Final report - MASTS Small Grant Scheme (£3000), ref. SG188

Genetic patterning of sociality in Icelandic killer whales (*Orcinus orca*)

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Main objective

The goal of this project was to understand the social organization and mating patterns of herring-feeding Icelandic killer whales by quantifying patterns of genetic differentiation within and between groups using nuclear markers (microsatellites). Filling this gap in knowledge is essential for conservation and management of this population, and for improving the existing scientific knowledge, goals relevant to MASTS.

Contribution

The MASTS Small Grant ref. SG188 contributed to the expenses involving laboratory work, DNA extraction, genetic sex identification, genotyping at 22 microsatellite loci and preservation of the biopsy samples of Icelandic killer whales.

Rationale

Among killer whales, kinship is believed to be one of the most important features of their social structure. The best-studied populations in this regard are the Northeast Pacific 'resident' fish-eating killer whales and the mammal-eating killer whales (also referred to as 'transients' or Bigg's killer whales). In both mammal-eating and resident populations, there are high levels of philopatry at the population and subpopulation level, with no dispersal of either sex (Hoelzel et al. 1998; Barrett-Lennard 2000). Both populations are formed by matrilineal basic units, composed of mothers and all of their descendants, both male and female (Bigg et al. 1990); however, some social dispersal (i.e. movement of individuals among social groups within a population) is observed in mammal-eating killer whales (Baird and Whitehead 2000). In these populations, associations are based upon kinship and the mother-offspring bond is extremely strong. Therefore, members of matrilineal units have high levels of relatedness. Although kin-mediated sociality is considered universal among killer whale populations, the specific patterns might not be the same in populations that exhibit different social strategies. Recently, Reisinger et al. (2017) found that among Marion Island (Southern Ocean) mammal-eating killer whales, relatedness within social units was higher than relatedness between social units. However, relatedness and social association strength were not significantly correlated. In the Marion Island mammal-eating population, some dyads of strongly associated individuals were not related and some highly related individuals were not strongly associated.

The Icelandic herring-eating killer whale population has a different social structure than the resident and mammal-eating populations in the Northeast Pacific (Tavares et al. 2017). Icelandic social clusters were highly diverse in complexity, some with heterogeneous associations among members, in contrast

with the cohesive matrilineal units in the killer whale populations found in the Northeast Pacific (Tavares et al. 2017). Additionally, the fluid associations on herring grounds involved close proximity associations among individuals with distinct observed movement patterns (Tavares et al. 2017), which could correspond to variations in diet (Samarra et al. 2017). Considering such social characteristics, it is hypothesized that kinship may play a different role in this population, compared to the well-studied Northeast Pacific populations.

Dataset and analyses

Biopsy samples of 60 wild photo-identified Icelandic killer whales were collected from a research vessel in both winter (February and March 2013 and 2014) and summer (July 2014 and 2015) fieldworks in Iceland (Figure 1). One extra skin sample was obtained from a necropsy of a photo-identified Icelandic killer whale stranded near Grundarfjörður, West Iceland in March 2016. The necropsy was performed by the Marine and Freshwater Research Institute (Iceland). A total of 61 individual Icelandic killer whales were sampled, genotyped at 22 microsatellites and assigned a sex based on genetic analysis (Figure 2). These individuals had three different observed movement patterns: roughly half of the individuals were seen year-round in Iceland (31 individuals seen in both the winter and summer) and about half of the individuals were seen only during one particular season (17 were only seen in the winter and 13 were only seen in the summer). Forty-seven individuals were sighted enough days (at least 5 different days) to be included in the social structure analysis using photo-identification data and were assigned to a social cluster (Tavares et al. 2017). The constructed dataset of genotyped photo-identified individuals was used to test the role of kinship, gene flow and genetic divergence in the Icelandic population.

Results and Discussion

Kinship was positively correlated with associations and relatedness was higher within than between both social clusters and observed movement patterns. However, kinship was not a prerequisite for social cluster membership, and some social clusters were formed by kin and non-kin members. It seems that in the Icelandic population, associations in seasonal herring grounds among small sets of related individuals (pairs, triplets or small subclusters) and less related or non-kin conspecifics might be advantageous. This could allow for flexible and rapid adaptation of foraging group size to the varying sizes of herring schools, ultimately increasing foraging efficiency.

Individuals with different observed movement patterns were likely philopatric, since no sex-biased dispersal was detected. While the three observed movement patterns had differences in microsatellite allele frequencies, these were still low. There was exogamy (mating outside) of observed movement patterns and social cluster, and no inbreeding was detected. The contemporary herring distribution seems to promote geographic and temporal overlap of individuals with diverse observed movement patterns; social mixing, in turn, promotes gene flow among individuals with distinct observed movement patterns. However, the apparent lack of dispersal of both sexes maintains genetic structure within the population.

Planned Output/Deliverables

These results will be published in peer-reviewed journals as two papers: one on the genetic substructure in the Icelandic population and another on the relation between kinship and association in the social structure of the population.

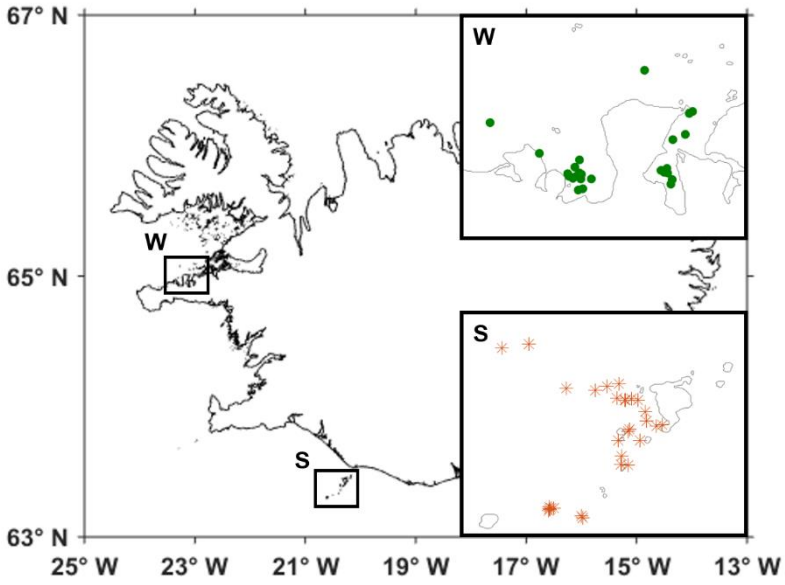

Figure 1. Map of the locations where biopsy skin samples of Icelandic killer whales were collected in (W) Grundarfjörður and Kolgrafafjörður in the winter and in (S) in Vestmannaeyjar in the summer.

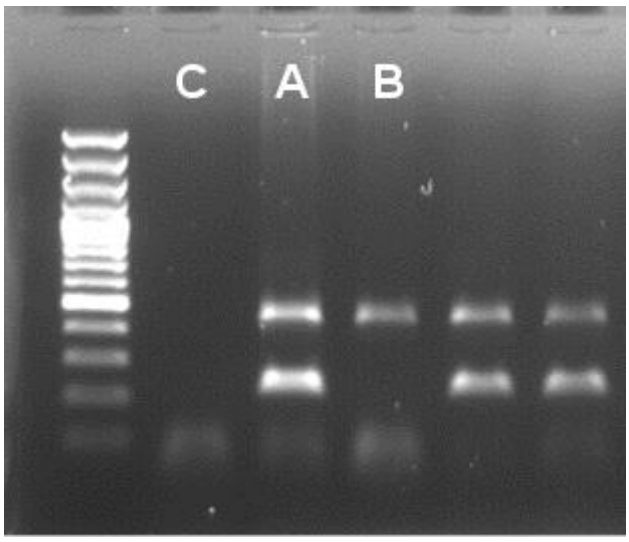

Figure 2. Photograph of a 1.5% agarose gel with 100 bp GeneRuler ladder (Thermo Fisher Scientific), stained with ethidium bromide, showing successful amplification of ZFX/ZFY region (top bands) and SRY region (lower band), allowing for genetic identification of sex. A is a sample of a male since it has both bands and B is a sample of a female, only presenting the ZFX/ZFY band (Jayasankar et al. 2008). C is a negative control.

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