Does genetic variation on the shy–bold continuum influence carnivore attacks on people? Evidence from the brown bear

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Abstract Little is known about the heritable behavioural traits of attacks by large carnivores on people. During the last 30 years attacks by brown bears *Ursus arctos* on people in the Cantabrian Mountains of Spain have been disproportionately concentrated in the eastern subpopulation. Excluding factors such as the existence of a single unusually bold bear, a higher human population density, particular human activities promoting encounters, or clear habitat differences in the area of this subpopulation, we propose that a plausible explanation for the unbalanced geographical attack pattern is that this subpopulation, separated a century earlier from the western subpopulation, may harbour a higher proportion of bolder bears. In the absence of genetic analyses this explanation remains speculative, but supports the hypothesis that genetic variation on the shy–bold continuum may influence attacks of large carnivores on people.

Keywords Attacks, brown bear, Cantabrian Mountains, shy–bold continuum, Spain, *Ursus arctos*

Selection from hunting and human persecution can potentially affect heritable behavioural traits (Allendorf & Hard, 2009), including some characters associated with the shy–bold continuum of behaviour (Wilson et al., 1994) that could be related to attacks of large carnivores on people (Penteriani et al., 2016). In North America and Eurasia, many of these attacks are by the brown bear *Ursus arctos* (Penteriani et al., 2016; Bombieri et al., 2019) and, although rare, they can undermine conservation efforts (Herrero, 2002; Penteriani et al., 2016). Studies of attacks by brown bears on people have focused mainly on the characteristics of the bears and the type and behaviour of the people involved (Bombieri et al., 2019), but geographical patterns of bear attacks have rarely been assessed. In their global study of brown bear attacks on people, Bombieri et al. (2019) did not find a significant difference in the number of attacks between continents or between countries with different hunting practices. For the Cantabrian Mountains of Spain, some data on attacks by bears were provided by Naves et al. (2017), but the lack of definition of a bear attack prevents full interpretation of these data.

As a result of human persecution, the brown bear population in the Cantabrian Mountains became separated into western and eastern subpopulations in the early 20th century, and the two subpopulations have been genetically disconnected for most of the time since then (Pérez et al., 2009). Although effective protection from the end of the 20th century has promoted an increase of the population and the migration of males between the two subpopulations (Gonzalez et al., 2016), gene flow was detected for the first time only in 2008 (Pérez et al., 2010). Here, we study the geographical patterns of attacks by brown bears on people in the Cantabrian Mountains and discuss the factors that may explain the concentration of attacks in the eastern subpopulation, where there are fewer bears.

The ranges of the western (5,500 km²) and eastern subpopulations (3,100 km²) are separated by 90 km of disturbed habitat devoid of breeding females (Fig. 1), and the number of bears in the western subpopulation is almost six times greater (Gonzalez et al., 2016). During 2009–2018 a mean of 28.1 and 4.9 females with cubs have been detected annually in the western and the eastern subpopulations, respectively (Fundación Oso Pardo, 2020). The main economic activity in the Cantabrian bear range is cattle farming, although tourism is becoming more prominent; in 2017 human population densities were 11.0 and 7.1 inhabitants/km² in the areas of the western and eastern subpopulations, respectively (National Statistics Institute, 2017).

During 1989–2019 we compiled details of all known attacks by bears on people in the Cantabrian Mountains, i.e. incidents in which a bear made intentional physical contact with a person, resulting in injury to the person (Smith & Herrero, 2018). We compiled information on attack cases from a wide network of wardens, hunters and naturalists in the Cantabrian Mountains with whom we have been in contact since 1989, when we began ongoing annual monitoring of females with cubs (Gonzalez et al., 2016). Cases involving serious injury were widely featured in the media, but those resulting in minor injuries would otherwise have gone undetected. For every attack we spoke with the people directly affected (except in one case, for which we spoke with

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Received 3 April 2020. Revision requested 4 June 2020.
Accepted 5 August 2020.

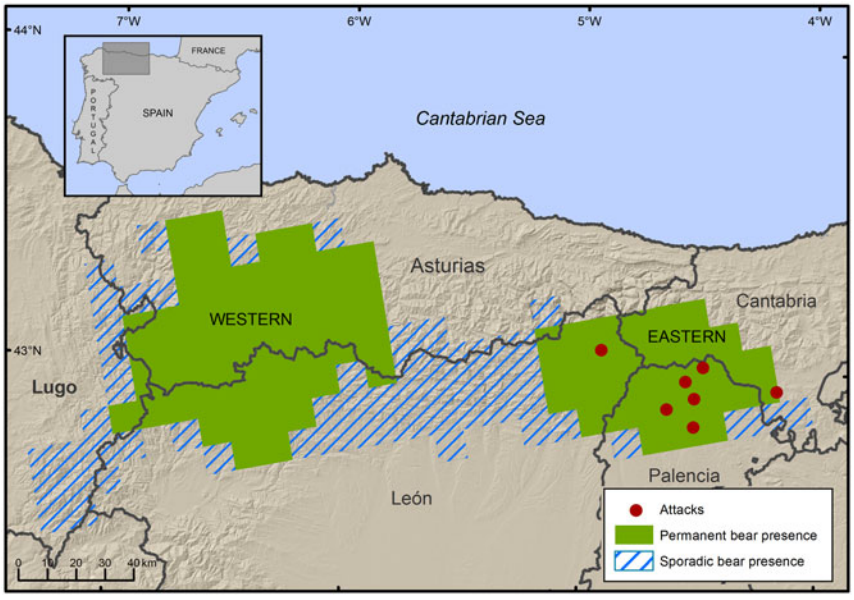

FIG. 1 The ranges of the western and eastern subpopulations of the brown bear *Ursus arctos* in the Cantabrian Mountains, Spain, and the location of recorded attacks of bears on people during 1989–2019.

a friend of the person affected to whom he recounted the attack the day after it occurred), and the following day or within a few days we visited each attack site to measure the bear's footprints and assess the circumstances of the event.

We recorded seven attacks of bears on people, spanning 1999–2018 (Fig. 1, Table 1). In all cases the bears reacted defensively to unexpected encounters, as has been noted in other studies (Smith & Herrero, 2018; Støen et al., 2018; Bombieri et al., 2019). We did not record any lethal attacks. Of the seven people involved in the attacks, four suffered minor or minimal injuries, and three were admitted to hospital (Table 1).

Although we have worked extensively throughout the range of the Cantabrian bear, all the attacks recorded were in the eastern part of the range (Fig. 1), even though the number of bears in this subpopulation is much lower than in the western subpopulation. The observed frequency of attacks in the eastern subpopulation was significantly different from expected (χ^2 with Yates correction = 35.29, df = 1, $P < 0.0001$).

At least four of the seven attacks were by different individual bears, thus ruling out the involvement of a single unusually aggressive individual. In one attack a female with two 15 month-old cubs was involved (case 4, Table 1) and the other attacks were by solitary bears. In case 5, the person who suffered the attack rated the bear as a medium-sized specimen, and in at least four cases (1, 3, 6 and 7) the bears were large adult males (in three cases forepaw width was > 120 mm, authors' unpubl. data; in the other case we observed the bear during our follow-up field inspection). Although male bears can move extensively, the time lapse between the oldest (1999, case 1) and most recent (2015 and 2018, cases 6 and 7) attacks by large males suggests they were caused by different individuals (Table 1).

The people attacked were a representative sample of the normal users of bear range (wardens, hikers, and local people collecting non-timber forest products; Table 1), all of them moving cross-country. The same range of users devoted to similar activities pass through the area of the western subpopulation, where we recorded no attacks during 1989–2019.

Differences in accessibility and habitats could play a role in bear attacks. Lamamy et al. (2019) compared the landscape characteristics of the two subpopulations. The eastern range has fewer rocky and rugged areas, which could potentially facilitate human–bear encounters, but this area has a lower human density, with shorter road and trail lengths, generally at higher altitudes and in more forested areas, which could potentially have the opposite effect. However, the differences between the western and eastern landscapes are subtle, and we believe it unlikely these differences alone could give rise to the disparity in the number of attacks between the two areas.

Excluding the presence of one particularly aggressive bear in the eastern subpopulation, differences in people's activities between the two areas, or a higher human population density and a closer proximity of bears to people in the eastern subpopulation, a plausible explanation for the unbalanced geographical attack pattern may be that the bears of the eastern subpopulation are bolder than those to the west. Benazzo et al. (2017), noting the docile temperament of the Apennine bears (no attacks on people were recorded during the last 100 years), examined any divergence between Apennine and non-Apennine bears at 22 genes associated with tame or aggressive behaviour. They found a significant enrichment of fixed differences in these genes, suggesting that genetic drift or hunting of the more aggressive or bold individuals may have led to a genetically mediated

Table 1 Details of the seven attacks by brown bears *Ursus arctos* on people (all men) recorded in the Cantabrian Mountains, Spain (Fig. 1), during 1989–2019.

Case (date)	Village, Province	Person attacked, age (years)	Available details of bear	Circumstances	Injuries
1 (30 Dec. 1999)	Casavegas, Palencia	Hiker, 35	Adult male[1]	Followed bear tracks in snow until he reached the resting bear, who attacked him & fled.	Severe bite to thigh that affected femoral artery & vein. Required surgery; healing took several weeks.
2 (15 May 2004)	Lebanza, Palencia	Local, 75	Not known	Whilst picking mushrooms, bear suddenly ran over him & fled.	Minor injuries to knee & wrist when falling to ground; discharged from hospital after 1 week.
3 (26 Apr. 2007)	Casasuertes, León	Ranger, 50	Adult male[1]	Walked into cave to replenish feeder for wild ungulates; bear was feeding in cave, ran over man & fled. Pet dog present.	No injuries caused by bear. Light scratches to face from falling into bushes.
4 (14 Apr. 2010)	Rebanal de las Llantas, Palencia	Ranger, 56	Female with 2 cubs	Attacked whilst walking in dense bush; bear pinned him down, bit his calf muscle & fled when man stopped resisting.	No wounds; bite in calf muscle was so soft that it did not cause any bleeding.
5 (27 Sep. 2012)	Dehesa de Montejo, Palencia	Hiker, 48	Medium-sized bear	Three hikers walking off road met bear, which was probably near a carcass (vultures present nearby). Bear suddenly charged the first in line, gently bit his foot & fled.	Minor wounds: two stitches in foot.
6 (3 June 2015)	Villaescusa del Bardal, Cantabria	Photographer, 35	Adult male[1]	Attacked when checking bush cameras baited for bears. Bear bit his arm & fled.	Radial displacement & fracture of ulna, tears in arm. Surgery, healing took weeks.
7 (6 Mar. 2018)	Polentinos, Palencia	Local, 77	Adult male[2]	Collecting deer antlers in dense bush when his dog harassed resting bear, which pushed man away with slap on chest & fled.	Minor injuries: fissured rib & a bruise on the thigh.

[1]Deduced from paw print size.
[2]Observed during the field inspection.

shift in Apennine bear behaviour. As the Cantabrian bear population was separated into the western and eastern subpopulations during the early 20th century, a similar process may have led to genetically mediated differences in bear behaviour in the two subpopulations. The inbreeding that has characterized the small Cantabrian subpopulation until recently may have fixed some characters that were selected by chance, possibly because the boldest or most aggressive individuals were eliminated from the western subpopulation but some of them survived in the east, later disseminating this trait. Selection as a result of hunting and human persecution can potentially affect heritable behavioural traits in brown bears (Leclerc et al., 2019) and other large mammals (Lone et al., 2015). In the absence of genetic analyses comparing the two Cantabrian bear subpopulations this explanation remains speculative, but supports the hypothesis previously discussed by Penteriani et al. (2016) that genetic variations along the shy–bold continuum may influence attacks of large carnivores on people and thus the chances of the recovery of threatened populations.

Acknowledgements We thank Juan Traba, John Muddeman and two anonymous reviewers for their helpful comments.

Author contributions Study conception: all authors; project management: GP; data collection: GP, assisted by co-authors; writing: JCB, assisted by co-authors.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

References

Allendorf, F.W. & Hard, J.J. (2009) Human-induced evolution caused by unnatural selection through harvest of wild animals. *Proceedings of the National Academy of Sciences of the United States of America*, 106, 9987–9994.

Benazzo, A., Trucchi, E., Cahill, J.A., Delser, P.M., Mona, S., Fumagalli, M. et al. (2017) Survival and divergence in a small group: the extraordinary genomic history of the Endangered Apennine brown bear stragglers. *Proceedings of the National Academy of Sciences of the United States of America*, 114, E9589–E9597.

Bombieri, G., Naves, J., Penteriani, V., Selva, N., Fernández-Gil, A., López-Bao, J.V. et al. (2019) Brown bear attacks on humans: a worldwide perspective. *Scientific Reports*, 9, 8573.

Fundación Oso Pardo (2020) *The Number of Bears and Where They Live*. fundacionosopardo.org/wp-content/uploads/2020/05/ficha1_en.pdf [accessed 21 December 2020].

Gonzalez, E.G., Blanco, J.C., Ballesteros, F., Alcaraz, L., Palomero, G. & Doadrio, I. (2016) Genetic and demographic recovery of an isolated population of brown bear *Ursus arctos* L., 1758. *Peer J*, 4, e1928.

Herrero, S. (2002) *Bear Attacks: Their Causes and Avoidance*. Revised edition. Lyons & Burford, New York, USA.

Lamamy, C., Bombieri, G., Zarzo-Arias, A., González-Bernardo, E. & Penteriani, V. (2019) Can landscape characteristics help explain the different trends of Cantabrian brown bear subpopulations? *Mammal Research*, 64, 559–567.

Leclerc, M., Zedrosser, A., Swenson, J.E. & Pelletier, F. (2019) Hunters select for behavioral traits in a large carnivore. *Scientific Reports*, 9, 12371.

Lone, K., Loe, L.E., Meisingset, E.L., Stamnes, I. & Mysterud, A. (2015) An adaptive behavioural response to hunting: surviving male red deer shift habitat at the onset of the hunting season. *Animal Behaviour*, 102, 127–138.

National Statistics Institute (2017) *Municipal Population Census*. www.ine.es/dynt3/inebase/index.htm?padre=525 [accessed 25 March 2020].

Naves, J., Fernández, A., Revilla, E. & Penteriani, V. (2017) Ataques de osos pardos a personas en la Cordillera Cantábrica en los últimos cuarenta años (1975–2015). In *Abstracts SECEM Congress*, p. 102. 4–7 December 2015, Burgos, Spain,

Penteriani, V., Delgado, M.M., Pinchera, F., Naves, J., Fernández-Gil, A., Kojola, I. et al. (2016) Human behaviour can trigger large carnivore attacks in developed countries. *Scientific Reports*, 6, 20552.

Pérez, T., Naves, J., Vázquez, J.F., Seijas, J., Corao, A., Albornoz, J. et al. (2010) Evidence for improved connectivity between Cantabrian brown bear subpopulations. *Ursus*, 21, 104–108.

Pérez, T., Vázquez, F., Naves. J., Fernández, A., Corao, A., Albornoz, J. et al. (2009) Non invasive genetic study of the Endangered Cantabrian brown bear (*Ursus arctos*). *Conservation Genetics*, 10, 291–301.

Smith, T.S. & Herrero, S. (2018) Human–bear conflict in Alaska: 1880–2015. *Wildlife Society Bulletin*, 42, 254–263.

Støen, O.-G., Ordiz, A., Sahlén, V., Arnemo, J.M., Sæbø, S., Mattsing, G. et al. (2018) Brown bear (*Ursus arctos*) attacks resulting in human casualties in Scandinavia 1977–2016; management implications and recommendations. *PLOS ONE*, 13, e0196876.

Wilson, D.S., Clark, A.B., Coleman, K. & Dearstyne, T. (1994) Shyness and boldness in humans and other animals. *Trends in Ecology & Evolution*, 9, 442–446.