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Acanthinodera cumingii (Coleoptera: Cerambycidae) in the diet of carnivores of the Nahuelbuta Mountain Area, south-central Chile

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Abstract
Acanthinodera cumingii, is the largest long horned beetle of Chile that shows morphological and behavioural differences between sexes. In this species female are diurnal, flightless and larger than males. These features make the females to be consumed by four carnivores in south central Chile. The results show a low frequency of consumption and only appear in 15% of feaces analyzed, and no structure of the head and the prothorax were found, suggesting that predators have difficulty to consume this species and before eating these structures need to be removed by the predators

Keywords: Mechanical defense, predatory behaviour, pronothum hook, Jaws, Feaces

1. Introduction
The "mother of the snake" (madre de la culebra: *Acanthinodera cumingii* Hope 1833), is an endemic longhorned beetle of central Chile, distributed from the southern part of the region of Coquimbo (31°30´S) to the north of the Araucanía Region (38°S) [1, 2, 3]. Adults of this species are active from October to end of January [4], and it is more common to the south of its distribution [5]. Morphology and behaviour differs between females and males; while the former are larger, mainly diurnal and flightless, males are nocturnal and flying [2]. These features make the females of *A. cumingii* a potential prey easier to be consumed by predators. However females are infrequently preyed by native predators. For instance, on the coast of the Maule Region, the frequency of *A. cumingii* in the diet of kodkod (*Leopardus guigna*), culpeo fox (*Lycalopex culpeus*) and gray fox (*Lycalopex griseus*) was scarce, representing < 30% of the feaces analyzed [6]. Similarly, in Andean and coastal areas in the Araucania Region, no consumption of this species was recorded by gray foxes [7, 8]. Low consumption or even the absence of *A. cumingii* in predators' diets may be a consequence of seasonal shifts in the availability of this species [9] or other factors such as physical defense of *A. cumingii*, which may reduce its predation rate by natural predators. Nevertheless, these hypotheses have not been previously considered. Consequently, the reports of consumption of Coleoptera by carnivores in Central Chile are still scarce [6, 9]. In this study, we describe the presence of *A. cumingii* in the diets of four carnivorous occurring in the Nahuelbuta Mountain Area (NMA), and discuss the implications of these findings in the context of the physical defense of this species against its natural predators.

2. Materials and methods
We collected a total of 70 feaces of kodkod, culpeo fox, Darwin's fox and gray fox species during Austral summers of 2012 to 2014 covering an area of 10,000 ha in NMA (37°46´S; 72°59´W). Because the difficulties in identifying scats at species level by morphology and size in an area where four canid species (including domestic dog) and a small felid are sympatric, we distinguished scats through DNA analysis. DNA was isolated from each scat with a QIAGENS tool Kit (QIAGEN, CA, USA), amplifying a fragment of the mitochondrial cytochrome *b* gene, and comparing the resulting sequences to those of reference samples. Analyses were done at the Primate Immunogenetics and Molecular Ecology (PRIME) Laboratory, University of Cambridge, UK. Posterior to DNA identification, feaces were measured, weighed and crumbled manually in order to separate material of *A. cumingii*.

3. Results and Discussion

The consumption of *A. cumingii* by carnivores in Nahuelbuta National Park was low, being present only in 15.71% of feaces analyzed (11/70). All specimens consumed were females, which is consistent with that observed in other studies [6]. In general, the presence of parts of *A. cumingii* for each carnivore species analyzed was low; gray fox (14.28%), culpeo fox (11.53%), Darwin's fox (28.57%) and kodkokd (10%) (Fig.1). The studied carnivores showed differences in the total number of individuals consumed, being the Darwin's fox the top consumer of *A. cumingii* (n= 9), followed by culpeo fox and gray fox (3 ind. each), and kodkod (1 ind.) (See supplementary appendix). The same pattern across predator species was found for the individual of *A. cummingi*/feaces ratio (Fig. 1).

Among the structures of *A. cumingii* found in the feaces (see supplementary appendix for more details), neither structure of the head nor the prothorax were observed (Fig. 2a). These hard structures might easily resist the passage through the digestive tract of predators. These results suggest that *A. cumingii* is not an easy prey to consume, because its strong jaws capable of cutting wood and a thorn in sickle shape on both edges of the pronotum (see Fig 2b). Thus, these structures might represent physical defense against predators, whose shape makes it hard to swallow (i.e tracheal-esophageal obstruction by the engagement of the structure). It is presumed that the consumption of *A. cumingii* would then be associated with an acquired skill of the predators, that would discard the dangerous structures before consuming the remainder of the individual. The risk of preying on females of *A. cumingii* by predators can be compensated by the high nutritional value of this insect, especially when females are gravid (carrying 200 eggs of about 7 mm. length [4]) and by their large body size [1].

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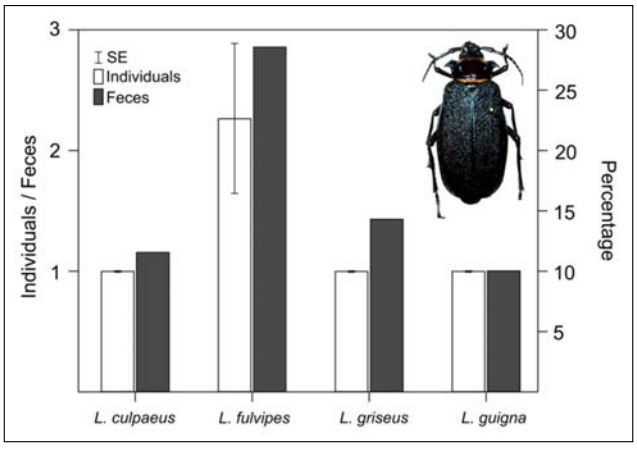

Fig 1: Presence of *Acanthinodera cumingii* in feces of carnivores present in the Nahuelbuta National Park. White bars: ratio of individuals by feaces with *A. cumingii*. Gray bars: percentage of feaces with *A. cumingii*.

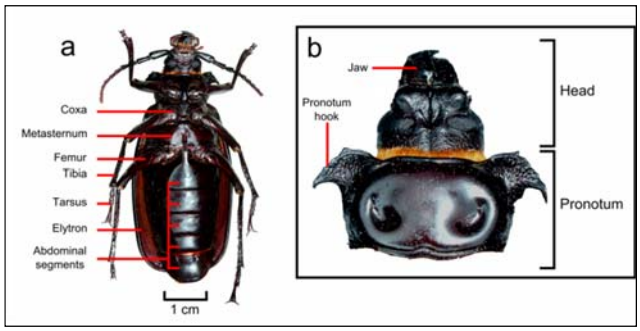

Fig 2: Detail of *Acanthinodera cumingii* pieces. a) pieces of *A. cumingii* most common found in the feaces of carnivores in this study, together with the amount found, b) pieces of *A. cumingii* not found.

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Supplementary appendix

S1. Data from feaces used in this study. N= specimens number of *Acanthinodera cumingii* consumed by individual carnivore, date = date of fecal collection, carnivore= carnivore species assigned through the faaces, Alt = altitude above sea level at which the faaces samples was collected, W = weight in grams of the feaces samples and pieces = *A. cumingii* pieces found in each of the feaces, along with the amount found.

N	Date	Carnivore	Altitude (m a.s.l.)	P	Pieces
1	21.1.12	*L. griseus*	735	10	Female genitalia (1), femur (1)
1	22.1.12	*L. griseus*	735	3,2	Abdominal sternites (2)
1	22.1.12	*L. griseus*	735	3	Female genitalia (1), pieces with abdominal segments (4), Metanotum with wing (1), trochanter (1).
1	22.1.12	*L. culpaeus*	735	3,5	Abdominal ventrites (one with visible female genitalia) (2)
1	22.1.12	*L. guigna*	735	3	Abdominal ventrites (3)
1	-	*L. culpaeus*	988	3	Pieces with abdominal segments (4), femur-tibia (1)
1	16.1.14	*L. culpaeus*	784	12,4	Last abdominal ventrite (1), esternite (1), piece of elytra and tibia(1)
3	16.1.14	*L. fulvipes*	805	5	pieces with abdominal segments (11), female genitalia with the last ventrite (3), femora (3), trochanter (1), metasternum (1)
4	16.1.14	*L. fulvipes*	795	9	Pieces with abdominal segments (10), female genitalia with the last ventrite (4), trochanter (1), coxa-femur (1), femora (2)
1	17.1.14	*L. fulvipes*	947	2	Metaepisternum (1), abdominal ventrite (1), femur (1)
1	17.1.14	*L. fulvipes*	959	4	abdominal ventrite (1), Trochanter (1)