When Orioles Turn Red

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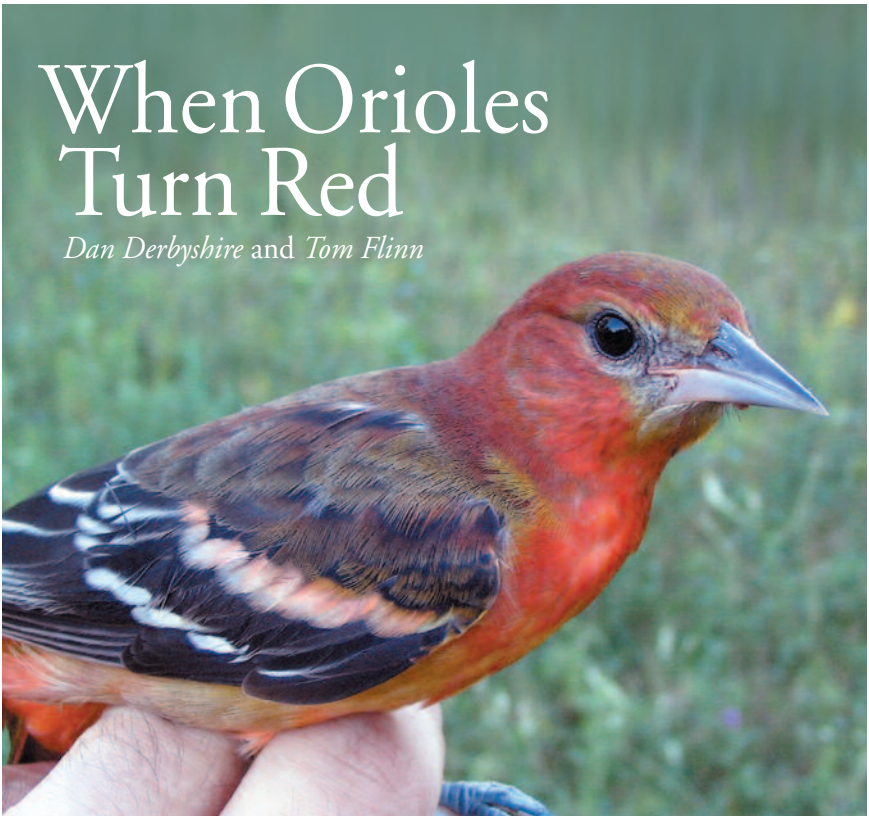

Figure 1: Baltimore Oriole at Tommy Thompson Park Bird Research Station, Toronto, ON, 22 August 2005. *Photo: Dan Derbyshire*

In August 2005, a Baltimore Oriole (*Icterus galbula*) that had unusual reddish hues to its plumage was captured at the Tommy Thompson Park Bird Research Station in Toronto. The authors believe that this aberrant colouration was caused by something in the diet of this bird.

While some degree of colour variation is found in many species of birds, a search of the literature has revealed no described instances of diet-induced erythrism (reddening) in Baltimore Oriole involving the carotenoid rhodoxanthin. To elucidate this possibility we will look at the following topics: the area where the bird was captured, a description of the bird's aberrant colouration, a general look at how birds attain the colours they exhibit, the involvement of rhodoxanthin in colour variation of Cedar Waxwings (*Bombycilla cedrorum*) and its suspected role in colour variation in some other species.

Background

Tommy Thompson Park is the largest area of natural habitat that exists on the central Toronto waterfront. The park, commonly considered Toronto's "urban wilderness", was designated an Important Bird Area (IBA) by Birdlife International in recognition of the significant numbers of nesting and migratory birds that can be found there. Tommy Thompson Park Bird Research Station (TTPBRS) was established by Toronto and Region Conservation to deliver monitoring, research and educational programs focused around birds and the environment. The migration monitoring program at TTPBRS includes daily standardized mist-netting, banding, census and point counts during spring and fall seasons.

A Red Oriole

An unusual looking first year Baltimore Oriole was captured and banded early on the morning of 22 August 2005. This individual showed pronounced red colour variably distributed throughout the head, breast and undertail, with some lighter red hue present in the greater coverts, back and belly (see Figure 1). The bird was briefly examined, photographed and released, without any clarity as to the nature of its aberrant colouration. Another bird with less obvious red colouration had been captured earlier that same week. While it had been dismissed as an isolated oddity, a bird that had perhaps been stained, the appearance of the second and much redder bird gave notice that further investigation was warranted.

In first basic plumage one would expect the areas that were significantly reddened would be coloured yellow to pale orange. Within most species there is a range of colour variation that would be considered normal for a given plumage. On a broad scale, this colour variation can delineate recognizable forms, such as races or colour morphs. On an individual level, the colour(s) of some birds of a given species will appear 'brighter' than others in the same plumage. However, the bird in question was significantly redder than would be expected in any plumage attained by Baltimore Oriole.

Colour in Birds

The significance of colour in the life of a bird cannot be overstated. The subtleties of feather colour, or lack thereof, have implications for mate selection, social status, camouflage and differentiation.

Colours in birds are mainly produced in three ways, either structurally (blue, white), chemically (red, yellow, orange) or both (green). There is no pigment that produces the vivid colour of the male Indigo Bunting (*Passerina cyanea*). The feathers only appear blue to the eye due to a complex structure within the feathers and how that structure reflects light. This type of colour is therefore structural instead of chemical.

Another example of structurally generated colour is the shimmering green and purple iridescence of the Common Grackle (*Quiscalus quiscula*).

Birds exhibit a phenomenal range of colours which in most cases are derived from chemical compounds called pigments. There are two basic types of pigments involved, melanins and carotenoids. Melanins are produced endogenously (*i.e.* from within) and are the pigments that produce brown, black and gray plumages. Carotenoid pigments are usually obtained exogenously (*i.e.* externally) from food sources. These carotenoid pigments are responsible for the warmer colours of red, orange and yellow in North American birds. There are many sources of carotenoids and they can be found in both plant and animal material consumed by birds. After ingestion some carotenoids are deposited into feathers in an unmodified form. Carotenoids may also be chemically modified by birds to produce new compounds, allowing a greater range of colour possibilities. Species such as the Scarlet Tanager (*Piranga olivacea*), Northern Cardinal (*Cardinalis cardinalis*) and House Finch (*Carpodacus mexicanus*) take carotenoids obtained from their diet and modify them to produce red compounds called 4-keto-carotenoids to attain the red hues in their plumage (McGraw *et al.* 2001). Other modified compounds, called canary xanthophylls, are responsible for the bright yellow colours of many species including American Goldfinch (*Carduelis tristis*) (McGraw *et al.* 2001).

Figure 2: Orange tail band on Cedar Waxwing at TTPBRS, Toronto, ON, 26 August 2005. *Photo: Dan Derbyshire*

Origin of "Orange-Tailed" Cedar Waxwings

Beginning in the early 1960s, some Cedar Waxwings started appearing with rectrices that were orange-tipped rather than the usual yellow-tipped (Figure 2).

The initial appearance of this phenomenon was a mystery, although the suspicion was that it was related to a change in diet. The onset of the colour change roughly coincides with the species population doubling in size from 1965-1979, although aberrant colouration was noted prior to 1965.

The first orange-banded Cedar Waxwing in the Cornell University Vertebrate Collection is from 1961 (Witmer 1996).

By the late 1980s, chemical analysis of orange-coloured tail tips had recovered a carotenoid with a deep red hue, named rhodoxanthin. This pigment was generally believed to be acquired directly from the diet and deposited unmodified (Hudon and Brush 1989). This discovery was unusual in that 4-keto-carotenoids are responsible for most of the red-coloured feathers of North American birds. The only areas coloured red on Cedar Waxwings are the 'waxy' red tips on the end of the secondaries, and the pigment responsible for that is a 4-keto-carotenoid named astaxanthin (Brush and Allen 1963).

Rhodoxanthin is present in small amounts in several plant species native to North America, including conifers and yews. However, if the source of rhodoxanthin in the aberrantly-coloured waxwings was from a native species, one would expect that they would have always had orange tail bands. Analysis of possible introduced sources of rhodoxanthin revealed that the chemical is found in the berries of Morrow's Honeysuckle (*Lonicera morrowii*), a non-native species (Brush 1990). The berries of Tartarian Honeysuckle (*Lonicera tatarica*), another introduced species, were not tested, but based on its close relationship to Morrow's Honeysuckle, and the fact that the two species readily hybridize in the wild, it is believed that they also contain rhodoxanthin (Mulvihill *et al.* 1992, Witmer 1996).

Honeysuckles (genus *Lonicera*) comprise more than 180 species of fruit bearing shrubs or vines. Non-native species of honeysuckle ("bush" honeysuckles) were first introduced to North America in the 19th century. During the 1950s, the shrubs were endorsed by the U.S. government as a viable plant for restoring wildlife habitat, which led to a dramatic range expansion and increase in abundance of the plants. The increase in numbers of these fruit-bearing ornamental shrubs has been credited as being a factor behind the population increase of the Cedar Waxwing in the mid-20th century (Witmer 1996).

Confirmation that rhodoxanthin found in honeysuckle berries could redden the tail tips of Cedar Waxwing came when Witmer (1996) conducted feeding experiments in the controlled environment of an aviary. Rectrices replaced when the berries of Morrow's Honeysuckle were fed to the waxwings were orange-tipped, and those produced after a switch to a rhodoxanthin-free dog chow diet were yellow-tipped.

In the case of the Cedar Waxwing the tips of the rectrices are normally pigmented yellow by canary xanthophylls (McGraw *et al.* 2001). Rhodoxanthin is so closely chemically related to the canary xanthophylls that it can be deposited unmodified using the same chemical pathways that would normally mobilize and deposit canary xanthophylls. Research on erythristic Cedar Waxwings has revealed that reddening occurs only at the onset of feather growth, when rhodoxanthin (red) mixes with canary xanthophylls (yellow) to produce orange-

coloured tail tips. This type of diet-induced erythrism can only occur during a moult of feathers normally pigmented by carotenoids and when the diet contains rhodoxanthin or some other red carotenoid. The most common introduced source of rhodoxanthin is "bush" honeysuckles.

Juvenile Cedar Waxwings with orange tail bands have been noted commonly over the past four years of banding at TTPBRS. Many of these individuals were so recently fledged that it is almost certain they were born at Tommy Thompson Park where bush honeysuckles are abundant and widespread.

Figure 3: White-throated Sparrow with orange lores at TTPBRS, Toronto. ON, 1 October 2006. *Photo: Dan Derbyshire*

Cases of Diet-induced Colour Variation

Since the initial discovery of erythristic Cedar Waxwings, several other species have been described with aberrantly reddened plumage. Only those tracts of feathers that are yellow or orange, meaning they are pigmented by carotenoids, have been warmed or reddened. None of the unusually reddened feathers from species other than Cedar Waxwing have previously been formally tested for the presence of rhodoxanthin. The assumption has been that the aberrant colouration is related to rhodoxanthin in the diet.

After Cedar Waxwing, the species most frequently documented in the literature as exhibiting colour aberration believed to involve rhodoxanthin is White-throated Sparrow (*Zonotrichia albicollis*). The only area of bright yellow on White-throated Sparrow is the lores, and over the years there have been several published reports of the lores being orange. The earliest description in the literature of White-throated Sparrows with orange lores comes from New York state in 1994 (Brooks 1994). Other reports have come in from Michigan (Craves 1999) and Pennsylvania (Leppold and Mulvihill 2006). Single White-throated Sparrows with orange lores were banded at Tommy Thompson Park in the falls of both 2005 and 2006 (see Figure 3). The rate of incidence of erythrism in White-throated Sparrows at Tommy Thompson Park is much lower than in Cedar Waxwings (personal observation). Powdermill Nature Reserve in Pennsylvania has reported Kentucky Warblers and Yellow-breasted Chats with aberrant orange colouration

(Mulvihill *et.al.* 1992). Powdermill has also reported cases of erythrism in Scarlet Tanager and Yellow Warbler (Leppold and Mulvihill 2006). In all cases birds were moulting when honeysuckles were fruiting and available.

A New Species Involving Rhodoxanthin-induced Erythrism

Tartarian Honeysuckle and Morrow's Honeysuckle are common at TTPBRS and 2005 was a bumper year for the berry crop (Figure 4). Nest searching at Tommy Thompson Park during that summer revealed a Baltimore Oriole nest 15 metres above a dense patch of bush honeysuckles. Monitoring of this nest made it clear that these adults were relying on honeysuckle fruit as the primary food source for either the young, for themselves, or both. Feeding flocks consisting of waxwings, orioles, robins and other species were observed gorging on these berries during the first few weeks of August. These observations suggest that various species will feed heavily on honeysuckle fruit during both the breeding season and early autumn migration period. The period from late summer into fall is the time of active prebasic moult for most passerine species, including Baltimore Oriole. We cannot be certain that the unusually reddened Baltimore Oriole captured and banded on 22 August was reared

Figure 4: Honeysuckle berries at TTPBRS, Toronto. ON, in 2005. *Photo: Dan Derbyshire*

at Tommy Thompson Park, however, the necessary circumstances were in place for making that a strong possibility.

Parkes (1993) describes five instances of erythristic Baltimore Orioles from the northeastern United States. One is a bird he banded on Great Gull Island, N.Y., in 1985. His subsequent search for similarly affected specimens in museum collections turned up three more individuals in the American Museum of Natural History (AMNH 54807, 521485 and 789515). Two were collected in New York state, but AMNH 521485 lacks any collection data. His final instance is a bird banded at Block Island, R.I., in 1988. Parkes states that the aberrant colouration was likely diet related but did not have chemical analysis to confirm which pigments actually caused the reddening.

The story of aberrantly coloured orioles in Canada became more intriguing when further reports of "red" Baltimore Orioles surfaced in fall 2005 from Ste-Catherine, Quebec, and Halifax, Nova Scotia. The individual from Halifax caused a stir in the local birding community as the bird was first incorrectly identified as a Flame-colored Tanager. The trend continued in fall 2006, when two individuals from TTPBRS and as many as twelve individuals from McGill Bird Observatory in Montreal, Quebec, were captured, showing varying degrees of atypically warm plumage.

Unpublished results of chemical analysis, performed by Dr. J. Hudon of the Royal Museum of Alberta, show that rhodoxanthin was present in some of the feather samples collected at McGill Bird Observatory in 2006. Baltimore Oriole now joins Cedar Waxwing as the only North American species where aberrant colouration has been chemically proven to be the result of rhodoxanthin deposition. Note that this does not mean that every Baltimore Oriole with aberrantly reddened plumage necessarily obtained it through the ingestion of rhodoxanthin.

Conclusions

The emergence of orange-tailed Cedar Waxwings in the 1960s coincided with the rapid spread of bush honeysuckles at that time. The diet of Cedar Waxwing is more dependant on fruit than any other species in North America and, therefore, it is not surprising that they would take advantage of a new and readily available source of berries. What is surprising is the appearance (or at least documentation) in the early 1990s of colour aberration, postulated to be linked to rhodoxanthin, affecting other species such as White-throated Sparrow. The sudden appearance of "red" Baltimore Orioles in Canada in 2005 and 2006 is likewise mysterious. The Baltimore Oriole is a known frugivore, although their diet during the summer months relies more heavily on insects (Rising and Flood 1998). Knowing this, it is unclear as to why this species would suddenly appear with plumage

effects from deposition of rhodoxanthin roughly half a century later than the Cedar Waxwing. Since no feather samples were collected from the 2005 TTPBRS bird it cannot be proven that the cause of its aberrant colouration was the deposition of rhodoxanthin. However, the circumstantial evidence seems to point to this bird as the first documented example of rhodoxanthin-induced colour variation occurring in Baltimore Oriole in Canada. While that assertion can ultimately neither be proven or disproven, the 2005 TTPBRS bird did set in motion a chain of interest and research that resulted in the confirmation of rhodoxanthin-induced colour variation in a new species.

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