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Running Title: Energy Content of Seeds of Palmer's Pigweed in Southeastern New Mexico

Abstract

Palmer's pigweed (*Amaranthus palmeri*) is a common grassland plant that occurs across much of North America. It is often considered a weed but is an important source of food for many game birds. We analyzed the energy content of seeds of Palmer's pigweed obtained from the crops of scaled quail (*Callipepla squamata*) collected from plains-mesa sand-scrub habitat in Eddy and Lea counties, New Mexico. Seeds were dried for 48 hours at 60°C to remove moisture and then analyzed for gross caloric value (i.e., energy content) in an oxygen bomb calorimeter. Energy content of seeds of Palmer's pigweed from New Mexico averaged 16.6 J/kg (4.0 kcal/g), and was among the lowest values obtained when compared to those of many seeds previously reported from the diet of scaled quail and other granivorous birds.

Introduction

Understanding the energy content of food items is important for conservation and management of wildlife and their food plants, as it helps wildlife managers make decisions on planting or removing potential food items that may be invasive or weedy. Feeding habits of scaled quail (*Callipepla squamata*) are well-studied (Lehman and Ward 1941; Schemnitz 1961; Ault 1981; Rollins 1981; Ault and Stormer 1983; Campbell-Kissock *et al.* 1985; Medina 1988), including several studies conducted in southeastern New Mexico (Davis and Banks 1973; Davis *et al.* 1975; Griffing and Davis 1976; Best and Smartt 1985; Hunt and Best 2001b). A previous study (Hunt *et al.* 2020) measured the energy content of seeds of common sunflowers (*Helianthus annuus*) consumed by free-living scaled quail, and a study (Saunders and Parrish 1987) conducted in

Kansas measured the assimilated energy of some potential food items by captive scaled quail, including two species in the genus *Amaranthus* (commonly referred to as amaranths or pigweeds). Studies have measured energy content of some known and potential food items of other birds living in the same areas, such as mourning doves (*Zenaidura macroura* — Schmid 1965; Shuman *et al.* 1988; Hunt *et al.* 2019); some of the items measured are known or potential food for scaled quail.

A study of feeding habits of scaled quail in southeastern New Mexico determined that seeds of Palmer's pigweed (*Amaranthus palmeri*) made up a substantial portion (5.3%) of the total mass of crop contents, and were present in 35.0% of the crops (Hunt and Best 2001b); another study (Davis *et al.* 1975) reported smaller amounts of seeds of Palmer's pigweed. Seeds of Palmer's pigweed are also reported to be a food item of other birds, such as northern bobwhites (*Colinus virginianus* — Hunt and Best 2001a) and mourning doves (Hunt 1999). Although energy content of seeds of pigweeds from Kansas has been measured (Saunders and Parrish 1987), no such measurements have been conducted on seeds of *A. palmeri* from sand-scrub habitat of New Mexico. We used an oxygen bomb calorimeter to determine the energy content of seeds of Palmer's pigweeds from Eddy and Lea counties in New Mexico.

Methods and Materials

This study is an offshoot of long-term studies of lead poisoning of game birds (Best *et al.* 1992a; 1992b) and studies of feeding habits of game birds in southeastern New Mexico (Hunt 1999; Hunt and Best 2001a; Hunt and Best 2001b). The study area is at the Waste Isolation Pilot Plant in eastern Eddy County and western Lea County. All scaled quail were collected in

uncultivated, shinnery oak-honey mesquite (*Quercus havardii-Prosopis glandulosa*) habitat, part of the plains-mesa sand-scrub vegetation type (Dick-Peddie 1993). A number of studies of the feeding ecology of scaled quail have been conducted in this area (Davis and Banks 1973; Davis *et al.* 1975; Griffing and Davis 1976; Best and Smartt 1985; Hunt and Best 2001b). The study site is heavily grazed by cattle.

In late summer and autumn in 1981 and 1982, 178 scaled quail were collected by shooting as encountered. Collected birds were placed on ice within 10 minutes of shooting to minimize effects of post-mortem digestion (Dillery 1965; Farner 1960; Sedinger 1986); no effect of digestion on crop contents was observed and no residue from containment within the crop was detected. Crops were removed, placed into plastic vials, and frozen. Contents of crops were later thawed, separated by type of food, and placed into envelopes for drying. Food items were dried for 48 hours at 60°C to remove moisture. Food items were identified by comparison with samples of plants collected at the study site, and by using identification manuals (Davis 1993; Martin and Barkley 1961). We used seeds thus collected rather than raw seeds from the habitat to ensure that the samples included food actually consumed by scaled quail.

Samples of seeds of *Amaranthus palmeri* were analyzed for gross caloric value (i.e., energy content) in an oxygen bomb calorimeter (Model 1341, Parr Instrument Company, Moline, Illinois). Samples of seeds came from 11 individual scaled quail with crops that contained enough seeds for analysis; each sample weighed 0.5 - 1.0 g. Seeds were combusted in the oxygen bomb; after combustion, the bomb was washed and bomb washings were titrated with sodium carbonate to allow adjustment of results for nitrate content (Jessup 1960). Results are reported in J/kg; kcal/g are given in parentheses for comparisons with previous studies.

Results

The 11 samples analyzed contained an average of 16.6 J/kg (4.0 kcal/g — range, 15.5-22.6 J/kg [3.7-5.4 kcal/g]; standard deviation, 2.0 J/kg [0.5 kcal/g] — Table 1). This figure is comparable to that previously obtained for an unspecified species of *Amaranthus* (19.2 J/kg [4.6 kcal/g], Saunders and Parrish 1987) and less than many other tested food items in the diet of scaled quail and other seed-eating game birds.

Table 1. Gross caloric value (energy content) of seeds of Palmer's pigweeds (*Amaranthus palmeri*) in the crops of scaled quail (*Callipepla squamata*) collected from Eddy and Lea counties, New Mexico, summer and autumn, 1981-1982.

Sample No.	Energy in J/kg (kcal/g)
SQ038-81a	15.9 (3.8)
SQ038-81b	15.9 (3.8)
SQ038-81c	15.5 (3.7)
SQ038-81d	16.3 (3.9)
SQ039-81a	16.3 (3.9)
SQ039-81b	22.6 (5.4)
SQ040-81	16.3 (3.9)
SQ004-82a	15.5 (3.7)
SQ004-82b	15.5 (3.7)
SQ021-82	16.3 (3.9)
SQ023-82	16.7 (4.0)

Discussion

Our study demonstrates that seeds of Palmer's pigweed have an energy content less than most food items from previous studies. For example, Robel and Harper (1965) reported an average of 24.7 J/kg (5.9 kcal/g) for seeds of common sunflowers, and 23.0 J/kg (5.5 kcal/g) for seeds of giant ragweeds (*Ambrosia trifida*) collected in Kansas. A study of potential food items for greater prairie-chickens (*Tympanuchus cupido* — Heffron and Parrish 2005) listed 14 different commercial feeds and seeds that had energy content equal to or greater than that which we measured for Palmer's pigweed; the greatest energy content in that study was for hulled domestic sunflower-seed chips (27.6 J/kg [6.6 kcal/g]). A study of seeds of Texas doveweeds (*Croton texensis*) in crops of mourning doves conducted at the same study site as the current study (Hunt *et al.* 2019) reported an average energy content of 21.8 J/kg (5.2 kcal/g). In a study of 9 food items collected from crops of mourning doves in North Dakota, Schmid (1965) found that 8 of the 9 items tested contained more energy than the Palmer's pigweed measured in this study; only corn (*Zea mays*, 17.1 J/kg [4.1 kcal/g]) and wheat (*Triticum aestivum*, 16.7 J/kg [4.0 kcal/g]) were comparable. Likewise, Shuman *et al.* (1988) tested 8 varieties of seeds that were considered to be potential food items for mourning doves in Kansas, and found all had greater energy content than the Palmer's pigweed tested in our study. Davison (1958) categorized some types of amaranth as "inferior" food plants for northern

Energy Content of Seeds of Palmer's Pigweed in Southeastern New Mexico

bobwhites, meaning they were poorly digestible or lacking in availability. Our study seems to indicate that amaranth may also be inferior because of lower energy content.

Palmer's pigweed is considered to be an important agricultural pest because it has spread widely beyond its original range in the desert Southwest to much of North America, grows as a weed in many crops including corn and cotton (*Gossypium hirsutum*), and is resistant to many commonly used herbicides (Ward *et al.* 2013). Palmer's pigweeds are often associated with disturbance (Sauer 1955), often being found in dumps, along roadsides and railway rights-of-way, in farms, and in fields. Much of southeastern New Mexico is heavily grazed by cattle, and much of the landscape has been highly modified by usage for extraction of petroleum and natural gas (Hunt 2004), so that Palmer's pigweeds grow abundantly. Although Palmer's pigweed usually flowers and fruits in summer and autumn, the plant has been observed to flower in all months of the year in the southwestern United States and Mexico (Sauer 1955). Individual plants are highly prolific; some have been recorded producing up to 600,000 seeds in a single year (Ward *et al.* 2013). Availability of seeds of Palmer's pigweeds helps explain their prevalence in the diet of scaled quail (Hunt and Best 2001*b*) and other granivorous birds of the area, despite the relatively poor energy content demonstrated herein.

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