Global Ecology and Conservation 3 (2015) 802–813

Contents lists available at ScienceDirect

Global Ecology and Conservation

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

Original research article

Unreliable population inferences from common trapping practices for freshwater turtles

Melissa R. Tesche, Karen E. Hodges *

Department of Biology, University of British Columbia Okanagan, Science Building, 1177 Research Road, Kelowna BC V1V 1V7, Canada

ARTICLE INFO

Article history:
Received 19 February 2015
Received in revised form 1 April 2015
Accepted 2 April 2015
Available online 16 April 2015

Keywords:
Mark–recapture
Painted turtles
Survey design
Chrysemys picta
Statistical inference
Bias

ABSTRACT

Fundamental questions in ecology and conservation require reliable data about population size and structure. For freshwater turtles, such data are often obtained via mark–recapture trapping, but commonly used trap types are biased in the sex and age classes they sample although these biases are seldom quantified. We present data from 11 populations of Western painted turtles (*Chrysemys picta bellii*; 1107 turtles total, *n* caught per pond 6–322) captured in hoop traps, dip-nets, and basking traps to examine bias in captures and the impact on estimates of population size and sex/age ratios. Hatchlings and juveniles were primarily captured in dip-nets, while hoop nets had the lowest capture rates for adults. Most turtles were caught only once; among recaptures, the majority were recaptured in the same trap type. Estimates of population size and sex/age ratios varied strongly when we calculated results from each trap type separately versus combining all captures. These results show clearly that turtle sampling that uses only one trap type will almost certainly mis-estimate population size and sex/age ratios. These results are troubling in the light of current practice: of population studies of North American turtles published during 2009–2014, 45% used only one trap type, and 49% of studies did not even mention possible sampling biases. The conservation implications are serious, as current trapping efforts probably result in erroneous population estimates and sex/age ratios, which may encourage management actions that are not needed or may obscure actions that are in fact necessary for viable populations.

1. Introduction

Turtles are globally in decline, with the IUCN classifying 47% of 331 described turtle species as Vulnerable, Endangered, or Critically Endangered (Van Dijk et al., 2012). For semi-aquatic turtle species, declines are due largely to land-use changes and habitat destruction (Gibbons et al., 2000; Lesbarrères et al., 2014), and even turtle species that were once quite common are becoming at-risk and are in need of population monitoring. Lovich and Ennen (2013) reviewed the state of our conservation knowledge for North American turtles, finding that most imperiled turtles have inadequate research to support conservation efforts meaningfully.

Unfortunately, it is hard to obtain reliable population data for freshwater turtles. Low and variable rates of capture are common in turtle studies (Bluett, 2011), and if not enough turtles are recaptured, or if the traps capture certain groups preferentially, inferences about population status will be misleading (Gamble, 2006; Koper and Brooks, 1998; Lindeman, 1990). It is therefore critical to focus on developing better methods and study designs to capture more turtles and to reduce biased sampling of the populations, thus improving inferences about the populations (Bluett, 2011; Jackson et al., 2008).

* Corresponding author. Tel.: +1 250 807 8763.
E-mail address: karen.hodges@ubc.ca (K.E. Hodges).

http://dx.doi.org/10.1016/j.gecco.2015.04.001
2351-9894/

Further, population density of adults alone is not a reliable indicator of population stability in turtles, although adults are easier to capture than are hatchling or juvenile turtles (Pike et al., 2008). Without high quality demographic data for all sexes and ages, there could be significant time lags between the start of recruitment failure and detectable population decline among adult turtles. Freshwater turtles are long-lived, often with high mortality rates for eggs and hatchlings, intermediate survival rates for juveniles, and low adult mortality (Griffin, 2007). Population sizes, sex-ratios, age structures, and stage-specific mortality rates are thus of great value to any monitoring program. Adult sex ratios have also recently become an important piece of demographic information for studies examining whether roads near ponds induce higher mortality of females, as females may need to cross roads to access nesting habitat (Aresco, 2005; Dorland et al., 2014; Marchand and Litvaitis, 2004a; Steen and Gibbs, 2004).

Common capture methods for freshwater turtles include baited hoop nets, baited and non-baited basking traps, and dip-nets. Captures in each trap type are biased by behavioral differences among turtles and between size classes and sexes (Cagle and Chaney, 1950; Frazer et al., 1990; Gamble, 2006). Females may be more attracted to basking traps as they have higher energetic demands due to larger body size and egg production (Carrière et al., 2008; Lefevre and Brooks, 1995). Hatchling and juveniles often elude the hoop nets and basking traps that are successful with adults (Congdon, 1993; Mali et al., 2013; Ream and Ream, 1966; Sexton, 1959). Hoop nets may be male-biased, with hypothesized mechanisms that males are attracted to captured females (Cagle and Chaney, 1950; Frazer et al., 1990) or that females are more likely to escape (Brown et al., 2011).

Biases among trap types have been known for decades, as Ream and Ream (1966) recommended combining data from multiple trap types to minimize bias. Koper and Brooks (1998) compared capture results from hoop nets and dip-nets to the assumed population size of a well-studied population of adult painted turtles, *Chrysemys picta marginata* in a 1.7 ha pond (total N caught $= 78$); even when they applied analytical and statistical techniques thought to improve accuracy, most results underestimated the number of known marked adults by more than 10%. Using multiple trap types simultaneously would, in theory, capture more turtles, assuming that traps were biased in different ways (Koper and Brooks, 1998). It might also help negate trap-shy responses as animals caught initially in one trap type would not have been exposed to other trap types, thus potentially increasing recapture rates.

Here, we address sampling strategies for populations of the western painted turtle, *Chrysemys picta bellii* in southwestern British Columbia, Canada, near the northwestern edge of their geographic range. Painted turtles are nationally listed as Special Concern in this region (COSEWIC, 2006), and as Endangered in coastal BC. Painted turtles are semi-aquatic, depending on lakes, ponds, or slow-moving water bodies for foraging, mating, and hibernation, as well as upland habitats for nesting (Steen and Gibbs, 2004). In addition to suitable nesting habitats, painted turtles require connectivity between habitats, with connected ponds serving as drought refugia and sources of genetic variation. We deliberately sampled across the spectrum of local pond types (e.g. elevation, surrounding environment, size) to assess how these common trap types performed in the face of this variability and to see how trapping-based demographic estimators performed for very different population sizes of painted turtles. This design mimics sampling that might occur for a conservation assessment or landscape study in a region.

Our objectives were to (a) evaluate performance of three common turtle capture methods for painted turtles, (b) quantify the impact of combining data from all the trap types on population estimates and their variability, and (c) contextualize our results in the light of current trapping practices used in studies of North American freshwater turtles. We used hoop nets, basking traps, and dip-nets to catch western painted turtles in 11 separate locations, then we used mark–recapture analyses to assess how each method performed. We also analyzed the value of each trap type for capturing different age classes and sexes. We used multi-state modeling to determine transition probabilities of turtles among trap types, to see whether using multiple trap types increases the likelihood of recapture, which would increase the confidence in mark–recapture estimates.

2. Materials and methods

We trapped turtles in the Okanagan Valley of southcentral British Columbia, Canada, between May and September, 2009. The Okanagan Valley is semi-arid, with large lakes on the valley bottom bordered by low-sloped hills of open canopy ponderosa pine (*Pinus ponderosa*) forest, sagebrush (*Artemisia tridentata*) dominated shrub-steppe, and grasslands. Western painted turtles were trapped at 11 ponds throughout the valley, ranging in elevation from the valley bottom at 298–924 m (Table 1). Ponds ranged from urban to rural and were selected to represent the range of known turtle habitats in the Okanagan. Each pond was trapped for a single session of 3–8 days (we trapped longer at sites with low recapture rates; trapping duration was not linked to numbers caught per pond, Table 1). Trapping was done only on sunny days. Three trapping methods were used at each pond: basking traps, hoop nets, and captures with dip-nets. Three hoop nets (76.2 cm diameter, 3.81 cm^2 mesh, Memphis Net and Twine, Tennessee, USA) were secured with steel posts in the vegetated shallows of each pond and baited by dangling a pierced can of cat food inside the middle hoop. Three basking traps (Sun Deck Turtle Trap, Heinson's Country Store, Texas, USA) were also set at each pond. These traps were made of wire ramps attached to a floating PVC frame with a submerged wire basket; we secured traps in areas of the pond where we observed high numbers of basking turtles and we baited them with cat food. All traps were set within a 50 m diameter of a central point in the pond.

We also used fish landing nets from shore or canoe to scoop turtles from the open water or mud. To keep this effort similar across ponds, all dip-net captures were completed by the same 4 people. Basking traps and hoop nets were set in the