

Impacts of Historical Hydroperiod on Bird Predation of Emergent Aquatic Insects.

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Full-Time Independent Research
Summer 2017

Abstract

As global climate changes ephemeral freshwater systems face changes in historical hydroperiod with a shift towards shorter wet periods. Vernal ponds are one such type of lentic ephemeral system; in general they are relatively small and shallow, which causes them to dry in late spring or early summer. Their size allows vernal ponds to have a close connection with the terrestrial environment adjacent to them, and changes in their hydroperiod could have effects on both the species, which inhabit the ponds. Emergent aquatic insects are an important food source for terrestrial birds and shifts in hydroperiod may affect the availability of this resource. The present study investigates how birds in the Mexican Cut Nature Preserve interact with ponds of different hydroperiods. There were a greater number of bird observations at permanent ponds than at temporary ponds (Linear mixed effects model, $p < 0.001$, $F = 68.82$). Permanent ponds are more diverse and consistent systems, which may attract birds to them. More research is required to understand how birds interact with aquatic systems to better aid in conservation efforts in the future.

Introduction

The earth's climate is predicted to change on average 0.2°C over the next decade (IPCC 2014). However, particular regional systems, such as mountains, are expected to see more extreme changes. In mountains and high elevational regions, climate models predict that warming rates will be enhanced when compared against lower elevation areas at the same latitudes especially during colder seasons (Rangwala et al. 2013). Climate change does not just result in altered temperatures. Changes in regional hydrology are predicted to be one of the most important consequences of global climate change (Brooks 2009). Warmer temperatures can lead to increased evapotranspiration lowering the water levels in aquatic systems even in areas with consistent precipitation (Oechel et al. 2000). Shifts in the amount of water in a system may contribute to a change in the species that a given pond is able to support.

Ephemeral freshwater systems are unique habitats that are especially vulnerable to climate change as their existence is dependent on both short-term weather patterns and long-term climates (Brooks 2004). Lentic ephemeral systems, like vernal ponds, only exist for a short period of time after the snow melt, drying in early to mid summer and staying dry until the following spring (Wissinger et al. 1999). Therefore, hydroperiod and hydroregime are two of the most important abiotic influences on the ecology of ephemeral systems (Brooks 2005). Along the different hydroperiods in pond systems there are shifts in the communities that the ponds support. Permanent ponds are able to support those insects with longer larval stages because they remain filled throughout the duration of the larval stage, by contrast only those insects with shorter more succinct larval stages are able to emerge out of the temporary ponds before drying occurs (Wissinger et al. 1999). The longevity of permanent ponds also allows them to support predator communities, such as salamanders, further influencing the types of insect which are able to survive in the ponds (Wissinger et al. 1999). Temporary ponds cannot support these populations and as a result those insects that live in them do not need to account for the risk of predation (Wissinger et al. 1999).

Due to their usually small size and ephemeral nature, temporary aquatic environments are often more closely linked to neighboring riparian zones by the flow of materials across the

boundary when compared to permanent aquatic ecosystems (Baxter et al. 2005, Richardson et al. 2010). Emergent aquatic insect are an important link between freshwater and terrestrial ecosystem by providing a subsidy for birds in riparian areas (Nakano and Murakami 2001, Baxter et al. 2005, Richardson et al. 2010, Richardson and Sato 2015). Aquatic insects make up a substantial portion of riparian bird diets, making up 10-40% of a birds energy flow dependent on taxa (Nakano and Murakami 2001). Therefore, a change in the biomass of insects that are able to emerge from a given system may lead to a sharp decline in the available food source for birds and other terrestrial predators. This becomes more important in sub-alpine regions where harsh conditions limit food resources, increasing the importance of aquatic insect subsidies to terrestrial predators (Epanchin et al. 2010).

There are abundant wetlands along the sub-alpine valleys of the western slopes of the Rocky Mountains (Wissinger et al. 1999), therefore is an ideal system to look at the effects of hydrology on cross ecosystem effects of freshwaters on birds. The present study looked to investigate how the emergence of aquatic insect adults differs between temporary and permanent ponds and how bird predations changes between these two different pond types. We predict that insects in temporary ponds will be stranded by the drying habitat, and therefore be consumed by detritivorous and scavenging/opportunistic foraging birds. However, in permanent ponds, the insects will emerge as adults and be consumed by aerial predator birds. A second possible prediction is that there has been selection pressure for the insects to emerge early in temporary ponds, therefore emergence still happens, but earlier than in permanent ponds. Birds then will be aerially foraging early season in temporary ponds and late season in permanent ponds.

Methods

Pond Sites

The Mexican Cut Nature Preserve (MCNP), a wetland complex in the Elk Mountains of central Colorado, contains a complex of adjacent basins of varying hydroperiods (Wissinger et al. 1999). There are three main hydroperiods in the pond system, Vernal, Autumnal, and Permanent. Vernal ponds are temporary pools that dry in early summer and do not refill until the following spring with the snow melt (Wissinger et al. 1999). As a result of their drying temporary ponds are often the least diverse of the ponds in the MCNP. Permanent ponds are those ponds, which have not dried in the last fifty years and remain water filled through the entire summer, they have the highest diversity of benthic macroinvertebrates (Wissinger et al. 1999). All ponds in our survey had data loggers to measure water level and dry date.

Bird Surveys

Three temporary and three permanent ponds were chosen at MCNP for bird observations, resulting in a total of 6 sites. I performed visual bird surveys at each pond over a six-week period, with at least 6 observations per pond site. Surveys were conducted shortly after sunrise, mid day, and before sunset. Birds within the survey boundary were identified and counted using 8x binoculars. Birds were surveyed for twenty minutes in four five-minute intervals. Each bird within the site was counted and identified within each five-minute interval. The ponds were divided into three zones of use, identified as pond, riparian zone (0-3 meters from pond edge), or terrestrial ecosystem (>3 meters from pond edge), and the pond zone was further divided into wet or dry area.

Bird Behaviors

During the 20-minute survey at each site, I also characterized the behavior of each bird. Birds were characterized as: riparian feeding, aerial feeding, flying over, loafing, moving around in the area, calling, scavenging, or territorial. Any additional disturbances that disrupted normal activity, either predator related or anthropogenic, were also recorded.

Data Analysis

Mixed effect models were used to analyze the difference between bird use of temporary and permanent ponds. Fixed-factor predictor variables included pond hydrology, pond zone, time of day, and day of year. Random-factor predictor variables were other environmental variables measured, such as daily temperature, wind speed, precipitation, and cloud cover. Response variable was number of birds. To analyze bird composition at each site, I used a non-metric multidimensional scaling (NMDS) ordination. All analyses were conducted in R (RCoreTeam 2016).

** Note: The ordinations and environmental variable tests have not yet been run.*

Insect Emergence

Insect emergence, the mechanism for how hydrology alters bird feeding, were collected with insect emergence traps placed on the surface of the ponds. I will help with these methods as a part of the research team, however they will not be the focus of my individual research project.

Results

During the survey the most common bird species included: Dark-eyed Juncos (DEJU), Gray Jays (GRAJ), Olive-sided Flycatchers (OSFL), Pine Grosbeaks (PIGR), White-crowed Sparrows (WCSP), American Robins (AMRO), Mountain Chickadees (MOCH), and Broad-tailed Hummingbirds (BTAH). We also saw Yellow-romped Warblers (YRWA), Downy Woodpeckers (DOWO), and Swainson's Hawks (SWHA) though very rarely. DEJU were the most observed bird species followed by GRAJ and OSFL.

Moving around, calling, and flying over were the most commonly seen behaviors and the majority of birds were seen doing one or more of them (Fig. 1). Only OSFL and BTAH were seen aerial feeding, and riparian feeding of both insects and vegetation was seen in PIGR, AMRO, GRAJ, and WCSP (Fig. 1). Terrestrial feeding on mushrooms around the ponds was seen in GRAJ (Fig. 1).

When the number of observations during the twenty-minute survey was compared between temporary ponds and permanent ponds, there were a higher number of visitations at permanent ponds (Fig. 2; Linear mixed effects model, $p < 0.001$, $F = 68.82$).

Discussion

Bird visitation rates at permanent ponds were higher than at temporary ponds, with some temporary pond surveys recording only one or two observations in the time period (Fig. 2). The majority of the bird behaviors observed were not indicative of foraging but they did imply that the ponds and pond edges are active parts of the birds habitat regions and territories. In the few bird that were seen foraging either aerially or in riparian zones it was often impossible to determine, which insects birds were actually consuming. Comparisons against past years drying

dates shows that while this years late drying was unusual it is not completely unheard of for two of our temporary ponds to not have dried at this point. It appears that is the latest that pond seven has dried according to past records from data loggers.

Bird preference for permanent ponds may be a preference for the more diverse communities of organisms that permanent ponds are able to support as a result of their built up benthic layers and consistent habitats (Wissinger et al. 1999). Permanent ponds also have a larger surface area and therefore larger riparian and terrestrial zones around them; as a result permanent ponds might be more appealing for their increased diversity of surrounding habitat as well (Wissinger et al. 1999). Overall permanent ponds are a more consistent landscape feature and they are therefore more appealing to birds.

This preference for permanent ponds may be detrimental for birds in a changing climate and shifts in hydrology as a result of climate change towards more temporary life cycles in ponds have the potential to damage these interactions. Close linkages between ephemeral freshwater systems and surrounding ecosystems mean that changes climactic changes while be exacerbated as they effect not only the aquatic systems and organism that inhabit them, but also any terrestrial animals that are dependent on the system (Baxter et al. 2005). Birds appear to have a preference for permanent ponds but a shift in hydroperiod to more temporary could create potential loss of food and habitat for riparian birds.

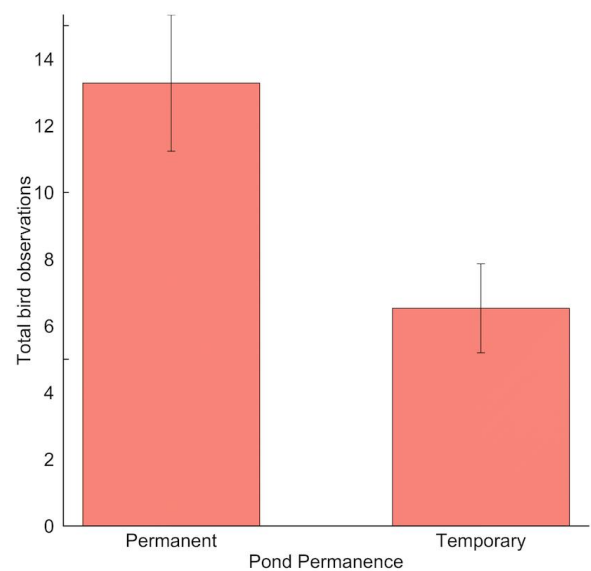
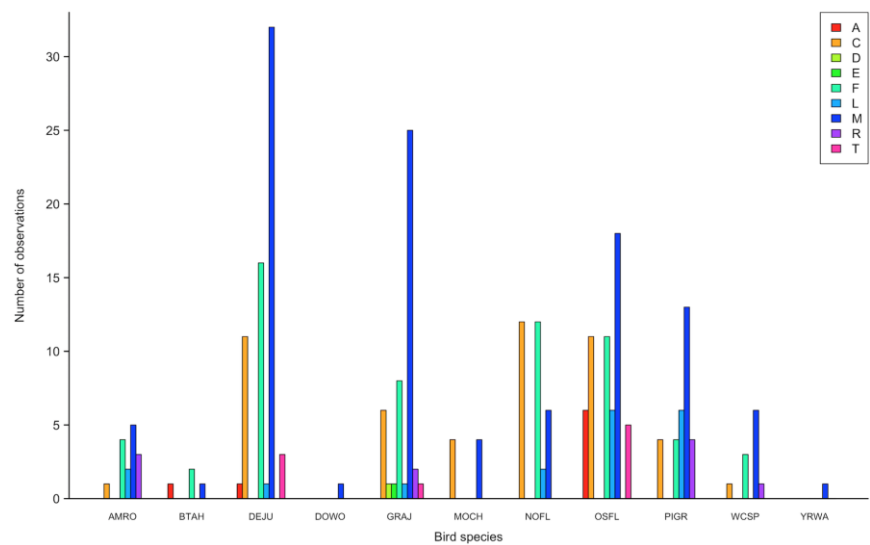
As a result of the ponds not drying during the survey period it would be interesting in the future to observe how the bird preference shifts after the temporary ponds have dried. We would also like to include a greater number of ponds within the MCNP to understand whether our observed trends are universal in that system. For this experiment we did not include semi-permanent ponds as their hydroperiods is so variable, but we would also like to investigate what trends in terms of bird visitation they have. A comparison between aquatic insect emergence rates as calculated through emergence traps would also be able to create a more complete picture of this specific ecosystem interaction.

As climate shifts, the existence of ephemeral freshwater systems are under threat and it is important to understand how these systems effect their surrounding ecosystems to create a complete picture of how ecosystems are changed by anthropogenic actions.

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Figures and Tables



Pond Zones Around Pond 15

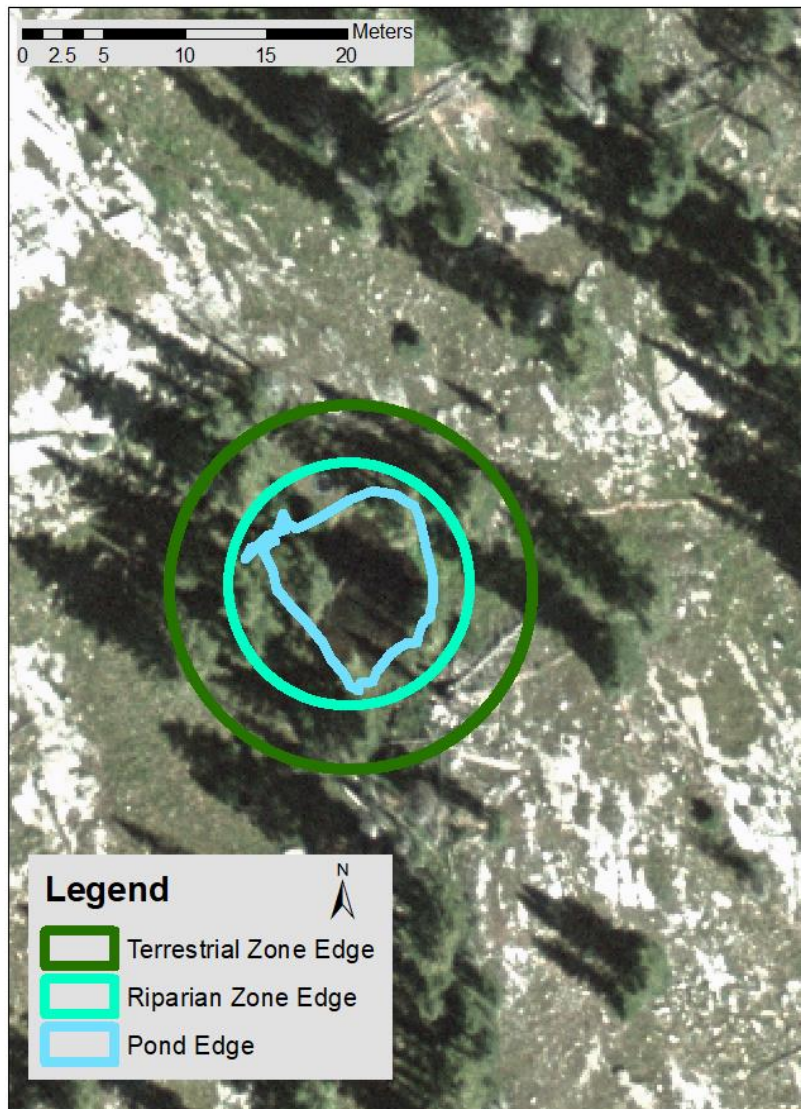


Figure 1. Number of times each behavior was recorded for a bird species. Species are labeled with four-letter alpha codes. Behavior codes are: A = aerial feeding, C = calling, D = dipping, E = Terrestrial Feeding, F = Flying over, L = loafing, M = moving around, R = riparian feeding, T = Territorial.

Figure 2. Comparison of the total number of observations at temporary and permanent ponds during the twenty-minute observation period (Linear mixed effects model, $p < 0.001$, $F = 68.82$).

Figure 3. Map of pond 15 showing example terrestrial, riparian, and pond zones.