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LETTERS AND COMMENTS

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Recalibrating risk: Implications of squirrelpox virus for successful red squirrel translocations within mainland UK

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Introduced grey squirrels (*Sciurus carolinensis*) cause native red squirrel (*Sciurus vulgaris*) decline via resource competition (Wauters, Gurnell, Martinoli, & Tosi, 2002) and carry squirrelpox virus (SQPV). Infection is sporadically transmitted to red squirrels and spreads within the population—precipitating disease. Sainsbury et al. (2020) assert that UK mainland red squirrel reintroductions cannot be justified in light of international guidance and that translocations will fail because of SQPV. They suggest animal suffering will result because grey squirrel control cannot be sufficient to prevent epidemic disease amongst sympatric red squirrels.

We concur that following international species translocation standards (IUCN, 2013) is fundamentally paramount and animal welfare vitally important. However, standards require translocation proposals to consider all locally prevailing factors (IUCN, 2013), which for red squirrels entails complex assessment beyond binary consideration of squirrelpox viral disease. IUCN (2013) also recommend calibrating the likelihood and impact of identified risks; crucially including those associated with non-intervention. For example, genetic variation loss occurs in isolated red squirrel populations (O'Meara et al., 2018) and consequently reinforcement translocations have offered the only viable conservation option to prevent extinction, even where grey squirrels threaten (Halliwell & Jenkins, 2019; Ogden, Shuttleworth, McEwing, & Cesarini, 2005). IUCN (2013) recommend removing, but accept sufficiently reducing, identified extinction causes. Water vole (*Arvicola amphibius*) (Rees, 2018) and red kite (*Milvus milvus*) (Evans et al., 1999) UK translocations occurred because planners deemed that, although extinction threats remain (American mink, *Neovison vison* (Telfer, Holt, Donaldson, & Lambin, 2001) and illegal persecution (Madden, Rozhon, & Dwyer, 2019) respectively), such factors are sufficiently reduced locally.

Although widespread red squirrel disease was reported from the early 20th Century (Shorten, 1954), the absence of modern diagnostic testing, and confounding symptoms of other infections mean the SQPV contribution is unknown (McInnes, Deane, & Fienga, 2015). SQPV significance emerged after the late 1980s (Gurnell, 1987) with epidemiological testing advances establishing grey squirrels as a SQPV reservoir and demonstrating infection transmission to red squirrels results in disease (Carroll, Russell, Gurnell, Nettleton, & Sainsbury, 2009; Sainsbury, Nettleton, Gilray, & Gurnell, 2000; Tompkins, White, & Boots, 2003).

Squirrelpox disease outbreaks vary in geographical scale and number of confirmed cases (Chantrey et al., 2014; McInnes, Coulter, Dagleish, Deane, et al., 2013; McInnes, Coulter, Dagleish, Fiegna, et al., 2013). For example, McInnes, Coulter, Dagleish, Fiegna, et al. (2013) report only four localized cases recorded across southern Scotland in 2007, while Chantrey et al. (2014) report a "generally stable" Merseyside red squirrel population despite an average of 5.75 SQPV cases annually until a catastrophic 87% population decline associated with 73.50 annual cases. In captive populations, the proportion of animals unaffected also varies (e.g., Carroll et al., 2009; Shuttleworth et al., 2014). Thus, we can reasonably conclude such variation will influence population recovery rates to pre-outbreak levels. Everest et al. (2017) report two confirmed cases within a Welsh metapopulation where surveillance at 200 locations across 720 km^2 (Robinson & Shuttleworth, 2019) detected global index dermatophilosis infection (Holmes, Duff, et al., 2019; Holmes, Everest, Spiro, Wessels, & Shuttleworth, 2019) and demonstrated squirrelpox disease died out without causing local extinctions. Spatial modeling predicted that had infection spread, regional red squirrel extinction would not occur (Jones, White, Lurz, & Shuttleworth, 2017).

To derive lessons from squirrelpox viral disease outbreaks, we must consider prevailing local circumstances, especially when infection occurred during translocation. Importantly, historical management approaches should not be calibrated against our contemporary published scientific SQPV research, but instead viewed as a limited historical understanding of how grey squirrels affected red squirrels. This explains why grey squirrel control was limited or absent in ultimately unsuccessful experimental translocations during the 1990s (Lawton, Waters, & Shuttleworth, 2015; Pritchard, 1996).

Sainsbury et al. (2020) cite Carroll et al. (2009) to illustrate that grey squirrel control cannot prevent interspecific SQPV infection. Importantly, earlier documentation quantifying the effectiveness of control (Gurnell, Sainsbury, & Venning, 1997; Gurnell & Steele, 2002) indicates hundreds of grey squirrels were culled in the immediate area during this translocation; grey squirrels were present at release enclosures even gaining access inside. In summary, Gurnell and Steele (2002) stated, "there is no evidence that grey squirrels were cleared from any part of the study area for any length of time using the control effort applied." In contrast, Schuchert, Shuttleworth, McInnes, Everest, and Rushton (2014) report on grey squirrel eradication where SQPV seroprevalence progressively declined from 1999 to 2010 from 52% to 4% amongst residual grey squirrels. However, red squirrel translocations first occurred when grey squirrel population seroprevalence was at 40%, twice the 20% threshold below which McInnes et al. (2015) suggest infection is not an imminent threat. This is the largest Welsh red squirrel population (Shuttleworth et al., 2015) monitored since 1998 (Shuttleworth, 2003) and expanding from 4× to 12× 10×10 km squares between 2005 and 2017 (WSF, 2018) and from 40 to 750+ adults (Halliwell et al., 2015) because grey squirrel incursion is effectively managed (Robinson & Shuttleworth, 2019).

Differences in grey squirrel control effort (Robertson et al., 2016), geographical isolation and evolving rapid responses to incursion (Robinson & Shuttleworth, 2019) contributed to the contrasting failure and success reported by Carroll et al. (2009) and Schuchert et al. (2014) respectively. The successful modern volunteer-based co-ordinated approach to grey control (Shuttleworth et al., 2020), based on decades of learning, sadly came after regional red squirrel population extinctions. This included extinctions from within enviable geographical defendable locations when compared with landscapes where extant remnant populations exist. Mainland populations commonly have grey squirrel sympatry and high landscape connectivity (Gurnell et al., 2006). Sainsbury et al. (2020) allude to successful conservation translocations being only temporary, destined eventually to succumb to SQPV epidemics. However, translocating species often means the original threat remains (e.g., climatic change) but is ameliorated at the new site (see Chauvenet, Ewen, Armstrong, & Pettorelli, 2013; Willis et al., 2009). As grey squirrels currently occupy every county in England, scientifically well-conceived red squirrel translocation into highly defendable geography is a legitimate management tool to explore in synergy with wider national conservation approaches including pine marten (*Martes martes*) restoration (Sheehy, Sutherland, O'Reilly, & Lambin, 2018).

In a rapidly changing world, we must collaborate, learning from past endeavors to facilitate dynamic conservation. A disease risk zero tolerance could result in freezing crucial conservation programs into inaction (Ballou, 1993; Callen et al., 2020; Hayward et al., 2019).

CONFLICT OF INTEREST

None of the authors have conflict of interest.

AUTHOR CONTRIBUTIONS

Craig Shuttleworth structured the initial draft manuscript framework. Conor McKinney, Nikki Robinson, and

Stephen Trotter inputted landscape lessons from the successful community-based EU LIFE14 NAT/UK/000467 and National Lottery Heritage Fund mainland grey squirrel control demonstration project. Matt Hayward and Deborah Brady provided advice on IUCN translocations and welfare considerations. Laura Gardner, Andrew Greenwood, Nick Jackson and Kim Wood provided lessons learned from 20 years of red squirrel conservation translocations including associated epidemiological findings. Paul Cross and Simon Valle provided species conservation overview with respect to risk management. Together the authors contributed to the development of the paper.

ETHICS STATEMENT

This is a review containing scientific opinion and has not needed to involve an ethical review committee.

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