacetate transaminase-2	Heart muscle	Tris-citrate (8.0)	Cathodal
Lactate dehydrogenase-1	Heart muscle	Tris-citrate (8.0)	Anodal
Peptidase-1	Heart muscle	Tris-hydrochloric acid (8.5)	Anodal
Peptidase-2	Heart muscle	Tris-hydrochloric acid (8.5)	Anodal
Indophenol oxidase	Liver	Tris-maleate (7.4)	Anodal
Albumin[b]	Liver	Lithium hydroxide (8.2)	Anodal
Prealbumin	Liver	Lithium hydroxide (8.2)	Anodal
Hemoglobin	Heart muscle	Tris-hydrochloric acid (8.5)	Anodal and cathodal[c]
Protein-1	Liver	Lithium hydroxide (8.2)	Anodal
Protein-2	Liver	Lithium hydroxide (8.2)	Anodal
Protein-3	Liver	Lithium hydroxide (8.2)	Anodal
B. *Proteins differing between species; hybrid phenotypes intermediate*			
6-Phosphogluconate dehydrogenase	Liver	Tris-maleate (7.4)	Anodal
Isocitrate dehydrogenase-1	Breast muscle	Tris-citrate (6.7)	Anodal
Adenylate kinase	Heart muscle	Histidine (7.0)	Cathodal

[a] Described in detail by Selander et al. (1971).
[b] One heterozygote in sample of *H. rustica* (see text).
[c] Two hemoglobin components.

white (with some cinnamon laterally) as in *P. fulva*. The rectrices had prominent subterminal white spots on their inner vanes as in *H. rustica* and were not immaculately dark brown as in *P. fulva*. Most conspicuously, the rump was buffy orange as in *P. fulva*, not blue-black as in *H. rustica*.

BIOCHEMICAL EVIDENCE

Protein variation was analyzed in extracts of breast muscle, heart muscle, and liver of the two apparent hybrids and of eight specimens of *H. rustica* and eight specimens of *P. fulva* from the transect area. Techniques of electrophoresis and enzyme-specific staining followed those of Selander et al. (1971), as adapted for birds by Nottebohm and Selander (1972).

Most of the proteins assayed were invariable or nearly so in electrophoretic mobility in our samples of *H. rustica* and *P. fulva*. No allozymic variation within or between species was detected in 18 of the 22 proteins examined, as shown in table 1. As far as we were able to determine by electrophoresis, all individuals in our samples were homozygous for the same allele at each locus encoding these proteins. Similarly, both species had the same common allele at the albumin locus; the sample of *P. fulva* was monomorphic, but one individual of *H. rustica* was heterozygous for the common allele and another encoding a slower-migrating band. The darkest staining (anodal) esterase in liver extracts was highly variable individually in number and position of bands, but this enzyme could not be scored as a single-locus system.

Only three proteins showed consistent interspecific differences and thus provided a basis for detecting hybridization. For each of these the phenotypes of the two presumed hybrids were intermediate.

6-Phosphogluconate dehydrogenase. All specimens of *P. fulva* displayed a fast-migrating band and those of *H. rustica* had a slow-migrating band. The two hybrids had a three-banded phenotype, with the "hybrid" or heterodimeric band staining much darker than the homodimeric bands. The mobilities of the fast and slow homodimers were identical with those of *P. fulva* and *H. rustica*, respectively.

Isocitrate dehydrogenase-1. Individuals of *P. fulva* had a single rapidly migrating band and those of *H. rustica* displayed a slower band. Both hybrids showed a single band of intermediate mobility, apparently representing the activity of a heterodimeric molecule. Although organisms heterozygous for IDH usually display relatively weak homodimeric bands (Manwell and Baker 1970), we found no trace of these in the hybrid individuals. Because these birds were maintained in a frost-free freezer (at a minimum temperature of −15°C) for several months prior to our electrophoretic analysis, we suspect that the homodimers had denatured. Of the enzymes examined in our survey, IDH is the one most likely to show loss of activity during periods of storage, even in tissues or extracts held at temperatures as low as −80°C (Selander, unpubl. data).

Adenylate Kinase. Individuals of *P. fulva* had a single fast-migrating band of adenylate kinase activity, while those of *H. rustica* show a slow-migrating band. Both hybrids displayed a two-banded phenotype and, thus, apparently were heterozygous at the locus encoding this enzyme.

DISCUSSION

The biochemical evidence of heterozygosity at three structural gene loci strongly supports the morphologically based interpretation of the two juveniles as interspecific hybrids. Two hypotheses concerning

the origin of the hybrids may be advanced. One posits that introgressive hybridization is occurring: both adults attending the nest were parents of all nestlings, at least one parent was a hybrid (perhaps a backcross), and the disparate phenotypes of the young were the result of recombination. The second (and more attractive) hypothesis is that both attending adults were "pure" *H. rustica*; the nestling of *H. rustica* phenotype was their issue; and the two young of intermediate phenotype were the result of a mismating of the female *H. rustica* and a male *P. fulva*, possiby that associated with nest B.1 on the opposite wall of the culvert, 10 ft from nest B.5. Further work to determine the frequency of hybridization and the extent, if any, of introgression is currently in progress.

Several putative hybrids between *Hirundo rustica* and the Cliff Swallow (*Petrochelidon pyrrhonota*), identified morphologically, have been reported (Trotter 1878, Mearns 1902, see also Suchetet 1897, Gray 1958). One of these individuals was reproductively active; it had constructed a nest with a male of *H. rustica* and was about to lay when collected (Trotter 1878). This presumed hybrid and another described by Mearns (1902) displayed a light rump patch and spotted rectrices similar to those of the specimens described here.

Our findings suggest that there is little variation at structural gene loci in populations of *P. fulva* and *H. rustica* in central Texas. Taken together, our samples of these species show an average heterozygosity (proportion of loci in heterozygous state per individual) of only 0.3% over the 22 loci assayed (hemoglobin considered for this purpose to be encoded by one locus). This value contrasts with an average of 5.8% in populations of 24 other species of vertebrates (mostly rodents) reported by Selander and Johnson (1973). The only other bird for which a comparable estimate is available is the Chingolo (*Zonotrichia capensis*), in which heterozygosity averages 3.5% (15 loci) (Nottebohm and Selander 1972). Whether low genic variability is characteristic of all populations of *P. fulva* and *H. rustica* (or, indeed, of swallows in general) remains to be determined.

Another significant aspect of our findings is the close genic similarity between *P. fulva* and *H. rustica*. On the basis of the observed allelic representation at 22 loci, we calculate a coefficient of genic similarity (S, scaled from 0 to 1; see Rogers 1972) of 0.860. This value is similar to those derived for sibling and semispecies of rodents and even for some conspecific populations of mammals and lizards; and it is well over the range ($S = 0.18$–0.32) reported for nonsibling (but congeneric) species of other types of vertebrates and of fruit flies (Selander and Johnson 1973).

Because of the general morphological similarity of swallows, Mayr and Bond (1943) questioned the reality of generic limits in this family and suggested that grounds for separating *Petrochelidon* from *Hirundo* were particularly weak. The occurrence of hybridization between *Hirundo* and *Petrochelidon* and the biochemical evidence of close genic similarity between *H. rustica* and *P. fulva* strongly support this viewpoint.

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LITERATURE CITED

GRAY, A. P. 1958. Bird hybrids. Commonwealth Agricultural Bureaux. Farnham Royal, Bucks, England. 390 p.

MANWELL, C., AND C. M. A. BAKER. 1970. Molecular biology and the origin of species. Sidgwick & Jackson, London. 394 p.

MARTIN, R. F. 1974. Syntopic culvert nesting of Cave and Barn Swallows (*Petrochelidon fulva, Hirundo rustica*) in Texas. Auk 91:776–782.

MAYR, E., AND J. BOND. 1943. Notes on the generic classification of the swallows, Hirundinidae. Ibis 85:334–341.

MEARNS, E. A. 1902. Description of a hybrid between the Barn and Cliff Swallows. Auk 19:73–74.

NOTTEBOHM, F., AND R. K. SELANDER. 1972. Vocal dialects and gene frequencies in the Chingolo Sparrow (*Zontrichia capensis*). Condor 74:137–143.

ROGERS, J. S. 1972. Measures of genetic similarity and genetic distance. Studies in Genetics 7 (Univ. Texas Publ. 7213):145–153.

SELANDER, R. K., AND J. K. BAKER. 1957. The Cave Swallow in Texas. Condor 59:345–363.

SELANDER, R. K., AND W. E. JOHNSON. 1973. Genetic variation among vertebrate species. Ann. Rev. Ecol. Syst. 4:75–91.

SELANDER, R. K., M. H. SMITH, S. Y. YANG, W. E. JOHNSON, AND J. B. GENTRY. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation in the old-field mouse (*Peromyscus polionotus*). Studies in Genetics 6 (Univ. Texas Publ. 7103):49–90.

SUCHETET, A. 1897. Des Hybrides a l'Etat Sauvage Regne Animal. Tome Premier. Classes des Oiseaux. Librairie J.-B. Bailliere et fils. 1001 p.

TROTTER, S. 1878. Description of a hybrid (*Hirundo horreori-lunifrons*) between two North American swallows. Bull. Nutt. Ornithol. Club 3:135–136.

WAUER, R. H., AND D. G. DAVIS. 1972. Cave Swallows in Big Bend National Park, Texas. Condor 74:482.

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