

Patterns of ectoparasite prevalence in the mountain white-crowned sparrow, *Zonotrichia leucophrys oriantha*

Student: Mikayla R. Thistle

Mentor: Ross R. Conover

Advanced Independent Research

Summer 2013

Patterns of ectoparasite prevalence in the mountain white-crowned sparrow, *Zonotrichia leucophrys oriantha*

Mikayla R. Thistle and Ross R. Conover

ABSTRACT

We examined how ectoparasites affect body condition and other traits that indicate individual health in mountain white-crowned sparrows (*Zonotrichia leucophrys oriantha*; hereafter, MWCS). We also investigated the factors that potentially influence susceptibility to ectoparasites in the MWCS population. Using both visual inspection and dust-ruffling, we determined ectoparasite loads in individual MWCS of a wild population. We related ectoparasite load to various life-history traits, including body condition, crown-white proportion, and sex. Our results show that crown-white proportion, a correlate of condition and a strong social signal, is lower in individuals hosting macro-ectoparasites. This is likely a balance of the effect of ectoparasites on their hosts with ectoparasites selecting for high conditioned hosts. We observed a significantly higher ectoparasite load in male MWCS than in females which may be attributed to physiological and behavioral differences between the sexes. This study highlights the need for additional experiments that can isolate health effects of ectoparasitism from traits that increase susceptibility of ectoparasitic infestation. Thus, we may be able to determine the effect of ectoparasite load on social signaling, sexual selection, and overall health.

INTRODUCTION

Ectoparasitic infestation can be costly to an avian host, as large infestations cause feather and skin damage as well as anemia due to blood loss (Clayton et al. 2008). Bird hosts can repair this tissue damage and reduce ectoparasite loads through increased preening and other preventative measures, but at the cost of increased metabolism (Booth et al. 1993) and reduction of other life history traits (e.g., growth, immunology, reproduction; Fitze et al. 2004a, Fitze et al. 2004b). Although the direct consequences of ectoparasitism are clear, the effect of ectoparasites on the long-term condition of avian hosts as well as the characteristics that increase susceptibility to ectoparasites remain poorly understood.

Research suggests that breeding individuals are more susceptible to ectoparasitic infestation than non-breeding individuals (Hamstra and Badyaev 2009). Reproductive hormones

of the host may even be triggering the reproduction of ectoparasites (Rothschild and Ford 1972). Carrying an ectoparasite load is especially costly during reproduction (Møller 1993). It has been found that parasitized birds may be less attractive to the opposite sex as individuals may have less brilliant plumage and ornamentation or they may sing a shorter song (Garamszegi et al. 2005). In particular, parasitic infestation and the resulting immune response may be altering singing behavior in a way that influences mate selection (Gilman et al. 2007, Munoz et al. 2010). Because their ability to find a mate may be reduced, they may have low fitness. Highly infested birds may also change time of reproduction and show decreased parental investment (Møller 1993). Fitness is reduced as infested parents have smaller clutch sizes (Fitz et al. 2004). Richner et al. (1993) found that hen flea, *Ceratophyllus gallinae*, infestation causes lower fledgling success, higher offspring mortality, and decreased size in great tit, *Parsus major*, chicks. As ectoparasite loads alter the fitness of individuals, it is important to understand how parasites may be targeting hosts and the extent to which they are lowering host condition.

Resource availability may affect the severity of ectoparasitic infestation as well (Sheldon and Verhulst 1996). Only individuals who can feed sufficiently and remain healthy enough to synthesize parasite defenses will be able to maintain low ectoparasite numbers (Lochmiller et al. 1993). However, when burdened with ectoparasites, avian life-history tradeoffs likely include increased food requirements or decreased condition and fitness. According to the optimal foraging theory, we may assume that individuals are always feeding to their maximum ability (MacArthur and Pianka 1966). Parasitized individuals experiencing an increased demand for food will have to allot more time and energy to foraging instead of preening and building immune defenses. This may result in a positive feedback loop resulting in increasingly lower condition, fitness, and survivability.

However, others argue that ectoparasites may not be most successful when associated with birds of low condition (Tschirren et al. 2007, Bize et al. 2008). Tschirren et al (2007) show that female hen fleas have greater reproductive success when they breed on great tits (*Parsus major*) that have had greater food availability earlier in life. Similarly, bat mites preferentially infest bats that are well-fed over individuals who are food-restricted (Christe et al. 2003). These individuals of high condition may harbor higher ectoparasite loads because their nutritional value indirectly increases parasite fitness. Bize et al. (2008) suggests that parasites experience maximum survival on hosts of intermediate condition. Hence, more research is clearly needed to

tease apart the patterns of ectoparasite susceptibility in bird hosts and their associated effects on demography and condition.

This study aims to elucidate the patterns of ectoparasitism in mountain white-crowned sparrows (*Zonotrichia leucophrys oriantha*). Due to the high energetic cost of hosting ectoparasites, we hypothesize that MWCS that are heavily parasitized will be of lower condition. Similarly, we hypothesize that crown-white proportion will be lower in parasitized individuals as it is a signal of condition. We suspect that females will be more heavily parasitized than males because producing eggs and rearing offspring is highly energy intensive. Finally, we hypothesize that parasitized individuals will visit baited traps more often than non-parasitized individuals and that food-supplemented sites will have a lower frequency of ectoparasitism due to greater resource availability.

METHODS

Study Site

This study was conducted during 2001 and 2013 in the upper East River Valley of the Gunnison National Forest, north of the Rocky Mountain Biological Laboratory in Gothic, Colorado (38°95'N, 106°98'W, 2910-3000 m) (Fig. 1). We monitored birds at four long-term research sites along the unpaved Forest Road 317. Vegetation at all sites included predominantly various willows (*Salix* spp.), *Veratrum* sp., and *Potentilla* sp. amongst a diverse community of wildflowers.

To investigate the effects of resource availability on parasite frequency and abundance, the four research sites were divided into two food-supplemented (FS) sites, FS1 and FS2, and two non-food-supplemented (NS) sites, NS1 and NS2 (Fig. 1). All trap locations at FS1 and FS2 were baited with a handful of seed every day regardless of opening traps. At NS1 and NS2, traps were only sparingly baited with seed when traps were opened.

Bird Trapping and Processing

Individual MWCS were captured using wire Potter traps baited with wild bird seed composed primarily of white proso millet. Seed was baked to prevent the growth of non-native plants. Ten to thirteen traps were placed on each of the four sites, and rotated between 17-20 trap locations. Most traps were set in willow patches and slightly concealed. In 2001, observations were from 24 May to 29 July, and in 2013 observations were from 16 June to 22 July. Trapping

largely occurred between 0600 and 1200 hours. Traps were checked for captured birds every hour and locked open once trapping was completed so that birds may still feed. Target mist netting with playback recordings were used to capture individuals that were not captured in the Potter traps.

At first capture, MWCS were sexed by the presence of an enlarged cloacal protuberance in males or a brood patch in females. MWCS received a uniquely numbered, butt-end, United States Geological Survey metal leg band (size 1B). Males were banded on their right leg and females on their left. Individuals were also banded with a unique combination of three color bands, allowing for identification without capture. We measured length of the tarsus, culmen, wing chord, cloacal protuberance and rectrices as well as crown and stripe width, abdominal and furcular fat, and mass. Fat was visually determined on a scale from 0 (no fat) to 5 (bulging fat) and, in females, the stage of brood patch development was rated from 0 (no brood patch) to 3 (full brood patch; Ralph et al. 1993). A body condition index determined by calculating the residuals of a linear regression of body weight against tarsus length (Veiga 1993, Green 2001). This regression was significant in 2001 ($r^2 = 0.1179$, $df = 52$, $p = 0.0118$), 2013 ($r^2 = 0.0544$, $df = 86$, $p = 0.0298$), and with combined 2001 and 2013 data ($r^2 = 0.045$, $df = 140$, $p = 0.008$), thus tarsus length is positively correlated with mass. The trap site of each capture was also recorded.

In 2001, ectoparasite load was estimated for each individual by visually examining the flanks, belly, throat, chin, nape, back and rump. The total number of ectoparasites including louse eggs, lice (Phthiraptera) and mites (Acari) were counted (Walther and Clayton 1997). To determine the ectoparasite load of each individual in 2013, we employed a dust-ruffling technique similar to that described by Walther and Clayton (1997). About a thimble-sized amount of Evergreen® Pyrethrin dust (1% pyrethrin), an insecticide safe for mammals and birds derived from *Chrysanthemum*, was worked into the feathers of the bird for up to ten minutes using a small paint brush. At this time, any ectoparasites fell from the body and into a plastic container lined with a sheet of paper. Due to the unreliability of using dust-ruffling to recover mites (Walther and Clayton 1997), only macro-ectoparasites (chewing lice (Phthiraptera), fleas (Siphonaptera), and flies (Diptera)) were counted and collected in a tube of 90% ethyl alcohol for identification. Ectoparasite load was measured as the total number of macro-ectoparasites removed. We do not expect these procedural differences to bias the data because the methods of

visual inspection and dust-ruffling used in this study have been found to yield comparable results (Koop and Clayton 2013).

Statistical Analyses

To determine what factors may be affecting body condition in MWCS, we compared the mean condition of male and female MWCS using a t-test. We examined the effect of seasonality on condition by using a general linear model. To determine how ectoparasites may be affecting host condition and also to elucidate which life history traits may drive ectoparasitic infestation in MWCS populations, we ran t-tests to see how key morphological traits relate to ectoparasite load. Specifically, we used t-tests to show any differences in mean condition and crown-white proportion with the presence or absence of macro-ectoparasites. A general linear model was used to determine if there was a change in condition with increased ectoparasite load. We also used a t-test to determine whether average ectoparasite load was different between male and females MWCS. To examine the effect of resource availability on ectoparasite load, we compared the number of individuals who hosted macro-ectoparasites in food supplemented sites to non-food supplemented sites using a Fisher's Exact Test. We also ran a t-test to determine whether individuals on average had a different ectoparasite load in food supplemented sites when compared to non-food supplemented sites. Finally, we used t-tests to see whether parasitized individuals visited traps more often than individuals with few ectoparasites. All statistical analyses were completed using JMP Pro® software (version 10.0.0; SAS Institute, Inc.).

RESULTS

In 2001, 57 different MWCS were found hosting ectoparasites through visual examination and in 2013, 10 of 107 captured and dust-ruffled MWCS were found hosting macro-ectoparasites (chewing lice, fleas, flies).

Using data from 2001 and 2013, we found that sex and date significantly affect body condition (Fig. 2, Fig. 3). On average, males had a greater body condition than females ($t=2.697$, $df=100.656$, $P=0.004$) and condition decreased as the season progressed ($t=-2.57$, $df=140$, $P=0.011$).

Average body condition did not differ between individuals hosting macro-ectoparasites and individuals free of macro-ectoparasites ($t=-0.333$, $df=12.247$, $P=0.745$) in 2013 MWCS. A

trend was found in average body condition as measured by residuals that it increased with increased total ectoparasite load in 2001 ($t=1.69$, $df=52$, $P=0.0964$; Fig. 4).

In 2001, male MWCS were found to host significantly more ectoparasites than females ($t=2.598$, $df=40.775$, $P=0.007$; Fig. 5).

2013 measurements of crown-white proportions show that individuals hosting macro-ectoparasites have a significantly lower crown-white proportion than individuals without macro-ectoparasites ($t=-2.764$, $df=15.213$, $P=0.0072$; Fig. 6).

There was no significant difference in body condition between individuals living in food supplemented sites and non-food supplemented sites in 2001 and 2013 ($t=-1.073$, $df=99.479$, $P=0.286$). Individuals with macro-ectoparasites do not visit traps with a significantly different frequency than individuals who were not hosting macro-ectoparasites ($t=0.402$, $df=11.928$, $P=0.695$). Similarly, individuals with different ectoparasite loads do not visit traps with significantly different frequencies ($t=0.48$, $df=56$, $P=0.634$). MWCS living in food-supplemented sites did not have a significantly different frequency of macro-ectoparasitic infestation than individuals in non-food supplemented sites (Fisher's Exact Test, $df=1$, $P=0.265$). However, in 2001, individuals in food-supplemented sites did have a significantly greater mean ectoparasite load than individuals in non-food supplemented sites ($t=-1.687$, $df=40.134$, $P=0.050$).

DISCUSSION

This study aimed to identify patterns of ectoparasitic infestation in the MWCS population of the Upper East River Valley, determine the effect of ectoparasites on the condition and health of their hosts, and investigate factors that may make an individual particularly susceptible to ectoparasitism. We found a trend that shows MWCS with higher ectoparasite loads tend to have a higher condition. Previous studies have shown a negative correlation between ectoparasite load and condition (Weddle 2000, Whiteman and Parker 2004). Because ectoparasites deplete host resources, it is expected that parasitized individuals have a lower condition index. Opposing literature highlights a lack of understanding in the host-parasite system. This conflict has been demonstrated in studies involving nestlings (Roulin et al. 2003, Tschirren et al. 2007, Brommer et al. 2011, Heylen and Matthysen 2011). The "Tasty Chick Hypothesis" states that weaker nestlings may be more attractive to parasites due to their lower immune response (Christe et al.

1998). However, the contradictory “Well-Fed Hypothesis” argues that parasites will often show host preference to stronger, well-developed chicks as they can provide more nutrient resources to their hosts (Christe et al. 2003). Parasites may choose hosts of higher condition because they may positively affect their fitness (Brommer et al. 2011, Heylen and Matthysen 2011). Heylen and Matthysen (2011) have demonstrated that more well-developed, healthier great tit chicks are selected by the tick, *Ixodes arboricola*, more often than less-developed and weaker chicks. Because these individuals can provide more resources to the parasite and have greater survivorship, their parasites may have higher reproductive success. 2001 data shows that more heavily parasitized individuals were found in food supplemented sites. This supports the idea that parasites may be attracted to hosts with more nutritional value. Heylen and Matthysen (2011) also suggest that the sensory capabilities of parasites may enable them to select for certain physiological traits in hosts. Balashov (1972) also suggests that ectoparasites, in particular ixodid ticks, can more easily obtain food sources from hosts of high condition because they have a warmer body temperature.

However, this may be confounded with our finding that males have a higher condition than females. Because more males were found to have high ectoparasite loads (see below), it may falsely appear that ectoparasite load is positively correlated with body condition. We expect that variability in female mass due to egg mass did not influence our data as this increase in mass would have increased female condition.

We observed that individuals that hosted macro-ectoparasites had a lower crown-white proportion than individuals without macro-ectoparasites. Because badge size has been found to be a fairly accurate measure of condition in birds (Veiga 1993), this result contradicts our finding that MWCS of higher condition tend to be more heavily parasitized. Birds with smaller badges show a decreased ability to defend territories along with the resources the territory holds (Laubach et al. 2013). These parasitized individuals who may need additional food sources to make up for energy loss may find it even more difficult to find sufficient food as they experience increased agonism from territorial males. Since increased crown-white proportion in male MWCS is used as a symbol of territoriality and dominance, female choice based on crown-white proportion may lead to sexual selection. If females select against males that are parasitized, one may expect to observe a decrease in their crown-white proportion.

We also found that males have significantly more ectoparasites than females. Previous studies have found marked sexual dimorphism in immune response (Møller et al. 1998, Folstad and Karter 1992). In many bird species, males are found to have significantly smaller spleens than females (Møller et al. 1998) and high testosterone levels are linked to immunosuppression (Folstad and Karter 1992). Male MWCS may simply come into contact with more parasites as the territorial sex with more mobile behavior. Finally, males must expend extra energy defending their territory and singing. Thus, the cost of these activities may reduce the amount of energy allocated to parasite defense.

Because the abundance of macro-ectoparasites in this MWCS population is so low, it is necessary to take new directions in future research. To tease apart causality in ectoparasitic infestation, we hope to experimentally manipulate ectoparasite load by introducing chewing lice to wild, unparasitized MWCS. We would then monitor the condition of the bird, changes in ectoparasite load, and changes in behavior that may indicate energy reallocation. As part of a long term study, we would also like to trace the condition and ectoparasite load through all developmental stages on MWCS as it may help us determine when MWCS are most susceptible to ectoparasites and how infestation may alter the long-term health of individuals. Because there is still much debate on host choice in ectoparasites comparing condition changes in MWCS through all life stages may allow us to determine what host characteristics are attractive to parasites as well as how parasites affect individual health.

Studying changes in ectoparasite load in different habitats and over an elevational gradient may elucidate the effects of environment and weather on host-ectoparasite relationships. It may also provide useful insight both on how condition differs between populations and how individuals select territories. As they fly up valley during migration, MWCS may be separating themselves based on health, with individuals of lower condition settling on habitat extremes because they either lack the energy to continue their journey or cannot compete for resources in optimal territories. Future research may be able to answer how MWCS populations organize themselves within habitat.

Finally, we would like to study the transmission of ectoparasites within and possibly between populations. We would like to determine how the parasites are spread from one individual to another, as well as what is controlling the timing of the onset. This may provide information on

behavioral changes (breeding, territory defending, preening), as well as changes in time and energy budgets throughout the season.

In conclusion, our results show ectoparasite load may be affecting condition in MWCS; however, more work must be done to differentiate effects of ectoparasitism from causes of susceptibility. Ectoparasite load may be influencing important social signals in MWCS populations as well, which may affect territory defense and sexual selection. Lastly, behavioral studies aiming to examine altered resource allocation and energy budgets of parasitized MWCS may elucidate the true health and social costs of ectoparasitism.

ACKNOWLEDGMENTS

We would like to thank Harriet Morgan and Rachel Siller for field assistance, the Rocky Mountain Biological Laboratory for logistical assistance, and Johannes Foufopoulos for collaboration. Research was conducted under USGS federal bird banding permit #23680 and state of Colorado scientific collection license #13TRb2060. All procedures were approved by the Rocky Mountain Biological Laboratory Animal Care and Use Committee.

LITERATURE CITED

- Balashov YS. 1972. Bloodsucking ticks (Ixodidea) – vectors of diseases of man and animals Entomological Society of America, Miscellaneous publication, 8:159-376.
- Bize P, Jeannerat C, Klopfenstein A, and Roulin A. 2008. What Makes a Host Profitable? Parasites Balance Host Nutritive Resources against Immunity. *The American Naturalist*, 171(1): 107-118.
- Booth DT, Clayton DH, and Block BA. 1993. Experimental demonstration of the energetic cost of parasitism in free-ranging hosts. *Proceedings of the Royal Society of London B*, 253:125-129.
- Brommer JE, Pitala N, Siitari H, Klun E, and Gustafsson L. 2011. Body Size and Immune Defense of Nestling Blue Tits (*Cyanistes caeruleus*) in Response to Manipulation of Ectoparasites and Food Supply. *The Auk*, 128(3): 556-563.
- Christe P, Giorgi MS, Vogel P, and Arlettaz R. 2003. Differential Species-Specific Ectoparasitic Mite Intensities in Two Intimately Coexisting Sibling Bat Species: Resource-Mediated Host Attractiveness or Parasite Specialization? *Journal of Animal Ecology*, 72(5): 866-872.
- Christe P, Møller AP, and de Lope F. 1998. Immunocompetence and Nestling Survival in the House Martin: The Tasty Chick Hypothesis. *Oikos*, 83(1): 175-179.

- Clayton DH, Adams RJ, and Bush SE. 2008. Phthiraptera, the Chewing Lice in Parasitic Diseases of Wild Birds. Eds. Atkinson CT, Thomas NJ, and Hunter DB. John Wiley and Sons, Inc.
- Fitze PS, Clobert J, and Richner H. 2004a. Long-term Life-history Consequences of Ectoparasite-modulated Growth and Development. *Ecology*, 85(7): 2018-2026.
- Fitze PS, Tschirren B, and Richner H. 2004b. Life History and Fitness Consequences of Ectoparasites. *Journal of Animal Ecology*, 73: 216-226.
- Folstad I and Karter AJ. 1992. Parasites, Bright Males, and the Immunocompetence Handicap. *The American Naturalist*, 139(3): 603-622.
- Garamszegi LZ, Heylen D, Møller AP, Eens M, and de Lope F. 2005. Age-Dependent Health Status and Song Characteristics in the Barn Swallow. *Behavioral Ecology*, 16(3): 580-591.
- Gilman S, Blumstein DT, and Foufopoulos J. 2007. The Effect of Hemosporidian Infections on White-Crowned Sparrow Singing Behavior. *Ethology*, 113: 437-45.
- Green AJ. 2001. Mass/Length Residuals: Measures of Body Condition or Generators of Spurious Results? *Ecology*, 82(5): 1473-1483.
- Hamstra TL and Badyaev AV. 2009. Comprehensive Investigation of Ectoparasite Community and Abundance Across Life History Stages of Avian Host. *Journal of Zoology*, 1-9.
- Heylen DJA and Matthysen E. 2011. Experimental evidence for host preference in a tick parasitizing songbird nestlings. *Oikos*, 120: 1209-1216.
- JMP Pro®, Version 10. SAS Institute Inc., Cary, NC, 1989-2013.
- Koop JAH and Clayton DH. 2013. Evaluation of two methods for quantifying passeriform lice. *Journal of Field Ornithology*, 84(2): 210-215.
- Laubach ZM, Blumstein DT, Romero LM, Sampson G, and Foufopoulos J. 2013. Are white-crowned sparrow badges reliable signals? *Behavioral Ecology and Sociobiology*, 67:481-492.
- Lochmiller RL, Vestey MR, and Boren JC. 1993. Relationship between Protein Nutritional Status and Immunocompetence in Northern Bobwhite Chicks. *The Auk*, 110(3): 503-510.
- MacArthur RH and Pianka ER. 1966. On Optimal Use of a Patchy Environment. *The American Naturalist*, 100(916): 603-609.
- Martin TE and Geupel GR. 1993. Nest-Monitoring Plots: Methods for Locating Nests and Monitoring Success. *Journal of Field Ornithology*, 64(4): 507-519.
- Møller AP. 1993. Ectoparasites Increase the Cost of Reproduction in their Hosts. *Journal of Animal Ecology*, 62(2): 309-322.

- Møller AP, Sorci G, and Erritzøe J. 1998. Sexual Dimorphism in Immune Defense. *The American Naturalist*, 152(4): 605-619.
- Munoz NE, Blumstein DT, and Foufopoulos J. 2010. Immune System Activation Affects Song and Territorial Defense. *Behavioral Ecology*, 21:788-793.
- Ralph, C. John, Geoffrey R. Geupel , Peter Pyle, Thomas E. Martin, and David F. DeSante. *Handbook of field methods for monitoring landbirds*. Albany, Calif.: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station, 1993.
- Richner H, Oppliger A, and Christe P. 1993. Effect of an Ectoparasite on Reproduction in Great Tits. *Journal of Animal Ecology*, 62: 703-710.
- Rothschild M and Ford B. 1972. Breeding Cycle of the Flea *Cediopsylla simplex* is controlled by breeding cycle of host. *Science*, 178: 625-626.
- Roulin A, Brinkhof MWG, Bize P, Richner H, Jungi T, Bavoux C, Boileau N, and Burneleau G. 2003. Which Chick Is Tasty to Parasites? The Importance of Host Immunology vs. Parasite Life History. *Journal of Animal Ecology*, 72(1):75-81.
- Sheldon BC and Verhulst S. 1996. Ecological Immunology: Costly Parasite Defences and Trade-offs in Evolutionary Ecology. *TREE*, 11(8): 317-321.
- Tschirren B, Bischoff LL, Saladin V, and Richner H. 2007. Host Condition and Host Immunity Affect Parasite Fitness in a Bird-Ectoparasite System. *Functional Ecology*, 21(2): 372-378.
- Veiga JP. 1993. Badge Size, Phenotypic Quality, and Reproductive Success in the House Sparrow: A Study on Honest Advertisement. *Evolution*, 47(4): 1161-1170.
- Walther BA and Clayton DH. 1997. Dust Ruffling: A Simple Method for Quantifying Ectoparasite Loads of Live Birds. *Journal of Field Ornithology*, 68(4): 509-518.
- Weddle CB. 2000. Effects of Ectoparasites on Nestling Body Mass in the House Sparrow. *The Condor*, 102(3):684-687.
- Whiteman NK and Parker PG. 2004. Body Condition and Parasite Load Predict Territory Ownership in the Galápagos Hawk. *The Condor* 106:915–921.

APPENDIX

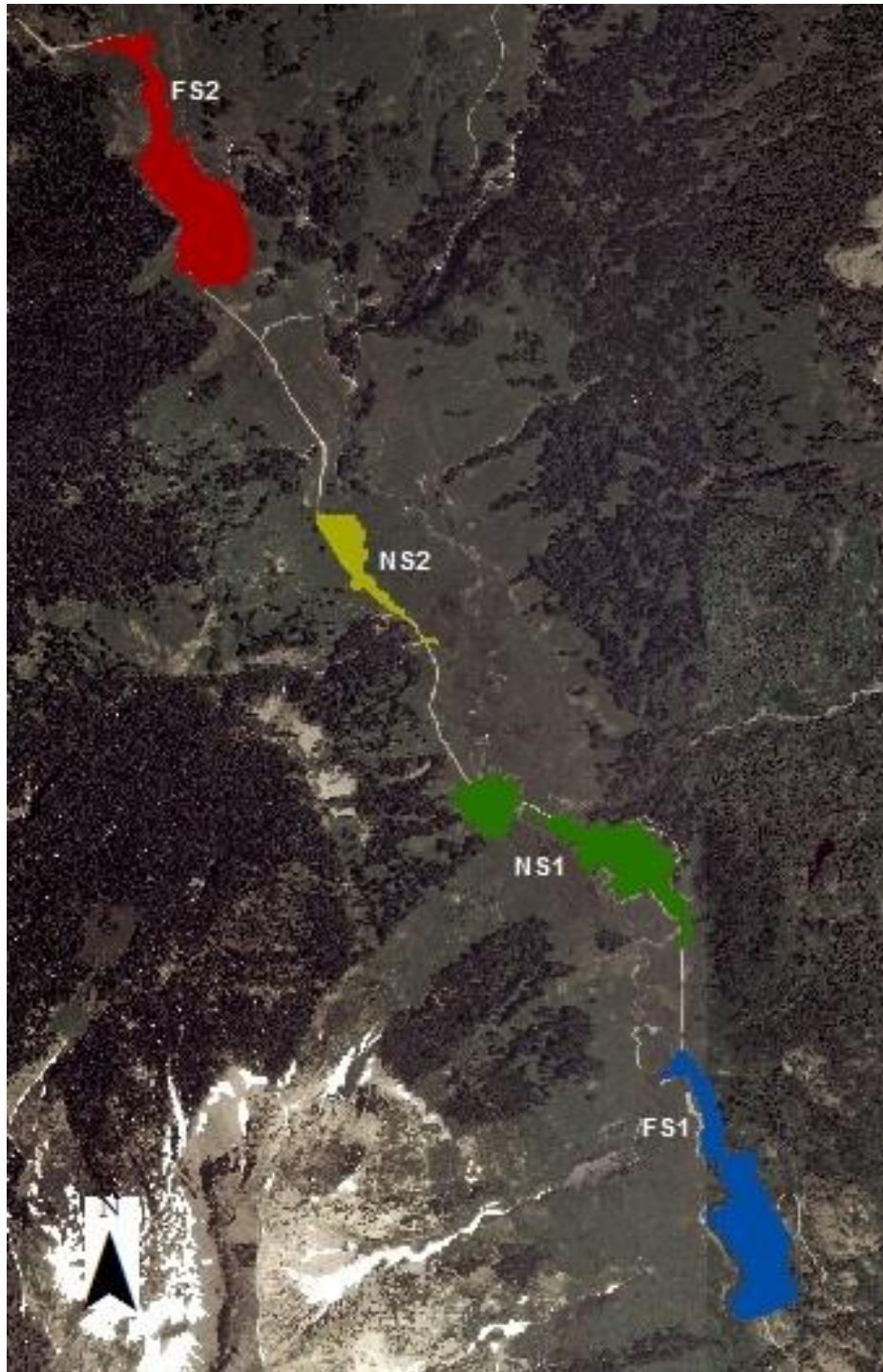


Fig. 1 Site Map

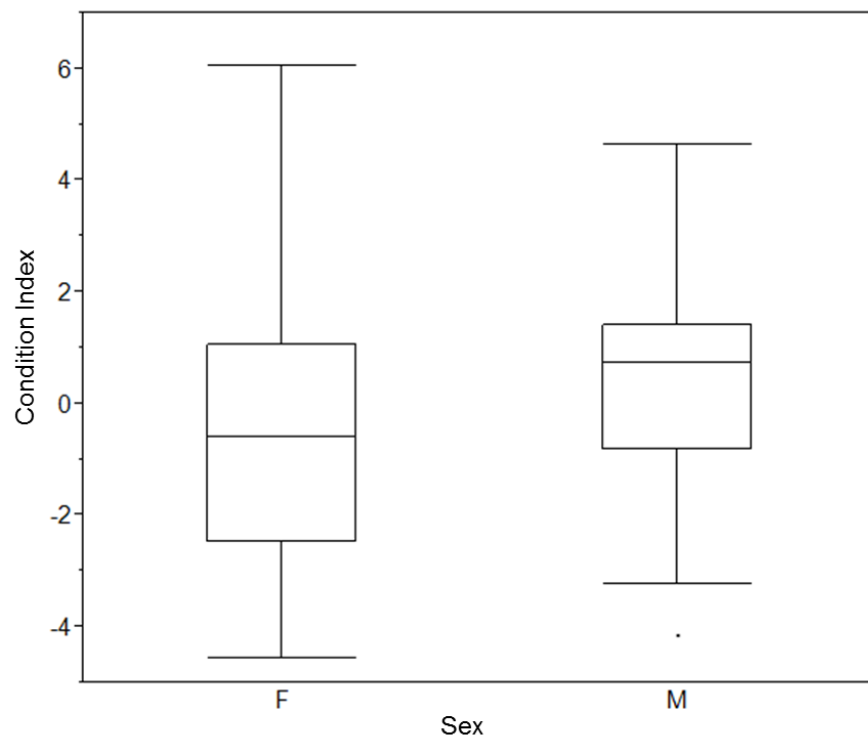


Fig. 2 Effect of sex on condition. 2001, 2013

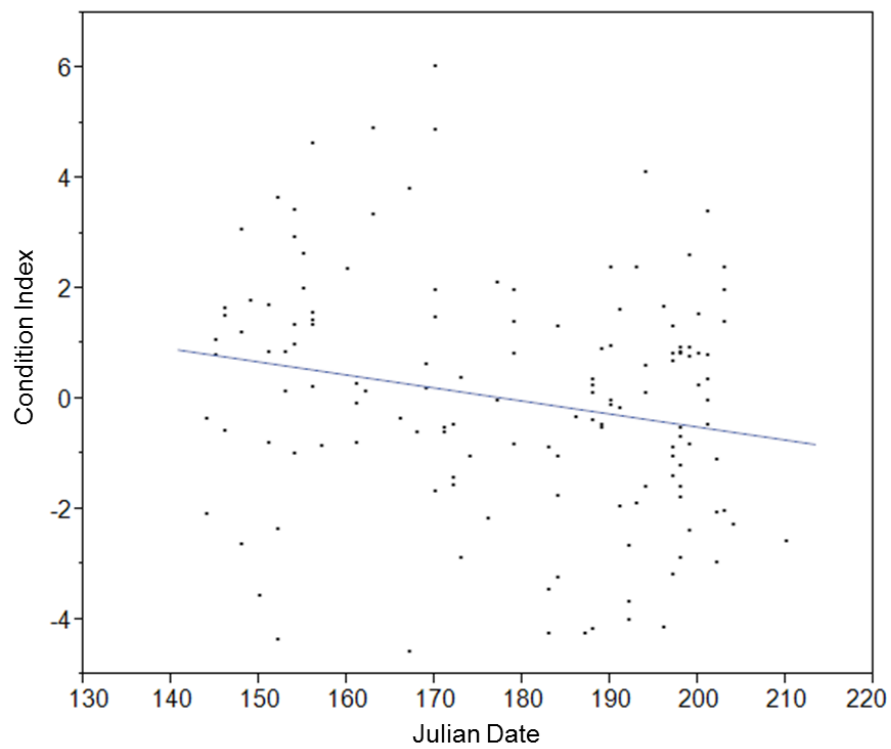


Fig. 3 Seasonality of condition. 2001, 2013

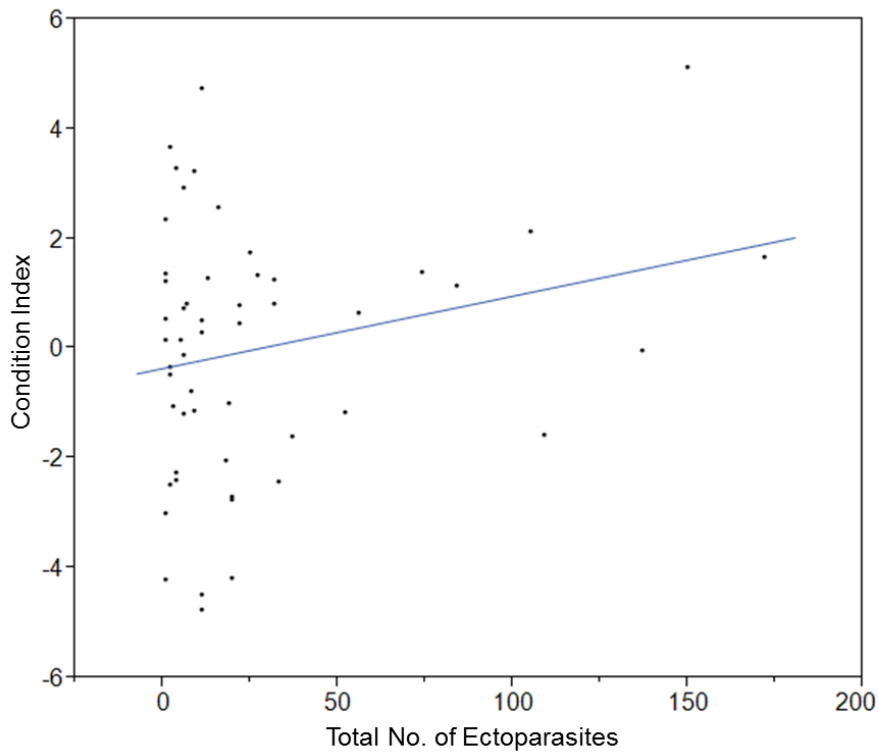


Fig. 4 Effect of ectoparasite load on condition of MWCS. 2001 $R^2 = 0.0533$

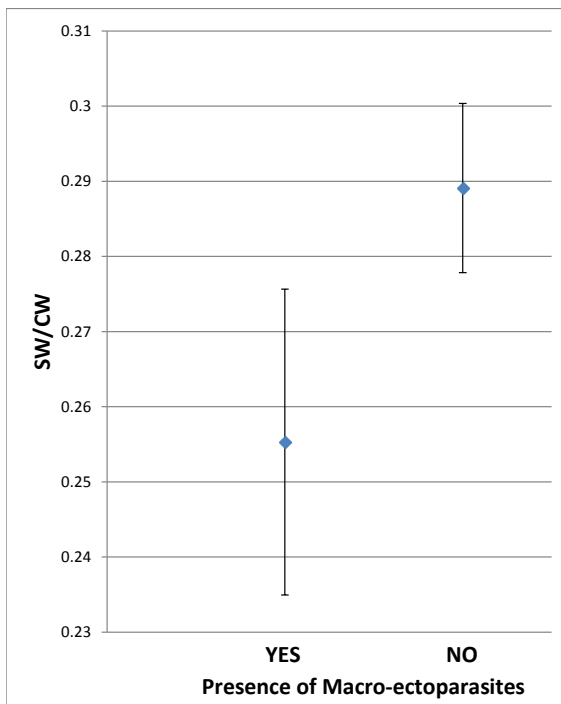


Fig 5. Average stripe width to crown width ratio in MWCS with and without macro-ectoparasites. Bars represent a 95% confidence interval. 2013

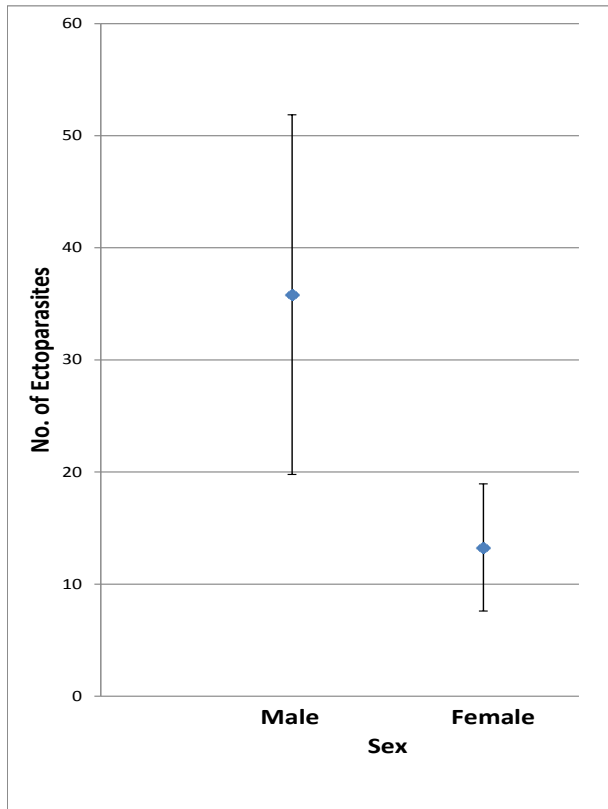


Fig 6. Average number of ectoparasites on male vs. female MWCS. Bars represent a 95% confidence interval. 2001