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Short communication

Fission-fusion social structure of a reintroduced ungulate: Implications for conservation

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ABSTRACT

In a reintroduced population, the social behavior of the species can strongly affect the long-term viability of the population through its effects on movement, information flow, disease spread and the population's genetic variability. Therefore, information on the social behavior of a reintroduced population can contribute to conservation practices; however, its importance is often underestimated. The initial phase of the Asiatic wild ass's (*Equus hemionus*) reintroduction in Israel has been considered a success, and the population is currently estimated at more than 250 individuals. However, the current social structure of the population remained unknown. We aimed to study this important population trait and to provide helpful information for efficient conservation and management protocols. The study was based on direct observations that were conducted over four consecutive years, and on the analyses of groups' composition and female groups' stability. Female groups accompanied by males constituted only 5% of the total 659 observations, males were observed to be mainly solitary or in groups of various sizes, and females were organized in non-stable groups, indicating that the reintroduced population exhibits a fission-fusion social structure. Identifying the social structure for the species in the expanding Negev population of the Asiatic wild ass can assist in implementing future reintroductions and can contribute to effective management decisions aimed at protecting the species.

1. Introduction

Reintroductions have become a common tool in wildlife management and conservation (Soorae and Seddon, 1998; Lipsey and Child, 2007; Seddon et al., 2007). In the case of species extinction in the wild, particularly in keystone species whose activities affect many other organisms (Simberloff, 1998), the importance of reintroduction as an ecosystem restoration tool is even higher (Polak and Saltz, 2011; Armstrong and Seddon, 2008). Nevertheless, many reintroduction attempts fail (Fischer and Lindenmayer, 2000). This is because reintroduction success depends on various factors, including the initial population size released, demography parameters, the availability of natural habitats and the effective removal of the original cause of decline (Fischer and Lindenmayer, 2000; Ewen et al., 2012). Another factor that has often been neglected is the species' social structure (Seddon et al., 2007), which can influence the long-term viability of a

reintroduced population by affecting the movement of individuals, population range expansion (Le Gouar et al., 2011), information flow, and disease spread (Manlove et al., 2014). Therefore, studying the social structure of reintroduced populations is highly important, and the findings can be directly translated into conservation practice and management plans (Anthony and Blumstein, 2000) and can aid in assessing the reintroduction status in terms of its success (Berger-Tal and Saltz, 2014). In social species, the formation of groups in a pattern that resembles that of established populations may be one indication for the reintroduction's success, while altered patterns of social behavior may result in reduced average fitness in the population, affecting the persistence of the entire population (Berger-Tal et al., 2011; Caro and Sherman, 2012). In this study, we focus on the social structure of the reintroduced Asiatic wild ass (*Equus hemionus*).

The Asiatic wild ass is an elusive, critically endangered species. It was once abundant in western Asia, including Israel's Negev Desert, but

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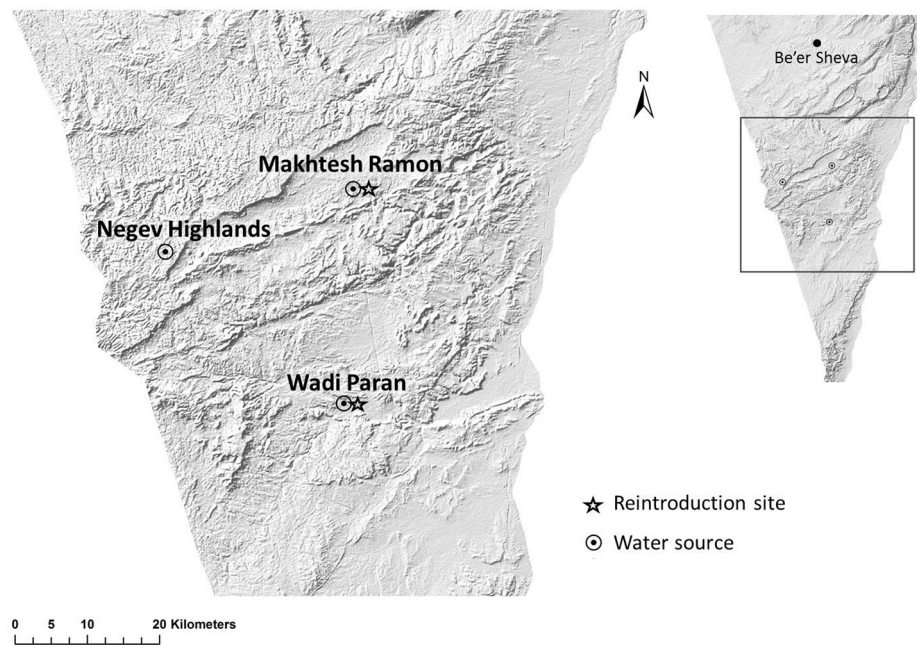


Fig. 1. Reintroduction sites and main water sources in the wild ass distribution range in the Negev Desert.

declined throughout its range due to hunting and habitat loss. The local subspecies, *E. h. hemippus*, endemic to the Middle East, became extinct in the early twentieth century. In 1968, a breeding core was established at the Hai-Bar Yotvata Reserve from 11 individuals belonging to the Iranian (*E. h. onager*, 3 M, 3 F) and the Turkmanian (*E. h. kulan*, 2 M, 3 F) subspecies (Saltz and Rubenstein, 1995). Between 1982 and 1993, *E. hemionus* ssp. (resulting from the mixture of the two subspecies) was reintroduced into the Negev Desert by the Israel Nature and Parks Authority (INPA); between 1982 and 1987, 28 individuals (14 M, 14 F) were reintroduced into Ein Saharonim, in Makhtesh Ramon, and between 1992 and 1993, 10 additional individuals (3 M, 7 F) were reintroduced into Wadi Paran, about 35 km south of Ein Saharonim (Fig. 1). The reintroduction procedure was well documented, and the reintroduced population was intensively monitored in the years following the reintroduction (Sinai, 1994; Saltz et al., 2006). During the late 1990s, the population naturally expanded its geographical range to the Northern Negev Highlands and the Arava Valley (Fig. 1). The initial phases of the wild ass reintroduction into the Negev have been considered a success: the population size increased from 38 to an estimated size of 250–400 individuals (Renan et al., 2015), the population's geographical range has expanded and the females' annual reproductive success was found to be high (at around 0.5, Speyer, 2012). However, the current social structure of the population, an important factor in the population's long-term persistence, was not known.

Equids are typically organized into one of two social organizations (Klingel, 1975). In “female defense polygyny” (here referred to as a “harem” structure), stable groups of females and their young live in strong association with usually one (occasionally two) dominant stallion, and non-dominant males live in separate all-male bachelor groups (Klingel, 1975; Boyd et al., 2016). This social organization characterizes three wild species (takhi, *Equus przewalskii*, plains zebra, *E. quagga*, and mountain zebra, *E. zebra*) and the feral horse (*E. caballus*). In “resource defense polygyny” (here referred to as a “fission-fusion” structure), females and their young tend to live in non-stable groups, and dominant males protect good quality territory rather than female groups. The dominant, territorial males are solitary, while the subordinate, non-territorial males live in unstable all-male bachelor groups (Klingel, 1975; Rubenstein, 1986; Moehlman, 1998a). This social organization characterizes three wild species (kiang, *E. kiang*, Grevy's zebra, *E. grevyi*, and the African wild ass, *E. africanus*) and the feral ass (*E. asinus*). The

situation in the remaining species, the Asiatic wild ass, *E. hemionus*, will be discussed below.

The harem species inhabit more mesic habitats, while the fission-fusion species tend to live in semi-arid and arid habitats. This has led to the hypothesis that environmental factors determine which of the two basic social organizations will appear in equids (Klingel, 1975; Rubenstein, 1986): In relatively rich and homogeneous mesic landscapes, the lack of competition for resources among females enables the formation of stable and cohesive groups, allowing males to dominate mating opportunities when defending a specific female group. In poor and heterogeneous arid landscapes, competition over resources and the different physiological needs of females (e.g., lactating females need to drink more frequently than non-lactating females) break the groups' cohesiveness, leading females to live in fission-fusion groups (Rubenstein, 1986). This social structure also provides the opportunity to adjust the group size to the amount of resources in a specific area or in a particular season. Under this non-stable group condition, dominant males invest their energy in defending valuable territories that will attract females and increase their mating opportunities. Several studies on feral donkeys and horses have shown that differences in environmental conditions can change the social organization, even within the same species, causing a shift from the common social organization of that species (Rubenstein, 1981; Moehlman, 1998b). Potentially, this may also occur in wild equids who share with the feral equids the same social structures.

According to this environmental-effect-on-the-social-organization hypothesis, the Asiatic wild ass, which inhabits arid and semi-arid habitats, is expected to form a fission-fusion social system. However, this may not always occur, and there is an ongoing debate in the literature regarding the Asiatic wild ass's social structures (Boyd et al., 2016). Studies of Mongolian and Turkmenian wild asses (Bannikov, 1958; Rashek, 1973; Feh et al., 2001) described their social structure as harem. Conversely, studies of Iranian (Nowzari et al., 2013), Tibetan (Neumann-Denzau and Denzau, 2007; St-Louis and Côté, 2009) and Indian (Rubenstein et al., 2007; Sundaresan et al., 2007) wild asses, but also studies of Mongolian (Neumann-Denzau and Denzau, 2007; Kaczensky et al., 2008) and Turkmenian wild asses (Klingel, 1998; Neumann-Denzau and Denzau, 2007), described a fission-fusion structure and questioned the interpretation of previous observations. One way to explain these conflicting descriptions is to suggest that the

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