G.1: Evolution, Ecology, and Conservation of Monochromatic Ducks (Organizers: Ron Bielefeld and Bruce Dugger)

G.1.1: Dugger - Bielefeld

Monochromatic Ducks – a Primer

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Introduction to the session.

G.1.2: Lavretsky

Genomics of New World Mallard-Like Ducks

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The New World (NW) mallard group includes the dichromatic mallard (Anas platyrhynchos), and four monochromatic taxa; American black duck, (A. rubripes), Mexican duck (A [p.] diazi), and two subspecies of mottled ducks (Florida, A. fulvigula fulvigula; and West Gulf Coast. A. f. maculata). Although all NW taxa are phenotypically diagnosable, resolving their taxonomic relationships has been challenging due to genomic similarities attributable to their recent ancestry and/or hybridization. Using ddRAD-seq methods, we sequenced 3,029 autosomal and 198 Z-chromosome markers from a total of 166 samples (24–43 per taxon). For both marker-types, the monochromatic taxa each clustered into independent groups; however, American black ducks were largely indistinguishable from mallards. Under a neutral scenario in which genetic divergence is driven by genetic drift, the expected ratio for Z:autosomal differentiation is < 1.33, because Z loci have 0.75 the effective population size of autosomal loci. Comparing mallards to each monochromatic taxa recovered elevated Z divergence, with Z:autosomal ratios ranging between 4 and 6.5, and evidence of positive selection acting on 2-4% of Z-linked markers, but < 0.5% of autosomal markers. Furthermore, aligning markers along the Z chromosome revealed a region of elevated differentiation that was shared between all mallard-monochromatic comparisons; this region was less-differentiated or absent for pair-wise comparisons of monochromatic taxa. These results suggest that the Z-chromosome is at a later stage of divergence between mallards and monochromatic taxa and that this differentiation is likely driven by selection acting on traits that are Z-linked and derived in mallards. Overall, ddRAD-seq markers provided high resolution regarding the evolutionary history of the NW mallard clade. Furthermore, they revealed strong support for phylogenetic relationships within this group, suggesting that black ducks and mallards are sister species, this pair is sister to Mexican ducks, and the two mottled duck populations are a separate lineage.

G.1.3: Wells^

Why Are Some Ducks Brown?

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Sexual dichromatism is a striking characteristic of many waterfowl species. Yet in others, the buffy, brown plumage of males makes them hardly distinguishable from their female mates. There is general consensus that monochromatism in Anas ducks has been recently and repeatedly derived from dichromatic ancestors. However, the selective pressures that underlie these repeated transitions are not well understood, and may vary among monochromatic species. In this talk I will review hypotheses for the secondary evolution of monochromatism, with specific attention to the ecology of monochromatic ducks of North America and the Pacific Islands. I will present comparative evidence from other avian groups (galliforms, raptors, and sparrows) that exhibit similar evolutionary transitions to monochromatism, and address the proximate physiological mechanisms associated with the expression of brown plumage. Finally, I will present preliminary evidence linking seasonal monochromatism (i.e., eclipse plumage) of male mallards (*Anas platyrhynchos*) to persistent monochromatism in male Hawaiian ducks (*Anas wyvilliana*).

G.1.4: Devers

Evolution, Ecology and Conservation of the American Black Duck

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The American black duck (*Anas rubripes*) is closely related to other monomorphic *Anas* species and the mallard (*A. platyrhynchos*) and was once considered a single species (*A. obsura*) with the mottle duck (*A. fulvigula*). Historically, the black duck was the most abundant dabbling duck in eastern North America with a breeding range stretching from Ontario to Newfoundland and south into the Great Lakes States and North Carolina. It is a partial short-distance migrant with a non-breeding range extending from the southern Canada to Mississippi and Alabama across to South Carolina. The population experienced a decline of >50% between the 1950s and 1990s, but the decline was not uniform across the species range. Several hypotheses have been proposed to explain the decline including over-harvest, competition and hybridization with mallards, decrease in the quantity and quality of wintering and breeding habitat, and environmental contaminants. To this day there is a no consensus as to the cause of the decline or current limiting factors. Black duck annual survival ranges from 0.47-0.67 and is lowest among juvenile females and highest among adult males; patterns similar to mallards. Similarly, reproductive rates appear similar among black ducks and mallards, though estimates of continental fall age ratios are slightly lower. Despite the similar demographic rates and lower harvest rates, the black duck breeding population has remained stable in eastern Canada whereas the mallard population continues to grow. Challenges facing black duck managers include lack of detailed information regarding productivity; resource extraction, agricultural, and climate change effects on the breeding grounds; and urban growth and sea-level rise effecting non-breeding habitat. Under the Coordination of the Black Duck Joint Venture and Black Duck Adaptive Harvest Management Working Group, researchers and managers are developing and implementing tools to address these challenges and ensure the future of the American black duck.

G.1.5: Wells^

Geographic Variation in Hybridization Between Mallards and Hawaii's Koloa Maoli

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Hybridization is common in birds, and particularly widespread among waterfowl. However, hybridization with feral mallards (*Anas platyrhynchos*) has emerged as a major threat to the genetic persistence of several monochromatic *Anas* species. In the Hawaiian Islands, hybridization with mallards, and resulting introgression, is the primary threat to the endemic koloa (Hawaiian duck, *Anas wyvilliana*). However, this threat may not affect all Hawaiian populations equally; knowledge of which populations are most impacted by hybridization will help target conservation efforts. Hence, we used multilocus genotypes and Baysian assignment of 288 individuals, sampled from 14 locations, to compare hybrid prevalence at two geographic scales: 1) among the main Hawaiian Islands, and 2) between urban and managed wetland habitats. Additionally, we used mitochondrial haplotypes, which are maternally inherited, to determine the direction of introgression among different populations. Putatively "pure" koloa were found on all islands except for Maui, but were more common in managed wetland than urban habitat. Hybrids were most numerous on Oahu and Maui, and hybrid prevalence on Kauai appears quite low. Though sample sizes were small, the direction of introgression varied by island and by habitat. On Oahu, 90% of hybrids in the urban habitats had mallard mitochondrial haplotypes compared to 10% with koloa haplotypes, indicating the majority of hybridizing pairs were female mallards and male koloa; in the managed wetland habitat these proportions were reversed, indicating the majority of hybridizing pairs were female koloa and male mallards. Higher prevalence of genetically "pure" koloa, and hybrids with koloa mothers, in managed wetland as opposed to urban habitat is consistent with previous work on koloa habitat preference. Species differences in habitat preference, coupled with female philopatry, may underlie geographic variation in the prevalence and direction of hybridization among populations.

G.1.6: Haukos

At What Scale Should Mottled Ducks be Managed?

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The mottled duck (*Anas fulvigula*) has a different life history strategy than other monochromatic North American waterfowl. By being non-migratory, the species must fulfill all of its life history needs in the same habitats. Further, limited mobility restricts individual and population response to extreme environmental events, habitat loss and degradation, and effects of climate change. For the Western Gulf Coast Population (WGC; Texas and Louisiana), mottled ducks persist as scattered populations primarily in fresh – brackish coastal marsh with the greatest densities on the Chenier Plain of Texas and Louisiana. Population fragmentation in the WGC has occurred as the result of urbanization, extensive conversation to agriculture, salt-water intrusion, industrial development, invasive species, and lack of management for the entire life cycle. The WGC population persists primarily as a metapopulation occupying isolated local and regional patches of habitat within an ever increasing matrix of landscapes resistant to movement. Band recovery data indicate little movement among regional populations limiting immigration, emigration, and genetic exchange. Population goals are available for the entire WGC population and Texas and Louisiana, but have yet to be stepped down to regional populations. Harvest management occurs independently between the Central and Mississippi Flyways with little consideration of movement patterns between Flyways. Regional habitat and population goals are currently nonexistent. Limiting factors, space use, and habitat selection are fairly well known for the Chenier Plain population, but inference to other populations may not be appropriate for estimating carrying capacity for mottled ducks. Population demography and relationships between vital rates and available habitat have not been developed, but are needed prior to setting regional management goals. Development of hierarchical habitat management objectives within a metapopulation framework with consideration of regional habitat constraints and impacts may have greater influence on species viability than top-down state or WGC level population goals.

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H.1.1: Krainyk^

Prioritizing Mottled Duck Habitat for Conservation Along the Western Gulf Coast

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The mottled duck (*Anas fulvigula*) is a year-round resident of the Gulf of Mexico Coast. Because of its population decline in the western Gulf Coast, the mottled duck is a species of concern among state and federal agencies. The disappearance of suitable nesting and brood-rearing habitat is the primary factor believed to be responsible for the population decline. Therefore, a priority for increasing abundance of the mottled duck is to increase nest success and brood survival by preserving or creating landscapes with suitable nesting and brood-rearing habitat in appropriate spatial configurations. Our objective was to develop a decision support tool that will aide stakeholders in decision making processes by consolidating available biological and ecological knowledge and taking into account temporal and spatial variation at the landscape level. Our deliverable products use available biological knowledge of mottled duck nesting and brood rearing requirements to develop spatially explicit models that 1) identify currently suitable mottled duck nesting and brood-rearing habitat prioritized for protection, 2) identify and prioritize wetland basins for freshwater enhancement that can provide suitable brood-rearing habitat, and 3) identify and prioritize areas where grassland establishment can provide suitable nesting habitat. Results from our spatial models show that only 1,495 acres of currently suitable nesting habitat and 2,337 acres of currently suitable brood-rearing habitat fall within the top 10% of our priority ranking for conservation. This makes up approximately 0.05 % of the total currently suitable habitat identified by the model. The ratio of nesting to brood-rearing habitat area along the central and lower Texas Coasts is highly skewed towards nesting habitat (> 78% nesting habitat), suggesting that wetland enhancement or creation in these areas could provide large amounts of suitable habitat. Throughout the upper Texas Coast and coastal Louisiana, the ratio of nesting to brood-rearing habitat is nearly 1:1. Additionally, results from landscape level analyses indicate that approximately 400,000 acres of wetland habitat and 300,000 acres of grassland habitat could become suitable for breeding mottled ducks if appropriate wetland enhancement or grassland establishment measures were implemented. Our decision support tool, based on the best available biological information, will aid managers in identifying habitat patches where conservation efforts will have the largest impact on the mottled duck population.

H.1.2: Feddersen

Keeping the Florida Mottled Duck a Monochrome

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The mottled duck (*Anas fulvigula*) in Florida has long been considered the same species as mottled ducks occurring in the western gulf coast areas of Texas and Louisiana. However, some authorities on the subject believe the birds in these two population are separate subspecies, *Anas fulvigula fulvigula* in Florida and *Anas fulvigula maculosa* in the western gulf coast. Recent genetic and phenotypic studies of the two birds may back up this assertion. Regardless, these two populations of birds have been and will continue to be managed separately. Over the past three decades, research investigating population trends, habitat use, movements, and survival of Florida mottled ducks has identified the biggest threat to the continued existence of this endemic monochromatic duck; genetic introgression from feral mallards (*Anas platyrhynchos*). Accordingly, the most recent research efforts have focused on developing the tools and techniques needed to identify 1) mottled ducks from non-mottled ducks, in real time, while in the field and 2) areas of high inter-species contact. Studies to take place over the next few years will assess the mottled duck versus non-mottled duck population, providing information necessary to develop and initiate protocols that will combat the introgression threat with the goal of conserving a Florida mottled duck population that Florida citizens can enjoy in perpetuity.

H.1.3: Varner

Movements and Seasonal Use of Habitats by Female Mottled Ducks in Southeast Florida

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Florida will continue to undergo high rates of habitat loss, primarily as a result of urbanization. In addition, invasive species are a major threat to Florida's biodiversity. The Florida mottled duck (*Anas fulvigula*), a bird unique to the state, is particularly vulnerable to loss of wetland habitats and hybridization with feral mallards. Because mottled ducks are more likely to encounter feral mallards in urban habitats, we trapped and radio-marked adult females in urban (n = 99) and rural (n = 146) areas to estimate home ranges and rates of movement into and out of urban areas. We also determined habitat use in urban and rural areas during the breeding (1 Feb–31 Jul), post-breeding (1 Aug–18 Nov), and hunting (19 Nov–31 Jan) periods and estimated seasonal habitat selection of rural female mottled ducks. Urban females used mostly aquatic habitats in low and high intensity human development year-round. Rural ducks used freshwater marshes throughout the year, but selection of other habitat types varied seasonally. Use of glades marsh and agricultural habitats by rural ducks peaked during the breeding season. Rural ducks selected artificial impoundments and reservoirs during the post-breeding and hunting periods. Median home range size of rural females was more than 65 times greater than that of urban females. Our results suggest the spread of mallard genetic introgression caused by females leaving urban areas may be slow because as few as 6% of the adult females moved between urban and rural areas. Focusing wetland conservation efforts on freshwater marshes and artificial impoundments in south Florida would likely benefit mottled ducks.

H.1.4: Pollander^

Timing and Movements of Mottled Ducks in Georgia and South Carolina

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Mottled ducks (*Anas fulvigula*) inhabit various coastal marsh habitats, ranging from freshwater prairies to saline coastal marshes in the southeastern United States. The species is considered non-migratory, but there is little information detailing individual movements within short or long temporal periods. Likewise, as residents mottled ducks are assumed to maintain home ranges, but band returns and coarse-scale telemetry data collected by previous studies suggests that movements away from maintained home ranges may occur. However, fine-scale data are also lacking in regards to the frequency and timing of movements outside of the home range. In August 2014, we captured and outfitted 9 mottled ducks (7 males and 2 females) with satellite GPS transmitters, which recorded 4 locations per day. Our objectives were to document daily distance traveled, document duration, timing, and distances traveled on excursions outside established home ranges, and document timing, duration, and distances traveled by mottled ducks to establish new home ranges. We determined distances between GPS locations using a Euclidean distance function. We found that average daily distances moved from capture through present varied from 72 m to 21,279 m (mean = 8,559 m, SE = 4,779 m). Three individuals left established home ranges and established new home ranges 46,232 m to 245,765 m (mean = 150,013 m SE = 83,518 m) away from their original home range. These new home ranges were established in ≤3 days. Four individuals made excursions outside their home range averaging 65,717 m (SE = 17,248 m); all returned to their previous home ranges in ≤4 days. These data suggest that mottled ducks in Georgia and South Carolina should be managed as one population rather than two separate populations.

H.1.5: Kneece^

Survival and Recovery of Mottled Ducks in Coastal South Carolina 2008-2014

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Mottled ducks (*Anas fulvigula*), comprising a genetically distinct subspecies (*A. fulvigula fulvigula*) are endemic to the western Gulf Coast (WGC) and peninsular Florida, respectively. Between 1975 and 1983, approximately 1,300 mottled ducks were introduced to coastal South Carolina from their endemic range. Fall banding was initiated in 2008 within the Santee Delta and Ashepoo, Combahee, Edisto Rivers Basin to estimate mottled duck survival and harvest. We acquired 3,471 banding and 442 harvest records of mottled ducks captured during remigial molt in 2008-2014. We used the dead recovery model with Brownie parametrization in Program MARK to estimate annual survival (S) and recovery probabilities (f) among combinations of age (juvenile [banded year of hatch] or adult [banded > 1 year after hatch]), sex, year, and band type/material (1-800 or web-address aluminum or web-address stainless steel). We ranked models using quasi-Akaike's Information Criterion (QAICc) adjusted for small sample size and a variance inflation factor ($\hat{c}$ = 1.4408) calculated from 1,000 bootstrap simulations of the global model. We averaged survival and recovery estimates among competing models (ΔQAICc ≤ 2). Survival varied by age and sex whereas, recovery probability varied by age, sex, and band type. We calculated harvest rates (K[c]) from recovery probabilities (f) using the equation $f / \lambda = K(c)$ where λ is the band reporting rate (0.73). Annual survival was greatest for adult males (0.60 ± 0.04 [SE]) and adult females (0.59 ± 0.05), followed by juvenile females (0.40 ± 0.12), and juvenile males (0.35 ± 0.08). Recovery and harvest rates were greatest for juvenile males (0.092 ± 0.01; 13% [harvest rate]), then adult males (0.08 ± 0.007; 11%), juvenile females (0.052 ± 0.01; 7%), and adult females (0.046 ± 0.006; 6%). Aluminum bands (1-800 and web-address) had slightly higher recovery rates than stainless steel (web-address) bands, however, 95% confidence intervals of beta included zero. Annual survival of adult mottled ducks was comparable to adult survival in other regions (0.47-0.58), except Georgia (0.35). Juvenile female survival was similar to estimates from the entire range (0.35-0.47), whereas, survival of juvenile males appears equivalent to those in Georgia (0.35), but lower than juvenile males elsewhere (0.48-0.91). Recovery rates of mottled ducks in South Carolina were lower than those from Georgia (0.19-0.22), likely because banding in Georgia occurred at an intensively hunted wildlife management area. Recovery rates of South Carolina mottled ducks were similar (0.06-0.13) to those in Florida and the WGC, with juvenile males and adult females having the greatest and least recovery rates, respectively. Harvest rates of South Carolina mottled ducks are similar to eastern mallards (*A. platyrhynchos*; 0.141), but unlike mallards, annual survival may affect mottled duck populations beyond those breeding season metrics (e.g., nest success) deemed critical for Midcontinent mallards. We found no evidence that recovery rates differed between band materials, which is consistent with herring gulls (*Larus argentatus*) marked with similar bands. Future research that estimates survival of females, ducklings, and broods will be needed to more fully understand population change in South Carolina mottled ducks.

H.1.6: Shipes

Social Indices of Breeding Mottled Ducks in Coastal South Carolina

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Mottled ducks (*Anas fulvigula*) are endemic to Gulf Coastal United States and Mexico. Birds from Florida, Louisiana, and Texas were released in coastal South Carolina from 1975-1983, but autecology of mottled ducks is little known there. To begin investigating nesting ecology of mottled ducks in coastal South Carolina, we conducted Indicated Breeding Pair surveys of mottled ducks in spring 2010-2011 in the Ashepoo, Combahee, and Edisto (ACE) Rivers Basin. We used lone and social groups of mottled ducks as indicators of breeding behavior to begin linking potentially important breeding habitats for these birds in the region. We conducted surveys from one-half hour before sunrise to 1 hour after sunrise once weekly in diverse but representative wetland types in the region. During each survey we collected salinity, water depth, size of the entire wetland surveyed, and numbers of mottled ducks seen and their corresponding social groupings, following standard survey protocol. We conducted a combined 330 surveys in 11 wetlands from March-June 2011-2012, and counted 4,472 individual mottled ducks in various social groups; these total observations included 1,497 (59%) pairs of mottled ducks, compared to all other birds in other social categories. The greatest proportion of pairs was observed in May across both years. We used occupancy modeling and found that the area of the entire wetland surveyed was positively associated (β=0.31, 95% CI=0.25-0.39) with breeding mottled ducks and was the only variable that was biologically meaningful. Our results corroborate those from Texas where breeding mottled duck pairs were positively correlated with wetland size. Larger wetland impoundments may provide a greater interspersion between vegetation and open water (e.g. hemi-marsh) and therefore more habitat complexity could attract breeding mottled ducks.