Adverse effects of hunting with hounds on participants and bystanders

Adrian Treves[a¥*], Laura Menefee[b†*]

[a] Nelson Institute for Environmental Studies, 30A Science Hall, 550 North Park Street, University of Wisconsin, Madison, WI, 53706, USA, +1-608-890-1450, atreves@wisc.edu,

[b] Department of Literature, Leeward College, University of Hawai'i, Pearl City, HI and Sierra Club Wisconsin Chapter, mail c/o A. Treves, 30A Science Hall, 550 North Park Street, University of Wisconsin, Madison, WI, 53706, USA, menefee.laura@gmail.com

[†] These authors have contributed equally and share first authorship.

*** Correspondence:** atreves@wisc.edu, menefee.laura@gmail.com

Abstract

In the face of biodiversity crises and concerns raised about animal ethics, some societies are re-examining many human uses of animals. One activity that may once have been unobjectionable has undergone little scrutiny in most countries: hunting mammals with free-running hounds. We present two novel datasets about this under-studied `behavioral interaction and hunting method. In the state of Wisconsin, USA, hounds and gray wolves occasionally interacted aggressively and human by-standers reported adverse interactions with hounds and their handlers. Such self-selected samples cannot be used to extrapolate rates in space or time but do provide new information. Between 1999 and 2012, 176 hounds were reported to have suffered injury during encounters with wolves. No government data were collected on how many wolves or other non-target animals were injured by hounds. We describe the grouping `behavior, patterns of injury and vulnerability to attack, hound phenotypes, and other ethological data associated with aggressive wolf-hound interactions. We analyze wolf life

history, seasonal life history patterns, bite locations on hound bodies, consumption of hound carcasses, and the outcomes of interactions to test two hypotheses for wolf-hound interactions. We find weak or no support for either and propose new hypotheses focusing on the behavior of hounds and handlers primarily. We also report handler and hound interactions with human bystanders. Between 2015-2021, bystanders (n=105) reported various adverse incidents with hounds and handlers, interactions with law enforcement, and other events associated with hunting with hounds. We propose reforms to policy for wildlife, hunting, and law enforcement, and reforms to husbandry by hound handlers.

Keywords: human-carnivore conflict and coexistence, dog, illegal take, poaching, wolf

Introduction

In the face of biodiversity crises and concerns raised about animal ethics partly caused by climate change and partly by human-induced mortality, some societies are re-examining many human uses of animals that once seemed unobjectionable. For example, uses of poison, off-road vehicles, fire suppression, etc. have undergone scrutiny for their societal benefit-cost estimates and their effects on domestic animals, wildlife, and ecosystem health. One human activity that may once have been unobjectionable has undergone little scrutiny: hunting with free-running hounds loosed far from their owners.

In our search for work on hunting with dogs or hounds in Google Scholar, the search phrase ‘hunt with (hound or dog)’’ yielded 38,300 results declining by half when ‘-bird’ was added to the search string to exclude bird-hunting with dogs. By contrast, ’hunt -bird ‘yielded 3.16 million results. Therefore, hunting with hounds is under-studied. Judging from one court case in Wisconsin, the practice of hound-hunting is protected from outside scrutiny (Brown v

Kemp2021). Yet, the practice of hunting mammals with hounds has been recorded since 8,000 years at least (Guagnin et al., 2018), praised by President Theodore Roosevelt in 1902 (Roosevelt, 1902), and is legal in numerous countries and several U.S. states (Heberlein, 2000; Hristienko and McDonald, 2007). Despite its long history, loosing mammal-hunting hounds to pursue prey, some as large as brown (grizzly) bears, *Ursus arctos*, may have harmful effects on people in their path, on the hounds themselves, and on target and non-target wildlife they encounter or pursue (Grignolio et al., 2011; Gompper, 2013). Therefore, we present data on reports by self-selected owners alleging harm to their hounds, following interactions with wolves. We also present self-reported perceptions of human by-standers who experienced the `behavior of hounds during training or hunting. We offer these two data sets to describe the side-effects of this poorly studied hunting method.

Non-target animals and their interactions with hounds

When pets kill wildlife, biodiversity may diminish or ecosystem health may deteriorate (Grignolio et al., 2011; Gompper, 2013). Dogs are potential predators of domestic animals and wild ones (Bowers, 1953; Ciucci and Boitani, 1998). `behavioral changes in wildlife are often reported. For example, black bears *U. americanus* were reported to avoid encounters with hounds and in so doing approach people and major roads more frequently (Stillfried et al., 2015). Some animals will stand their ground when hounds encounter them (Treves et al., 2002; Wydeven et al., 2004; Backeryd, 2007). Larger size and greater competitive ability of the wild animals may alter the risk posed by hounds and vice versa. Hounds are often used for pursuit of mammals larger than individual hounds. When hounds encounter animals that can defend themselves effectively, the hounds may be injured. Researchers have examined aggressive

encounters between wolves and dogs in many regions (Fritts and Paul, 1989; Backeryd, 2007; Kaartinen et al., 2009).

The States of Wisconsin and Michigan, USA, have a relatively longer history of such research. Spatial patterns of wolf *Canis lupus* attacks on hounds are somewhat predictable (Treves et al., 2002; Wydeven et al., 2004; Bump et al., 2013; Olson et al., 2014). The risk of an attack appeared to be higher in areas with more public land, larger wolf packs, closer to a wolf pack, and when baits were left out longer. Here, we examined self-reports by owners on the characteristics of both canids involved, and self-reported correlates of the outcomes of wolf-hound interactions (WHI).

At the time of our study, it was illegal for hounds to attack wild animals. Nevertheless, such attacks might have occurred anyway. We do not have evidence of which animal in a WHI initiated aggression or escalated it to the point of injury or death. We only present data on the outcomes for hounds because outcomes for wolves were not documented. Federal law under the Endangered Species Act and state law against animal fighting would both require authorities to collect data on the latter. We cannot explain why the database contained no such information. Therefore, we cannot rule out the possibility that wolves responded defensively to hound attacks. The evidence for wolf attacks on hounds came from handlers seeking compensation or other forms of redress (Treves et al., 2002; Ruid et al., 2009; Treves et al., 2009). In a prior study, a number of wolf deaths caused by other canids were invariably attributed to other wolves (Treves et al., 2017b). Yet, veterinary pathologists might not be able to reliably distinguish large dogs, such as hunting hounds, from wolves by simple scrutiny of bite marks without DNA analysis (Plumer et al., 2018). Therefore, our sample is necessarily

biased toward handler concerns and outcomes for hounds. This does not rule out that wolves were the aggressors or that wolves remained unharmed by hounds.

We focus on the `behavior of hounds, wolves, and handlers as reported by by-standers. We test two ethological hypotheses about WHI. First, the predation hypothesis predicts WHI occur when wolves attack hounds for food, and second, the territoriality hypothesis predicts that WHI occur when wolves defend territory or pups (Treves et al., 2002; Wydeven et al., 2004).

Hounds and humans

Much research has measured attitudes of hound-handlers towards wolves (Supplementary Material 1). In brief, as a group, hound-handlers have the lowest tolerance for wild wolves in any group measured thus far. There are no published data on hound-handler' encounters between by-standers and either handlers or their free-running hounds. The Sierra Club Wisconsin Chapter (SCWC) began to fill the gap with the survey we report here. As part of a National Sierra Club initiative, the SCWC subcommittee discussed the first-hand reports members had received of by-stander experience. Because such first-hand reports are likely to be remarkable, most reports were adverse. The SCWC subcommittee requested information from local law enforcement in the counties from which reports and also the Wisconsin Department of Natural Resources (WDNR) for incident report data. They were informed by both agencies that "no such data were recorded." Thus, SCWC members led an effort at gathering information more broadly and systematically.

Material and methods

Wolf-hound interactions (WHI) `behavior, grouping, and phenotype

During our study period, hounds were legally used to hunt many mammals, including smaller carnivores and black bears. Bear hunting in Wisconsin occurred legally from the last week of August into October, and hound training was legal in July and August (Treves et al., 2009; Treves et al., 2010). Hound hunters accounted for approximately 40% of the annual take by bear hunters (Treves et al., 2010; Olson et al., 2014). Typically hounds were loosed from vehicles and allowed to run far from owners, without control (Wydeven et al., 2004). Hounds were often fitted with global positioning systems (GPS) or VHF radio-collars, allowing the owner to follow remotely the movements of hounds and determine when and where a bear had been treed. Hunters used groups of up to 6 hounds to track and trail prey during training or hunting (Wydeven et al., 2004).

We examined WHI from 7 August 1999 through 19 January 2012. Case files documented 145 killed and 31 injured hounds deemed by state or federal verifiers as “confirmed” (85%) or “probable” (15%) WHI, see methods in (Treves et al., 2002). We believe most WHI incidents were reported because of a compensation program characterized as more generous than other jurisdictions (Naughton-Treves et al., 2003; Treves et al., 2009). Bump et al. (Bump et al., 2013) suggest fewer WHI are reported in Michigan’s wolf range because hound owners receive no compensation. Owners with confirmed losses in Wisconsin were eligible to receive up to $2,500 per hound based on the estimated value of the hound. Since the compensation program began in 1985, nearly $350,000 dollars were paid to hunters to compensate for hounds injured or killed by wolves. Between 1985 and 2006, payments for hunting hounds comprised 37% of all compensation (Treves et al., 2002; Naughton-Treves et al., 2003; Ruid et al., 2009; Treves et al., 2009). WDNR provided compensation for domestic animals injured or killed by wolves,

133 including hounds (Treves et al., 2002; Ruid et al., 2009; Treves et al., 2009). United States
134 Department of Agriculture agents assumed responsibility for verifying WHI in 1990, and
135 conducted most of the investigations used in our analysis of WHI (Willging and Wydeven, 1997).
136 WHI case files included written reports and forms documenting field investigations,
137 including necropsy data, photos, veterinary reports, and anecdotal reports handlers. During the
138 early years of record-keeping, documentation and reporting of depredations lacked uniformity;
139 thus, some portions of the data were missing, resulting in lower sample sizes for various
140 analyses. We limited our analysis of WHI to hounds used to hunt bears, bobcats, or coyotes. A
141 total of 91% of WHI occurred while pursuing these species, which involves different breeds and
142 use of hounds than for other quarry, such as waterfowl, upland birds, or rabbits. Hounds that
143 hunt large prey such as bears or coyotes are typically breeds of large size and build, frequently
144 Plott (18-27 kg), or larger hound breeds (Bluetick, Redbone, or Walker coon-hounds (18-36 kg).
145 Occasionally, WHI files did not specify the type of prey being pursued. In these cases, if the
146 breed of hound was one of the five listed above, we assumed the WHI occurred while pursuing
147 the above three wildlife species. In total, we report on 176 case files. We quantified the
148 frequency of WHI among breeds of hounds. If the hound was reported as a mix of multiple
149 breeds, we used the first breed listed. We pooled breeds in an “other” category when a single
150 breed had too few WHI to meet the assumptions of the *chi*-squared test. No data are available
151 on breed frequencies or preference by hunters in Wisconsin, with which we could estimate
152 relative risk by breed.
153 Our analysis of the body site bitten was limited because a number of hound carcasses
154 were partially or wholly consumed before retrieval by an owner arriving late at the scene. We

155 pooled head, neck, and throat into one category and all other sites in another category, to test
156 if outcomes of WHI differed by bite site.

157 We compared hound group size, number of hounds involved in the WHI, and wolf pack
158 size using (1) number of wolves seen and reported by hunters (observed), and (2) WDNR-
159 reported wolf pack sizes from the winter preceding the WHI (censused). Because wolf packs
160 exhibit fission-fusion sociality and packs disaggregate often in the summer (Mech, 1970), when
161 many WHI occurred. Wolf packs in Wisconsin average 4 adults in late winter (range 2-12),
162 usually composed of offspring of the two (usually) unrelated alpha breeders. By summer, pups
163 are exiting the dens but range near them or near other pack rendezvous sites until the pack
164 regularly fuses and travels long distance in mid- to late Fall. During this time, most wolf pack
165 members return periodically to rendezvous or den sites to assist with pup-rearing, and
166 consequently have higher food demands, perhaps requiring wolves to forage more frequently
167 (Ruprecht et al., 2012). From birth until the end of August, wolf pups experience the highest
168 growth rates, with September representing a critical month for weight gain (Kreeger, 2003). In
169 some cases, wolf pups have been observed gaining as much as 3.6 pounds per week (Van
170 Ballenberghe and Mech, 1975). Pup growth, critical to survival, is limited by food quality and
171 availability. By late August, growth begins to taper (Pulliainen, 1965), as does rendezvous site
172 use (Van Ballenberghe and Mech, 1975; Kreeger, 2003; Ruprecht et al., 2012). We acknowledge
173 R. P. Thiel for the suggestion that seasonality of wolf life-history on an annual cycle would
174 predict more risk of WHI in late summer and autumn because of all pack members and
175 especially pups' caloric needs. Finally, we analyzed the temporal occurrence of WHI as it relates

to public hunting seasons, and we compared the frequency of WHI during the hound-training period (July-August) to that during the bear-hunting season (treated as September-October).

Handler `behavior and husbandry

The state wildlife agency implemented several methods for mitigating or preventing WHI, including compensation for handlers' self-reported losses, encouraging the use of warning devices on collars to deter wolves, and statewide communication to hunters on recent hound injuries and their locations, and designation of Wolf Caution Areas (WCAs). The state communicated the location of higher-risk WCAs online, posted in the field, and in other ways to handlers (Wydeven et al., 2004; Olson et al., 2014). Within WCAs, the WDNR recommended that bear hunters release hounds >2 miles from known rendezvous sites. Prior work documented handlers' willingness to risk hounds in posted WCAs, even within the same season and even within hours of previous WHI or WCA posting (Wydeven et al., 2004; Olson et al., 2014). Compensation records also document multiple payments to the same owner or handler within a single season (Treves et al., 2009). These data suggest not all hunters heeded the state's warnings. Compensation programs did not clearly reduce WHI rates. Much scholarly discussion has focused on the moral hazard (in short, negligent owners have no incentive to protect their animals if they will be paid for losses). Prior research on Wisconsin's compensation program addressed moral hazards (Naughton-Treves et al., 2003; Treves et al., 2009). The state only changed the source of the funds, not the conditions for payment since that work was published. Therefore, cooperation of the state legislature may be essential to changing an incentive for WHI to occur into a disincentive for hounds and non-target animals to be put at risk. Handlers may be able to prevent WHI by using protective vests or stronger collars

198 (Backeryd, 2007; Khorozyan et al., 2020), keeping hounds leashed until the targeted game
199 species is located, or bringing first aid kits on the hunt, although the possible effect of these
200 interventions has not been studied in Wisconsin.

201 Survey of by-standers

202 The Sierra Club Wildlife Committee (SCWC) subcommittee on Protecting Native Forests and
203 Wildlife collected systematic information from by-standers' experiences of hound hunting. The
204 SCWC led and posted the survey on the Sierra Club Wisconsin Chapter website through 2015-
205 2021, and administered the survey. The survey appeared at
206 https://www.sierraclub.org/wisconsin/protecting-native-forests-wildlife accessed 20 August
207 2022. SCWC members also printed hard copies of the instrument and distributed these at wolf
208 and wildlife related meetings and conferences in Wisconsin in 2015 and 2016. SCWC also
209 invited any members of the public who described adverse hounding encounters to fill the
210 online report. Therefore, respondents were self-selected with attendant biases.

211 We analyzed anonymized data stripped of identifying information by the SCWC
212 administrators. The 25-question survey (Supplementary Material Appendix 1) is organized in
213 four sections: Observations; Trespass; Property Damage, Personal Injury or Threats; and
214 Interactions with Law Enforcement, totaling 22 yes/no questions and 4 items that allowed
215 unstructured responses to elaborate on answers. Respondents could identify county of
216 residence and interaction, if different. Respondents were asked how many hounds they saw
217 during each interaction they reported. When two respondents mentioned the same interaction
218 but different numbers of hounds, LM averaged and rounded up for the number of hounds.

About 80% of respondents used the online form to report anonymously, and 20% sent their responses directly to SCWC via mail, phone, email, or in person while being assured of anonymity. LM screened the sample to eliminate responses which identified no adverse incident involving hunting hounds, as these respondents generally used the report format to express an opinion about the practice of hunting with hounds, which we did not analyze because it was outside the purview of this survey (Supplementary Material 2). We screened for multiple reports of the same incident with identifying factors such as location and date. After the screening, the sample presented here appears to come from independent incidents although we had no way to verify location or date.

Statistical analyses

We performed statistical analyses (SAS Institute, 2013) using Student's paired *t* tests to compare the differences in average estimated ages of hounds and numbers of wolves during the attack, in relation to the outcome of the WHI (i.e., killed or injured) after evaluating if variances were equivalent (*F* test). All statements of statistical significance are based on $P \leq 0.05$. We used Spearman rank correlations to detect associations between multiple continuous variables.

Ethical note

The data presented are exempt from approvals for research on human subjects because (a) the data were collected by another organization (WDNR and SCWC) and distributed to the authors without individually identifiable information; (b) all SCWC survey responses were completely anonymous; and (c) the identity of complainant handlers was likewise unknown to

us and redacted from records by the state agency that received the complaints. Use of hounds for hunting is a state-regulated activity. No research was conducted on the hounds.

Results and Discussion (as allowed by instructions to authors, p.9 para 3)

Wolf-hound interactions (WHI) `behavior, grouping, and phenotype

In 176 case files, we found 140 independent WHI cases during our study period, where a case reported on the same day and location by different owners were pooled into one WHI. Records included 145 killed (83%) and 31 injured (17%) hounds, similar to 71% and 82% reported in Nordic countries (Kojola and Kuittinen, 2002; Backeryd, 2007). The high percentage of fatalities in both cases might reflect that handlers sometimes took hours to find a distant hound. Therefore, sub-lethal injuries might not be attributed to a WHI if handlers and hounds reunited long after it ended; this effect would bias WHI records upward to more fatalities. Similarly, the cases involving distant handlers might not have escalated to lethal injuries if the handlers had arrived earlier.

Wolf injuries and deaths in WHI were not documented nor reported in case files. Another possible source of missing data might come from misidentifying wolves as the wild interactant, given the availability of compensation for such WHI and not for casualties from other wildlife (Treves et al., 2009). In total, 89% of WHI occurred while hunters reported pursuing black bears, bobcats *Lynx rufus* 6%, coyotes *C. latrans* 4%, raccoons *Procyon lotor* 1%). However, we lack independent data on the animal being pursued by those hounds at the time of WHI. We also lack the relative frequencies of targeting each species with hounds statewide and over time. There was no association between the outcome of WHI categorized as either injury or death and the prey being pursued by hunters ($X^2 = 1.9$, $P = 0.75$, $df = 4$, $n = 140$). The

262 bear-hound-training period accounted for 62% of WHI, whereas the bear-hunting season
263 accounted for 28% despite being the same length approximately. Outcomes were not
264 associated with month annually (X^2 = 8.5, P = 0.38, df = 8, n = 176, Table 1). These two results
265 suggest that seasonality and Wolf reproductive timing did not predict injury or death of hounds,
266 which undermine both the predation and territoriality hypotheses. We lack information on the
267 frequency with which WHI was initiated by hounds, which could result in very different causal
268 hypotheses focused on the motivations of hounds and handlers.

269 Neither sex nor age of the hounds was associated with the outcome of WHI (sex X^2 =
270 1.32, P = 0.25, df = 1, n = 151; age t = -0.71, P = 0.49; variances were equal F = 0.49). The
271 Treeing Walker Coonhound was the most common breed in WHI (33.3%, n = 51), followed by
272 the Plott (27.5%, n = 42). There was a significant association between breed and outcome (X^2 =
273 10.7, P = 0.03, df = 4, n = 176). Notably, the Plott fatality frequency of 95.4% was higher than
274 the average 81.2% (Table 1). Plott hounds are the smallest and most vocal hound breed
275 commonly used in Wisconsin for mammals. Small body size has been implicated in the risks and
276 fatalities associated with WHI (Fritts and Paul, 1989; Peterson, 1995; Backeryd, 2007; Kaartinen
277 et al., 2009). The Plott breed is also known for its baying vocalizations, which might alert wolves
278 from a long distance. Similar elevated risks of dog vocalizations were reported in Nordic
279 countries (Backeryd, 2007; Kaartinen et al., 2009). Small size may make a hound more
280 vulnerable to head and neck bites. Bites to the neck were associated with higher fatality rates in
281 a Scandinavian study (Backeryd, 2007).

282 Our analysis on hound body site bitten was limited to 109 WHI. We cannot be certain
283 that wolves inflicted every bite because of the above-mentioned delays in discovering hounds

284 and the missing center created by compensation only for attacks by wolves. Of the 109
285 carcasses with bite information, 50 provided one bite location (46%), 37 provided two locations
286 (34%), and 22 provided 3 or more locations (20%). Considering all bite locations (n = 193), the
287 single most frequent bite site was the neck (33%), followed by back (17%), upper thigh (12%),
288 and chest (10%). We considered bites to the head, shoulders, neck (as opposed to throat), back,
289 and upper thighs as indicative the hound had been lower than its attacker. Those upper body
290 parts were represented in 72% of the 193 bites whereas under-parts (throat, groin, sternum,
291 ribs, lower legs, abdomen) were represented in 28% of bite locations. We found no relationship
292 between body site bitten and outcome, when we separated neck and head bites from others
293 (X^2 = 1.5, P = 0.22, df = 1, n = 66).

294 Another factor affecting the vulnerability of canids to attack by other canids is numerical
295 superiority. An average of 1.3 hounds were injured or killed per WHI (maximum 5 in a single
296 WHI). The size of the hound group averaged 3.8 *SD* 1.4, n = 57; only 3 (5%) of those WHI involve
297 a single hound in the handler's control; and also the number involved in the WHI (2.6 *SD* 1.3, n
298 = 47 with 9 (19%) of those WHI involving only 1 hound, were both similar to the number of
299 wolves observed by handlers (2.9 *SD* 1.2, n = 15), the census pack size for the pack blamed by
300 the state or federal agent tasked with verifying the report (2.4 *SD* 1.0, n = 19; n = 4 included
301 information for both observed and censused). The outcomes were not associated with the
302 number of hounds, number of wolves, or difference between the two in a given WHI by any of
303 the measures of group size or pack size above (Welch test assumes unequal variance, $F < 0.72$,
304 $P > 0.41$ in every test). Wolves injured or killed hounds in groups with superior numbers in 44%
305 of WHI with such data (n = 16). Aggression between wolves and coyotes in Yellowstone

National Park had fatal consequences when wolves outnumbered the smaller coyotes, but not when coyotes outnumbered wolves, suggesting that group size exerted less influence than individual body size differences in determining outcomes between canids (Ballard et al., 2003; Merkle et al., 2009). In our study, if wolves were motivated by predation or territorial defense as suggested by the two hypotheses, we might expect pack size to predict the outcomes of WHI. Again, this suggests the need for new hypotheses as above.

Of 80 deaths with data on consumption of a carcass, 49% of hound carcasses were partially consumed. Of those 80 hounds consumed by wolves, 71% occurred July–August and 27% in September–October. When we combine the former timing of WHI, site location of bites, and the consumption data above, we can test two hypotheses about the cause of WHI. The timing of WHI presents equivocal evidence for both hypotheses. Higher frequencies of WHI occurred during the hound training period in July and August than during the autumn black bear hunt in September and October (Table 1). Elevated risk in July and August might have been associated with the practice of baiting, as wolves visit bear bait sites in search of food (Bump et al., 2013). In Wisconsin, bear bait sites could be legally established as early as April and could last the entire wolf pup-rearing season. Bump et al. (2013) documented that the risk of WHI was three to seven times greater in Wisconsin than in adjacent Michigan, citing the extended bear-baiting period as a probable cause for the much higher risk of WHI in Wisconsin. That might support the predation hypothesis. However, bear baiting was confounded with wolf pup defense predicted by the territoriality hypothesis. The hound training period coincided during the study with wolf use of rendezvous sites or den sites. See the introduction for the life-history on an annual cycle of wolves, which the majority of hound packs would not experience in the

same way because of human provisioning, aseasonal reproduction, and more human intervention in breeding `behavior. The consumption of hound carcasses might corroborate the predation hypothesis, but that is not persuasive because consumption was recorded in only approximately half of the WHI and we do not know if the wolves that attacked were the consumers. Nor can we rule out that consumption followed after the primary motivation for aggression in either the hounds or the wolves. The hound carcasses and bite locations provided limited insight. Bites to head, neck, and throat represented 41% of bite locations on hound carcasses. The predation hypothesis might find support from this result because cranio-cervical killing bites are associated with predation by many mammals (Steklis and King, 1978; Van Valkenburgh and Ruff., 1987). But the greater height of wolves off the ground then off most towns would predict such bite locations in any case. In sum, we find equivocal support for both hypotheses. This could imply both are correct or we are missing information, such as whether the hounds were pursuing Wolves. We also do not have information on the body condition of any of the participants, which seems essential data to test the prediction hypothesis.

Handler `behavior and husbandry

Husbandry, such as avoidance of rendezvous sites and use of bells on collars were difficult to evaluate, because of a lack of data on prevalence, use, and effectiveness of these potentially preventive methods. Overall, 55 (31%) records reported whether hounds in WHI wore bells on their collars, with 20 (36%) wearing them and 35 did not (64%). But we have no data on the use of bells among hounds that did not enter the WHI database and the majority of records did not contain any information on devices. Outcomes were not associated with hunter self-reports of affixing bells to collars. Another step handlers might take to protect hounds and

wolves would be to release hounds only in low-risk areas. The state did not systematically collect data on whether air warnings about high-risk WCAs were heeded. The WHI records did not contain such information.

Survey of by-standers

In all, 105 respondents reported adverse incidents with hunting hounds from 51 Wisconsin counties, 4 Michigan counties, and 5 counties from other states. The average number of incidents per county was 2. Seven respondents declined to specify location, but timing distinguished the reports from other respondents' reports. The 105 respondents reported 119 separate incidents (Table 2). Of the 105, 42% reported the hounds observed were not accompanied by a handler; similarly, 41% reported finding abandoned or lost hounds on their property. In those cases, some respondents reported contacting local animal shelters, law enforcement or handlers via phone numbers on collars. Overall, 63% of 105 respondents described incidents of trespass including hounds running on their property without permission, handlers found on property without permission, or running hounds on property after being denied permission. Beyond trespass, 18% of respondents described illegal or nuisance `behavior: damage to property caused by hounds, including downed fencing, damaged landscaping and gardens, injury to self and livestock, dead wildlife left on property, vandalism or litter. Most seriously, 11% reported injury to pets or livestock by hounds, although 24% reported knowledge of hounds attacking others 'pets or livestock. Of the 105, 8% describe direct encounters with hounds resulting in personal injury or being chased.

Moreover, 31% reported threatening altercations with hound handlers, including being unwillingly detained by hound handlers 'trucks on public roads, or their own private driveways.

Of 105 respondents, 51% of respondents reported they “feel intimidated by hound handlers,” and 44% feared retaliation from handlers for reporting confrontations to law enforcement.

Finally, respondents describe being given false information by law enforcement officers, including local sheriffs and game wardens, and also reported filing official complaints upon which no discernible action was taken. Overall, 36% of 105 respondents believed a conflict of interest existed for law enforcement officers, including game wardens, because of relationships between officers and handlers, or because the officers were believed to hunt with hounds themselves. Prior research studies report that hound handlers as a group contain a substantial contingent willing to break the law and flout regulations intended to protect animals and more so than other groups active in wolf range (summarized in SM 1). Actual poaching evidence is consistent with the above survey reports (see Conclusions)

Comparing numbers of hounds from WHI and survey data

Survey respondents reported 2–8 hounds per interaction (average 3.7, mode 2). That average is identical to the average number of hounds that handlers reported in their pack in WHI above. This seems to be corroborating evidence of accuracy in reports of hound pack sizes in both datasets, as neither set of complainants was aware of the other. Given the rarity of single hounds (5%) in WHI, the bystander reports of >1 hound seem unsurprising. Similarly, bystanders reported >6 hounds in 3 events (8% of reports that include these data) but handlers never reported >6 in their pack after a WHI. The legal limit per handler was multiple handlers may release more than 6 hounds. The topic of comparing self-reports by handlers and self-reports by bystanders raises an issue of expertise and deference to it. A common assumption in peer-reviewed commentary on hunting is that hunters have lay knowledge gained through local

experience and expertise in their practices. This often plays out among academics and manager-authors as favoring the views and preferences of local communities and of hunters over others, especially outside experts (von Essen et al., 2015; Redpath et al., 2017; Richardson, 2022). But that assumption is unjustified when two local, lay types of expertise are pitted against each other as in an unknown proportion of our data when hound handlers and the bystanders complaining about them were equally local and both held lay expertise. The second flaw is when the lay bystanders complained to law enforcement experts about hounds or handlers, then the power asymmetry is reversed from the usual academic debate. In short, the local, lay expert complainant deserves the attention and compassion typically reserved for local hunters. Therefore, we call for more just and fair consideration of the under-represented and marginalized in wildlife management.

Conclusion

Hunting mammals with hounds has rarely been investigated. Here we fill the gap partly with self-reported data on the `behavior of hounds and wolves associated with aggressive wolf-hound interactions (WHI). Also, we present self-reported data on the husbandry of handlers and the experiences of bystanders exposed to hound and handler `behavior. We report a shortage of data on wolf casualties. Our inability to find strong support for either the predation hypothesis or the territoriality hypothesis, which focus on wolf motivation for WHI, suggests either a multi-causal phenomenon or we lack hypotheses for the motivation of hounds to initiate WHI. The lack of a seasonal pattern in our data argues against the notion that wolves are the primary aggressors; WHI may be a mutual affair or may be largely initiated by hounds.

415 Treeing Walker coonhound was the breed most commonly involved in WHI. Most WHI
416 were fatal for hounds. Plott hounds were disproportionally represented among fatalities. We
417 could not confirm or reject a protective role of special collars with bells or defensive features.
418 Nevertheless, we recommend the state obligate veterinary clinics that treat hounds for wildlife
419 injuries to report each such incident so the welfare of hounds and preventive actions taken by
420 handlers can be evaluated by professional veterinarians and wildlife scientists. In light of recent
421 findings that studded leather collars protect cattle against leopards (Khorozyan et al., 2020),
422 recommending more precautions by handlers seems prudent. A majority of WHI involved
423 hounds pursuing black bears compared to other prey but none could confirm what animal the
424 hounds were pursuing when WHI began. Outcomes of WHI (injury or death of hounds) were
425 not associated with the number of wolves observed or censused near the site, or the numerical
426 differences between wolves and hounds, hound age, hound sex, the species of prey targeted by
427 hunters, or the month in which WHI occurred. Regarding numerical superiority, perhaps both
428 the large group sizes of hounds (up to 6 per owner) in Wisconsin and uncertainty about the
429 number of wolves involved, has obscured associations with the fatality rates during WHI.
430 We report bystanders perceptions of unlawful actions involving trespass, property
431 damage, attacks, threats, intimidation and harassment of by-standers or their domestic
432 animals, perpetrated by both hounds and handlers. The survey data and WHI self-reports by
433 handlers are self-selected samples, which cannot be verify directly or used to extrapolate rates,
434 frequencies, or representativeness in space, time, or demography. Nevertheless, the data are
435 the first of their kind to our knowledge and deserve consideration. If even a small proportion
436 are accurate, the data support improved husbandry of hounds, more transparent law

enforcement, and wildlife protections against hounds. We found little financial or non-financial incentive for the self-reports other than bystander dissatisfaction with law enforcement response or value-based disapproval of hounding. By contrast, our other self-selected data set (handler complaints of hound losses in WHI) were motivated by a compensation program that paid for injured or dead hounds. That program also seems to need reform given that no information on harm to wolves was collected despite legal protections for wolves. It might be impossible to verify that the handlers or hounds were acting lawfully at the time of the WHI. Furthermore, the size of packs of hounds (up to 6) and the possibility that multiple handlers can run multiple packs in the same area simultaneously creates a clear danger for wolves and other non-target animals.

These results highlight a need for improved regulation, greater oversight and more energetic enforcement of activities involving the use of hounds during hunting. Our results are also consistent with earlier findings of more serious wildlife crimes (SM 1). Wolf-poaching is the major cause of mortality in US wolf populations (Treves et al., 2017a). Much of the poaching involves concealment or destruction of evidence, which reflects intent to break the law, has repeatedly risen in incidence along with policies that permit some legal wolf-killing in several US wolf populations (SM 1). These findings indicate that would-be poachers profit from governmental laxity to act unlawfully or that would-be poachers use the cover of legal hunting to act unlawfully (Chapron and Treves, 2016a; b; Santiago-Ávila et al., 2020; Louchouarn et al., 2021; Santiago-Ávila and Treves, 2022). Most recently, data reveal that cryptic poaching rose during hound training, bear-hunting seasons, and deer-hunting seasons (Santiago-Ávila and Treves, 2022). The 2021 Wisconsin wolf-hunt saw the most rapid season closure and over-kill in

Wisconsin wolf management history with 218 wolves killed in <72 hours with >80% being killed by hunters using hounds (Treves et al., 2021). Unpublished necropsy data collected by the Great Lakes Indian Fish & Wildlife Commission indicate hounds delivered potentially lethal bites during those hunting incidents, which represent unlawful take by hunters (Treves et al., 2021). Taken altogether, these data suggest law enforcement is needed.

In USA wildlife law, the Endangered Species Act (ESA) and federal court cases surrounding it make clear that some hound handlers are vulnerable to prosecution. First, any "take" of wolves (including harassment, pursuit, injury, killing, etc.) is prohibited under the ESA regardless of whether the perpetrator knew the wild animal harmed was listed (Newcomer et al., 2011). The absence of data revealed by this study indicates that hounding is not adequately regulated. Because wolves were often a federal- or state-listed species during our study, the practice of hound-hunting in wolf pack territories should be prohibited when wolves are a listed species unless it can be regulated to reduce WHI near zero. Prohibitions on non-selective killing methods in the range of endangered species and prohibitions on hunting non-listed species of similar appearance such as coyotes (Newsome et al., 2015), might resolve some WHI. Potential legal jeopardy does not stop at the hound handlers. Given the state wildlife agency and law enforcement refused the SCWC request for information or had no such documents (see Introduction), the alleged infractions by handlers may still be within the statute of limitations. Systematic and repeated failure to investigate or prosecute complaints of illegal activity can make a department vulnerable to lawsuits and the imposition of oversight by higher authorities (e.g., federal consent decrees). Legal jeopardy arises for the agency because the doctrine of prosecutorial discretion may not protect a law enforcement agency from charges of systematic

neglect of unlawful activities (Newcomer et al., 2011) and see allegations of such systematic neglect in a case involving wolves (Wild Earth Guardians v USA2015).

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617

618 **Table 1.** The number of hounds reported in wolf-hound interactions by breed and month

Breed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bluetick	0	1	0	0	0	0	3	6	8	0	0	1
Plott	0	0	0	0	0	0	11	20	9	3	0	0
Redbone	0	1	0	0	0	0	4	4	1	0	0	1
Walker	0	0	0	1	0	0	16	19	16	3	1	5
Other	1	2	0	0	0	0	12	15	8	0	0	4
Totals	**1**	**4**	**0**	**1**	**0**	**0**	**46**	**64**	**42**	**6**	**1**	**11**

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621 Table 2. Bystander reports (n=105) of 119 adverse interactions with hounds or their handlers
622 across counties of Wisconsin, USA. Because a respondent might report more than one
623 interaction, we present the counties from most reports 6) to fewest (1), the names of the 51
624 counties mentioned in reports, the sum of interactions per row, and the maximum number of
625 hounds reported in a single interaction. When multiple reports were filed about the same
626 interaction and the number of hounds differed, we counted only one interaction and averaged
627 the number of hounds, rounding to the higher integer.

Reports per county	**Sum of the interactions**	**Maximum number of hounds in a single interaction**	**Counties with interactions reported**
6	15	8	Bayfield, Iron, Sawyer
5	5	5	Forest
4	4	6	Langlade
3	13	6	Chippewa, Dane, Marathon, Polk, Washburn
2	18	6	Dodge, Douglas, Dunn, Florence, Lincoln, Oconto, Price, Shawano

1	62	8	Ashland, Barron, Brown, Burnett, Calumet, Cheboygan MI, Columbia, Cuyahoga OH, Door, Eau Claire, Fond du Lac, Gogebic, MI, Green, Houghton, MI, Jackson, Kenosha, Kewaunee, Macon, GA, Manitowoc, Marin, CA, Marinette, Milwaukee, Nash, NC, Oneida, Ontonagon, MI, Outagamie, Ozaukee, Rock, Rusk, St. Croix, Sheboygan, Taylor, Trempealeau, Vernon, Vilas, Walworth, Washington, Waukesha, Winnebago, Wood

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