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Estimate of *Trichomonas gallinae*-induced Mortality in Band-tailed Pigeons, Upper Carmel Valley, California, Winter 2006–2007

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ABSTRACT.—Band-tailed Pigeons (*Patagioenas fasciata*) wintering at Hastings Reservation in central coastal California during winter 2006–2007 died in large numbers between January and March 2007. Laboratory analysis of carcasses indicated that *Trichomonas gallinae* was responsible for the die-off. During the height of the die-off, a survey of 2.5 km of suitable riparian habitat resulted in 373 pigeon carcasses being found. Based on a subsample of carcasses, mean turnover rate was 2.8 days with a 95% confidence interval of 2–10 days. Extrapolating to suitable habitat over the 52.7-km^2 study area resulted in a conservative estimate of 43,059 dead pigeons, assuming a conservative carcass turnover rate of 10 days. This estimate of mortality is nearly three times the largest trichomoniasis mortality event previously recorded for Band-tailed Pigeons and at least twice the number harvested annually in the United States. Local mortality of pigeons in Monterey County, California may have been several times this estimate based on the presence of considerable similar habitat in the nearby Ventana Wilderness. *Received 27 July 2007. Accepted 14 December 2007.*

Band-tailed Pigeons (*Patagioenas fasciata*) range from Alaska into South America and are seasonally migratory on the Pacific Coast (Keppie and Braun 2000). Most large flocks wintering in central coastal California depart in late April, arriving in British Columbia in May (Keppie and Braun 2000). At Hastings Reservation in the upper Carmel Valley, Monterey County in central coastal California, pigeons are most numerous in winter and fluctuate among years (Davis et al. 1980). From October 2006 to March 2007 large flocks were present feeding largely on coast live oaks (*Quercus agrifolia*) acorns, many of which were still present on a small number of trees throughout the winter. Although a few dead birds are found in most years when pigeons are abundant, unusually high mortality was noted starting in January 2007 with many chronically sick birds observed that were unable to fly and dying.

Band-tailed Pigeons in California and elsewhere are known to have significant mortality due to infections of *Trichomonas gallinae* (Stabler and Braun 1975, 1979; Cole 1999). Our objectives in this paper are to report on the causes of the observed pigeon mortality and present an estimate of the number of pigeons involved.

METHODS

We documented mortality of Band-tailed Pigeons in the vicinity (36° 23′ N, 121° 33′ W) of Hastings Reservation in upper Carmel Valley, California where elevation ranges from 310 to 1,100 m. Pigeons moved widely during the day over a larger area, but roosting at night was usually along riparian corridors. Dead and dying birds were regularly found in these riparian corridors from early January to late March 2007.

Estimating the number of dead pigeons required several steps. First, three observers walked a 2.5-km census transect on Hastings Reservation along Robertson Creek on 7 February 2007 searching the ground on both sides of the creek for fresh pigeon carcasses. Patches of fresh, dry feathers from birds recently depredated, dead birds, and still alive but nonvolant individuals were mapped using handheld GPS units and coordinates were taken for each bird. These data were transformed to distances from a central axis for use with the program DISTANCE® (Thomas et al. 2006) to calculate sample estimates and the effective strip width of the sampling transect.

Second, we estimated the carcass decomposition (turnover) rate by surveying a 1.4-km

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stretch of dirt road paralleling Robertson Creek at the Hastings Reservation over 18 days (8–26 Feb 2007). Thirteen marked birds, visible from the road, were checked each day until a carcass was removed by scavengers or the feather pile became indiscernible because it was matted and reduced by rains. We calculated the mean decomposition time (time until they would no longer be counted as present) of these 13 birds using Kaplan-Meier survival analysis (SPSS 2000) and used the upper bound of the 95% confidence interval of mean survival time to calculate a conservative estimate of carcass turnover time.

Third, an estimate of the total riparian areas used by pigeons for roosting at night and at a similar elevation to the Robertson Creek site examined in the first step was obtained using GIS layers in ArcGIS (ESRI 2007). All contiguous stream courses fitting our criteria within the larger study area, supported with observations of dead or dying pigeons in their vicinity, were identified and the area along them was buffered with a 56.4-m strip (based on the effective strip width from program DISTANCE®, as detailed below) to calculate area. We did not include the high, dry, south-facing streambeds of the watershed as these areas are dominated by relatively short shrubs, lack tall oak trees, and are rarely used by Band-tailed Pigeons. Informal telephone interviews with land managers of the nearby U.S. Forest Service and private lands confirmed the presence of many dead and dying Band-tailed Pigeons within the study area.

We conservatively estimated the period during which mortality occurred to be 60 days (15 Jan to 15 Mar). The total number of Band-tailed Pigeons carcasses occurring during this time period within the study area was estimated using the formula below.

$$\text{Total pigeon carcasses} = D \cdot RA \cdot (1/MST) \cdot P,$$

where D = the density of pigeons (carcasses/ha) in the Robertson Creek census transect, RA = the total estimated riparian area within the study area, 1/MST is the turnover rate of dead carcasses (the inverse of the upper bound of the 95% confidence interval of mean survival time [MST]), and P = the length of the period during which pigeon mortality was significant.

The California Animal Health and Food Safety Laboratory System (CAHFS) and R. W. Gerhold, Wildlife Disease Section, University of Georgia, Athens, Georgia, evaluated the dead pigeons; the latter used an Inpouch TriTrichomonas Test pouch kit (Cover et al. 1994). Samples were collected at several times during the study and pigeons consistently showed diagnostic symptoms of infection by *T. gallinae* (caseous, obstructive lesions within the upper areas of the digestive tract; Cole 1999). Freshly dead pigeon carcasses (25) were collected, frozen, and deposited in the Museum of Vertebrate Zoology, University of California, Berkeley.

RESULTS

All Band-tailed Pigeons found dead or dying had clinical signs of trichomoniasis including low body weight, listlessness, caseous or cheesy, yellowish lesions in the mouth, throat, and around the beak, and tendency to fall over when forced to move (Stabler and Braun 1975, 1979; Cover et al. 1994). Laboratory test results were positive for *Trichomonas gallinae* and negative for West Nile virus (R. W. Gerhold and K. D. Hanni, pers. comm.).

We counted 373 dead pigeons over the 2.5-km transect surveyed along Robertson Creek on 7 February 2007. Based on the GPS coordinates of the birds, DISTANCE® calculated an effective (one-half) strip width of 28.2 m (μ in Buckland et al. 1993). We therefore used 56.4 m as the ArcGIS buffer function to calculate the area of the survey transect along the winding riparian corridor, producing an estimated density of dead birds of 26.45 birds/ha. We estimated 271.3 ha of comparable riparian habitat within the larger 52.7-km^2 study area. Assuming densities of dead birds comparable to that found on the transect conducted at Hastings, this yields a total of 7,177 pigeon carcasses detectable at any one point in time along the riparian corridors of the study area.

We observed relatively high densities of feral pigs (*Sus scrofa*), coyotes (*Canis latrans*), and raptors including Barn Owls (*Tyto alba*), Red-tailed Hawks (*Buteo jamaicensis*), and Cooper's Hawks (*Accipter cooperii*) in the census transect. Unsurprisingly, this resulted in relatively rapid estimated carcass turnover times. The mean time to carcass decomposition was 2.8 days with a 95% confidence interval of 2–10 days based on Kaplan-Meier survival analysis of 13 marked carcasses checked over an 18-day period in February 2007.

We assume the death rate was constant over the peak of the mortality event. The number of dead individuals was conservatively estimated to have turned over at least six times yielding a total estimate of 43,059 dead pigeons within the total study area during the 2-month period of peak mortality.

DISCUSSION

Mortality attributable to *T. gallinae* during winter 2006–2007 was high relative to other major causes of mortality of Band-tailed Pigeons. The estimated numbers of this species harvested over their entire range in the United States for 1999, 2000, 2004, and 2005 averaged 20,550 per year (USDI 2006a, b). Epizootic trichomoniasis in Band-tailed Pigeons has been reported previously (Cole 1999) with the largest prior estimate of mortality being 16,000 pigeons. A series of reports of trichomoniasis in Band-tailed Pigeons from northern California (USGS 1995, 2004, 2006) estimated 2,000, 2,000, and 300 deaths, respectively.

Our survival analysis assumes that mortality was constant over the period considered. It is possible, however, that we missed the period of peak mortality, as we did not immediately recognize the severity and extent of the die-off, and were spurred to conduct quantitative sampling some time after peak mortality may have occurred.

It is also likely the mortality extended much farther than we were able to confirm. U.S. Forest Service employees were not available to conduct searches for pigeons along the riparian areas in the nearby Ventana Wilderness, a large (~3,500 km^2) mostly inaccessible area that is similar to the habitat at Hastings Reservation. Mortality may also have extended well into the upper Carmel and Arroyo Seco watersheds of the Ventana Wilderness where large flocks of Band-tailed Pigeons are common in winter (Roberson and Tenny 2002). Thus, the total number of birds affected by the event within Monterey County may have been several times our estimate of ~43,000 birds.

The mortality event reported here is far in excess of what has been previously observed and is far more significant than hunting mortality over the species' North American range. Despite the die-off, flocks of pigeons remained common through late March within the study area.

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Winter Ecology of Yellow Rails Based on South Carolina Specimens

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ABSTRACT.—Arthur T. Wayne collected 58 Yellow Rails (*Coturnicops noveboracensis*) during seven winters between 1903 and 1918 at one locality on the Atlantic coast in Charleston County, South Carolina. The collection represents the largest known series of Yellow Rails from a single wintering site and provides information about the winter ecology of this species. There was no evidence that Yellow Rail numbers varied between winters. The sex ratio was significantly biased toward females suggesting the occurrence of differential wintering. Yellow Rails were collected mainly in wet (freshwater) fields with short dense grass, the same features of Yellow Rail habitats in coastal Texas. Yellow Rails were consistently located in the same habitats as LeConte's Sparrow (*Ammodramus leconteii*). Two other grassland species, Henslow's Sparrows (*A. henslowii*) and Sedge Wrens (*Cistothorus palustris*), had habitat occupancy patterns significantly different from that of Yellow Rails. *Received 6 June 2007. Accepted 21 November 2007.*

The Yellow Rail (*Coturnicops noveboracensis*) has been studied in breeding areas (Peabody 1922, Terrill 1943, Stalheim 1974, Anderson 1977, Bookhout and Stenzel 1987, Gibbs et al. 1991, Robert and Laporte 1999, Popper and Stern 2000, Robert et al. 2000) and in captivity (Stalheim 1975). Historically, migratory populations of the Yellow Rail occupied a discontinuous breeding range from the Northwestern Territories to New Brunswick, Canada, south to the latitudes of Connecticut and Oregon, USA (Bookhout 1995), and wintered primarily on the coastal plain from North Carolina to Texas. Most information about the species in winter is from studies conducted on the Gulf coast of Texas (Grace et al. 2005), and little is known about Yellow Rails overwintering on the Atlantic coast. A series of 58 specimens collected at one locality in South Carolina between 1903 and 1918 provides information about patterns of occurrence, habitat use, and sex ratios in winter. The objective of this paper is to compare these data with that available from other areas of its wintering range.

METHODS

This paper is based on the field work of Arthur T. Wayne who, in 1903–1913, collected 56 Yellow Rails in Charleston County, South Carolina. I examined 36 of the skins and confirmed the information on their labels accurately reflected entries in his specimen ledgers, which are archived at the Charleston Museum. Additional data were contained in Wayne's correspondence and published papers. These sources provided the gender, collection date, and collection location of each specimen. The skins are not accompanied by habitat information, but Wayne recorded the name of the field where each bird was collected, and his letters and articles contained descriptions of the fields. I assume that each of Wayne's collecting trips involved about the same amount of time. He usually worked at one location each day and took 3–4 speci-

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