IJP: Parasites and Wildlife 7 (2018) 261–267

Contents lists available at ScienceDirect

IJP: Parasites and Wildlife

journal homepage: www.elsevier.com/locate/ijppaw

Avian trichomonosis mortality events in band-tailed pigeons (*Patagioenas fasciata*) in California during winter 2014–2015

Krysta H. Rogers[a,*], Yvette A. Girard[b], Leslie W. Woods[c], Christine K. Johnson[b]

[a] Wildlife Investigations Laboratory, California Department of Fish and Wildlife, 1701 Nimbus Road, Suite D, Rancho Cordova, CA, 95670, United States
[b] Karen C. Drayer Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, 1089 Veterinary Medicine Drive, Davis, CA, 95616, United States
[c] California Animal Health and Food Safety Laboratory, University of California, Davis, 620 West Health Sciences Drive, Davis, CA, 95616, United States

ARTICLE INFO

Keywords:
Avian trichomonosis
Band-tailed pigeon
Epidemic
Trichomonas gallinae
ITS1/5.8S rRNA/ITS2
Fe-hydrogenase

ABSTRACT

Avian trichomonosis is an upper digestive tract disease of birds typically caused by the protozoan parasite *Trichomonas gallinae*. In California (U.S.A), trichomonosis is known to cause periodic epidemics in the Pacific Coast band-tailed pigeon (*Patagioenas fasciata monolis*), a migratory upland game bird. We summarize the mortality events that occurred during winter 2014–2015 including the duration, estimated mortality, pathology, and genetic identity of infecting parasites. Increased mortality was reported from locations in 25 counties between November 2014 and June 2015. Based on reports, carcasses received, wildlife rehabilitation center admissions, site visits, and regular monitoring by local personnel, total mortality was estimated at 18,440. At necropsy, birds had multiple coalescing lesions in the oral cavity involving the upper palate and/or around the tongue and glottis, esophagus, crop, and/or proventriculus. Birds collected from Contra Costa (63.9%; 30/47); Marin (75.0%; 6/8), San Mateo (46.7%; 14/30), and Santa Clara (35.0%; 37/106) counties were more likely to have lesions extending into their head involving muscle, sinuses, ear canals, eye sockets, and bone ($\chi^2 = 62.9$; $df = 11$; $P < 0.001$). Histopathologic findings included pharyngitis, esophagitis, myositis, and air sacculitis of the pneumatic bone of the skull. Mixed bacterial colonies were found multifocally at the fronts of the necrosis in six of the eleven birds examined histologically. Infecting trichomonads included *T. gallinae* subtype A2 (n = 5), un-typed *T. gallinae* (n = 4), mixed infection with *T. gallinae* subtype A2 and *T. stableri* (n = 1), and mixed infection with un-typed *T. gallinae* and *T. stableri* (n = 1). The winter 2014–2015 epidemic was the largest on record in terms of duration, locations, and birds affected. Infection dynamics may have been exacerbated by the drought in California. Increased monitoring of band-tailed pigeons is needed to understand the long-term impacts of large-scale mortality events on their population.

1. Introduction

Avian trichomonosis is a disease caused by a protozoan parasite affecting a diverse array of species with columbids being especially susceptible (Forrester and Foster, 2008). The parasite most frequently isolated from infected birds is *Trichomonas gallinae* of which 15 different subtypes have been identified based on the internal transcribed spacer (ITS) region (Gerhold et al., 2008; Grabensteiner et al., 2010). Further genotyping of *T. gallinae* strains can be accomplished by sequencing the hydrogenosomal Fe-hydrogenase gene (Lawson et al., 2011; Chi et al., 2013). Infection can range from subclinical in carrier birds, to the development of caseonecrotic lesions in the upper digestive tract and death. Birds become infected by ingesting contaminated water or food while adult columbids can directly infect their chicks when feeding them crop milk (Forrester and Foster, 2008). Once infected, the parasite multiplies rapidly in the oral cavity invading the mucosa leading to parasite-mediated desquamation and development of lesions (Kietzmann, 1993). Infected birds typically become emaciated as the lesions block the passage of food and eventually die from starvation or suffocation if the lesions block the airway (Forrester and Foster, 2008). As such, sick birds are often weak and reluctant to fly, have difficulty swallowing and exhibit labored or open-mouth breathing with death occurring typically 10–14 days post-infection (Stabler, 1947; Perez-Mesa et al., 1961). While the death of an individual bird from trichomonosis may occur any time of the year, epidemics or mortality events tend to have a distinct seasonality within an avian species, typically coinciding with the period of closest contact between conspecifics often including an influx of immunologically naïve juveniles. In California,

* Corresponding author.
E-mail addresses: Krysta.Rogers@wildlife.ca.gov (K.H. Rogers), ygirard@cerus.com (Y.A. Girard), lwwoods@ucdavis.edu (L.W. Woods), ckjohnson@ucdavis.edu (C.K. Johnson).

https://doi.org/10.1016/j.ijppaw.2018.06.006
Received 28 March 2018; Received in revised form 27 June 2018; Accepted 30 June 2018

these events occur most frequently in mourning doves (*Zeneida macroura*) during the spring and summer (Stabler and Herman, 1951) and band-tailed pigeons (*Patagioenas fasciata*) during the winter (Rogers et al., 2016a).

Whereas mourning doves range across the continental United States, band-tailed pigeons have a more limited range with two distinct populations inhabiting the western U.S., the Interior (*P. f. fasciata*) and Pacific Coast (*P. f. monolis*) subspecies (Keppie and Braun, 2000). Interior band-tailed pigeons occur in the southwestern U.S. and Mexico, while Pacific Coast band-tailed pigeons occur primarily from British Columbia south through southern California. While once an important game bird in the western U.S., both populations have undergone drastic declines resulting in reduced hunting opportunities (Seamans, 2016). Periodic trichomonosis epidemics have been documented since the mid-1940s within the Pacific Coast population and are an important factor in their decline, with near annual mortality events occurring since the early 2000s (Rogers et al., 2016a). Estimated mortality during these events is highly variable from year to year (Stromberg et al., 2008; Rogers et al., 2016a), but has the potential to be more than 2–3 times higher than the annual harvest, which typically ranges between 6000–10,000 pigeons (Seamans, 2016). In contrast to most other game birds, such as doves, turkeys, and waterfowl, the reproductive rate for band-tailed pigeons is relatively low. A pair of band-tailed pigeons produce, on average, one chick per year (Keppie and Braun, 2000) which may result in slow recovery when the population experiences large losses of individual birds through trichomonosis epidemics and harvest.

In previous studies, *Trichomonas gallinae* Fe-hydrogenase subtype A2, was the only *T. gallinae* subtype isolated from band-tailed pigeons during epidemics in California (Girard et al., 2014b). Subtype A1 has also been isolated from band-tailed pigeons in California, however, at a much lower prevalence and only during non-epidemic time periods (Girard et al., 2014b). In Europe and Canada, subtype A1 is the most common subtype isolated from avian species including songbirds, raptors, and columbids (Lawson et al., 2011; Chi et al., 2013; McBurney et al., 2015; Stockdale et al., 2015). In addition to *T. gallinae*, band-tailed pigeons were also found to be infected with a newly described species, *T. stableri*, which is more closely related to the human pathogen *T. vaginalis* than to *T. gallinae* (Girard et al., 2014a). *Trichomonas stableri* has been isolated from band-tailed pigeons both during epidemics and non-epidemics and occurs at a lower prevalence than *T. gallinae* (Girard et al., 2014a); however, both parasites cause similar disease, highlighting the importance of molecular characterization of parasites when attributing mortality events to a specific etiology.

Historically, trichomonosis epidemics involving Pacific Coast band-tailed pigeons have only been documented during the winter when the majority of the population is overwintering in central and southern California (Rogers et al., 2016a). During this time, pigeons form large flocks increasing contact between individuals at communal water sources and facilitating parasite transmission between susceptible birds. Similar to infections in other columbids (Bunbury et al., 2007) the likelihood of an epidemic occurring during a given winter in band-tailed pigeons is correlated with weather conditions, namely warmer temperatures and lower precipitation, which may improve parasite viability while increasing contact between individual birds at fewer available water sources (Rogers et al., 2016a).

This pattern of winter-only trichomonosis mortality events changed in 2014, when events were documented for the first time during the summer in at least three central California locations (Rogers et al., 2016b). During summer, band-tailed pigeons are more dispersed for breeding activities compared to winter (Keppie and Braun, 2000) presumably leading to reduced contact between pigeons and reduced opportunity for parasite transmission. However, 2014 was the warmest year on record in California, followed by 2015, the second warmest year on record (http://ca.water.usgs.gov/data/drought/). By early 2015, California was entering a fifth year of drought with roughly 94% of the state classified in severe drought according to the National Drought Mitigation Center (http://droughtmonitor.unl.edu).

Here we describe the avian trichomonosis mortality events involving Pacific Coast band-tailed pigeons that took place during winter 2014–2015 in California. Our analysis includes a summary of the geographic range and duration of events, numbers of birds affected, histopathological analysis of diseased birds, and molecular characterization of infecting parasites. By evaluating the characteristics of these epidemics, we improve our understanding of the impacts of large-scale disease events on the population health of this declining upland game bird.

2. Materials and methods

2.1. Mortality reports

The California Department of Fish and Wildlife's (CDFW) Wildlife Investigations Laboratory (WIL; Rancho Cordova, CA) is responsible for investigating causes of mortality in the state's wildlife. Incidents of sick and dead band-tailed pigeons were reported to WIL by department staff, the public, wildlife rehabilitation centers, and other government agencies by phone, e-mail, and online mortality reporting form (www.wildlife.ca.gov). Information compiled from these reports included date reported, location, number of sick and dead pigeons observed, and start and end dates of mortality, if applicable. When possible, a site visit was made to locations with reported mortality to confirm the bird species involved and to record numbers of sick and dead birds, habitat characteristics, and food and water sources.

Reports of avian mortality are also provided to WIL by the California Department of Public Health (CDPH; Richmond, CA) through their Dead Bird Hotline. The Dead Bird Hotline was established in 2003 for West Nile virus surveillance and enables the public to report dead birds to CDPH via a toll-free telephone number or online form (www.westnile.ca.gov). From these reports, incidences of band-tailed pigeon mortality were compiled.

Finally, wildlife rehabilitation centers in California are required to submit an annual report to CDFW of all wildlife admitted into the center under their permit. These reports total the number and final disposition (released, transferred, pending, euthanized, died, or DOA) of each species admitted to the center between January 1 and December 31 in a given year. While these reports do not denote date, location, or reason for intake for each individual animal, they do provide intake numbers for each species for the geographic area (e.g. county) in which the center is located. Band-tailed pigeon intake numbers were compiled by county from the 2015 annual reports for the 41 wildlife rehabilitation centers reporting band-tailed pigeon intake.

2.2. Post-mortem examination

Avian trichomonosis mortality events were defined as ≥ 5 birds dying in the same geographic location over several days to weeks (Rogers et al., 2016a). Once alerted to mortality, an effort was made to collect a subset of carcasses from outbreak locations for post-mortem examination and sampling for trichomonad isolation. Carcasses were received at WIL and stored in a freezer ($-20\,^{\circ}C$) until the post-mortem examination. Prior to the examination, the carcass was thawed at $4\,^{\circ}C$ for 24–48 h and gross findings were recorded including age, sex, presence and location of lesions, adipose deposition, condition of organs, and abnormalities (e.g. injuries). Birds were aged by plumage as juveniles (hatch year), subadults (second year), or adults (after second year) (Sanders and Braun, 2014). Nutritional condition was assessed by degree of adipose deposition and mass (grams). Adipose deposition was rated as none (no subcutaneous or internal adipose), trace (no subcutaneous and minimal internal adipose), and moderate to heavy (adequate subcutaneous and internal adipose).