

Video-documentation of American Black Bear (*Ursus americanus*) foraging on algae in livestock tanks on a conservation property in western Montana, USA

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Abstract

Algae is an important food for many wildlife species. For ursids, marine algae is documented in Polar Bear (*Ursus maritimus*) diets, but freshwater algae has not been reported in American Black Bear (*Ursus americanus*) diets. We installed remote cameras at livestock tanks, in which freshwater algal blooms grew, to document Black Bear foraging behaviour. We video-documented algae foraging by four unique bears of both sexes and of different age classes. Algae foraging by two cubs and one adult female likely represented exploratory sampling because these three bears minimally foraged and did not subsequently return to the livestock tanks to forage on algae again. One adult male foraged on algae during three separate occasions, indicating his algae foraging was non-exploratory. We discuss possible hypotheses to explain freshwater algae consumption by Black Bear, including nutritional benefit, physiological relief, and parasite expulsion. Our study is the first to report algae foraging by American Black Bear, and our findings suggest that the benefits of *Cladophora* species for wild animals may be greater than is currently understood.

Key words: Algae; behaviour; *Cladophora* species; foraging; remote cameras; *Ursus americanus*

Introduction

Algae is an important food resource for many marine (Arthur and Balazs 2008; Hata and Umezawa 2011; Reverter *et al.* 2020; Meekan *et al.* 2022) and terrestrial (McKnight and Hepp 1998; Holgerson *et al.* 2017; Bassett *et al.* 2022) wildlife species. For North American ursids, consumption of marine algae by Polar Bear (*Ursus maritimus*) is well documented (Harrington 1965; Russell 1975; Gormezano and Rockwell 2013), but consumption of freshwater algae by terrestrial bears is less well understood. A review of 178 papers, reports, dissertations, and theses on Grizzly Bear (*Ursus arctos*) diet in the Greater Yellowstone Ecosystem during 1891 through 2013 found only one documented case of freshwater algae in Grizzly Bear scat (Gunther *et al.* 2014). For this one case, the authors suggested that algae ingestion was unintentional (i.e., the bear was feeding on other foods) or represented exploratory sampling (i.e., the bear was sampling algae while searching for new

foods). Studies of American Black Bear (*Ursus americanus*) diet based on scat (e.g., Tisch 1961; Raine and Kansas 1990; Lesmerises *et al.* 2015; McLaren *et al.* 2021) and stable isotope (Hatch *et al.* 2011; Hopkins 2011; Dykstra 2015) analyses have similarly reported no evidence of algae consumption by Black Bear.

Beyond scat and stable isotope data, observations of bears foraging in the wild can provide insight into their diet. However, direct observation of foraging by wild Black Bear is challenging because they are wary and have relatively large spatial requirements (Powell *et al.* 1997). Remote photography, increasingly used to estimate wildlife occupancy, density, and survival (Karanth and Nichols 1998; O'Brien *et al.* 2010; O'Connell *et al.* 2011; Reynolds-Hogland *et al.* 2022a,b), may also provide opportunities to document wildlife foraging behaviour. We installed a network of remote cameras on a conservation property in western Montana, USA to document and evaluate Black Bear behaviour (Sawaya *et al.* 2017;

Reynolds-Hogland *et al.* 2023a,b), including foraging activity. Here, we present video-documentation of five cases of algae foraging by three Black Bears and photo-documentation of one case of presumed algae foraging by another bear.

Methods

Study site

Our study was conducted on MPG Ranch (46.70722°N, 114.00444°W), a 6191-ha conservation property in the Northern Sapphire Mountains in western Montana, USA (Figure 1). Historically, the

property had been intensively managed for livestock for 100+ years, but was purchased in 2009 and transitioned to a conservation property with ongoing ecological restoration (Lekberg *et al.* 2013; Durham *et al.* 2017; Mummey *et al.* 2018; Sheng *et al.* 2022). Livestock fencing was removed, but artificial livestock tanks that existed in 2009 were retained to provide drinking water and aquatic habitat for wildlife (Sawaya *et al.* 2017).

The elevation at MPG Ranch ranges from 966 to 1833 m. Dominant tree species on the eastern and northern portions of the property include Douglas-fir

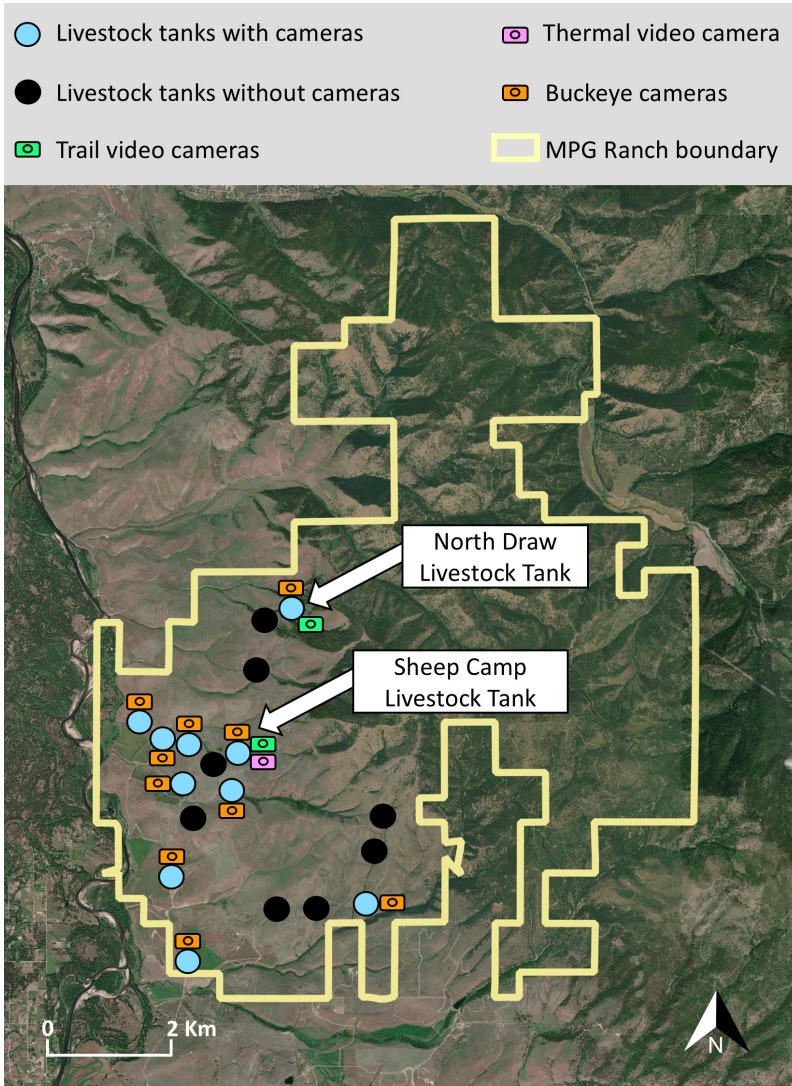


FIGURE 1. MPG Ranch, a 6191-ha conservation property in the Northern Sapphire Mountains in western Montana, USA. At the Sheep Camp livestock tank, we video-documented algae foraging by four unique Black Bear (*Ursus americanus*) of both sexes and of different age classes, during 2012–2022.

(*Pseudotsuga menziesii* (Mirbel) Franco), Ponderosa Pine (*Pinus ponderosa* Douglas ex Lawson & C. Lawson), Subalpine Fir (*Abies lasiocarpa* (Hooker) Nuttall), and Trembling Aspen (*Populus tremuloides* Michaux). The southern and western portions are dominated by agricultural land, open grass-covered slopes, sagebrush steppe, dry open forests, and narrow deciduous woody draws that lead to bottomland riparian cover types (Noson and Rodrigues 2015; Durham *et al.* 2017). MPG Ranch provides habitat for a wide variety of songbirds, corvids, raptors, insects, reptiles, amphibians, small mammals, mesocarnivores, and large mammals, including American Black Bear, Mountain Lion (*Puma concolor*), White-tailed Deer (*Odocoileus virginianus*), Mule Deer (*Odocoileus hemionus*), Moose (*Alces americanus*), and Elk (*Cervus canadensis*).

Video cameras

During 2011–2022, we installed video cameras at 88 camera stations to observe and document bear behaviour. A camera station was defined as one or more video cameras aimed at one unique feature, such as a livestock tank, pond, wildlife trail, rub tree, etc. We used Browning models 8FHD-P and BTC-7A (Morgan, Utah, USA), Stealth Cam models STC-DVIRHD and STC-G42NG (Grand Prairie, Texas, USA), Reconyx XR6 UltraFire (Grand Prairie, Texas, USA), and Bushnell model 1197678 (Overland Park, Kansas, USA) video camera systems. For our broader

Black Bear research program, we evaluated video data from camera stations aimed at all features to estimate bear demography (Reynolds-Hogland *et al.* 2022a,b). Herein, we focus on video data collected from only camera stations aimed at livestock tanks, which documented bear algae foraging events (Figure 1).

We installed four camera stations at four different livestock tanks. One camera station was installed in 2012, one in 2013, and two in 2014. The two camera stations installed during 2012 and 2013 were removed after one year owing to unproductivity (Table 1). The other two camera stations, aimed at the Sheep Camp livestock tank and the North Davis livestock tank (Figure 1), successfully video-captured Black Bear and were active during 2014–2022. Video cameras recorded for one-minute intervals at up to 60 frames/s, were motion-activated, had a one-minute time delay, and were operational 24 hr/day. Video settings were selected to maximize detection of animal behaviours, individual identification, and camera battery life. Video data were stored on secure digital (SD) cards. We checked all video cameras every 2–3 weeks during the summers of 2011–2014 and replaced camera batteries at least four times annually. During 2015–2022, we checked cameras and replaced camera batteries every six weeks from March to November, annually.

Thermal video camera

In summer 2016, we installed one AXIS Q1931-E thermal network camera (AXIS, Lund, Sweden) at the

TABLE 1. Duration of time that trail, Buckeye, and thermal cameras were active at each livestock tank on MPG Ranch in western Montana, USA, 2012–2022. NA means not applicable.

Livestock tank ID	Trail camera	Buckeye camera	Thermal camera
Waley Tank 1	2012	NA	NA
Waley Tank 2	2013	NA	NA
Sheep Camp Tank	2014–2022	2013–2022	2016–2022
North Draw Tank	2014–2022	2013–2022	NA
Woodchuck Ridge Stock Tank	NA	2013–2022	NA
Lower Sheep Camp Tank	NA	2013–2022	NA
Tongue Creek Stock Tank (L)	NA	2013–2022	NA
Tongue Creek Tank (U)	NA	2014–2022	NA
Sainfoin Bench Stock Tank	NA	2014–2022	NA
Orchard Stock Tank	NA	2016–2022	NA
Entrance Tank scale	NA	2017–2022	NA
Middle Sheep Camp Tank	NA	2017–2022	NA
Baldy Draw	NA	NA	NA
West North Draw Tank	NA	NA	NA
Mid Woodchuck Creek Tank	NA	NA	NA
Lower Woodchuck Creek Tank	NA	NA	NA
South Sheep Camp Stock Tank	NA	NA	NA
South Tongue Creek Stock Tank	NA	NA	NA

Sheep Camp livestock tank (Figure 1) to monitor thermoregulation of wildlife that immersed in this water source and because wildlife activity was relatively high at this livestock tank (P.W.R. unpubl. data). The thermal camera at the Sheep Camp livestock tank provided a view of wildlife that differed from the view provided by the non-thermal video camera station that was also aimed at the Sheep Camp livestock tank. The thermal camera was motion-triggered, had no time delay, and was powered by batteries with a solar charger. Videos were stored on a SD card, which we regularly maintained during 2016–2019.

Still photos

During 2013–2022, we installed Buckeye Orion and Buckeye X80 Wireless cameras (Buckeye Cam, Athens, Ohio, USA) at 77 Buckeye stations (Figure 1). Ten of the 77 Buckeye stations were aimed at 10 different livestock tanks. Five Buckeye stations aimed at livestock tanks were active from 2013 to 2022, two were active from 2014 to 2022, one was active from 2016 to 2022, and two were active from 2017 to 2022 (Table 1). Buckeye cameras collected still images, were motion-triggered, had a 10–15-s time delay, and sent images through a wireless network using radio frequency. Images were received by a PC Base antenna and stored onto an Apple Mac mini, during 2013–2022. Buckeye cameras were remotely monitored continuously throughout the study period. If a Buckeye camera was moved by an animal or if a battery was low, we immediately readjusted the camera position and replaced batteries.

Genetic data

We installed hair collection stations (Kendall *et al.* 2009) to determine genetic identity, maternity, and paternity of individual Black Bear (Reynolds-Hogland *et al.* 2022b). We used genetics and unique physical characteristics to determine individual identity of algae-foraging bears. During 2013–2022, we collected >1500 bear hair samples at 36 rub posts and rub trees. Details of genetic analyses, which were conducted by the National Genomics Center for Wildlife and Fish Conservation (Missoula, Montana, USA), are provided in Ramsey *et al.* (2019). No animal care protocol was required for the non-invasive collection of photo and genetic data that we collected.

Classifying capture events

We scrutinized every video and still photo to identify individuals and to document and classify bear behaviours. The vast majority of bears on our study site had unique traits (e.g., chest blazes, ear notches, head and snout shapes, distinct coat patterns, scars and bare spots, eyebrow colours, relative ear sizes, profile snout shapes, snout moustaches, snout colours, and temporalis and masseter sizes), which we used to help

identify individuals (Ramsey *et al.* 2019; Reynolds-Hogland *et al.* 2022a). We also linked visual markers of individuals with their genetic identifications, following Ramsey *et al.* (2019). We classified individual bears into four age classes: cub (<1 year old), yearling (1–2 years old), subadult (2–4 years old), and adult (≥ 5 years old; Hebblewhite *et al.* 2003; Obbard and Howe 2008). We used a 1-hr threshold to separate capture events when an individual moved out of the camera frame and then returned (Reynolds-Hogland *et al.* 2023b).

Results

Video cameras

During 2012–2022, we documented 381 bear visits to the Sheep Camp and North Draw livestock tanks. Algae grew in both of these but algae-foraging by Black Bear was observed only at the Sheep Camp livestock tank. Thus, we focus on Black Bear video-captures at only the Sheep Camp livestock tank. At least 22 individual bears visited the Sheep Camp livestock tank 148 times during 2015–2022 (Table S1). Algae was present in the Sheep Camp livestock tank during 46 visits by 16 different bears. We identified the algae growing in the livestock tanks to the genus *Cladophora*.

We documented one adult male (Bear M2) foraging on algae in the Sheep Camp livestock tank during three separate events in fall 2019 (Figures 2–4). During all three occasions, the livestock tank was full of water with a relatively large algal bloom. Bear M2 immersed himself in the water and grabbed algae with either his mouth or forepaws. Then, Bear M2 chewed the algae. After Bear M2 ate algae the first time on 8 September, he returned to the Sheep Camp livestock tank on 12 September and 5 October and consumed algae during both subsequent visits (Videos S1–S3).

Thermal video camera

We documented >60 thermal video-capture events of Black Bear at the Sheep Camp livestock tank. On 25 September 2019, adult female Bear F2 and her two cubs visited this tank. One of Bear F2's cubs put its forepaws into the water and pulled algae out of the tank and chewed it. The cub appeared to spit out at least some of the algae, which dropped to the ground (Video S4). On 1 October 2019, a different adult female (Bear F11) and her three cubs visited the tank. One of Bear F11's cubs used its mouth to grab algae from a metal grate that was placed in the tank to allow small animals to escape (Video S5).

Still photos

During 2012–2022, we classified >140000 still images from Buckeye cameras. Algae was found in all 10 livestock tanks that had Buckeye cameras. We



FIGURE 2. Frames from a video-capture (Video S1) of adult male American Black Bear (*Ursus americanus*) M2 foraging on algae on 8 September 2019, in a livestock tank on MPG Ranch in western Montana, USA. Photos: MPG Ranch.

documented several wildlife species foraging on algae in livestock tanks (Figure 5), including White-tailed Deer, Mule Deer, Elk, and Black-billed Magpie (*Pica hudsonia*). At 1:50 on 8 October 2019, one Buckeye image documented adult female Bear F2 at the Sheep Camp livestock tank with material that appeared to be algae dangling from her mouth (Figure 5f). The video camera that was also aimed at the Sheep Camp livestock tank failed to video-capture this algae foraging event.

Discussion

American Black Bear is an opportunistic omnivore (Benson and Chamberlain 2006; McLaren *et al.* 2021) with a broad dietary niche (Hatch *et al.* 2011) that shifts with seasonally available foods (Powell *et al.* 1997; Bowersock *et al.* 2021). To date, algae has not been reported in Black Bear diets. Here, we video-documented two cases of algae foraging by two different Black Bear cubs and three separate cases of algae foraging by one adult male Black Bear (Bear M2). We

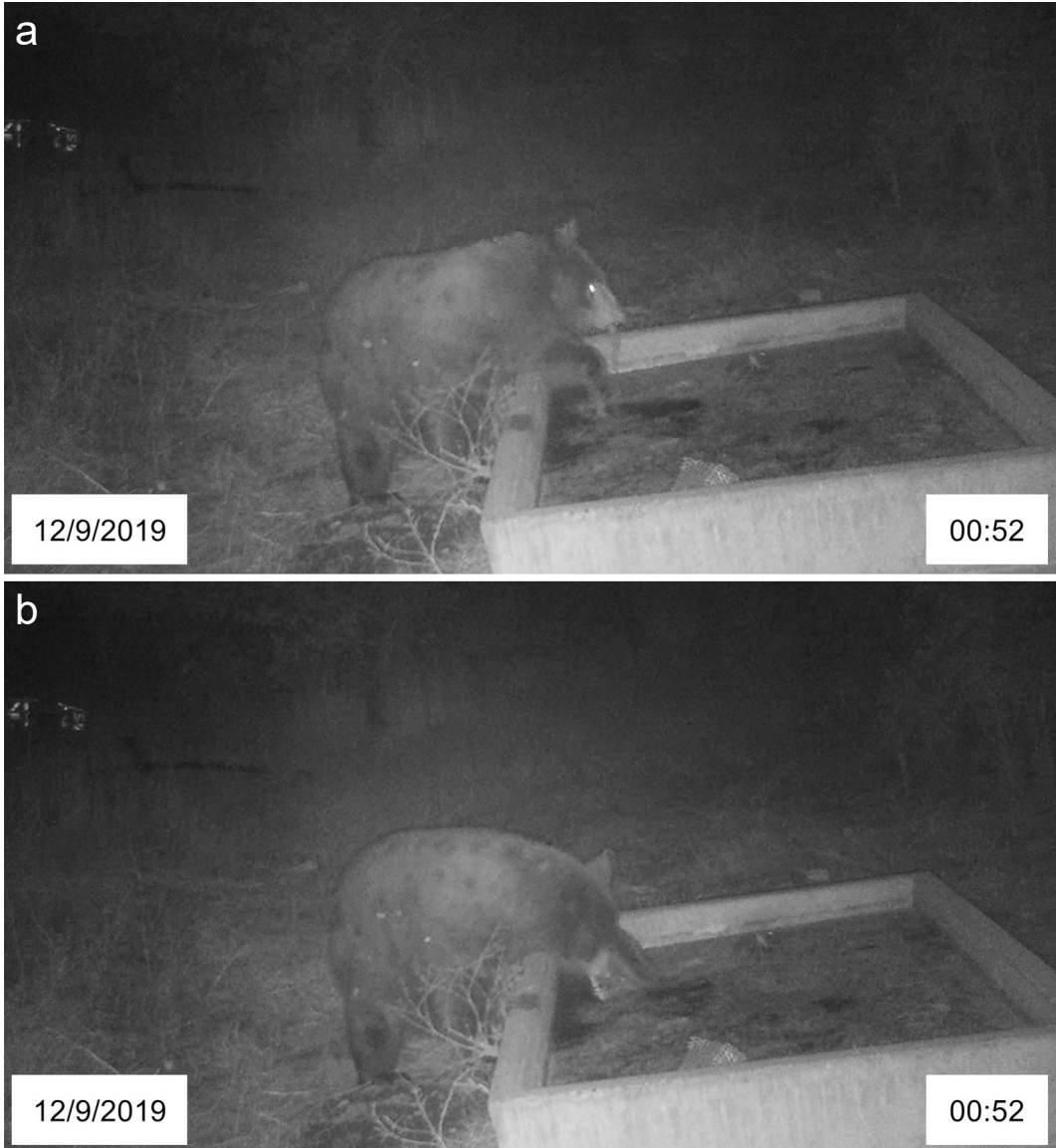


FIGURE 3. Frames from a video-capture (Video S2) of adult male American Black Bear (*Ursus americanus*) M2 foraging on algae on 12 September 2019, in a livestock tank on MPG Ranch in western Montana, USA. Photos: MPG Ranch.

also photo-documented one adult female Black Bear (Bear F2) with material that appeared to be algae dangling from her mouth.

Algae foraging by the two cubs and the adult female (Bear F2) was likely exploratory or unintentional. Both cubs chewed very little algae and did not subsequently return to the livestock tank to forage on algae again. Similarly, adult female Bear F2 was photo-captured with algae-like material dangling from her mouth only once.

Alternatively, Bear M2 foraged on algae in the Sheep Camp livestock tank during three separate occasions in fall, 2019: on 8 September (Figure 2), 12 September (Figure 3), and 5 October (Figure 4). This repeated foraging behaviour indicates that Bear M2 was not sampling algae during at least the last two algae foraging events.

We identified the algae in the livestock tanks to the genus *Cladophora*, a globally widespread, macroscopic, freshwater green algae (van den Hoek *et*



FIGURE 4. Frames from a video-capture (Video S3) of adult male American Black Bear (*Ursus americanus*) M2 foraging on algae on 5 October 2019, in a livestock tank on MPG Ranch in western Montana, USA. Photos: MPG Ranch.

al. 1995; Boedeker *et al.* 2010) consisting of >183 species (Munir *et al.* 2019; Michalak and Messyasz 2021). Seasonal blooms of *Cladophora* species can create detrimental environmental and recreational issues in freshwater bodies (Messyasz *et al.* 2015; Nutautaitė *et al.* 2021; Michalak and Messyasz 2021), but *Cladophora* species can also benefit wildlife because they contain biologically active ingredients (Nutautaitė *et al.* 2021). For example, the commonly occurring *Cladophora glomerata* contains

carotenoids (Khuantrairong and Traichaiyaporn 2012); minerals such as calcium, potassium, and selenium (Peerapornpisal 2007; Michalak and Messyasz 2021); vitamins A, C, E, B1, and B2 (Khuantrairong and Traichaiyaporn 2011; Michalak and Messyasz 2021); fatty acids (Laungsuwon and Chulalaksanakul 2014; Messyasz *et al.* 2015); glycosides (Khalid *et al.* 2012); enzymes (Verdel *et al.* 2000; Messyasz *et al.* 2015); amino acids and protein (Rani 2007; Messyasz *et al.* 2015; Michalak and Messyasz



FIGURE 5. Photo-captures of wild animals foraging on algae in livestock tanks on MPG Ranch in western Montana, USA. Photos: MPG Ranch.

2021). Thus, it is possible that Bear M2 foraged on algae for nutritional benefit.

Bear M2 foraged on *Cladophora* species during the fall, the time of hyperphagia for Black Bear. Common plants that Black Bears consume during fall in western Montana include Choke Cherry (*Prunus virginiana* L.), hawthorn (*Crataegus* L.), Service

Berry (*Amelanchier alnifolia* (Nuttall) Nuttall ex M. Roemer), huckleberry (*Vaccinium* L.), Red-osier Dogwood (*Cornus sericea* L.), Bristly Black Currant (*Ribes lacustre* (Persoon) Poirét), Bracted Honeysuckle (*Lonicera involucrata* (Richardson) Banks ex Sprengel), angelica (*Angelica* L.), and fruits of trees in the *Sorbus* (L.) genus (Tisch 1961). The protein

(20%) and fat (5%) content in *Cladophora* species (Peerapornpisal 2007) are similar to, or higher than, that in most common plants that Black Bear consume in fall. For example, the protein and fat content in Choke Cherry (7% protein, 4.2% fat; Costello *et al.* 2016), Service Berry (3.3% protein, 3.4% fat; Gunther *et al.* 2014), Bristly Black Currant; (5.6% protein, 3% fat; Gunther *et al.* 2014), and huckleberry (4–10% protein, 3–6% fat; Gunther *et al.* 2014) are lower or similar to that found in *Cladophora* species.

We do not know if Black Bear can digest *Cladophora* species. They are omnivores with short, simple digestive tracts (Stevens and Hume 1995; Gillman *et al.* 2020), so they are unable to fully digest plant matter (Bowersock *et al.* 2021). Humans are also omnivores, and they consume both fresh and dried forms of *Cladophora* species (Choobthaisong and Oupathumpanont 2021). Also, freshwater algal blooms can be digested by several livestock mammals including the omnivorous domestic Pig (*Sus domesticus*; Michalak and Chojnacka 2008). Black Bear, humans, and domestic Pig all have simple monogastric digestive systems. Thus, it is possible that Black Bear, like humans and domestic Pig, could digest *Cladophora* species.

In addition to containing proteins, carbohydrates, fat, minerals, and vitamins, *Cladophora* species also have anti-inflammatory and analgesic properties (Peerapornpisal *et al.* 2006). We observed Bear M2 limping throughout 2018 (Reynolds-Hogland *et al.* 2022b), and Bear M2 was still favouring his back left leg during 2019. It is possible that Bear M2 consumed *Cladophora* species in fall 2019 to help alleviate physical discomfort. Other wild animals such as elephants, birds, lizards, and some great apes self-medicate (Shurkin 2014). For example, Fruth *et al.* (2014) studied self-meditative behaviours by Bonobo (*Pan paniscus*) which occasionally consumed the leaf of *Manniophyton fulvum*. This plant has anti-inflammatory properties, which the authors suggest could provide physiological relief.

Alternatively, Bear M2 may have consumed algae to aide in the removal of intestinal parasites. Similar behaviour has been widely documented in African great apes (Huffman 2003). For instance, the consumption of whole leaves of non-nutritive plants by Chimpanzee (*Pan troglodytes*) has been linked with the expulsion of parasites (Wrangham 1995; Huffman *et al.* 1996; Huffman and Caton 2001; Huffman 2003).

It is also possible that the algae foraging we documented by Bear M2 was unintentional. Insects, an important component of the Black Bear diet (Tisch 1961; Graber and White 1983; Powell *et al.* 1997; Lesmerises *et al.* 2015), could have been present in the algal blooms that Bear M2 consumed. If so, Bear

M2 may have unintentionally consumed algae while he was foraging on insects. Incidental algae consumption is reported in Manatee (*Trichechus manatus*; Castelblanco-Martinez *et al.* 2009), where algae live in the leaves and roots of macrophytes that Manatees consume (Colares and Colares 2002; Guterres-Pazin *et al.* 2012). Although consumed inadvertently, algae is thought to provide protein or other nutrition to Manatees (Best 1981; Packard 1981; Guterres-Pazin *et al.* 2012). If Bear M2 unintentionally consumed algae, it is possible that algae provided nutritional benefit to Bear M2.

In conclusion, we documented American Black Bear and other wildlife foraging on freshwater algae in livestock tanks. In addition to providing water and opportunities for wildlife to thermoregulate (Sawaya *et al.* 2017), livestock tanks provided opportunities for algae to grow. The nutritional benefits of freshwater algae in the *Cladophora* genus are increasingly added to improve feed for domestic animals (Mihranyan 2011; Zulkiffly *et al.* 2013; Messyasz *et al.* 2015; Nutautaitė *et al.* 2021). Our findings suggest that the benefits of *Cladophora* species extend to wild animals. This finding has implications for wildlife conservation and management.

Author Contributions

Writing – Original Draft: M.J.R.-H.; Writing – Review & Editing: M.J.R.-H., C.B., G.S., A.B.R., R.A.D., K.T., M.V., and P.W.R.; Conceptualization: M.J.R.-H., C.B., G.S., A.B.R., and P.W.R.; Investigation: M.J.R.-H., C.B., G.S., A.B.R., R.A.D., K.T., and M.V.; Supervision: M.J.R.-H., A.B.R., and P.W.R.; Visualization: M.J.R.-H., C.B., G.S. and M.V.; Funding Acquisition: P.W.R.

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SUPPLEMENTARY MATERIALS:

TABLE S1. Video-documentation of wild American Black Bear (*Ursus americanus*) that visited stock tanks when algae blooms were and were not present, size of algae blooms, and if the individual ate the algae from the Sheep Camp livestock tank, on MPG Ranch in western Montana, USA, 2015–2022.

VIDEO S1. Video of adult male Black Bear (*Ursus americanus*) M2 foraging on algae in the Sheep Camp livestock tank on 8 September 2019 on MPG Ranch in western Montana, USA, posted at https://youtu.be/VJPRSVpO_7Y.

VIDEO S2. Video of adult male Black Bear (*Ursus americanus*) M2 foraging on algae in the Sheep Camp livestock tank on 12 September 2019 on MPG Ranch in western Montana, USA, posted at <https://youtu.be/znTg50s2SvW>.

VIDEO S3. Video of adult male Black Bear (*Ursus americanus*) M2 foraging on algae in the Sheep Camp livestock tank on 5 October 2019 on MPG Ranch in western Montana, USA posted at <https://youtu.be/zSbaJZ3SUHA>.

VIDEO S4. Video of adult female Black Bear (*Ursus americanus*) F2 with her two cubs of the year, one of which forages on algae in the Sheep Camp livestock tank on 25 September 2019 on MPG Ranch in western Montana, USA, posted at <https://youtu.be/Zqj-UbtFB04>.

VIDEO S5. Video of adult female Black Bear (*Ursus americanus*) F11 with her three cubs of the year, one of which forages on algae in the Sheep Camp livestock tank on 1 October 2019 on MPG Ranch in western Montana, USA, posted at <https://youtu.be/lia5HFNGWJM>.