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Short communication

Landscape-level field data reveal broad-scale effects of a fatal, transmissible cancer on population ecology of the Tasmanian devil

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ABSTRACT

In order to project and plan for the future of threatened species, conservationists require good quality estimates of basic population parameters, such as population sex ratios and breeding rates. These data can be difficult to obtain in many threatened species where pervasive threats perturb population dynamics. For Tasmanian devils, previous studies at several sites across Tasmania revealed demographic consequences of the fatal and transmissible devil facial tumour disease (DFTD). In the current analysis, we take advantage of broad-scale survey data across the state, since 2003, to examine the differences between DFTD-present and DFTD-absent populations at the landscape level. Consistent with expectations based on previous studies, we found that devils trapped in DFTD-present sites were significantly younger (based on tooth-wear age estimates) than those in DFTD-absent sites. Interestingly, we also found that females in DFTD-present sites were more likely to show evidence of breeding than females in DFTD-absent sites. This difference could not be attributed to differences in age or body condition. Devil populations are declining, so increased female breeding rate is unlikely to be successfully compensating for decreased lifespan as a result of DFTD at the population level. These data can be used to inform stochastic and evolutionary models of population dynamics for devils, and inform the assessment of conservation strategies for the species in the presence of disease.

Stochastic population modelling is used for a number of threatened species to inform conservation actions, because such population viability analyses are important in judging extinction risk (Morrison et al., 2016). However models are only as informative as the data they are built on, so basic population demographic data are essential for projecting the long-term outcomes of conservation management actions for a species. Tasmanian devils are the world's largest marsupial carnivore and, like other Dasyurids, have a relatively short life span of 5–6 years of age (Guiler, 1970). Devils are seasonally polyoestrous and have been known to breed between 2 and 5 years of age (Guiler, 1970; Keeley et al., 2012). The species is listed as Endangered (Environment Protection and Biodiversity Conservation Act, 1999; Threatened Species Protection Act, 1995; Hawkins et al., 2008) due to the emergence of an infectious clonal cancer, devil facial tumour disease (DFTD). Although there are other known transmissible cancers, such as one in dogs, *Canis lupus familiaris* (canine transmissible veneral tumour (CVT); Murgia et al., 2006) and another in soft-shell clams, *Mya arenaria* (Metzger et al., 2015), DFTD is the only known lethal transmissible cancer in vertebrates making it a unique conservation challenge. This transmissible cancer has since reduced devil numbers by 77% (Lazenby et al., 2018) and is found across the state of Tasmania with only small disease free pockets found in the north-west and south-west (DPIPWE, unpubl. data). Long-term studies in a number of devil populations have revealed population genetic responses to DFTD (Brüniche-Olsen et al., 2014; Epstein et al., 2016; Wright et al., 2017), in addition to changes in population ecology (Hamede et al., 2008; Jones et al., 2008; Lachish et al., 2009). In areas where populations have been greatly reduced by DFTD, there are reported instances of increased precocial breeding (at age 1) and a lack of older (>4 years old) individuals (Lachish et al., 2007).

Abbreviations: DFT(D), devil facial tumour (disease); DPIPWE, Department of Primary Industries, Parks, Water and Environment; NVA, Natural Values Atlas; STDP, Save the Tasmanian Devil Program.

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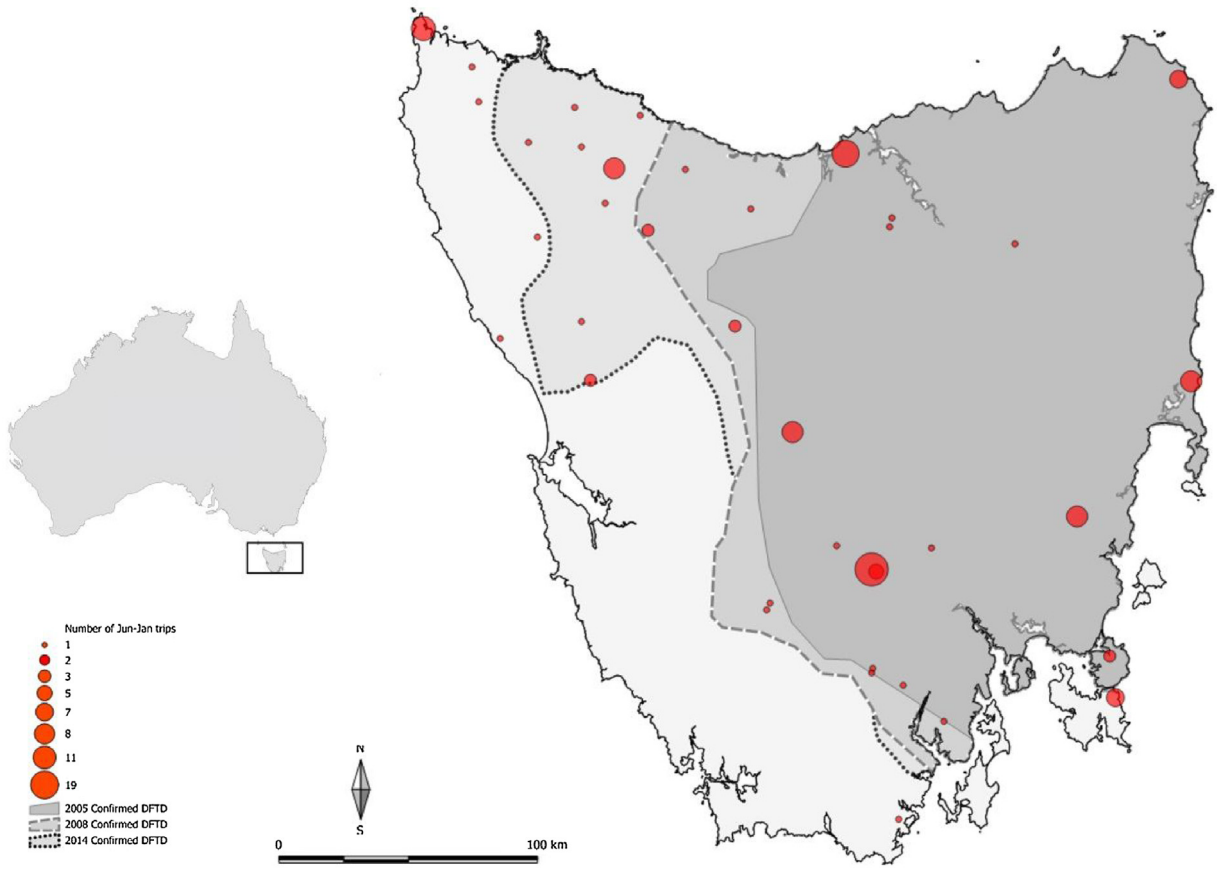

Fig. 1. Map of all 39 sites across Tasmania included in this analysis. The number of times a site was visited between June and January is indicated by the relative size of the location marker. Confirmed DFTD disease front areas are provided for 2005 (solid line), 2008 (dashed line) and 2014 (dotted line) (online version in colour).

The Save the Tasmanian Devil Program (STDP) is the Tasmanian and Australian Federal Government response to DFTD. Wild populations have been closely monitored by STDP field teams since 2003, given the emergence of DFTD and its recognition as a major threat to the species (Hawkins et al., 2006). The capture records of these trips present an invaluable resource for the analysis of devil demography in DFTD-absent and DFTD-present sites. The data can provide essential fundamental data for population, genetic and evolutionary modelling of devils, and will inform a greater understanding of the role of this fatal disease in modifying the demography of wild populations. The aim of this study was to quantify differences in key population-level demographic parameters (such as age distribution, sex ratio and fecundity) between DFTD-present and DFTD-absent sites, with a view to providing parameters for stochastic population models of genetic diversity (AlleleRetain (Weiser et al., 2012) and Vortex (Lacy, 1993, 2000)).

We used field survey data collated from 112 STDP-led survey 'trips' across 39 sites in Tasmania from 2003 to 2015 (Fig. 1; Supplementary Table S1), extracted from the Natural Values Atlas (NVA; www.naturalvaluesatlas.tas.gov.au) in December 2015. This data had been collected under the Standard Operating Procedures of the DPIPWE as part of their ongoing monitoring of the species; no new animals were captured for the purpose of this analysis. Trips were defined as all sampling nights undertaken within a calendar month. We examined only data collected between June and January (inclusive), as these are the months during which evidence of breeding will be detectable for female devils, enabling us to draw reliable inferences about reproductive rates. Sites were sampled an average of 2.87 times (SD = 3.70, range = 1 [25 sites] to 19 trips) (Supplementary Table S1).

Our full dataset included 7393 devil captures across Tasmania (mean 66.0 per trip, SD = 65.0). Of these, a primary or secondary ID (typically a microchip number) was recorded for 6628 (89.7%) captures; our analysis was restricted to only those records where individuals were uniquely identified (N = 2889 devils). In total, 1496 (51.8%) devils were captured more than once (mean capture observations per individual = 2.29, SD = 2.12, max = 31). Many recaptures occurred within trips, i.e. most animals (2308; 79.9%) were only seen on one trip (mean = 1.30 trips, SD = 0.75, max = 10 trips). Most animals were seen at just one site, and only 7 (0.2%) detected at two sites. Note that many sites were visited by trapping teams only once or infrequently. Data from animals that were recaptured within a trip were consolidated, so that each animal had just one entry in the dataset per trip. Where multiple measurements were recorded for a recaptured individual on a trip, only the first measurement was used.

The main objective of most trips was monitoring DFTD spread across the state, and so many sampling trips were undertaken at sites prior to DFTD arrival, or shortly after its first arrival. Considering the widespread devastation caused by DFTD, the disease was only observed a relatively small number of times in our dataset as a whole (286, 7.6% of observations; all animals were retained in the analysis). Because our purpose here was to evaluate demographic parameters of DFTD-present versus DFTD-absent sites, we considered a site as "DFTD present" if at least 1 animal with DFTD was observed ("DFT gross" score 4 or 5), and for all subsequent sampling trips to that site. We could therefore use this definition to characterise animals as coming from DFTD-present sites, regardless of the DFTD status of individuals. By this definition, 59 trips (52.7%, N = 112 trips) were classified as "DFTD-present" (Supple-