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An Ethogram of Commonly Observed Behaviors of the Endangered Bridled White-eye (*Zosterops conspicillatus)* in a Zoo Setting

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ABSTRACT.—The Bridled White-eye (*Zosterops conspicillatus*) is a tropical Pacific passerine endemic to the Mariana Island chain. We present an ethogram of the *Zosterops conspicillatus saypani* subspecies in which we describe the 34 most commonly observed behaviors categorized into the categories sexual, parental, antagonistic, social, maintenance, ingestion/egestion, movement, vocalization, resting behavior, and zoo artifacts. This ethogram may be useful for behavioral studies of the Zosteropidae family and allow taxonomic comparisons. Understanding the behavior of this species might also aid in enhancing conservation efforts. In addition, this ethogram adds to the few behavioral inventories of passerine birds reported so far. *Received 24 September 2015. Accepted 12 January 2016.*

Key words: behavior, Bridled White-eye, ethogram, Mariana Islands, Passeriformes, Zosteropidae, *Zosterops conspicillatus*.

The Bridled White-eye (*Zosterpos conspicillatus*), hereafter BRWE, is a tropical Pacific passerine with three sub-species endemic to five islands in the Mariana Islands chain: Guam (*Zosterops conspicillatus conspicillatus*), Saipan, Aguigan, Tinian (*Zosterops conspicillatus saypani*), and Rota (*Zosterops rotensis*; Craig 1989). The BRWE *conspicillatus* subspecies was extirpated from Guam by the introduced brown tree snake (*Boiga irregularis*) in the 1980s (Craig 1989, Vogt and Williams 2004). The BRWE is sexually monomorphic, measures 10 cm from beak to tail, and has an olive-green back, head, and wings, a yellow underside, and a bright white eye ring (Vogt and Williams 2004). It is a gregarious forest species that forages primarily for insects, which it supplements with fruit, nectar, and occasionally seeds (Pratt et al. 1987, Craig 1989, Craig and Beal 2001).

The purpose of this study was to assemble a comprehensive ethogram of behaviors seen in captive BRWE and to put them in the context of previous records, especially those made in the wild. Detailed descriptions and classifications of behavior are important in order to standardize behaviors for use in quantitative studies and to prevent drifts in classification during studies (Hanlon et al. 1994, MacNulty et al. 2007, Lichtenberg and Hallager 2008, Gokula 2011). Ethograms can be used to develop hypotheses and provide direction for future research and are essential for more advanced behavioral studies (Hanlon et al. 1994, MacNulty et al. 2007, Gokula 2011). In addition, ethograms may aid in the conservation of endangered species by providing managers with a baseline of behavior. Managers can make comparisons among populations and assess behavioral responses to environmental change either intended for management or of concern (Howe et al. 2015). Understanding how a species interacts with conspecifics, heterospecifics, humans, and the environment is necessary to implement effective conservation both in situ and ex situ (Lichtenberg and Hallager 2008, Gokula 2011). This ethogram can aid future studies on BRWE and other Zosteropidae by providing researchers with precise behavioral definitions that can be used as standards leading to testable hypotheses, allow species comparisons, and provide a standardized set of behaviors against which managers can compare changes in behavior in response to management.

METHODS

The study was carried out by observing captive BRWE at the Toledo Zoo in Ohio from February 2012 to July 2013 and comparing behaviors to published data on wild BRWE and information

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gathered from other zoos. Birds were housed in an off-exhibit breeding center in two mixed species flight cages. One flight cage measured 4.57 by 2.44 by 2.44 m (27.20 m^3) and held three male and two female BRWE, two Mariana Fruit Doves (*Ptilinopus roseicapilla*), and two Turquoise Tanagers (*Tangara mexicana*). The second flight cage measured 2.29 by 2.44 by 4.42 m (24.70 m^3) and held two male and two female BRWE as well as two Spangled Cotingas (*Cotinga cayana*) and two Red-Crested Finches (*Coryphospingus cucullatus*). In the wild, BRWE encounter Mariana Fruit Doves but not the other species.

We assembled the ethogram based on written notes taken during direct observation and video recordings taken with a JVC HD Everio GZ-HD520 video camera (JVC KENWOOD Corp., Yokohama-shi, Japan). We used both ad libitum and focal animal sampling (Altmann 1974, Hage 1983, Hanlon et al. 1994, Schneider et al. 2006, Lichtenberg and Hallager 2008, Perera and Kotagama 2013). Focal animal sampling was used primarily for nesting behaviors. Attending parents were observed for 5-min intervals. When birds were not nesting, focal animals were chosen by observing each flock member for 5-min intervals as well. Behaviors were noted on paper throughout the study period. Observations took place between 07:00–17:00 hrs Eastern Time (ET) and were conducted for 1 hr per day at variable times to capture a greater range of diurnal behaviors. Food was placed in the exhibit at the beginning of the observation period when no chicks were present and at 07:00, 12:00, and 16:00 hrs when chicks were present. We also collected quantitative data on the frequency and time course of aggression and the involvement of both sexes in parenting (OS, unpubl. data).

RESULTS AND DISCUSSION

Our ethogram consists of the 34 most commonly observed behaviors divided into 10 functional categories (Table 1; video recordings can be found at www.youtube.com/playlist?list=PLuj56WX281ETLno30ro2RFZnPylvbHLmY). We observed a courtship display whereby a male presented a piece of nesting material to a female and fluttered his wings while making a whining call. Wing vibration during courtship displays is believed to be an ancient trait among passerines and is present in sparrows, warblers, swallows, and nuthatches, among others (Nice 1943, Andrew 1961). Craig (1989) observed BRWE in the wild to communicate with conspecifics by tilting the head, moving the head side to side, and flicking their wings. We observed a similar behavior to precede aggressive attacks. Likewise, Craig (1989) observed this behavior prior to mobbing. The mechanisms of courtship and aggressive displays are believed to have similar origins within passerines (Andrew 1961).

Given that only three BRWE chicks have fledged in any captive breeding program to date, we were lucky to observe five parental behaviors during our observations. Both sexes in each pair participated in all of these behaviors. Studies of wild BRWE have documented pairs of adults incubating eggs, brooding nestlings, sanitizing the nest, and feeding nestlings, though sexes were not determined. Simultaneous nest building by two BRWE was not observed by Amidon et al. (2004), but the authors note that in most species of white-eyes studied to date both sexes have been observed to participate in nest construction, which is consistent with our results. Nest construction and parental care by both sexes is common in monomorphic passerines (Nice 1943).

We frequently observed BRWE to engage in aggressive interactions in our study. Contrary to this, Craig (1989, 1990, 1996, 2002) observed little aggression in wild birds. In his studies, territoriality was only observed in the immediate vicinity of nests and in the context of food access where aggressive encounters involved displacement, though birds did remain in a home range. We observed similar aggressive displays in our captive birds in the same contexts but to an apparently heightened extent. Zoo environments are known to increase aggression in social species (Glatston et al. 1984). For example, captive Zebra Finches (*Taeniopygia guttata*), a highly gregarious species, showed increased aggression levels as their enclosures decreased, especially during the breeding season and near nests (Poot et al. 2012). Our flights measured 27.20 m^3 and 24.70 m^3 and housed five and four BRWE, respectively. Birds were nesting throughout the study period (Feb 2011 to Jul 2012) with the exception of August 2011 and May 2012. The high aggression levels observed in our study might, therefore, be related

TABLE 1. Descriptions of behaviors exhibited by captive Bridled White-eyes.

Functional category	Behavior	Description
Sexual behavior	*Courtship display*	Male presents a piece of nesting material in his beak to the female and flutters his wings quickly.
	Courtship	The male allopreens the female, focusing efforts around the neck, head, contour feathers, hind-flanks, and tail.
	Copulation	Male preens female then rapidly mounts her back, balancing himself with his wings, and lands on her other side.
Parental behavior	*Nest building*	Birds build an open cup nest. Construction begins by both male and female making loops out of long fibrous materials such as coconut fibers and weaving these into a base. Once the base is made, the male and female take turns sitting inside the nest and weaving small cotton like material through the gaps.
	Incubation	Male and female alternate. Typically one bird at a time sits in the nest to keep the 1–3 eggs warm for development. Birds begin by approaching the attending parent who is sitting on the egg. The attending mate leaves once its social partner is within several inches of the nest. The newly incubating bird adjusts the egg with its beak; fluffs its breast, belly, and flank feathers; and settles its brood patch over the egg.
	Brooding	Both sexes participate. Attending parents take turns keeping the chick warm. The brooding parent does not leave until the other comes within close proximity to the nest. The newly brooding bird adjusts the chick with its bill; puffs its breast, belly, and flank feathers; and settles its brood patch over the chick. The brooding bird adjusts by shifting side to side several times. Birds stay alert with heads upright and eyes open.
	Nest maintenance	Both sexes participate. Using their beaks, the attending parents grab fecal pellets out of the nest and move them elsewhere, typically during feeding times.
	Chick-feeding	Both sexes participate. Attending parents prepare (see food preparation) live waxworms and maggots and bring them whole and place the food in the chick's mouth. Parents also deliver smaller items to the chick such as fruit flies, bean beetles, and fruit pulp.
Antagonistic behavior	*Threat display*	The territory holder faces the intruding bird, stretches out straight with smoothed head feathers, holds wings down while flitting them, and vocalizes with cheeps. Only males were observed giving threat displays.
	Displacement	Bird flies directly towards another bird in a rapid, straight flight causing the other bird to fly away without a fight. Both sexes were observed displacing other birds.
	Fight	Birds make physical contact by bumping breasts and biting each other. During the altercation, one bird may be pinned down against a branch. Both sexes were observed engaging in fights.
	Withdrawal	Bird retreats when attacked.
Social	*Allopreening*	One bird grooms another bird with its beak, typically focusing around the neck and head, but also around the legs, flanks, and vent. Recipients move their heads to either facilitate preening or evade the bill of the preener. This occurs typically by bending the head away, turning the head away, or pointing the bill upwards with erected feathers. The bird being allopreened typically has its eyes closed.
	Sharing	On one occasion we observed a bird preparing a wax worm and giving it to another flock member. More frequently we observed birds sharing nesting materials by presenting materials in the beak. We observed birds sharing nesting materials with flock members that were not social partners during periods when birds were not nest building in addition to partners sharing nesting material during nest construction.

TABLE 1. Continued.

Functional category	Behavior	Description
Maintenance	*Autopreening*	Bird smooths and cleans with its beak its own wings, throat, vent, and area around the legs. The neck and abdomen are tended to by bending the neck backwards and approaching from above. The breast is groomed by bending the head downwards. The top of the wing is smoothed and cleaned by outstretching the wing and bending the head sideways and approaching from above. The underwing is groomed by lifting the wing and approaching from underneath.
	Bathing	Birds flutter on leaf petioles while it rains.
	Sun bathing	Birds sit near the heat lamp, puff, and preen themselves.
	Scratching	Birds use indirect scratching where one wing droops and the foot on the same side is brought over the shoulder to scratch the head.
	Stretching	A bird fans its tail and extends one leg and wing contralaterally then extends the opposite wing and leg after retracting the first. In another variation the bird pulls its wings together along the back.
	Body fluffing/ feather settling	Feathers are erected from the head downwards towards the vent then smoothed down rapidly.
Ingestion/egestion	*Foraging*	Birds either search for food on the ground (ground foraging) or perch glean (Craig 1989). In ground-foraging the bird walks, hops, runs, or stands on the ground to find prey. Perch-gleaning occurs when a bird grabs prey from a foraging surface while perched (Fitzpatrick 1980). Birds move rapidly while perch-gleaning by short hops or flights.
	Food preparation	Wax worms are held in the beak and beaten on branches with lateral head movements. Birds run wax worms through the beak sideways to kill and soften the prey. Sometimes prey is abandoned after preparation.
	Eating	Food items are grasped in the beak, the head is lifted, and the food item is consumed. Fruits are consumed while perched rather than while hovering. On occasion birds were seen to hang upside down to eat fruits.
	Drinking	The bird lowers its beak into water or nectar and tilts its head upwards to swallow. The pattern is repeated several times. Birds may also drink rain water off of objects.
	Bill wiping	Bird rubs both sides of its bill on a branch.
	Defecation	Vent feathers and undertail coverts are puffed and body leans forward as feces are passed.
Movement	*Flight*	The bird uses short and rapid wing strokes to move through the air from one place to another.
	Hopping	The bird moves from one place to another by propelling itself with its feet.
Vocalizations	*Singing*	Males sing with their throats puffed. Bridled White-eyes have one song type. Pratt et al. (1987) described the song as a series of rolling chirps comprised of a high-pitched *tszeeip*. (Sound recordings can be found at macaulaylibrary.org/.)
	Other	A *chit-chit* call is used for flock communication. Whining calls accompanied males soliciting females and during aggressive displays. A scolding alarm-call is often used in response to attackers (Marshall 1945, Craig 1989, Craig 1996).
Resting	*Roosting*	Birds sit together to rest after bathing or preening for periods of around 5 min. Birds tuck their heads, close their eyes, and perch on one foot.
	Perching	The bird rests on a branch with breast feathers puffed but remains alert with open eyes.
	Panting	Bird breathes with an open beak while perching.
Zoo artifacts	*Cage stereotypy*	Bird flies in repetitive, invariant movements between the sides of the flight. In between flights, bird perches momentarily onto the wire siding before flying back to the other side of the flight. During flying and perching, the bird periodically emits a *chit-chit* call.

to insufficient space during nesting. Though nesting densities of wild BRWE have not been reported, closely related wild Capricorn Silvereyes (*Zosterops lateralis chlorocephala*) have average territory densities of 1 pair/30.72 m^2 during the breeding season (Catterall et al. 1982) compared to the vastly increased density in our study of 1 pair/ 2.66 m^2.

Allopreening is a commonly occurring behavior in all described members of the Zosteropidae family (Harrison 1965). We frequently observed allopreening during our study period, especially after bathing. Birds regularly preened social partners and other conspecifics. Males allopreened females, females allopreened males, males allopreened males, and females allopreened females, and sometimes two birds allopreened the same individual at the same time. During courtship, males were seen to allopreen females. Males have been reported to solicit allopreening from females during pair-formation in other members of the *Zosterops* genus (Harrison 1965). The BRWE in our study exhibited nearly identical patterns to those Harrison (1965) described for the Cape White-eye (*Zosterops virens*) and Oriental White-eye (*Zosterops palpebrosus*), suggesting that allopreening might be relatively uniform within the genus.

We frequently observed solitary maintenance behaviors such as autopreening, bathing, and scratching in the BRWE. In contrast to our study, Verbeek (1991) observed silvereyes (*Zosterops lateralis*) bathing in shallow water. We provided two 20-cm water bowls, but our birds were never observed to bathe in pools of water. Instead, they bathed frequently when we turned on misters. Birds only bathed for a few seconds at a time by fluttering on leaves but returned repeatedly to bathe more. Areas to bathe were limited, and birds frequently displaced each other. Bathing in wet foliage has been observed in many tropical species, and possibly assists in feather maintenance (Pettingill 1970). We often observed sun bathing after rain bathing, possibly to dry feathers. Sun bathing has been noted to be important in thermoregulation and feather care in various bird species ranging from mousebirds (Coliidae) to vultures (Cathartidae) (Kennedy 1969, Perera and Kotagama 2013). BRWE also exhibited indirect scratching. Head scratching allows feather maintenance in areas birds cannot reach with their bills (Pettingill 1970).

We were interested in captive feeding behaviors and dietary preferences (OS, unpubl. data). We provided BRWE with waxworms, mealworms, fruit flies, pinhead crickets, adult crickets, and maggots in addition to two pellet mixtures, nectar, and daily enrichment fruit. Occasionally we observed BRWE foraging for ants on the floor. The birds in our study appeared to prefer waxworms and fruit flies to other provided foods but also ate the pellet mixtures, nectar, and fruit. Craig (1990) reported that BRWE on Saipan fed on insects, flowers, nectar, and fruit. Marshall (1949) reported BRWE on Saipan, Tinian, and Guam to eat primarily berries measuring 4.5 mm in diameter, which they swallowed whole and supplemented with caterpillars, ants, and occasionally grasshoppers and snails. In contrast, on Guam, Jenkins (1983) only observed BRWE feeding on insects to suggest the importance of insects to the birds' diets. These differences might be caused by differences in time (seasons) and location. Marshall (1949) and Jenkins (1983) conducted observations year-round, whereas Craig (1989) only conducted observations in January and February during the colder and drier season on the Mariana Islands. Furthermore, Craig (1989) restricted his observations to native limestone forest and groves of tangantangan (*Leucaena leucoephala*), while Marshall (1949) and Jenkins (1983) conducted observations throughout the islands.

Craig (1989) and Marshall (1949) observed BRWE to occasionally hover and sally when chasing invertebrates. We did not observe this behavior, possibly because of a lack of flying insects in our flights. Captive environments are poor in potential prey organisms for insectivores, and commercial availability is not adequate to provide the variety encountered in the wild (Hayes et al. 1998). We frequently observed birds wiping their bills after eating fruit or insects. Bill-wiping is a behavior reported in many avian orders and serves to clean and hone beaks (Nice 1943, Clark 1970, Cuthill et al. 1992).

Behaviors such as cage stereotypies were often observed in our study. Cage stereotypies may be assumed when an animal moves along a precise and invariable path within a cage (route tracing) or when an animal repeatedly touches a particular spot (spot-picking; Keiper 1970). Cage stereoty-

pies develop when the environment of a captive animal provides little stimulation, restrains natural movements, restricts its home range, or causes an inability to escape from fear (Carlstead 1998). Aggression from conspecifics may further increase stereotypic behaviors. We used misting and an alternating insect and fruit feeding schedule as enrichment, but birds may have needed additional enrichment. Craig (1989) reported flocks of 10–40 BRWE on Saipan, and Marshall (1949) reported flocks of up to 50 BRWE. One of our flight cages held five BRWE while the other held four, each with four members of other species. Our cages and group sizes may have been too small to reduce aggression, allow more natural behaviors, and avoid stereotypies. Cage stereotypy has been successfully reduced in Eurasian Blue Tits (*Cyanistes caeruleus*) and Marsh Tits (*Poecile palustris*) by moving birds outdoors in the summer into larger flight cages with more vegetation and conspecifics (Garner et al. 2003). Stereotypy has been reduced in Atlantic Canaries (*Serinus canaria*) through addition of novel objects such as mirrors, placing caged individuals in close proximity, and through increasing group size (Keiper 1970). Stereotypy may be reduced in captive BRWE by moving birds to larger flights with larger flock sizes, more vegetation, and more opportunities for natural foraging behaviors.

Detailed descriptions of behavior are important for quantitative analyses of behavior, taxonomic keys for species identification, and comparing characters for phylogenetic studies (Hanlon et al. 1994, MacNulty et al. 2007). Zoos allow observation of some behaviors that are hard to observe in the wild (Irvine 2013). Perhaps most importantly, understanding the behavior of captive animals can aid breeding programs of endangered species (Hage 1983). We were able to observe and describe a variety of behaviors to build a comprehensive ethogram, and we hope that it will be used to improve captive conservation programs for BRWE and serve as a model for future behavioral and taxonomic studies.

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Two Species of Tanagers (Passeriformes: Thraupidae) Forage on Army Ant Workers (*Eciton burchellii*) carrying Immature Paper Wasps.

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ABSTRACT.—*Eciton burchellii* is a Neotropical army ant that consumes a variety of arthropods captured during swarm raids. Wasp larvae and pupae provide an important food source for *E. burchellii*, and this ant species is thought to be a major predator on immature wasps in many Neotropical areas. Some birds also prey on wasp brood. Numerous bird species regularly follow *E. burchellii* swarms but are thought to typically avoid eating army ants. Rather, the birds feed on the arthropods that the ant swarms flush from the leaf litter. I report observations of ant-following birds, the Gray-headed Tanager *Eucometis penicillata* and the Flame-colored Tanager *Piranga bidentata* consuming *E. burchellii* workers that were carrying Polistinae wasp larvae and pupae. It has been suggested that ant-following birds may impose a cost to army ants by consuming arthropods and competing with ants for food resources. Also, it has been speculated that army ants emigrate at night to avoid the loss of their brood to birds, but lack of direct observations of birds attacking ants for their brood makes this claim unsubstantiated. My observations of birds consuming wasp pupae and larvae being carried by *E. burchellii* are evidence of rarely observed direct stealing of prey and loss of ant foragers to ant-following birds. These observations suggest that birds would also eat the larvae and pupae of army ants if

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