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Beak abnormality hinders provisioning ability and reduces body condition of a female house wren (*Troglodytes aedon*)

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Abstract

Beak abnormalities have been reported in a wide range of species but typically affect only a small portion (<1%) of wild bird populations. Most research has focused on the prevalence, morphology, and causes of beak deformities, resulting in relatively little information on the consequences of these deformities for individual birds. Birds with abnormal beaks likely struggle to feed themselves, a situation that can only be exacerbated during the breeding season when they must provide food for not only themselves but also their offspring. We captured a female house wren (*Troglodytes aedon*) with abnormal mandibles during the 2016 breeding season. The female was lighter and smaller than normal, and her clutch size smaller and incubation and nestling periods slightly longer than normal. Using video recordings at the nest, we found that early in the nestling period the female's provisioning rate was lower and her time spent brooding greater than normal, yet she succeeded in rearing a smaller-than-average brood. We conclude that the female's abnormal beak was a severe handicap negatively affecting both her condition and her provisioning ability; however, it did not preclude her from raising a brood of nestlings.

Keywords

abnormality; beak; deformity; parental provisioning; video recording

Beak abnormalities have been reported across a wide range of avian species (Pomeroy 1962, Craves 1994). Termed avian keratin disorder (Handel et al. 2010), abnormalities often occur as a result of rapid epidermal growth of the outer keratinized layer of the beak, the rhamphotheca (Pomeroy 1962), and may coincide with morphological changes to other keratinized tissues such as plumage, claws, and skin (Van Hemert and Handel 2010, Van Hemert et al. 2012). Beak deformities are typically rare (<1%) in wild bird populations (Pomeroy 1962, Tweit et al. 1983, Nogales et al. 1990, Rockwell et al. 2003), and most reports are of single individuals (Craves 1994). Recently, however, epizootics of beak

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deformities have occurred in resident species in Alaska (Handel et al. 2010) and in other regions of North America (Van Hemert and Handel 2010, Van Hemert et al. 2012).

A wide range of beak deformities have been reported, including crossed mandibles, elongation of the upper or lower mandible, upward and downward curving of the mandibles, locked mandibles, lateral curvature of mandibles, and irregular surface appearance, brittleness, and increased thickness of the rhamphotheca (Pomeroy 1962, Craves 1994, Van Hemert et al. 2012). The causes of such abnormalities are many and varied, including nutritional deficiencies (Harper and Skinner 1998), infections (Gartrell et al. 2003, Galligan and Kleindorfer 2009), environmental contaminants (Ludwig et al. 1996), genetic mutations (Møller et al. 2007), developmental abnormalities (Grant and Grant 2014, p. 237), and injuries (Pomeroy 1962).

Beak deformities likely pose great challenges to carrying out daily activities and can lower the chances of surviving. Compared with birds with beaks falling within the range of normal variation, those with deformed beaks typically spend more time foraging and struggle to pick up food items; typically they turn their heads laterally to one side or use a scooping motion to grasp items (Pomeroy 1962, Handel et al. 2010, Van Hemert and Handel 2010). Similar movements are used to drink water (Pomeroy 1962). An abnormal beak can also hinder preening, leading to poor plumage condition and the inability to remove ectoparasites (Pomeroy 1962, Clayton et al. 2005, Van Hemert and Handel 2010). Nonetheless, there are reports of birds with major deformities being in good condition (e.g., Fox 1952, Pomeroy 1962), and it is possible that abnormalities can even enhance foraging success (Carothers and Balda 1970) because birds are generally adept at modifying their foraging behavior (Thorpe 1956, Lefebvre et al. 1997).

There are few data on the association of beak deformities with an individual's ability to rear offspring. Because the range in type and size of prey that an individual with an abnormal beak can capture is likely different from that of normal individuals, we compare the condition, provisioning ability, and reproductive success of an adult (AHY), female house wren (*Troglodytes aedon*) with a deformed beak with that of normal females in the population.

Methods

Northern house wrens are small (10-12 g), insectivorous songbirds with a broad breeding range across the mid-latitudes of North America. The study population breeds in secondary deciduous forest in McLean County, Illinois, USA (40°665'N, 88°89'W), where nestboxes have been in place since 1980. House wrens readily accept these nestboxes as sites in which to build their nests, and ~95% of the nests on the study area occur in the nestboxes (Drilling and Thompson 1988). See Lambrechts et al. (2010) for additional information on nestbox dimensions and materials.

Egg-laying begins in late April or early May and continues to early August at the study site. There are 2 peaks of nest initiation, the early season (late April-early May) and the late season (late June-early July), and only the female incubates eggs and broods nestlings but

both parents deliver food to offspring during the nestling period (Bowers et al. 2016). Johnson (2014) provides additional details on house wren biology.

Each year, we capture and band most of the adults and all the nestlings that survive to leave the nest in the nestbox-breeding population. Females are typically caught around the mid-point of the incubation period. All adults and nestlings are banded with a numbered, aluminum U.S. Geological Survey band. Males are banded with 3 additional colored Darvic bands (total of 2 bands/leg) so that they can be identified without recapture. Adults and nestlings are weighed to the nearest 0.1 g using a digital scale (Acculab Pocket Pro PP 250-B, Edgewood, NY, USA or an AWS AC-100, American Weigh Scales, Cumming, GA, USA) and tarsus length is measured to the nearest 0.1 mm using dial calipers. Nestlings are weighed and measured on brood-day 11 (brood-day 0 is the day the first nestling hatches).

Although we were not recording provisioning behavior at any nests in 2016, given the rarity of beak deformities, we recorded provisioning behavior of the abnormal female on 3 days with either a Kodak PlaySport Zx5 digital camera or a Canon T6I camera. For comparison, we used provisioning data from unmanipulated broods in a previous study (Figure 2 in Bowers et al. 2014a). We placed a dummy camera ≈ 1.5 m from the nestbox 24h before the first filming session and left the dummy there throughout the nestling period, filming on brood-days 3, 4, and 13. Once the parents had resumed provisioning after the disturbance we caused by replacing the dummy with a camera (6.5 min or less in each of the recordings), we recorded provisioning behavior for 60 min on brood-days 3 and 13 and 36.8 min on brood-day 4. The abbreviated brood-day 4 recording resulted from human error, and rates were extrapolated to 60 min. Murphy et al. (2015) found that 60 min was adequate for characterizing provisioning rates over longer periods. The 3 recording sessions were each begun between 0800–0900 h CST. We consider a provisioning trip to be one in which a parent carrying prey returns to and enters the nestbox (or delivers food to the other parent or to a nestling within the nestbox) and brooding to occur whenever the female is out of sight within the nestbox. The remainder of all recordings beyond 60 min was viewed and additional behaviors of interest were noted.

Prior to the beginning of egg-laying and long before the abnormal female was caught, her nest was assigned to a treatment in a nestling cross-fostering experiment that involved supplementing females with 5 corticosterone- or vehicle-injected mealworms (*Tenebrio molitor*) before and during egg-laying (Weber et al. 2018). The abnormal female's nest was assigned to the vehicle-injected control treatment and 2 of her hatchlings were exchanged with 2 hatchlings from another nest on brood-day 2. Each nestling was toe clipped for individual identification. For this reason, we compare the abnormal female's reproductive success with that of other control females in the experiment (hereafter 'control' nests; Weber et al. 2018), as well as that of unmanipulated females that were contemporaneously active on the study area in the 2016 late season ('unmanipulated' nests; Poorboy et al. 2018). Reported values are means $\pm$ standard deviation. Videos were scored by CFT.

Results

On 09 July 2016, we first captured an incubating After Hatching Year (AHY) female house wren with abnormal upper and lower mandibles that differed markedly from those of a normal female (compare normal, Fig. 1A, with abnormal female, Fig. 1B). The abnormal female had a chipped and blunt lower mandible and an upper mandible that was considerably longer than the lower and had a slight upward curvature. The tip of the upper mandible's rhamphotheca was noticeably thicker than normal and ended in a pointed tip. Consequently, the upper and lower mandibles could not close completely. In addition, she was missing the claw on the third and fourth digits of her right foot (Fig. 2).

Reproductive success

The female paired with a Second Year (SY) male that had been reared on the study area the previous year. He was socially polygynous, although only the last 3 days of the abnormal female's nestling period overlapped with the first 3 days of the nestling period of the male's other social mate.

The clutch of 4 eggs that the female produced in the late season (first egg laid on 29 June) was smaller than the late-season 2016 average in our population (69 unmanipulated nests: 5.4 ± 1.34 eggs, mode = 6 eggs; 16 control nests: 5.6 ± 0.73 eggs, mode = 6 eggs); overall, only 15 of the 85 (17.6%) unmanipulated and control nests had a clutch size of 4 or fewer eggs. The incubation period was 14 d, only slightly longer than usual (47 unmanipulated nests: 13.3 ± 0.74 d, mode = 13 d; 16 control nests: 13.1 ± 0.93 d, mode = 13 d), and all eggs hatched and 2 nestlings were swapped for 2 from another nest on brood-day 2. The 4 nestlings (2 foster and 2 of her own) were alive on brood-day 4; however, 1 of the abnormal female's genetic offspring disappeared from the nest between brood-day 4 and 11. One of the abnormal female's 2 offspring that had been moved to another nest also disappeared between brood-day 4 and 11. Ten of the 64 (15.6%) unmanipulated and control nests had 1 nestling disappear between brood-day 4 and 11. The abnormal female fledged 3 nestlings (2 foster and 1 of her own), which is lower than the late-season average for all females (47 unmanipulated nests: 4.9 ± 1.27 nestlings, mode = 5 nestlings; 16 control nests: 5.2 ± 0.75 nestlings, mode = 5 nestlings) and for only those females with a clutch size of 4 in which all eggs hatched (5 unmanipulated nests: 3.8 ± 0.45 nestlings, mode = 4 nestlings; 1 control nest: 4 nestlings). The length of the nestling period was 16 d, again slightly longer than average (47 unmanipulated nests: 15.1 ± 1.28 d, mode = 15 d; 16 control nests: 15.1 ± 1.09 d, mode = 15 d).

Provisioning, brooding, and preening behavior

On brood-day 3, the female made 5 provisioning trips in 60 min (1.25 provisioning trips/nestling/h) and the male 11 trips (2.75 trips/nestling/h). On brood-day 4, the female again made 5 (extrapolated) trips in 60 min (1.25 trips/nestling/h) and the male 8.2 (extrapolated) trips (2.1 trips/nestling/h). Thus, on brood-days 3-4, the female made a mean number of provisioning trips of 5/h and the male 9.6/h. On brood-day 13, the female made 14 trips (4.7 trips/nestling/h) and the male 12 trips (4.0 trips/nestling/h). The male successfully transferred prey to the brooding female 5 times on brood-days 3-4 and failed once after

trying to transfer the prey item 3 times. On one occasion the female ate the prey the male brought and, on another, she flew off with the prey item. On brood-day 13, both parents passed food to the nestlings that were inside and near the entrance of the box. Both parents removed fecal sacs during all 3 nest-watches.

The female spent 61% of the time brooding (i.e., within the nestbox) on brood-day 3 and 85.5% on brood-day 4 (pooled total = 70.5%). Both days had a morning low temperature of $\approx 19^{\circ}\text{C}$, $\approx 2^{\circ}\text{C}$ above the long-term average (National Oceanographic and Atmospheric Association; Minonk, Illinois, USA). The female spent almost a minute preening her breast and once reached to her uropygial gland while standing on the nestbox lid on brood-day 13.

Female and offspring traits

The female was lighter (10.8 g) and smaller (tarsus = 17.9 mm) than average (58 unmanipulated nests: 11.9 ± 0.67 g and 18.5 ± 1.39 mm, respectively; 16 control nests: 12.4 ± 0.57 g and 18.7 ± 0.42 mm). The 1 genetic offspring in the nest of the abnormal female was the lightest and smallest nestling (mass 7.6 g, tarsus 17.3 mm) compared with the 2 foster nestlings (10.6 g, 17.7 mm and 9.8 g, 18.4 mm). In contrast, the abnormal female's offspring in the foster nest was the heaviest and largest (11.1 g, 18.8 mm) compared with that female's own offspring (10.8 g, 18.9 mm and 9.6 g, 18.3 mm). In the abnormal female's nest, her own genetic offspring was markedly lighter and smaller than that typically seen during the late season (225 nestlings in unmanipulated nests: 9.9 ± 0.84 g, 18.5 ± 1.39 mm; 83 nestlings in control nests: 9.8 ± 0.90 g, 18.7 ± 0.65 mm), whereas her offspring in the foster nest was strikingly heavier than average.

The female was not recaptured on the study area in 2017 or 2018. None of the nestlings reared in the female's nest or in the foster nest recruited to the breeding population in 2017 or 2018. Her 2016 mate did return to breed in 2017 but not in 2018.

Discussion

Although bill abnormalities have the potential to be advantageous under some circumstances (Carothers and Balda 1970), the female's body condition, length of the incubation and nestling periods, and her provisioning behavior, when considered together, suggest that her dramatic abnormality hampered her ability to obtain sufficient food resources for herself, but that it did not make it impossible for her to rear a brood of nestlings. The extreme type of bill deformity that we describe here is extremely rare in our study population, as this is the only adult reported with an obvious abnormality in over 10,000 adult house wrens banded between 1980 and 2016. Although uncommon, toes with missing claws have been reported over that same period (CFT, 1980-2016, unpubl. data).

In house wrens, both parents share the responsibility, although not always equally, of provisioning their altricial young (Bowers et al. 2014a). On brood-days 3-4, the male provisioned at a higher rate than the abnormal female, as is usual in the study population (see figure 2 in Bowers et al. 2014a). Although the number of trips by the male (9.6 trips/h) was similar to the 10 trips/h made to late-season broods with 4 nestlings in that earlier study, the mean number of the female's provisioning trips (5 trips/h) was considerably lower than

the 9 trips/h reported by Bowers et al. (2014a). Brood-day 4 is the time of maximum nestling growth and the amount of food provided at this time is correlated with nestling body condition near the time of fledging and the likelihood that a nestling will recruit as a breeder to future breeding populations (Bowers et al. 2014b). Two of the 4 genetic offspring produced by the abnormal female went missing after brood-day 4 (e.g., 1 of the 2 genetic offspring in the abnormal female's nest and 1 of the 2 genetic offspring in the foster nest). We suspect that most single-nestling disappearances in our population result from starvation and other causes unrelated to nest predators because predators typically take all the nestlings. Despite a reduction in provisioning trips made by the female, the condition of 2 of the 3 nestlings were comparable to that of other late-season nestlings, although her own genetic offspring was smallest in her nest but largest in the foster nest. Likely, sibling competition and lower-than-average provisioning rates by the abnormal female on brood-days 3-4 resulted in differences in nestling condition on brood-day 11 within the abnormal female's nest. On brood-day 13, the abnormal female's provisioning rate exceeded that of the male, which is typical late in the nestling period (e.g., DeMory et al. 2010; Bowers et al. 2014a).

The time spent brooding by the abnormal female in brood-days 3-4 was higher than that previously observed (70.5% vs. $\approx$ 49%) in our population (Dorset et al. 2017), which is probably responsible for the low provisioning rate by the female as provisioning rate and brooding time are often negatively correlated (Bowers et al. 2015). We think it unlikely that the female's brooding behavior was a response to adverse weather conditions as the low temperatures on brood-days 3-4 were slightly above the long-term average for those days. There was light, intermittent rainfall on the morning of brood-day 3, but light rain does not typically increase brooding and reduce provisioning (CFT, 1980-2016, pers. observ.) and her provisioning rate on brood-day 4 without rainfall was the same as the day before. Increased brooding may have been an attempt by the female to reduce her own energy expenditure to maintain body condition.

We conclude that her abnormal bill was indeed a handicap, likely in multifarious ways, both for herself and her nestlings, yet she successfully fledged a brood of nestlings. She likely had difficulty in securing prey for herself, which may have delayed her breeding attempt until other females were starting their second brood of the season and also led to her low mass, small size, small clutch size, and slightly longer than normal incubation and nestling periods. Her poor condition also likely led to her increased brooding time and low provisioning rate early in the nestling period. Also, the unusual difficulty she had in taking proffered prey from her mate suggests that she may have had difficulty placing food in her nestlings' mouths. However, given our limited data, we are unable to conclude that the female's handicap in foraging greatly affected her ability to rear at least a small brood of nestlings. The reason for the poor condition of her genetic offspring in her own nest is unknown, as the fostered offspring in her nest were of average size. Its poor condition could be attributable to underlying genetic defects, which is not precluded by the fact that its sibling in the foster nest was heavier and larger than its foster siblings.

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Literature cited

- Bowers EK, Bowden RM, Sakaluk SK, Thompson CF. 2015 Immune activation generates corticosterone-mediated terminal reproductive investment in a wild bird. *American Naturalist*. 185:769–783.
- Bowers EK, Grindstaff JL, Soukup SS, Drilling NE, Eckerle KP, et al. 2016 Spring temperatures influence selection on breeding date and the potential for phenological mismatch in a migratory bird. *Ecology*. 97:2880–2891. [PubMed: 27859132]
- Bowers EK, Nietz D, Thompson CF, Sakaluk SK. 2014a Parental provisioning in House Wrens: effects of varying brood size and consequences for offspring. *Behavioral Ecology*. 25:1485–1493.
- Bowers EK, Hodges CJ, Forsman AM, Vogel LA, Masters BS, et al. 2014b Neonatal body condition, immune responsiveness, and hematocrit predict longevity in a wild bird population. *Ecology*. 95:3027–3034. [PubMed: 25505800]
- Carothers SW, Balda RP. 1970 Abnormal bill of a Western Meadowlark, *Sturnella n. neglecta*. *Auk*. 87:173–174.
- Clayton DH, Moyer BR, Bush SE, Jones TG, Gardiner DW, et al. 2005 Adaptive significance of avian beak morphology for ectoparasite control. *Proceedings of the Royal Society of London, Series B*. 272:811–817. [PubMed: 15888414]
- Craves JA. 1994 Passerines with deformed bills. *North American Bird Bander*. 19:14–18.
- DeMory ML, Thompson CF, Sakaluk SK. 2010 Male quality influences male provisioning in House Wrens independent of attractiveness. *Behavioral Ecology*. 21:1156–1164.
- Dorset EE, Sakaluk SK, Thompson CF. 2017 Behavioral plasticity in response to perceived predation risk in breeding House Wrens. *Evolutionary Biology*. 44:227–239. [PubMed: 28736461]
- Drilling NE, Thompson CF. 1988 Natal and breeding dispersal in House Wrens (*Troglodytes aedon*). *Auk*. 105:480–491.
- Fox W 1952 Behavioral and evolutionary significance of the abnormal growth of beaks of birds. *Condor*. 54:160–162.
- Galligan TH, Kleindorfer S. 2009 Naris and beak malformation caused by the parasitic fly, *Philornis downsi* (Diptera: Muscidae), in Darwin's Small Ground Finch, *Geospiza fuliginosa* (Passeriformes: Emberizidae). *Biological Journal of the Linnean Society*. 98:577–585.
- Gartrell BD, Alley MR, Kelly T. 2003 Bacterial sinusitis as a cause of beak deformity in an Antipodes Island parakeet (*Cyanoramphus unicolor*). *New Zealand Veterinary Journal*. 51:196–198. [PubMed: 16032325]
- Grant PR, Grant BR. 2014 40 years of evolution: Darwin's finches on Daphne Major island. Princeton (NJ): Princeton University Press.
- Handel CM, Pajot LM, Matsuoka SM, Van Hemert C, Terenzi J, et al. 2010 Epizootic of beak deformities among wild birds in Alaska: an emerging disease in North America? *Auk*. 127:882–898.
- Harper EJ, Skinner ND. 1998 Clinical nutrition of small psittacines and passerines. *Seminars in Avian Exotic Pet Medicine*. 7:116–127.
- Johnson LS. 2014 House Wren (*Troglodytes aedon*). *The birds of North America online*. Number 380.
- Lambrechts MM, et al. 2010 The design of artificial nestboxes for the study of secondary hole-nesting birds: a review of methodological inconsistencies and potential biases. *Acta Ornithologica*. 45:1–26.
- Lefebvre L, Whittle P, Lascaris E, Finkelstein A. 1997 Feeding innovations and forebrain size in birds. *Animal Behaviour*. 53:549–560.
- Ludwig JP, Kurita-Matsuba H, Auman HJ, Ludwig ME, Summer CL, et al. 1996 Deformities, PCB's, and TCDD-equivalents in Double-Crested Cormorants (*Phalacrocorax auritus*) and Caspian Terns

- (*Hydroprogne caspia*) of the upper Great Lakes 1986-1991: testing a cause-effect hypothesis. *Journal of Great Lakes Research*. 22:172–197.
- Møller AP, Mousseau TA, de Lope F, Saino N. 2007 Elevated frequency of abnormalities in Barn Swallows from Chernobyl. *Biology Letters*. 3:414–417. [PubMed: 17439847]
- Murphy MT, Chutter CM, Redmond LJ. 2015 Quantification of avian parental behavior: what are the minimum necessary sample times? *Journal of Field Ornithology*. 86:41–50.
- Nogales MA, Martin A, Zino F. 1990 Bill malformations of juvenile Cory's Shearwaters (*Calonectris diomedea borealis*) on Selvagem Grande. *Bocagiana*. 139:1–5.
- Pomeroy DE. 1962 Birds with abnormal bills. *British Birds*. 55:49–72.
- Poorboy DM, Bower EK, Sakaluk SK, Thompson CF. 2018 Experimental cross-fostering of eggs reveals effects of territory quality on reproductive allocation. *Behavioral Ecology*. 29:1190–1198. [PubMed: 30214135]
- Rockwell RF, Pezzanite BM, Matulonis P. 2003 Developmental abnormalities in wild population of birds: examples from Lesser Snow Geese (*Chen caerulescens caerulescens*). *American Museum Novitates*. 3400:1–14.
- Thorpe WH. 1956 Records of the development of original and unusual feeding methods by wild passerine birds. *British Birds*. 49:389–395.
- Tweit RC, Burk KB, Russell SM, Truan JB II, Walters PM. 1983 Incidence of crossed bills in Inca Doves. *North American Bird Bander*. 8:12.
- Van Hemert C, Handel CM. 2010 Beak deformities in Northwestern Crows: evidence of a multispecies epizootic. *Auk*. 127:746–751.
- Van Hemert C, Handel CM, O'Hara TM. 2012 Evidence of accelerated beak growth associated with avian keratin disorder in Black-Capped Chickadees (*Poecile atricapillus*). *Journal of Wildlife Diseases*. 48:686–694. [PubMed: 22740534]
- Weber BM, Bowers EK, Terrell KA, Falcone JF, Thompson CF, Sakaluk SK. 2018 Pre- and postnatal effects of experimentally manipulated maternal corticosterone on growth, stress reactivity and survival of nestling house wrens. *Functional Ecology*. 32:1995–2007. [PubMed: 30344358]

A

B

FIG. 1.

House wrens with normal (A) and abnormal (B) beaks. Note the chipped tip of the abnormal-beaked female's bottom mandible and that the upper and lower mandibles do not close in B. Photos by CJH.

FIG. 2.
View of the abnormal-beaked female house wren that includes the bird's right foot with missing claws on the third and fourth digits. Photo by CJH.