# Individual variance in avian blood parasite infections: causes and consequences

Progress Final Report of NKFIH PD124043
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## 1. The effects of early life conditions and paternity on Haemosporidian infection status

*The long-term effects of early life conditions:*

In this study, I aimed to investigate whether early life conditions affect the infection status and reproductive success of Collared Flycatcher recruits. The energetic demands of female and male nestlings in this species differ during growth, thus altered early rearing conditions (here experimentally altered sex ratio in the broods) may affect performance of males and females differently both on the short term (i.e. the growth and mortality when they are nestlings) and on the long term (e.g. reproductive success, Haemosporidian infection status when they are adults). In addition if females of this species actively participate in extra-pair matings to improve the genetic quality of their offspring, extra-pair nestlings may be less sensitive to parasitic infections.

Early rearing conditions of 477 nestlings (in 2017 and 2018 altogether) were manipulated to alter the brood sex ratios and thus the energetic need of the nestlings. Later on morphological and breeding data and blood samples were collected during the breeding seasons of 2018, 2019, 2020 from individuals recruiting to the study area as adults. The blood samples of all experimental nestlings from both years of the study were molecularly sexed to estimate the sex ratios in the broods. We have also analysed the short term effects of the experiment on the nestlings (i.e. on nestling growth and mortality) and the adults (feeding rate and recruitment rate to the study area). We found that neither the original brood sex ratio nor the experimental brood sex ratio was related to body mass gain of the nestlings. We also found that male nestlings grew faster than female nestlings. A greater variation in 2-day body mass among the nestlings was associated with a higher probability of losing at least one nestling before fledging. The results of this part of the study were presented at the **12th European Ornithologists' Union Congress and at the XXI. Hungarian Ethological Congress in 2019** (see below) and we are currently **writing up the manuscript**.

The molecular analysis of Haemosporidian parasites infecting recruiting adults in 2018, 2019 and 2020 is also ready and the analysis of the results is in progress.

*The long-term effects of extra-pair paternity:*

In two previous years blood samples and breeding data have been collected from all broods (including parents and nestlings) from our central nestbox plots to investigate whether there is a difference in blood parasite infection status of extra-pair vs. within-pair offspring when they are adults. We are finishing the molecular identification of extra-pair and within pair nestlings in the broods and the analyses of Haemosporidian parasite infections in the adults.

**2.1 The role of IGF-1 in Haemosporidian infections: a correlative approach**

In this study, two populations of Bearded Reedlings (*Panurus biarmicus*), one in the Hortobágy National Park and one in Lake Fertő were studied. In 2016 morphological characters of the individuals were measured and blood samples were collected to study the role of IGF1 levels in malaria resistance of the individuals. We have randomly selected 47 individuals in the Hortobágy population and 51 individuals in the Lake Fertő population and we have found extremely low malaria prevalence in these individuals (0,0% and 3,9% respectively). So I was unable to perform the planned analyses on this species. I have also did a literature search and compared our findings with prevalence data found in other bearded reedling populations and other reed dwellig passerines co-occouring with bearded reedlings.

We found that prevalence of avian malaria is consistently low also in other bearded reedling populations even though the prevalence of vectors transmitting avian malaria is high. Our results are even more striking as the prevalence of avian malaria is generally high in other reed dwelling passerines (between 23.2% and 55.0%). This may either suggest that Bearded Reedlings may avoid or quickly clear these infections, or these parasites cause high mortality in this species.

Our results were **published in Parasitology** (see below).

**2.2 The role of IGF-1 in Haemosporidian infections: an experimental approach**

In the second part of the study, IGF-1 levels were planned to be manipulated in young Bearded Reedlings males before their first moult into adult plumage. I predicted a decrease in blood parasite parasitaemia among IGF-1 implanted males, since previous studies found an immune system stimulating effect for IGF-1. However, in the study reported under 2.1 I have found an extremely low malaria prevalence both in the two studied Bearded Reedling populations which was turned out to be a general phenomenon in this species (see above).

Therefore we were unable to perform the experiment described under 2.2. Instead, I have started to study the malaria infection status of Barn Swallows (*Hirundo rustica*) in relation to different morphological and physiological characters of the individuals during breeding (see 5.).

**3. Malaria infection status of European Robins in relation to timing of autumn migration I.**

As reported in the previous year, in addition to the subprojects described in my proposal we have studied avian malaria infections in European Robins (*Erithacus rubecula*) during autumn migration in Hungary. We found no sex or age related differences in avian malaria prevalence and no relationship between infection status and body size or actual condition of the birds was found either. However, the timing of autumn migration differed marginally between infected and non-infected juveniles, so that parasitized individuals arrived later at the Hungarian stopover site. This is either because avian malaria infections adversely affect the migration timing or migration speed of the birds, or because later arriving individuals come from more distant populations with possibly higher blood parasite prevalence. The possible

delay that parasites cause in the arrival time of the birds during autumn migration could affect the whole migratory strategy and the breeding success of the birds in the next season.

The manuscript describing these results is now **published in Parasitology** (see below).

**4. The effects of different malaria parasites during the autumn migration of European Robins II.**

We have started to analyse the data collected for the previous study (the laboratory costs for this study was covered from the grant FK127917) further to study the effects of different malaria lineages on fat accumulation and arrival time to the resting sites during autumn migration. We found that individuals infected with a certain parasite lineage were heavier on average and juveniles infected with this lineage had higher probability of having a visible fat. On the other hand, adult birds infected with another lineage had lower probability of having a visible fat. These parasite lineages caused a significant delay in the timing of migration too.

We are currently summarizing our results and have started to write up the manuscript.

**5. Malaria infection status of Barn Swallows in relation to morphological and physiological characters of the individuals**

As avian malaria prevalence was so low in Bearded Reedlings I was unable to perform the study described under 2.2. Instead I have started a new collaboration in which we investigate malaria infection status of Barn Swallows in relation to different physiological and morphological characters of the individuals.

We collected reproductive effort and survival data and blood samples for physiological parameters from approximately 70 breeding pairs each year between 2015 and 2017. This dataset renders possible to explore reproductive senescence and changes of survival likelihood by advancing biological age, and whether these fitness parameters correlate with physiological condition within and among individuals. We predict that ageing is affected by oxidative physiology, however the rate of senescence is modified by parasitism.
For this project I have screened all the samples for blood parasites (the laboratory costs for this study was covered from the grant FK127917) and we have started the statistical analyses.

***6. The role of MHC genes in mate choice***

As the MHC gene complex has an important role in parasite defence, we have extended the field and laboratory work on collared flycatchers with the study of MHC gene complex in relation to mate choice and acoustic signals. Previous studies on other bird species showed that a correlation may exist between the MHC profiles of the individuals and their morphological, olfactory and colour traits which have important roles in mate choice. However, the correlation between MHC genes and bird song has not been examined previously. We are the first who studied the relationship between the MHC profile of the individuals and their acoustic signals. We found that neither the MHC allele diversity of the

individuals, nor the presence of certain MHC alleles correlated with the qualitative and quantitative characteristics of the song of collared flycatcher males. In addition, genetically more similar males had no similar song parameters either. However, the frequency of the song of the males correlated with the presence of a certain MHC allele which seems to impair the survival of the individuals. This means that certain aspects of bird songs may show reliable information about the quality of the males which helps the females to optimize their mate choice.

Our study based on these results is **published in Molecular Ecology**.

**Published papers related to the project in which the funding of NRDI is indicated:**

**Szöllősi, E.**, Tóth, Z., Mahr, K., Hoi, H., Lendvai, Á.Z. (2019) Extremely low malaria prevalence in a wetland specialist passerine. Parasitology 147:87-95. IF: 2,783

Ágh, N., Piross, I., Majoros, G., Csörgő, T., **Szöllősi, E.** (2019) Malaria infection status of European Robins seems to associate with timing of autumn migration but not with actual condition. Parasitology. 14:1-7. IF: 2,456

Garamszegi, L.Z., Zagalska-Neubauer, M., Canal, D., Blazi, G., Laczi, M., Nagy, G., **Szöllősi, E.**, Vaskuti, E., Török, J., Zsebők, S. (2018) MHC-mediated sexual selection on bird song: generic polymorphism, particular alleles and acoustic signals. Molecular Ecology 27:2620-2633. doi: 10.1111/mec.14703. IF: 6,086

**Conference contributions related to the project in which the funding of NRDI is indicated:**

Sarkadi, F., Szász, E., **Szöllősi, E.**, Kopena, R., Török, J., Rosivall, B. (2019) Hatással van-e a fiókák ivararánya a szülők következő évi visszatérésére és szaporodására? Poszter, XXI. Magyar Etológus Konferencia, Mátrafüred, Magyarország. Absztrakt kötet 61. oldal.

Gyarmathy, H., Kopena, R., **Szöllősi, E.**, Sarkadi, F., Szász, E., Török, J., Rosivall, B. (2019) A fészekaljak ivararányának hatása a szülői befektetésre. Előadás, XXI. Magyar Etológus Konferencia, Mátrafüred, Magyarország. Absztrakt kötet 14. oldal.

**Szöllősi, E.**, Tóth, Zs., Mahr, K., Herbert, H., Lendvai, Á.Z. (2019) Extrém alacsony malária prevalencia barkós cinegéknél. Poszter, XXI. Magyar Etológus Konferencia, Mátrafüred, Magyarország. Absztrakt kötet 63. oldal.

**Szöllősi, E.**, Tóth, Z., Mahr, K., Hoi, H., Lendvai, Á.Z. (2018) Remarkably low malaria prevalence in a wetland specialist passerine. Poster at the 12th European Ornithologists' Union Congress, Cluj-Napoca, Romania. Abstract booklet p151.

Rosivall, B., Sarkadi, F., **Szöllősi, E.**, Kopena, R., Szász, E., Török, J. (2019) The effect of brood sex ratio on offspring growth. Poster at the 12th European Ornithologists' Union Congress, Cluj-Napoca, Romania. Abstract booklet p210.

**Published paper marginally related to the project in which the funding of NRDI is indicated:**

Szász, E., Jablonszky, M., Krenhardt, K., Markó, G., Hegyi, G., Herényi, M., Laczi, M., Nagy, G., Rosivall, B., **Szöllősi, E.**, Török, J., Garamszegi, L.Z. (2019) Male territorial aggression and fitness in collared flycatchers: a long-term study. The Science of Nature. 106: 11. IF: 1,839

**Published paper in which the funding of NRDI is not indicated:**

Laczi, M., Garamszegi, L.Z., Hegyi, G., Herényi, M., Herényi, M., Ilyés, G., Könczey, R., Nagy, G., Pongrácz, R., Rosivall, B., **Szöllősi, E.**, Tóth, L., Török, J. (2019) Teleconnections and local weather orchestrate the reproduction of tit species in the Carpathian Basin. Journal of Avian Biology e02719 IF: 1,799

Nagy, G., Garamszegi, L.Z., Hegyi, G., Herényi, M., Laczi, M., Rosivall, B., **Szöllősi, E.**, Török, J. (2019) Digit ratio predicts the number of lifetime recruits in female collared flycatchers. Biology Letters. 15:20190051. IF: 3,323

Jones, W., Kulma, K., Bensch, S., Cichoń, M., Kerimov, A., Krist, K., Laaksonen, T., Moreno, J., Munclinger, P., Slater, F.M., **Szöllősi, E.**, Visser, M.E., Qvarnström, A. (2018) Interspecific transfer of parasites following a range-shift in Ficedula flycatchers. Ecology and Evolution. 8: 12183-12192. IF: 2,34