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Comparative Diet Analysis of *Canis rufus* and *Canis latrans*

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Abstract

Top predators control the biodiversity of plant life through regulation of both meso-predator and herbivore populations, a phenomena referred to as top-down effects. In areas of the Southeast where red wolves (*Canis rufus*) were once the top predators, meso-predator populations have flourished while the biodiversity of these ecosystems have declined. The recent appearance of the coyote (*Canis latrans*) in the former range of red wolves through their migrations eastward implies a potential for coyotes to fill the ecological niche left by red wolves. The similarity in size between coyotes and red wolves might indicate that coyotes could assume the former role of the red wolves due to their ability to hunt larger prey and consequently cause top-down effects in former red wolf ecosystems. To assess the possible ecological niche similarities of the two canid species, a comparative diet study is being conducted by analyzing more than 400 samples of coyote scat collected from the Yawkey Wildlife Center in Georgetown, SC from 2009-2011. Teeth and hair recovered from the scat samples will be identified to the lowest possible taxonomic level using mammal hair identification keys, as well as reference hairs and teeth. The results of the diet analysis will be compared to the documented diet of red wolves. If no significant diet overlap is observed then it could be assumed that coyotes have not assumed the functional role of the red wolf. A significant overlap in coyote and red wolf diets might indicate that the coyote is filling the role of top predator. These results have implications for management of ecosystems where red wolves were once abundant and now coyotes are prominent. If coyotes function as top predators, wildlife management plans should incorporate the potential top-down effects caused by coyotes when deciding on policies concerning biodiversity of flora and fauna in the local ecosystems.

Keywords: Coyote, red wolf, diet overlap

1. Introduction

The organization of an ecological community can be dependent upon the presence of a keystone species, whose actions can affect both the biotic and abiotic aspects of their surroundings. The removal of a keystone species drastically alters the diversity and abundance of the remaining species within the community[1]. In the case of the removal of a top predator, meso-predator and herbivore populations increase in response to the sudden decline in predation, while plant populations suffer from increased predation by greater numbers of herbivores[2]. Theoretically, the effects of the removal or extinction of a top predator can be reversed by introducing an ecological surrogate into the ecosystem; however, the implementation of this idea is limited only to species that are perfect ecological surrogates and no species have been found to fit this criteria[3]. Species may not be ecological surrogates, but they may be ecological equivalents, or two species that fill the same niche in an ecosystem or utilize resources in the same way[3]. Ecological equivalents are different from ecological surrogates in that surrogates can replace another species, but equivalents only share the same niche. Niche similarities and interspecific competition between two species are generally measured through a comparative diet analysis of two seemingly related species[3].

The red wolf (*Canis rufus)* existed in a large portion of the southeastern United States before the species was extirpated by settlers in order to protect domestic livestock[4]. Subsequently, southeastern ecosystems lost the red wolf, an apex predator, and herbivore and meso-predator populations flourished. Land use changes, such as the clearing of forests and the development of land for human residences, have made much of the habitat in the Southeast unfit for the red wolf and more hospitable for the coyote (*Canis latrans*), which was first spotted in South Carolina around 1978 as the species migrated from the mid-western region of the United States

The red wolf, ranging from 50-80 pounds[5] is smaller than its counterpart, the gray wolf, and slightly larger than the coyote, which can weigh from 30-40 pounds[6]. The similarity in size between the red wolf and the coyote indicate that both canids could be capable of consuming the same size prey. Red wolf diet consists of adult deer and fawns, raccoon, rabbit, nutria, rice rat and black rat, as well as fruits and invertebrates[7]. Coyotes have been described as opportunistic predators, preying upon deer fawns, smaller rodents, rabbits, raccoons, insects and soft mast[8, 9].

There are many studies of coyote food habits in the western United States; however, little research has been conducted on the diets of the coyotes that have migrated eastward, and no work has yet been published on how the diet of the coyote might relate to the diet of the extirpated red wolf. A comparative diet study would give insight into the potential effects of coyotes in southeastern ecosystems that are missing an apex predator, giving evidence for the hypothesis that coyotes might have assumed the former niche of the red wolf. The similarities in size and diet between the two canids may indicate red wolves and coyotes are ecological equivalents, as a significant amount of diet overlap between the two species could point to a high degree of niche overlap and similar resource use[10].

Understanding how the non-native coyote is currently affecting southeastern ecosystems will help biologists develop future wildlife management plans. Managers need to know what impact coyotes are having on plant populations as well as game species in order to decide how to manage controlled hunts and predator control programs. The South Carolina Department of Natural Resources' current policy encourages hunters and landowners to kill coyotes[11], which typically prey on fawns, to slow the decline in South Carolina's white-tailed deer population[8]. If the coyote can exert top-down control on meso-predator and herbivore populations in southeastern ecosystems, they could indirectly reestablish the diversity and abundance of populations within the community as they were when the red wolf acted as top predator.

The purpose of this project was to analyze coyote scats collected on a barrier island in South Carolina to determine the food habits of the coyote and compare those habits to documented red wolf diet[12] to determine if there are significant diet similarities and niche overlap between the two species.

2. Methods and Materials:

2.1 Coyotes:

2.1.1 study site:

Coyote scats were collected from 2009-2011 at the Yawkey Wildlife Center in Georgetown, South Carolina. The Yawkey Wildlife Center is preserved as a wildlife and waterfowl refuge area. The 24,000 acres of the center are comprised of marsh, fresh and salt water impoundments, freshwater bogs, maritime forest, barrier beaches, and long leaf pine habitat that is controlled with prescribed burns every two years[13]. Yawkey is home to a diverse array of mammals including white-tailed deer (*Odocoileus virginianus*), oppossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), Bob-white quail (*Colinus virginianus*), otter (*Lontra canadensis*), and fox squirrels (*Sciurus niger*)[13].

2.1.2 scat collection and analysis:

Scats were collected along transects and opportunistically along roads and paths. The location and physical condition (i.e. fresh, desiccated, etc.) of each scat was recorded before it was individually numbered. Each scat was washed with water over a metal screen and dried. The diagnostic parts were pulled out of each scat and sorted into packets for hair, bones, invertebrates, seeds, and feathers to be used in a hard-parts analysis. After representative samples of each of the above five categories were separated, the remainder of the scat was examined to determine the approximate proportion of each category (hair, bones, seeds, feathers and invertebrates) within each scat sample.

Dorsal guard hair color bands, as well as medulla and cuticular scale patterns were used to identify each mammal species present in the scat samples. Hairs from each scat sample were soaked in paraclear for at least fifteen minutes

in order to observe the internal structures, such as the medulla. An impression of the hair using a thin coat of clear nail polish was used to identify the cuticular scale pattern. A hair from the sample was pressed into clear nail polish coated onto a slide and was removed after the polish dried, leaving an impression of the exterior surface of the hair. Both the scale pattern and the medulla were observed microscopically and identified using a reference collection or keyed to the lowest taxonomic level[14]. The bones, teeth, and claws present in the scats were all observed macroscopically using a dissecting microscope and compared to reference collections from the Campbell Museum of Natural History in Clemson, SC.

Vegetation was analyzed for presence within the scat by reviewing the vegetation that had been separated from each sample and was categorized as purposefully ingested or accidentally ingested. Grass and seeds were deemed purposefully ingested and appointed a "1" for present. Oak leaves and pine straw were deemed accidentally ingested or not ingested at all but rather picked up with the scat sample and were appointed a "0" for not present. Grass found in small amounts (a few blades) within the sample was termed "maybe purposefully ingested" and was only counted half of the time.

To analyze the dietary components found in the scat, the proportion of each resource was calculated out of the total resources utilized by the coyotes. The total resources utilized were the sum of each occurrence for the identifications based on bone and hair, as well as the presence of vegetation. The total number of occurrences for each food category was divided by the total resources utilized as explained by Equation (1), in which *i* indicates the food category and p_{ik} is the proportion of resource *i* used by the species *k*. In this case, species *k* is defined as the coyote, while species *j* is the red wolf.

$$p_{ik(j)} = \frac{Number\ of\ Occurrences\ of\ i}{Total\ resources\ utilized\ \ by\ species\ k} \quad (1)$$

2.2 Red Wolves:

2.2.1 study site:

Red wolf diet data was compiled from work conducted at Alligator River National Wildlife Refuge (ARNWR)[12], home to the only free-ranging red wolf packs, in Manteo, North Carolina. The 154,000 acre refuge includes groundhogs (*Marmota monax*), nutria (*Myocastor coypus*), feral hogs (*Sus scrofa*), white-tailed deer, wild turkey (*Meleagris gallopavo*), raccoons and an array of small rodents[14]. It is composed of marsh, bog, swamp, agricultural areas, and high and low pocosin habitats.

2.2.2 red wolf diet analysis:

Previous work on ARNWR compared resource partitioning between six red wolf packs[12]. For our project this data was assembled into a comprehensive diet analysis of red wolves. To compile the diet data for the red wolves, the occurrences of all of the food categories were totaled across the six packs. The occurrences of each food category within the diets of the six packs of wolves was then added together and divided by the total number of resources utilized to get the proportion that each food category compromised in the packs' diet. Equation (1) is also used to determine the proportion of resource *i* of the total resources utilized by the red wolf, species *j*.

2.3 Niche Overlap:

2.3.1 analysis of niche overlap:

To determine the niche overlap between coyotes and red wolves, Horn's Index was calculated. Horn's Index is a proportion of similarity or overlap between two species[16]. It uses the proportion of resource *i* of the total resources utilized by each species[16]. This index has the least amount of bias when proportions of resource use are calculated as opposed to an index that would show the red wolf's dietary overlap with the coyote and a separate value for the coyote's dietary overlap with the red wolf[16].

$$R_0 = \frac{\sum p(ij) + p\,(ik) * \log(p(ij) + p(ik)) - \sum p(ij) * \log(p(ij)) - \sum p(ik) * \log(p(ik))}{2 * \log 2} \quad (2)$$

3. Results

Horn's index showed a moderate amount of diet overlap between red wolves and coyotes (R_0=0.53). Both coyotes and red wolves predated on most of the food groups found; however, the proportion of each food group in the predator's diet differed noticeably. This preliminary analysis of coyote diet consists of 72 scat samples, each with information on the vegetation, hair and bone present within the sample, out of over 400 samples that were collected on Yawkey. About 163 diet items were found in the completed coyote scat samples, making up a total of 15 families of mammal remains identified. The two main resource groups utilized by both predators were small rodents and rabbits; together, the two groups made up 30% of red wolf diet and 37% of coyote diet (Fig. 1). Both predators also consumed deer, smaller carnivores, and large rodents. The Scuridae, Cricetidae, Dipodidae, and Muridae families represented the small rodents, accounting for 31% of coyote diet. The Insectivora order, compromised of moles and shrews, made up 20% of coyote diet (Fig. 1). The most common food groups identified, including small rodents, insectivores, birds and vegetation, represent about 73% of a coastal coyote's diet (Fig. 1). Dellinger's[12] study on the foraging ecology of red wolves identified 590 diet items from the red wolf scat collected. The most important resources for the red wolf were deer and rabbit, compromising 38% and 13% of red wolf diet, respectively. Both wild boar and anthropogenic waste accounted for a portion of red wolf diet[12], two resource groups not found in coyote diet. Most noticeably, red wolf and coyote diet diverges in the proportion of deer, vegetation, small rodents and insectivores consumed. Red wolves consumed deer at a frequency six times that of coyotes, while coyotes predated on small mammals twice as often as the red wolf. Vegetation and insectivores were not recorded in the red wolf diet study[12].

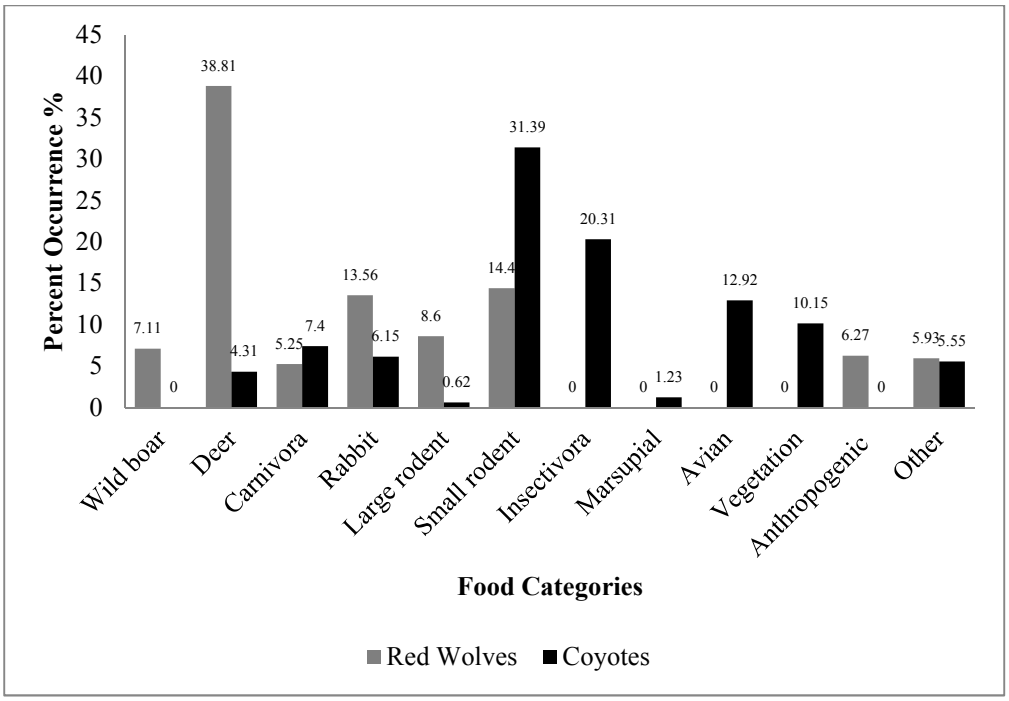

Figure 1. Frequency of occurrence of food categories in the diets of the red wolf and the coyote.

Figure 1. All food categories recorded for both red wolf and coyote diet studies and their relative proportions to the total resources utilized. The red wolf diet data was compiled from a study in Alligator River National Wildlife Refuge performed by Justin Dellinger from May to July during 2009 and 2010. The data presented on coyote diet was based on preliminary analyses of scat samples collected at Yawkey Wildlife Center in Georgetown, SC from 2009 to 2011.

4. Discussion

The Horn's index value and similarities in resource use are evidence that coyotes and red wolves show a moderate amount of overlap in their diets. Horn's index was calculated as a value of 0.53. This value is not close to 1.0, which would show complete overlap, nor is it close to 0, which would indicate no overlap. Both canid diets showed similarities in resources used, but at varying amounts. Both canids consumed white-tailed deer, rabbits, and small rodents such as rice, wood, and cotton rats. Red wolves had a more carnivorous diet consuming a greater percentage of larger prey such as wild boar, deer, and rabbits, than coyotes. Coyotes consumed a greater amount of smaller prey items, mainly small rodents and insectivores. American cotton rats, wood mice, voles, and shrews were commonly found in the coyote scat samples. Avian species also appear to be an important prey item to coyotes as they comprised almost 13% of the diet. Coyotes also seem to have a more omnivorous diet than red wolves as vegetation contributed 10% of the total resources utilized by the coyotes. These results vary from another study conducted on coyote diet at the Savannah River Site in South Carolina in 2006, which found that rabbits and small mammals comprised a lower percentage of the diet than other studies had documented[8]. White-tailed deer fawns were important to coyote diet during the spring and summer months at that site[8]. In the coyote samples identified in this study thus far, deer have not been found to be a major resource in the diet. This discrepancy may be due to differences in abundance of deer between the Savannah River Site and Yawkey Wildlife Center, the seasons in which the coyote scat was collected, or the small percentage of samples that have been analyzed. Schrecengost[8] reported that fawns were the most abundant mammalian resource found in coyote diet during the fawn-rearing season between May and July. As more coyote scat samples are analyzed, it may be found that deer comprise a larger percentage of the diet, indicating a higher degree of diet overlap between red wolves and coyotes.

The moderate diet overlap indicated by the similarities in prey species consumed by red wolves and coyotes lends evidence to the hypothesis that coyotes may be filling the top predator niche left by red wolves in the Southeast. The similarities in prey consumption show that coyotes might be affecting the same species as red wolves, but not to the same extent. However, coyotes may still indirectly affect plant diversity by eating small rodents, which are seed predators and herbivores. Coyotes show a greater tendency to consume smaller prey species, and thus may be having a more direct effect on lower trophic levels, as opposed to primarily consuming mid-sized animals in the meso-predator niche.

To better understand the niche southeastern coyotes are filling and how they are affecting the environment, it would be of use to complete a more extensive and time-consuming mark-recapture study in areas with and without coyotes. This type of study would give more insight into how coyotes are affecting prey populations and if they are exerting top-down control. Plant populations and recruitment would also need to be monitored in areas with and without coyotes to see if coyotes are affecting prey populations and thus increasing plant diversity.

Percent biomass is used to determine the number of individuals consumed[12]. It uses the weight of prey species and the measured weight of scat produced after the consumption of the prey item. Since percent biomass consumed was not measured in this diet study, it is unclear how much coyotes have affected the populations of each prey species. Because percent biomass was not calculated, it could not be determined how many individuals of each prey species were consumed. Thus, it cannot be concluded if coyotes are limiting population sizes because the population size and the proportion of each species they are consuming was not evaluated.

With this said, coyotes may not be exerting control over prey populations because they may be scavenging on remains. Coyotes are known to be opportunistic predators; instead of directly hunting prey, they may be eating carrion or road kill. Thus, they may not be controlling populations of species in the lower trophic levels or not having a large enough impact to impose top-down effects.

This study utilized two study sites, Yawkey Wildlife Center in South Carolina and Alligator River National Wildlife Refuge in North Carolina. The differences in habitat type, prey composition, and prey abundances make a completely accurate analysis of diet overlap almost impossible. Due to interspecific competition, coyotes that coexist with red wolves would be suppressed to meso-predators in the ecosystem. Because niche overlap and the potential for one species to be a top predator were being measured, separate areas where both species could act as top predators were necessary. A study area was needed where interspecific competition between coyotes and another canid species or large predator did not affect the way coyotes utilized resources. Coyotes needed to be able to act as the only top predator within the study site.

Red wolves cannot exist in most of their former range due to human conflicts and loss of habitat, two factors that also aided in the eastward migration of the coyote. The ecology of the coyote and its effects on the environment need to be further studied in order for land managers to make educated decisions regarding the control of coyotes. Diet overlap is an indirect way to measure the relationships between the trophic levels in an ecosystem. Therefore it

is vital that populations of prey and plant species in coyote home ranges are monitored to better understand if coyotes are exerting top-down effects. If coyotes are filling the niche left by red wolves, then managers need to know how to maintain a viable coyote population and maintain healthy prey populations.

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