First Record of a Hermaphroditic Muskrat

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ABSTRACT. This paper documents the first reported record of a hermaphroditic muskrat, *Ondatra zibethicus* L. A common semi-aquatic furbearer, muskrats are distributed across much of North America. During routine dissection of muskrat carcasses (n = 114) harvested by trappers in southern Ohio during 2010, 2011, 2012, 2014, and 2021, a subadult/adult specimen was observed to have what appeared to be fully developed ovaries and testes. A written description and photographic documentation of this hermaphroditic muskrat is provided.

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INTRODUCTION

This paper documents the first reported record of a hermaphroditic muskrat (*Ondatra zibethicus* L). The muskrat is one of the most widely distributed rodents in North America, and is present in all 88 Ohio counties (Harder and Cameron 2022). This semi-aquatic species inhabits ponds, streams, rivers, marshes, and swamps. It creates burrows in riparian habitat or builds lodges in ponds and marshes (Schwartz and Schwartz 2016). Primarily herbivores, muskrats in Ohio may also consume frogs, crayfish, clams, mussels, fish, and crustaceans (Harder and Cameron 2022).

Among the class Mammalia, hermaphroditic specimens have been reported for several orders of mammals including Lagomorpha (*Oryctolagus cuniculus*) (Sheppard 1943), Eulipotyphla (*Talpa occidentalis*, *T. europaea*, *T. romana*, and *T. stankovici*) (Sánchez et al. 1996), and Cetacea (*Delphinapterus leucas*) (De Guise et al. 1994). More frequent observations (n > 50) of a mixture of male and female internal genitalia have been noted for pigs (*Sus scrofa*, order Artiodactyla) (Crew 1924). Among the order Rodentia, hermaphrodism has been recorded for some individuals from laboratory populations of mice (assumed *Mus musculus*) (see Tarkowski 1964). Hooker and Strong (1944) compiled a list of reported observations for hermaphrodism in 9 rodent species but there was no indication of wild or captive status. Overall, the phenomenon of hermaphrodism appears to be extremely rare for wild rodents.

The adaptive advantages of hermaphroditism could include instances where it is difficult to find a mate, when one sex benefits from being either larger or smaller than the other, or instances of small, genetically isolated populations (Ghiselin 1969). There have been less than 5 cases of true hermaphroditism (i.e., distinct pairs of testes and ovaries) (Asdell 1942) reported for mammals (De Guise et al. 1994) from wild populations. The rarity of this phenomenon for mammals may be explained by the energetic cost to maintain 2 reproductive systems (Heath 1977).

As part of lab dissection activities for courses taught by the senior author at the University of Rio Grande, students obtained various organ morphometrics as well as determined sex and reproductive status of skinned muskrat carcasses that were supplied by local trappers. This hands-on learning opportunity resulted in the creation of baseline data to which future specimens from the region could be compared. Semi-aquatic mammals such as mink (*Neovison vison*), river otters (*Lontra canadensis*), and muskrats have served as bioindicators of aquatic ecosystem health and/or contamination (Halbrook et al. 1993; Harding et al. 1999; Ganoe et al. 2021). This includes assessment of spleen and adrenal glands as possible indicators of species-specific immune response and stress levels, respectively.

Among the specimens processed during this effort, one individual presented both ovaries and

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testes. This paper documents the first record of a hermaphroditic muskrat and compares some organ metrics of that individual to the balance of the specimens examined from southeast Ohio.

METHODS AND METHODS

Fresh or fresh-frozen skinned carcasses from southern Ohio were supplied by trappers. In the lab, carcass weight (nearest 0.1 kg) and length (nearest 1 mm) as well as weights (nearest 0.1 g) of heart, liver, kidney, spleen, and adrenal glands were recorded. Zygomatic breadth was measured (nearest 0.1 mm) using calipers to estimate age as subadult/adult or juvenile (Alexander 1951; Schofield 1955). Determination of sex focused on observing presence of testes or ovaries/uterine tissue—with uterine tracts extracted and inspected for the presence of placental scars.

Spearman correlation coefficients and scatterplots for all variables were generated using Minitab® 19.2 (Minitab 2020). Spleen and adrenal weight data were the primary focus, as status of these organs has been identified as possible indicators of immune response and stress levels, respectively (Christian 1955; Pankakoski and Tähkä 1982; Clark et al. 2006; Corbin et al. 2008).

RESULTS AND DISCUSSION

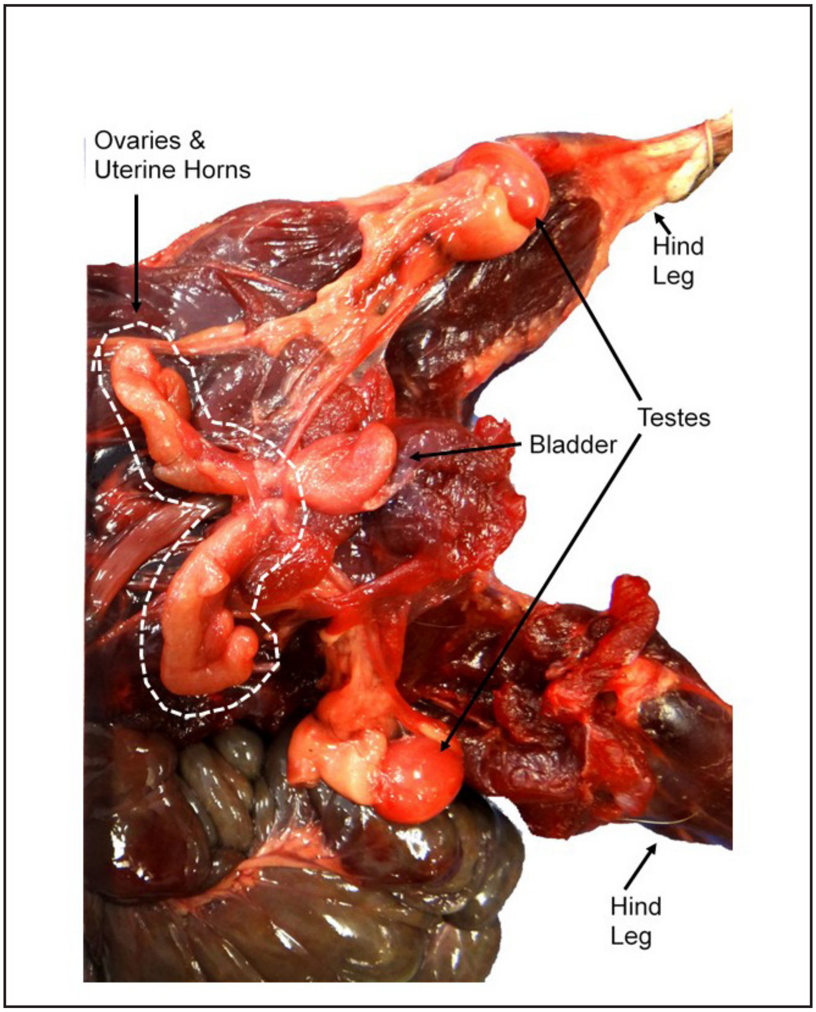
All muskrats were trapped in the November to December period. The 114 carcasses examined were categorized by the year of harvest (year of examination), approximate locality, and count: 2010 (2011)-Athens County, n = 19; 2011 (2012)-Athens County, n = 21; 2012 (2013)-Pickaway County, n = 19; 2014 (2015)-southern Ohio (specific counties unknown), n = 27; and 2021 (2022)-Gallia and Jackson Counties, n = 28.

One subadult/adult specimen (zygomatic breadth = 40.5 mm) harvested in 2012 from Pickaway County, Ohio, was determined to possess both male (testes) and female (ovaries and uterine tract) organs (Fig. 1). There was the appearance that each set of sexual organs were symmetrical (i.e., equal development on both sides), a form of true hermaphroditism (Asdell 1942). Examination of the uterine horns revealed no placental scars. Additional metrics for this specimen included a total length of 290 mm, body weight of 0.86 kg, liver weight of 45.0 g, spleen weight of 1.29 g, heart weight of 3.98 g, paired kidney weight of 6.54 g, paired adrenal weight of 0.19 g, and a total GI tract length of 2,483 mm. The trapper who provided the Pickaway County specimens indicated that all were harvested from one of the local creeks, and not a pond or marsh.

Across all specimens, spleen ($r_s = 0.58, p = 0.009$) and paired adrenal weights ($r_s = 0.55, p = 0.000$) had the highest correlations with liver weights. Spleen and paired adrenal weights were less correlated ($r_s = 0.40$, $p = 0.000$). Mean spleen weight (range) for male specimens was 0.63 g (0.16 to 1.35 g) and 0.62 g (0.12 to 1.40 g) for females. The 2012 Pickaway County hermaphroditic spleen weight (1.29 g) was well above average compared to males and females, and was clearly an outlier from that same 2012 sample of muskrats (Fig. 2). For adrenals, mean weight (range) for males was 0.12 g (0.02 to 0.27 g) and for females was 0.13 g (0.03 to 0.27 g). The hermaphroditic specimen mean adrenal weight was 0.19 g—well above the mean weight but within the range (0.02 to 0.27 g) for the male and female specimens.

The interpretation of these findings remains unclear, as neither of these weight differences (i.e., greater spleen weight and greater paired adrenal weight compared to the balance of the specimens processed from the Pickaway County sample) for this muskrat may have been related to its hermaphroditic condition. A larger spleen size may be associated with a heavier parasitic load, although for mammals it can also result in a larger reservoir for red blood cells (Corbin et al. 2008). Adrenal gland weights have been observed to increase in female muskrats during the spring, likely due to the onset of the breeding season with maximum weights reached in autumn (Pankakoski and Tähkä 1982). An increase in hostile social interactions may also explain adrenal enlargement in small mammals (Brenner et al. 1978; Bradley and Terman 1981). Such assessment in general, however, is difficult as reproductive state—as noted—can influence adrenal weight as well (Pankakoski and Tähkä 1982). Nonetheless, considering that this hermaphroditic specimen lacked placental scars indicates it had not bred. Therefore, the larger adrenal glands may indicate it was subjected to more than usual social strife.

The novelty of finding this single specimen at a single locality leaves much room to speculate how often hermaphroditism may occur in wild muskrat



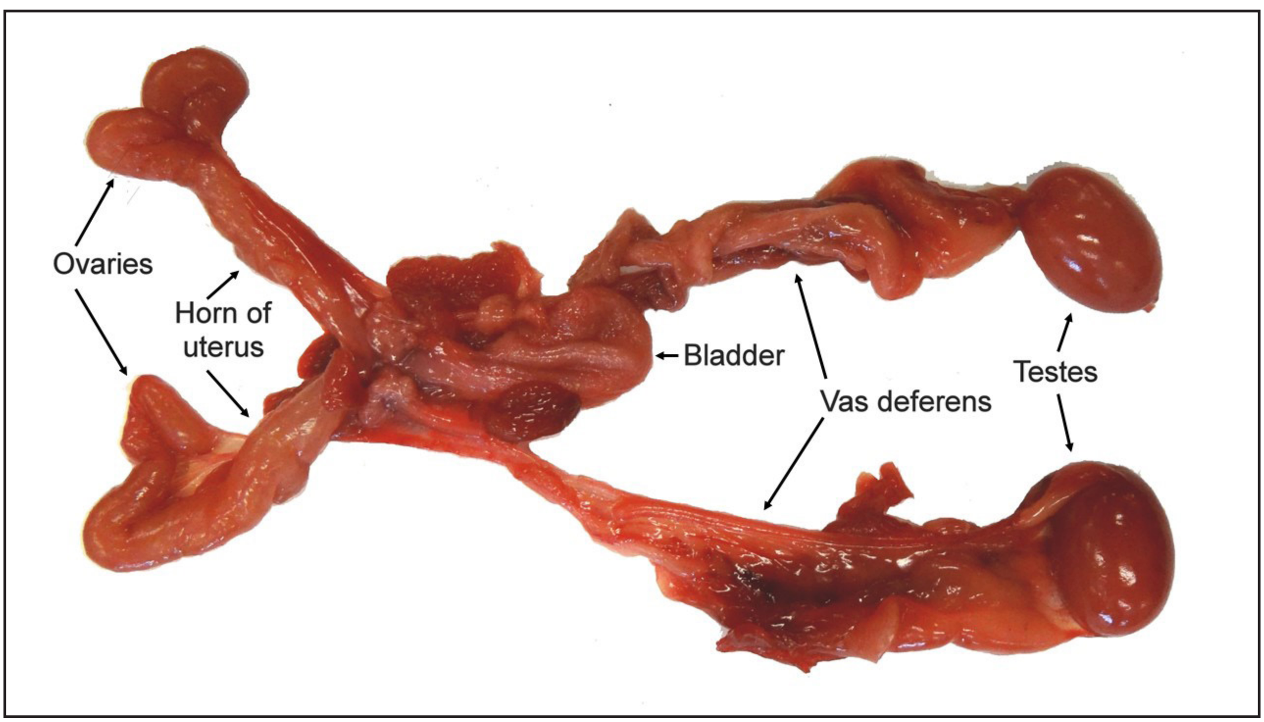


FIGURE 1. Hermaphroditic muskrat showing both male and female reproductive organs pre- (above) and post (below) extraction

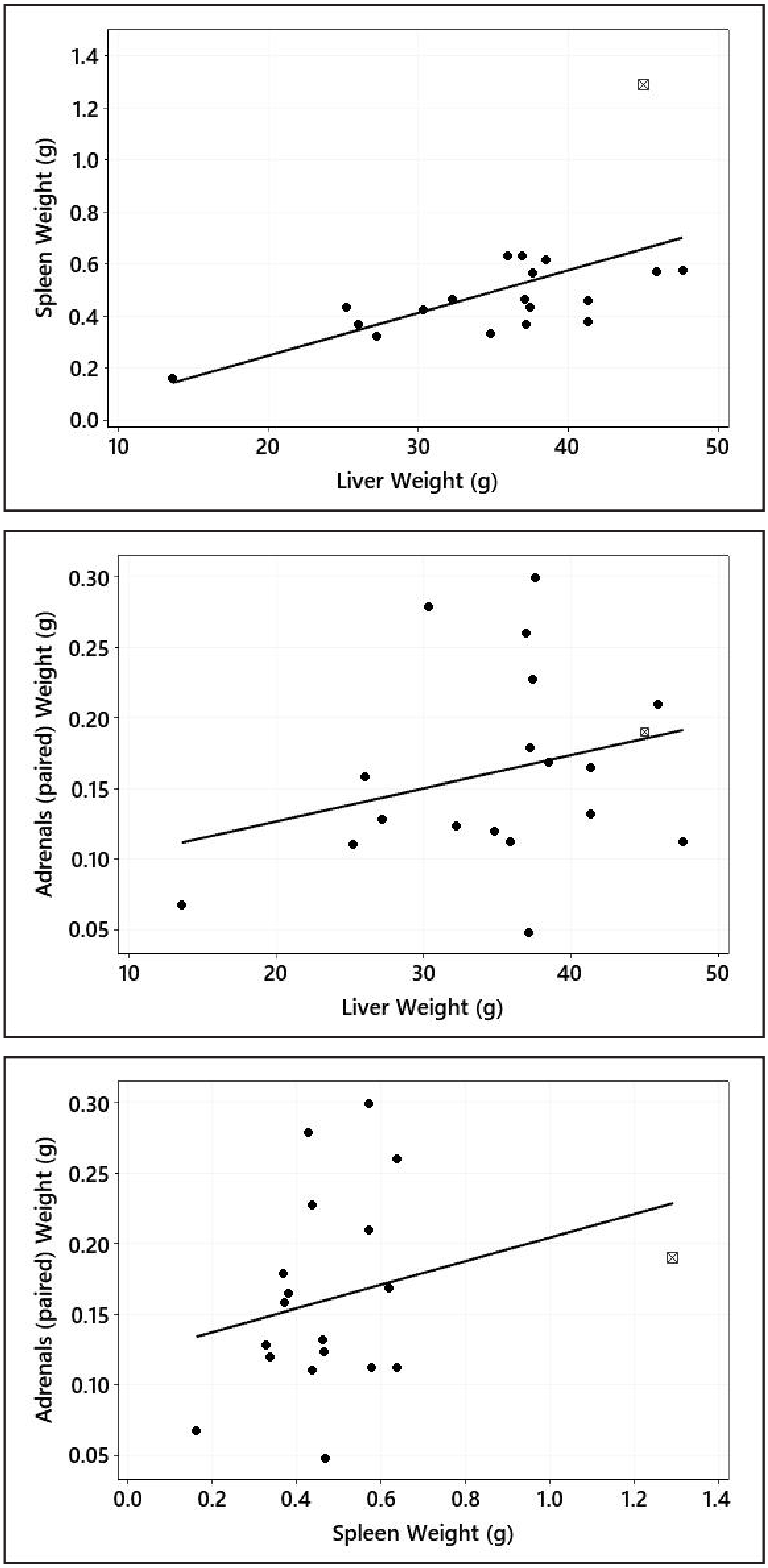


FIGURE 2. Scatterplots showing liver weight vs. spleen weight (top), liver weight vs. adrenal (paired) weights (center), and spleen weight vs. adrenal (paired) weights (bottom) for muskrat specimens harvested in 2012 from Pickaway County, Ohio. The square with the x represents the hermaphroditic specimen.

populations—but most likely it is extremely rare. Muskrats were intensely studied by state agencies and universities during the mid-1900s because of their importance as a furbearer, so it seems likely any specimens exhibiting this condition would have generated publication. More recently, declines of muskrat populations across much of its native distribution have been reported (Ahlers and Heske 2017). This has spurred renewed interest in studying possible explanations for those declines, mostly centering on habitat loss/degradation, changes in hydrology, and possibly disease (Ahlers and Heske 2017; Ganoe et al. 2021). Of these possibilities, and beyond the likelihood this was a total anomaly, habitat degradation might offer a possible explanation. Exposure to chemicals associated with pesticide and herbicide use or release of pharmaceuticals into aquatic systems may affect muskrat populations (Ahlers and Heske 2017). Whether such chemical exposure would be enough to affect sexual maturation of a muskrat is unknown; however, considering mammal development of gonads is under hormonal control (Asdell 1942), it is reasonable to project that such chemicals could explain the resulting hermaphroditic condition observed for the specimen reported herein. Endocrine-disrupting chemicals in the environment have been recognized to be associated with a variety of deleterious health effects not only for mammals but birds, fish, shellfish, and gastropods (Colborn et al. 1993). So far, however, the only evidence reported that chemical exposure—specifically perchlorate contamination—can produce androgenic effects that can result in functional hermaphroditism in a nonhermaphroditic vertebrate has been for the threespine stickleback (*Gasterosteus aculeatus*) (Bernhardt et al. 2006).

Due to the increased possibility of environmental contamination resulting from human activities (such as manufacturing and agricultural production), future research is needed to determine if endocrine-disrupting chemicals can result in hermaphroditic conditions for mammals, especially semi-aquatic rodents. This warrants greater consideration if hermaphrodism results in no, or lower, reproductive success for such individuals—especially in areas where local populations are already at risk or at the edge of their native range.

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