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FLORIDA SCRUB-JAYS (*Aphelocoma coerulescens*) DECAPITATE AND EAT HEADS OF FLORIDA IVORY MILLIPEDES (*Chicobolus spinigerus*)

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Millipedes (class Diplopoda) are prey for a wide variety of animals including invertebrates, mammals, reptiles, amphibians, and birds (Hopkins and Read 1992, Shelley 1999). Millipedes of the order Spirobolida are often large and slow-moving, easily attracting the attention of predators; however, predators are likely to be repelled by the strong, irritating chemical compound, 1,4-benzoquinone, secreted by many spirobolids (Blum 1981, Attygalle et al. 1993, Eisner 2003, Shear 2015). Here we report a predatory tactic that allows a bird to circumvent a spirobolid's chemical defense in order to feed on part of it.

Spirobolid millipedes have several defenses to repel potential predators. This includes coiling the body into a spiral with the head in the center and deploying defensive secretions of noxious chemicals (Eisner 1970). The millipedes have paired lateral oozing glands along most segments of the body but seem to lack them in segments immediately behind the head (Eisner 1970, Hopkins and Read 1992). These glands are simple pores that open and emit toxic secretions at the site of attack. By coiling the body when threatened, the head is brought within range of gland-bearing segments of the body for protection (Eisner 1970). In one spirobolid, the Florida ivory millipede (*Chicobolus spinigerus*) the two major components comprising 95% of the defensive secretion are 2-methyl-1,4-benzoquinone and 2-methoxy-3-methyl-1,4-benzoquinone (Blum 1981, Attygalle et al. 1993, Eisner 2003, Shear 2015). Quinones are irritating secretions, causing itching or pain to the exposed area. They are a common defense in many arthropods and have been shown to immediately cause predators to desist, retreat, and clean themselves. Invertebrates will use their front legs to cleanse antennae and drag mouthparts in soil. Frogs and lizards will spit the prey out and scrape their tongue and mouth. Rodents will wipe their muzzle with their paws or thrust it into soil. Similarly, birds will wipe their eyes and rub their head in their plumage (Eisner 1970).

Florida ivory millipedes are native to Florida, Georgia, and eastern South Carolina. They have the smooth cylindrical bodies (Shelley 1999) typical of this order. The dorsum is dark brown with posterior bands of light brown, yellow, or orange, narrow at the dorsal apex and growing wider ventrally until they cover the ventral side. Males range in size from a length of 39.0-85.0 mm and width of 4.4-9.5 mm. Females are slightly larger with lengths and widths ranging from 43.0-91.0 mm and 5.2-10.3 mm, respectively (Keeton 1960). Like most millipedes, they live in moist soil and feed primarily on decaying plant material (Hopkins and Read 1992). By burrowing through the leaf litter and soil, they reduce debris and aid soil nutrient cycling (Shelley 1999).

The Avon Park Air Force Range (APAFR) is a 43,000 ha active military training facility in Polk and Highlands counties, Florida. The Air Force oversees long-term monitoring of and habitat management on this site for several Threatened species, including the Florida Scrub-Jay (FSJ; *Aphelocoma coerulescens*). FSJs, Florida's only endemic bird species, are non-migratory residents and defend all-purpose territories in scrub and scrubby flatwoods habitats that are maintained in their mid-successional stage by periodic fires every 5-20 years (Woolfenden and Fitzpatrick 1996). FSJs are cooperative breeders, living in social groups consisting of a breeding pair and usually one or more helpers (Woolfenden and Fitzpatrick 1984). They are opportunistic and

omnivorous, eating a wide array of arthropods, small vertebrates, berries, and acorns (Woolfenden and Fitzpatrick 1996).

On 29 April 2018, we watched four adult FSJs in a patch of scrub on the Bombing Range Ridge, a high sandy ridge running north-south through the center of APAFR. The scrub is characterized by evergreen shrubs with sparsely scattered South Florida slash pine (*Pinus elliottii*) located on a dry sandy ridge (FNAI 2010). The shrub layer consists of myrtle oak (*Quercus myrtifolia*), sand live oak (*Q. geminata*), Chapman's oak (*Q. chapmanii*), saw palmetto (*Serenoa repens*), and scrub palmetto (*Sabal etonia*) with scattered young sand pines (*P. clausa*). This layer forms a dense cover, 1.0-3.0 m tall, interspersed with patchy openings of bare sand and sparse herbs. The habitat is bisected by a crushed shell road with wide (10.0 m), regularly mowed, grassy shoulders with a drainage ditch (0.5 m deep) on either side. The ditch remains moist during the rainy season and a thin layer of detritus has built up from grass clippings and debris runoff. We observed the jays taking turns foraging in the grassy shoulder between the road and the scrub. One of the helpers picked up a food item, broke a piece off, ate it, and dropped the rest. Upon inspection of the item that was dropped, we found a decapitated Florida ivory millipede. Within ten minutes the second helper and the breeding male performed the same action. Each time we confirmed that they were indeed decapitating and eating only the heads of the millipedes. Numerous decapitated and bleached out exoskeletons of the millipedes were found scattered throughout the grassy ditch. Although the well-drained sandy soils of the scrub may not be ideal habitat for the Florida ivory millipede, the moister drainage ditch in the grassy shoulder along the road may be the reason why they are present.

Because spirobolid millipedes do not have secretion glands near the head, a quick decapitation would likely prevent the glands from emitting and the millipedes would not have time to coil their bodies in defense, reducing the chance that the head is protected by secretions.

The few known predators of spirobolids have specialized modes of attack, including coatis' (*Nasua* spp.) practice of rolling the millipedes in dirt to remove external secretions (Weldon et al. 2006), decapitation and dismemberment by dung beetles (*Deltochilum valgum*; Larsen et al. 2009), and immobilization with toxic injection by assassin bugs (Ectrichodiinae spp.; Forthman and Weirauch 2012). Eisner et al. (1998) found that the larvae of the glowworm beetle *Phengodes laticollis* are able to incapacitate spirobolid millipedes by injecting a paralytic fluid near the head, then retreating underground until the defensive chemicals secreted by the millipede have dissipated. The larvae then can consume the bulk of the inner tissues while avoiding the chemical-laden glands. Eisner (2003) observed a different approach by an unknown predator in New York state, where he found a number of decapitated *Narceus annularis*, a species found throughout the eastern United States and Canada (Keeton 1960, Eisner 2003). This species is in the same family, Spirobolidae, as the Florida ivory millipede and emits the same chemical secretions (Blum 1981, Shear 2015). The predator was consuming only the head of the millipedes and leaving the glandular-lined bodies untouched. Eisner surmised that this predator may be a rodent. He designed an experiment in which he offered *N. annularis* millipedes to mice and shrews, but each were repelled by the chemical secretion discharged by the threatened millipede. Eisner was not able to conclude what type of predator was circumventing the chemical defenses of the millipedes by consuming only the heads.

If FSJs decapitate and eat the heads of millipedes to avoid the noxious chemicals then other birds may do this as well, offering a clue to Eisner's (2003) mystery predator. Provided the decapitation prevents emission of chemicals, the glands would still be full and may be further reason the jays avoid consuming the bodies. This avoidance could have been learned from observing more experienced jays prey on the millipedes, or from experiencing the negative effects of the chemicals themselves.

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