Cannibalistic Behavior of *Octopus vulgaris* in the Wild

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The first description of cannibalism in wild adults *Octopus vulgaris* is presented from three observations made off the Ría de Vigo (NW Spain), which were filmed by scuba divers. Two of these records occurred within the National Park of the Atlantic Islands of Galicia (NW Atlantic) in December 2012 and November 2013, and another at the southern part off the Ría de Vigo. These records, recorded with a Sony DV-Cam camcorder, allowed to obtain common traits in cannibalistic behavior: i) it was an intercohort cannibalism; ii) attacks were made by both males and females; iii) in two of the records, the preys were transported to the den, which was covered with stones of different sizes; iv) the predator started to eat the tip of the arms of its prey; v) predation on conspecifics occurred even if there were other abundant and available preys (i.e. mussels); vi) facing an intruder (i.e. diver) the predator defense of its prey while eating a conspecific was not a fix pattern; and vii) vii) the predator/prey weight relationship in the three cases ranged from 20 to 25 % body weight. The relationships between this behavior and sex, defense of territory, energy balance, food shortage, competition and predation, as well as how the attacker kills its victim are discussed.

Keywords: Cannibalism, behavior, *Octopus vulgaris*, cephalopods.

Supplementary materials: three AVI files.

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Cannibalism appears to be extensive in cephalopods (Hanlon & Messenger, 1996; Ibáñez & Keyl, 2010). Cannibalism occurs in several octopus species, including *Octopus vulgaris* Cuvier, 1797 (Hartwick et al. 1978; Nixon, 1987; Villanueva, 1993; Cortez et al., 1995). This behavior was observed in this species from analyses of *O. vulgaris* stomach contents (Guerra, 1978; Smale & Buchan, 1981; Smith, 2003)), and laboratory observations (Mangold, 1983; Hanlon & Messenger, 1996). Generally, large, old individuals attack and regularly eat smaller conspecifics. Nevertheless their contribution to diet seems to be rather low (Mangold, 1983; Smith, 2003).

Surprisingly, although it is a commonplace that *O. vulgaris* has a cannibalistic behavior in the field, as far as we know factual information on this behavior in the wild has not been presented so far. The aim of this paper is to report cannibalism in wild adults of *O. vulgaris* off the Ría de Vigo (Spain, north-eastern Atlantic).

Material and methods

Cannibalism in *O. vulgaris* was observed three times in the Ría de Vigo by scuba diving. The first record was made on a rocky bottom in the Cíes Islands, which belong to the National Park of the Atlantic Islands of Galicia (NAPAIG). It was carried out on December 11, 2012 (42°12.842N, 8°54.003W) at 12 meters depth and 13°C bottom temperature (BT). The second record was located next to the Estelas islands on July 13, 2003 (42°8.933N, 8°51.916W) on a sandy bottom at 18 meters depth and 15°C BT. The third one occurred also within NAPAIG on November 26, 2013 (42°11.335N, 8°53.685W) on a rocky bottom in the Cíes Islands at 14 meters depth and 12°C BT. The three records were made using a Sony DV-Cam camcorder.

These casual cannibalism records were obtained during a two years sampling program designed to determine the distribution and abundance of common octopus within NAPAIG. The size of the attackers and victims was estimated from the video recordings comparing them with

some elements of known dimensions (e.g. mussel and other bivalve shells). The sex of the predators was elucidated by external sexual dimorphism. Male *O. vulgaris* has selective enlarged suckers on their second and third arms.

Results

First record (Fig. 1a)

A male of about 2000 grams (g) of total body weight (BW), hidden in a rock cavity with the entrance blocked with stones of various sizes was located at 12 meters depth. After removing the stones, the diver observed that the male was holding an unsexed octopus of approximately 400 g BW. The animal was dead showing a pale white color and the tips of its arms eaten. The first response to the diver was a defensive posture in which the male pulls all eight arms tightly up over the head and mantle, exposing only the suckers. The prey was firmly held by the male, in spite of such defensive display. After a quiet moment and due to the insistence of the diver, the octopus broke the defensive posture and adopted a flamboyant display. Then it dropped the prey and fled to nearby rocks where it camouflaged.

Second record (Fig. 1b)

This record allowed filming a male of about 2200 g BW camouflaged in gravel–rocky bottom at 18 meters depth. The area around the octopus lair was covered with a high abundance of mussels (*Mytilus galloprovincialis*). A triangle of three bright white spots was observed in the animal: one small spot between the eyes, and two large and oval spots on the dorsal side of the first pair of arms (noted by white circle). In the presence of the diver, the animal began to move slowly carrying an octopus of about 540 g BW (sex unknown) inside the sack formed by the arms and the web. The diver realized that the prey was still alive because it poked and moved one of its arms between the dorsal pair of arms of the predator (noted in the Figure 3 by white

arrow). When the diver disturbed the male, it opened the arms and allowed the smaller octopus to escape.

Third record (Fig. 1c)

Corresponded to a female of about 1800 g BW, hidden in a rock cavity with the entrance blocked with stones of various sizes at 14 meters depth. The female was holding an unsexed octopus of about 350 g BW, sex unknown. The animal was already dead, with a pale white color and the tips of the arms eaten. After removing the stones from the entrance, the female released the prey and escaped. Then it fled to a nearby rock where it performed camouflage behavior. During this displacement, the animal showed three arms cut and forming stumps. Interestingly, another octopus of the same size as the female was found in the same crevice of the rock, hardly separated by 50 cm.

Figure 1. A) Male of *Octopus vulgaris* leaving a partially eaten octopus (upper right) after the insistence of the diver. B) Male of *Octopus vulgaris* wrapping an octopus (white arrow) inside the sack formed by the arms and the web. The male shows a triangle of three bright white spots (upper white box). C) Female of *Octopus vulgaris* hidden in a cavity but still holding a dead, partially eaten.

Common traits in *Octopus vulgaris* cannibalism

It was an intercohort type of cannibalism. Independent of sex: both males and females were predators. Once captured and dead, the prey was transported to the den which in turn was plugged with stones of different sizes. The predator begins to eat its victim by the tips of the arms. Predation on conspecifics occurred even if there were abundant and available prey (mussels) around. Facing an intruder (i.e. diver) the predator defense of its prey was not a fix

pattern while eating a conspecific. The predator/prey weight relationship in the three cases ranged from 20 to 25 % BW.

Discussion

The cannibalistic behavior evidences presented herein are reported and filmed for the first time in wild specimens of *O. vulgaris*. Studies of stomach contents indicated the existence of cannibalism in wild *O. vulgaris* in the Western Mediterranean Sea and the South Atlantic (Guerra, 1978; Smale and Buchan, 1981; Smith, 2003). The records presented in this paper confirm that cannibalism also occurs in the North-western Atlantic, which suggests that this strategy is widespread throughout the distribution range of *O. vulgaris*.

Little evidences of cannibalism were found in the *O. vulgaris* on-growing cages suspended in the Ría de Vigo, where segregation of sexes and excess of dens contributed to low cannibalism (Chapela et al., 2006). Such rare behavior only occurred in suspended cages when the cage was not simultaneously loaded with octopuses. Under such circumstance, old-large residents attacked and eaten smaller-new introduced specimens, even if food supply was enough. The predator grabbed the prey with seven arms inserting the remainder one in the funnel to suffocate the prey.

Our observations should be considered an intercohort cannibalism (*sense* Wootton, 1990) because it occurred between conspecific of very different size (and supposedly age): large, older animals prey upon individuals 4-5 times smaller. Smith (2003) observed that cannibalism occurred in large octopuses (>1,000 g), in agreement with other reports for *O. vulgaris* along the South African east coast (Smale and Buchan 1981). The fact that small specimens may be preyed by larger conspecifics in their natural habitats has been widely reported in many cephalopod species (see Hanlon & Messenger, 1996 for a review). This behavior had mainly been related to reproduction: small males may be vulnerable to cannibalism by larger females. Hanlon & Wolternding (1989) suggested that it might be advantageous for smaller partner to mate in the

open, despite the risk of predation, because of cannibalistic tendencies in octopuses. This behavior could be advantageous for octopuses to recognize the sex and reproductive status of other individuals before approaching closely (Boal, 2006). Sexual cannibalism has been documented in wild *O. cyanea* (Hanlon & Forsythe, 2008). Nevertheless, the observations in the present paper suggest that this behavior is more related to size rather than sex.

Defense of territory may be another cause for cannibalistic behavior in cephalopods (Ibáñez & Keyl, 2010). Octopuses are generally solitary, although high densities of some species have been reported in some species as in *O. joubini*, *O. briareus* and *O. bimaculoides* (Mather, 1982; Aronson, 1989; Forsythe & Hanlon, 1988). The existence of territorialism in octopuses is, however, controversial. Field studies of *O. vulgaris* in the Mediterranean and in Bermuda have indicated no signs of territoriality or dominance relationships (Altman, 1967; Kayes, 1974; Mather & O'Dor, 1991), and field studies of *O. joubini* (Butterworth, 1982; Mather, 1982) and *O. bimaculatus* (Ambrose, 1988) have also failed to demonstrate such evidence. Larger areas around dens are not defended (Boal, 2006). Nevertheless, octopuses forage from temporary home dens that they defend from other octopuses demonstrating spatial learning and territoriality, respectively (Boal, 2006). Our three records from their natural habitats, and well as those observed in on-growing cages, does not allow us to completely reject that cannibalistic behavior in *O. vulgaris* has some influence of territorial defense.

Some authors (e.g. Amaratunga, 1980) suggested that cannibalistic behavior might be provoked by the lack of available preys. Thus, the short finned squid *Illex illecebrosus* in captivity becomes cannibalistic after only three days of starvation (O'Dor, 1998). However, our results, and those from on-growing cages, showed that food shortages could be an important factor triggering cannibalism, but not the only one. The result of the second record indicated that there was a selection of prey: the predator chose to eat a conspecific instead of bivalves, which are usually common prey in their diet (Nixon, 1986). This choice for conspecifics instead of

mussels has also been observed in subtidal areas of the Ría de Vigo with high mussel abundance during early summer (R. Gómez & J.L. González per. comm.). This selection may be related to the energy balance: an octopus produces higher protein revenue per gram of meat than a bivalve, and also less energy is spent chopping an octopus than in opening several bivalves until reach the weight of meat provides by one octopus of the size found in the present observations. Access to food of high quality is one of the advantages for cannibalistic individuals (Calow, 1998). One of the direct positive effects of cannibalism may arise from the energy extracted from consuming conspecifics. Through its effects on fecundity and survival, cannibalism energy gain influence dynamic population (Claessen et al., 2003). Although *O. vulgaris* cannibalistic behaviour could have several causes, we tend to think that the most decisive is that the balance between the energy expended in getting a prey and the energy provided for it is as positive as possible.

Carrying the victim into its lair and cover the entrance should be considered also as an advantage: the attacker is not being exposed to predators and / or competitors. Observations on the behavior of *O. vulgaris* on an unexploited rocky reef habitat in Baía dos Tigres (Angola) showed that the activity patterns differed between sizes of octopus. Small octopus (<20 cm total length [TL]) were observed roaming during the night, whereas the large individuals (>20 cm TL) generally fed in their dens. This ontogenetic behavioral shift may be due to tidal constraints or could be a strategy to avoid cannibalism. This unique behavioral strategy is thought to be a means to reduce predation and reduce light intensity during the day (Beera & Potts, 2013).

It is well known that *O. vulgaris* paralyzes different species of crabs injecting cephalotoxin prior to ingestion (Ghiretti, 1960), and also that this species have different techniques to eat bivalves (Nixon, 1986 for a review; Guerra & Nixon, 1987; Fiorito & Gherardi, 1999). However, there is not information on how an octopus kills a conspecific. The results of our observations suggest that one of the ways to kill its victim is suffocating as occurred in *O. vulgaris* on-

growing cages and in *O. cyanea* (Hanlon & Forsythe, 2008). However, it cannot be excluded that the cessation of the victim happens for a cephalotoxin injection.

References

- Altman, J.S. 1967. The behaviour of *Octopus vulgaris* in its natural habitat: a pilot study. *Underwater Association Report of Malta (1966-67)*: 77–83.
- Amaratunga, T. 1980. Preliminary estimates of predation by the short-finned squid (*Illex illecebrosus*) on the Scotian Shelf. *Northwest Atlantic Fisheries Organization, Science Council Research Document* No. 80/II/31: 13 pp.
- Ambrose, R.F. 1988. Population dynamics of *Octopus bimaculatus*: influence of the history patterns synchronous reproduction and recruitment. *Malacologia*, 29:23-39.
- Aronson, R.B. 1989. The ecology of *Octopus briareus* (Robson) in a Bahamian saltwater lake. *American Malacological Bulletin*, 7:47-56.
- Boal, J.G. 2006. Social recognition: a top down view of cephalopod behaviour. *Vie et Milieu*, 56:69–79.
- Beera C.L. de & Potts, W.M. 2013. Behavioural observations of the common octopus *Octopus vulgaris* in Baía dos Tigres, southern Angola. *African Journal of Marine Science*, 35: 579-583.
- Butterworth, M. 1982. Shell utilization by *Octopus joubini*. Master Thesis. Florida State University, USA.
- Calow, P. 1998. *The encyclopedia of ecology and environmental management*. Blackwell, London.
- Chapela, A., González, A.F., Dawe, E.G., Rocha, F. & Guerra, A. 2006. Growth of common octopus (*Octopus vulgaris*) in cages suspended from rafts. *Scientia Marina*, 70: 121-127.
- Claessen, D., Roos, A.M. de & Persson, L. 2004. Population dynamic theory of size-dependent cannibalism. *Proceedings of the Royal Society of London B*, 271: 333-340.
- Cortez, T., Castro, B.G. & Guerra, A. 1995. Feeding dynamics of *Octopus mimus* (Mollusca: Cephalopoda) in northern Chile waters. *Marine Biology*, 123:497–503.
- Derusha, R.H., Forsythe, J.W. & Hanlon, R.T. 1987. Laboratory growth, reproduction and life span of the Pacific pygmy octopus, *Octopus digueti*. *Pacific Science*, 41: 104–121.
- Fiorito, G., & Gherardi, F. 1999. Prey-handling behaviour of *Octopus vulgaris* (Mollusca, Cephalopoda) on bivalve preys. *Behavioural Processes*, 46, 75-88.

228 Forsythe, J.W., & Hanlon, R.T. 1988. Effect of temperature on laboratory growth, reproduction
229 and life span of *Octopus bimaculoides*. *Marine Biology*, 98: 369-379.

230 Ghiretti, F. 1960. Toxicity of octopus saliva against crustaceans. *Annals of the New York*
231 *Academy of Sciences*, 90:726-741.

232 Guerra, A. 1978. Sobre la alimentación y el comportamiento alimentario de *Octopus vulgaris*.
233 *Investigación Pesquera*, 42:351-364.

234 Guerra, A. & Nixon, M. 1987. Crab and molluscs shell drilling by *Octopus vulgaris* (Mollusca,
235 Cephalopoda) in the Ría de Vigo (north-west Spain). *Journal of Zoology*, London, 211: 515-
236 523.

237 Hanlon, R.T., & Wolterding, M.R. 1989. Behavior, body patterning, growth and life history of
238 *Octopus briareus* cultured in the laboratory. *American Malacological Bulletin*, 7: 21-45.

239 Hanlon, R.T & Messenger, J.B. 1996. *Cephalopod Behaviour*. Cambridge University Press,
240 Cambridge. U.K.

241 Hanlon, R.T. & Forsythe, J. W. 2008. Sexual cannibalism by *Octopus cyanea* on a Pacific coral
242 reef. *Marine and Freshwater Behaviour and Physiology*, 41:19-28.

243 Hartwick, E.B., Breen, P.A., & Tulloch, L. 1978. A removal experiment with *Octopus dofleini*
244 (Wülker). *Journal of the Fisheries Research Board Canada*, 35: 1492-1495.

245 Ibáñez, Ch., M & Keyl, F. 2010. Cannibalism in cephalopods. *Reviews in Fish Biology and*
246 *Fisheries*, 20:123-136.

247 Kayes, R.J. 1974. The daily activity pattern of *Octopus vulgaris* in a natural habitat. *Marine*
248 *Behaviour & Physiology*, 2, 337-343.

249 Mangold, K. 1983. *Octopus vulgaris*. In: *Cephalopod life cycles. Vol. I. Species accounts*. (P.R.
250 Boyle, ed), pp. 335-367. Academic Press, London.

251 Mather, J.A. 1982. Factors affecting the spatial distribution of natural populations of *Octopus*
252 *joubini* Robson. *Animal Behaviour*, 30:1166-1170

253 Mather, J. A. & O'dor, R. K. 1991. Foraging strategies and predation risk shape the natural
254 history of juvenile *Octopus vulgaris*. *Bulletin of Marine Science*, 49, 256-269.

255 Nixon, M. 1987. The diets of cephalopods. In: *Cephalopod life cycles. Vol. II. Comparative*
256 *reviews*. (P.R. Boyle, ed), pp 201-219. Academic Pres, London.

257 O'Dor, R.K.1998. Squid life-history strategies. *FAO Fisheries Technical Paper*, 376: 233-254

258 Smale, M.J., & Buchan, P.R. 1981. Biology of *Octopus vulgaris* off the east coast of South
259 Africa. *Marine Biology*, 65: 1-12.

- 260 Smith, C.D. 2003. Diet of *Octopus vulgaris* in False Bay, South Africa. *Marine Biology*, 143:
261 1127-1133.
- 262 Villanueva, R. 1993. Diet and mandibular growth of *Octopus magnificus* (Cephalopoda). *South*
263 *African Journal of Marine Science*, 13: 121-126.
- 264 Wootton R J. 1990. *Ecology of teleost fishes*. Chapman and Hall, London.