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Development of an ethogram for Predatory behaviour in dogs

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Index

Abstract

Predatory Behaviour in domestic dog (Canis Familiaris) has been considered to stem from the Wolf (Canis Lupus) hunting sequence for a long time. Thus, any behavioural analysis of the hunting patterns performed on dogs has been studied in face of what was observed in its wild counterpart. Opposite to what was previously assumed according to their taxonomic classification and relatedness, further ecological and ethological studies performed on both the species had highlighted the differences in social structure between the two: pack composition and hierarchies, predisposition to tameness and therefore proximity to humans, which inevitably result in different hunting and foraging strategies. Furthermore, the ecological importance of the domestic dog must be considered, since following human migrations Canis Familiaris has become one of the most widespread animal species all over the world. Therefore, each interaction with a wide array of elements in the biosphere performed by the numerous dog populations all over each continent might produce significant additive effects in respect to the composition of the ecosystem in which they are present. To provide a more detailed and tailored description of this behaviour, observations featuring instances of predation in dogs have been collected from videoclips present in YouTube, Vimeo and other public sources. Such observations were then used to perform a behavioural analysis to identify the different phases that constitute the predatory behaviour sequence and to determine the criteria for their identification, to produce a functional ethogram. Such ethogram is not present in scientific literature about domestic dogs, therefore its validation would provide a valuable standardized instrument that would allow to reach a better understanding of the behaviour of this species and may have a consistent transitional value towards other canine species, given the high availability of dogs and the ease of working with them.

Introduction

Ethograms are defined as catalogues of standardized definitions aiming to describe the array of natural behaviours showed by a certain animal species, to provide an objective criterion to assess when such behaviours are manifested and showing relationships between units and the contexts in which they occur (Greenberg, 2017). These catalogues of definitions allow the collection of both qualitative data, as they identify and distinguish the different patterns that may be presented by the observed animals, and quantitative data about the frequency at which those behaviours are presented, leading to the ultimate goal of obtaining statistically relevant results. The reliability and the completeness of an ethogram is proportional to the variety of contexts described, the number of different individuals observed and the timing in which the observations are performed, on a daily and on a seasonal basis. The writing of an entire ethogram requires a preliminary review of the literature regarding the different behavioural sequences of the examined animal species and the ones that are phylogenetically close to it, by comparing between themselves the already existing studies to check for contradictions within and between them or to assess an eventual lack of information related to the species behaviour. The following step consists in the selection of the specimens and the location that is going to be used for the analyses; from then on, each behaviour can be observed and scored, both in live action and/or from recorded videos, by taking note of the patterns displayed at each observation and select the ones that are going to be part of the catalogue that will constitute the result of the analysis. The most reliable ethograms must be functional, meaning that they need to be organized into categories that reflect meaningful distinctions to the animal. In preliminary phases of the study or in case the species ethology is not well-known, a broader array of behaviours may be considered for the constitution of a species ethogram, listing in this way all the behaviours that the species is known to manifest. A further step in the behavioural analysis can be accomplished through the selection of specific behaviours from the generalised ethograms that may be of interest for testing a specific hypothesis, producing a Partial Ethogram, which is then validated in order to analyse a specific functional context, or may instead be used to build an Experimental Ethogram in order to analyse the manifestation of a certain specific sequence and its causes. Experimental ethograms are usually designed to be exclusive and exhaustive towards their division in categories. An Exclusive ethogram is one where each behaviour performed by the animal can only be categorized as one behaviour in the ethogram, meaning that the animal can only be recorded performing just one action at a time, which is determined through the exclusion of other actions that cannot happen simultaneously. An Exhaustive ethogram is one where every behaviour performed by the animal is assigned to a category in the ethogram. In an Experimental Ethogram all

the behaviours of the category considered for the analyses can be recorded in an easier and faster way, as behaviours irrelevant to the hypothesis can simply be ignored.

Predatory behaviour in canids, as shown by the available literature describing the observation of the behavioural sequence of the hunt in wild canids, is traditionally described by a basic ethogram composed of 3 phases: search, pursue, and capture, and has an important biological relevance to classify and measure foraging in most of behavioural studies (MacNulty, Mech & Smith, 2007). A huge amount of definitions has been proposed to describe the hunting sequence in wild canids such as wolves (Canis Lupus), foxes (Vulpes Vulpes), jackals (Canis Aureus), african wild dogs (Lycaon Pictus) and dingoes (Canis Lupus Dingo), each one with the aim of describing a sequence of actions that stemmed from the traditional scheme of search, pursue, and capture of the prey with the aim of providing a well-tailored observation of the predatory behaviour of the analysed species (MacNulty, Mech & Smith, 2007). This huge variety of representations has contributed to differentiate each canid species in a detailed fashion, but at the same time, as phases are added that tailor the ethogram to one or a few species, its usefulness as a general description will diminish. Thus, the need to split the behavioural continuum into categories must be balanced against the need for generality (MacNulty, Mech & Smith, 2007), as a universal ethogram for predatory behaviour in canids has not yet been validated. When the subject of the studies concerning predatory behaviour happens to be the domestic dog (Canis Familiaris), literature about the topic is poor compared with the one available for its wild relatives and ancestors, which appears to be a paradox, considering that no other carnivore species occurs so widely and with such a high average population density as domestic dog, which, as a result of its introduction carried out by humans, ends up to be present on every continent and practically every settled island (Wandeler et al., 1993).

Canis familiaris widespread distribution and adaptability are highly relevant factors for the ecology of this species, as domestic dogs occupy a wide and various array of ecological niches and places in the feeding chain (MacNulty, Mech & Smith, 2007), as they can interact in a lot of different ways with prey and other predators, becoming a relevant element in every ecosystem they are part of. The socio-ecology and diet of dogs, indeed, vary with their proximity to urbanized areas, and this in turn may affect their competitive interactions with wild carnivores (MacNulty, Mech & Smith, 2007). In most of the ecosystems, Domestic dog is regarded as a meso-carnivore; a midsized carnivore that can produce changes in the socio-ecological structure of native carnivores through predation and competition (Roemer et al., 2009). The high population density in which domestic dogs are present may be the main reason why this species enters in an exploitative competition with other carnivores, sometimes even outcompeting them if a limited prey base is present and the native carnivore populations are relatively small (Vanak & Gompper, 2009), thanks to the high number of

conspecifics that favours the additive or synergistic effects of pack hunting. This can ultimately lead to influence geographical distribution of native prey species and can dramatically limit their home ranges or even lead to their eradication (Roemer et al., 2009). The impact of meso-carnivores can be especially relevant in ecosystems lacking larger carnivores, on island ecosystems, in mainland localities where community composition is relatively simple, and where they represent non-native introductions (Roemer et al., 2009). This has been the case when in 1987, M. Taborsky study found out that a single female of German Shepherd was responsible of the killing of more than half of one of the largest kiwi populations in New Zealand. The area consisted in a commercial pine forest and had no predators to compete against the dog specimen, therefore it was able to kill about 500 out of 900 birds, reducing population density and biodiversity in a way that would need 10-20 years and a rigorous protection scheme to allow recover (Taborsky, 1988). Most of meso-carnivores are less vulnerable to extinction than larger carnivores (Purvis et al. 2000) as their widespread presence in nature and their smaller dimensions compared to native apex predators allow them to better cope with demographic stochasticity, local catastrophes, mutational meltdown, and inbreeding, while bearing higher rates of adaptation to a wide array of environments. On the other hand, the larger body size of the apex predators correlates with many extinction-promoting traits, such as low population densities, slower life histories and larger home ranges (McKinney, 1997).

Altogether with their low vulnerability to extinction cues, the competitive advantage of domestic dog compared to apex carivores might be due to the variety observed in pack composition and density as a result of its proximity to resources and to their availability. Indeed, both captive and wild populations can be present in the same territory, showing a pack composition which is not as tight and hierarchical as the one of its wolf ancestor, as it appears to be highly dependent on the availability of resources such as food, water, and shelter (Daniels & Bekoff, 1989), therefore rather than its kinship. Settlement patterns, rubbish and waste disposal, rules for keeping animals and other cultural practices are factors that influence the access of domestic dog packs to these resources in urbanized areas (Wandeler et al., 1993). Moreover, their widespread social acceptance makes easier for dogs to seek shelter nearby human settlements, providing them with protection and higher availability of resources compared to wild carnivores that are kept far from the same ranges. This relative dependence from humans is also reflected in the phenotypical expression of both the behaviour and the aspect of the domestic dog. The domestication process, indeed, could have been a driving force in determining such changes, as the selection of canids according to behavioural features has been shown to be capable of producing changes even at a morphological level, as it has been observed in silver foxes (Vulpes Vulpes) which were selected “according to tameness and only tameness” by Balayev et al. in a 40 year experiment, under which they had been developing

behavioural and even morphological and neurohormonal alterations that presented significant differences from their wild conspecifics (Trut, 1999). Even tough specific literature about predatory behaviour in dogs is scarce, the behavioural sequence of predation might have been one of the most relevant traits for what concerns genetic selection performed by breeders, which may have ultimately led certain dog breeds to develop or inhibit precise steps in their predatory sequence. One of the most popular hypotheses behind these behavioural differences is that instances of predatory behaviour sequence observed in breeds such as herding and guarding dogs, are the result of a retarded development of the predatory sequence inherited by the wolf. The organization of the predatory sequence may have become relaxed in dogs, due to a shift in niche from hunter to scavenger (Coppinger & Coppinger, 2001). This neotenization of predatory-like behaviour would be the reason of the lacking steps in the predatory sequence (Coppinger et al., 1987) and the reason herding and guarding dog breeds had developed special affinities with such tasks. If not for breeding and training purposes, predatory behaviour in dogs has not been a prominent matter of interest in the field of ethology. This behavioural sequence has been generally assumed to be homologous to the one showed by Canis Lupus, consisting in the phases of orienting, fixating, stalking, chasing, grab bite, kill bite, dissect, and consume (Schilder et al. 2019).

Although domestic dogs differ morphologically from wolves because of the domestication process influence, they still retain characteristics that make them potentially important members of the carnivore guild (Vanak & Gompper, 2009). They are indeed the most widespread carnivore species in the globe and are capable of exploiting resources and shelters unavailable to other predator species, influencing the interactions between predators and prey through their foraging activity and producing considerable shifts in the equilibrium of various kinds of ecosystems. This might be the reason why the ascension of dogs to apex predator status in various communities is likely to become more common, and thus a renewed effort may be needed to understand the dynamics and community-level interactions between them and other native species. (Roemer et al., 2009).

Aim of the thesis

An ethogram specifically tailored for the description of predatory behaviour in dogs is currently absent in scientific literature, but could be a valuable source of information to describe the dynamics of hunt used by Canis Familiaris, thus, helping to infer how this species manages to influence such a various amount of ecosystems. For these reasons the study proposed in this thesis has the purpose of writing a partial ethogram describing the Predatory Behaviour of the domestic dog. The experimental design according to which the behavioural analyses of the predatory sequence have been performed followed a qualitative design, with the aim to describe each detail of

the behaviour observed and the variability of their manifestation among the observations collected, rather than recording data about frequency and duration of each phase. Observations were collected from more than 500 videos selected from public sources such as YouTube and Vimeo, from which were selected the ones where the phase was more evident and clearer to assess. Following this selection, a further step has been made in differentiating the videos according to the context: on one hand were considered the videos showing dogs in a game/hunt context, where the sequence was clearly displayed with the aim of killing the prey, while on the other hand were collected the videos of predatory-like behaviours, that were shown towards other dogs, toys or even the owners. This distinction allowed us to determine the differences present according to the context in which similar behaviours have been recorded in the observed dogs, therefore providing a more refined and less biased description for videos that featured unequivocally predatory behaviour. Once this difference has been acknowledged, a further sample was taken from the pool of available videos, considering just the ones featuring instances of unequivocally predatory behaviour, allowing the performance of a behavioural analysis aiming to identify the phases composing the predatory behaviour sequence and to describe their manifestation and the possible variations that might occur.

Materials and methods

Collection of videos

The constitution of a functional ethogram requires a great pool of observations from where to obtain several different instances of the category of behaviour under investigation. When it comes to the domestic dog, this need of variety and magnitude in the observations must take into account also the fact that observations could involve dogs of different breed groups that are performing different hunting modalities.

To satisfy this demand and obtain a number of observations large enough to provide valuable data, we collected about 500 videos of dogs expressing predatory behaviour from publicly accessible archives on the internet such as YouTube and Vimeo. The selected clips were included in a database that was catalogued in an excel sheet, with an ID number to allow their identification. Using such material provided a lack of standardization in the set-up of the behavioural study, as the observed behaviours were expressed in an uncontrolled and non-experimental setting. However, the lack of standardization in the experimental design was compensated by the large number of

observations collected, as they represented a source of data that was widely representative of the studied species, allowing to consider various different contexts and breed groups. Moreover, according to Nelson and Fijn it is advised to include in research only clips derived from the original source that featured a low number of shots, in order to avoid heavily edited footages modified according to a narrative-based sequence and postproduction manipulation of the image, since that could alter the whole interpretation of the video itself and its scientific relevance. A further selection has been performed between the clips taken from public sources, aiming to find the most suitable ones to describe a context that was unequivocally predatory, meaning that the prey should have been alive and actively hunt by the dog, which could have displayed a more or less complete sequence, as established in the former steps of the analysis, but must have expressed at least a visible Biting phase, leading to a successful capture of the prey. This selection led the initial archive to be reduced to a sample pool of 20 videos.

Following this sampling process, the initial analytic work focused on identifying which specific phases of predatory behaviour could represent the base of this descriptive processes. According to the available literature, expert opinions, anecdotal descriptions made especially by Coppinger & Coppinger (Coppinger et al., 1987) and to previously developed ethogram of canids, the phases composing predatory behaviour of domestic dog were divided in Pointing, Stalking, Chasing and Biting. This structure was not intended to be a rigid scheme, but rather a starting point for the arrangement of an initial analysis. During the process of characterization of predatory behaviour, indeed, we tried to be unconstrained by this structure, willing to challenge and/or integrate such design with the results of the observations performed. In the first descriptive stages, in fact, it was decided to add a new pattern of behaviours to those being analysed, so the Searching phase was introduced. Pointing and Stalking phases had been incorporated in a single phase (Pointing/Stalking), as they were consistently alternated in most of the sampled videos. In the meantime, live observations of 19 different hunting dogs were filmed by our observers and were then incorporated in the analysis as a mean for direct observation of the predatory sequence and to convey information about observed variations in their facial expressions and sensory components. This has been useful to increase the quality of the observations and to better witness the sensory characteristics of dogs during the sequence, such as eye direction, blinking rate, nostril movements, ear movements, mouth opening and tongue presentation. During the collection of all these observations the breed group of each dog featuring in the clips had been registered, as attention had been paid to diversify the breeds of the analysed animals, reducing as much as possible the bias associated with them. Information collected from literature and anecdotal descriptions of Coppinger

et al. were then used to produce a general description for each one of the identified phases of predatory behaviour.

Searching

The dog looks/roams around the area, scanning the surroundings through vision and/or olfaction, looking for the prey.

Pointing/Stalking

The dog stands on its four limbs showing clear sensory orientation towards the presumed location of the prey, performing small steps to get closer to the area. The movement can be interrupted and turn into a still stance in which the dog is still oriented towards the presumed location of the prey. There is usually no defined pattern in which these actions manifest and alternate one another.

Chasing

The dog shows clear sensory orientation towards the prey and starts moving straight towards it.

Biting

The dog bites or at least tries to bite the prey, which than can be transported, released, or even killed and/or dissected to be consumed.

Behavioural analysis

As the sampling process was carried out, four independent observers had been required to provide a detailed description each of the 20 clips sampled from public sources. Each observer needed to focus on a specific phase between the ones considered in the analysis and describe it according to a structured scheme taking on account the posture, the movement, the timing and the expressive cues of the dog, as well as the features of the surrounding environment such as the presence of other dogs, humans or background noises. Each of the 20 clips was also double-checked by a second observer, which provided its own description for each of the phases involved, in order to rule out subjective differences and to look out for eventual confounding in each one of the resulting 80 observation produced.

Description templates

VIDEO NUMBER: Number of the video in the list

FILE NAME: title of the clip and its source

TIMING OF THE SEQUENCE: interval of time in the clip considered for the analysis and observation of the analysed phase.

CONTEXT DESCRIPTION: generalised description of the location of the clip, which takes on account the surroundings and the presence of other people, dogs or other sources of noise or distraction that may alter the manifestation of the behaviour of the dog.

TIMING OF THE OBSERVED PHASE: interval of time in which the sequence is observed

WHAT HAPPENS BEFORE THE OBSERVED PHASE: report of the phase of the predatory behaviour sequence precedent to the one observed or of eventual unexpected variations

WHAT HAPPENS AFTER THE OBSERVED PHASE: report of the phase of the predatory behaviour sequence that follows the one observed or of eventual unexpected variations in the following steps of the sequence

1. *MOVEMENT*: General description of the movement of the dog while performing the phase
2. *POSTURE:*
    - 2.1. *Center of gravity*: description of the weight distribution on the limbs of the dog according to its posture
    - 2.2. *Limbs:* positioning of the limbs
    - 2.3. *Torso alignment*: position of the torso according to the head and the hips of the dog
    - 2.4. *Head alignment*: position of the head according to the torso and the hips of the dog
    - 2.5. *Specific stances*: manifestation of specific stances such as Lordosis, Kyphosis, Sternal or Dorsal Recumbency etc.
3. *MUSCOLAR TENSION*: report of visible muscular contraction during the phase
4. *MIMICS/FACIAL EXPRESSIONS:*
    - 4.1. *Tail*: frequency and direction of tail strokes
    - 4.2. *Ears*: lowering or raising of ears
    - 4.3. *Mouth*: opening or closure of mouth during phase
5. *SPECIFIC BEHAVIOURS*
    - 5.1. *Olfactive exploration*: report of nostril movement during the phase if evident
    - 5.2. *Vocalizations*: report of sounds emitted by the dog during the phase
    - 5.3. *Signs of distress*: report if pacing, yawning, tail waving etc. are present
    - 5.4. *Urination/Defecation*: report if dog urinates or defecates during the phase
6. *SENSORY ORIENTATION*: direction of the look and of the body of the dog during the phase
7. BITE (Relative to Biting phase only)
    - 7.1. *Successful/Unsuccessful*: report if the dog managed to lend the bite on the prey
    - 7.2. *Position where the prey was bitten:* part of the body in which the bite was landed

7.3. *Kept or Released*: report if prey manages to escape or not

7.4. *Shaking*: report if prey has been shaken by the dog after its capture

8. PREY:

8.1. *Visibility*: report if the prey or some of its body parts are visible in the video

8.2. *Type*: which species is the prey

8.3. *What is doing*: action accomplished by the prey during the analysed phase

8.4. *Sounds emitted*: presence of vocalization from prey

8.5. *Prey Destiny*: report if prey is getting released or killed

9. *INTERFERENCES*: possible sources of interference such as other dogs, people, rumours etc.

10. *OTHER*: Additional information about the clip

11. *MOVEMENT* (Relative to Stalking phase only)

11.1. *Pace and gait*: pace at which the dog displays its movement during the stalking phase

11.2. *Direction*: direction towards which the dog moves

11.3. *Jumps or other variations*: peculiar variation in the movement of the dog during the stalking phase

If the phase was repeated each repetition must have been described as a new phase (e.g. biting 2, biting 3) by only describing the elements that differentiated from the previous observation of the phase. Each repeated observations for the same phase must have had its timing reported in the draft.

The differentiation among different dog breeds in the sample allowed the identification of a group of dogs that was consistently displaying a predatory sequence featuring Searching, Pointing/Stalking, Chasing and Biting, mostly directed towards avian preys such as pheasants. This group was referred as “Pointing dogs”, as compared to the other breeds of hunting dogs present in the videos these dogs were showing a well distinct Pointing/Stalking phase and presented peculiar recurring patterns of sensory expression and body positioning during the whole sequence. Only this group was considered in the following behavioural analysis, therefore only the observations featuring Pointing dogs had been used for the description of each phase. The reduction in sample size obtained with the isolation of the group of Pointing dogs aimed to obtain a sample as uniform as possible but had the effect of reducing the power of the study, as the margin of error was increased. In order to ensure a higher reliability of the results provided by this experiment, a solution would be to increase the sample size by dividing the initial sample in other groups of dogs performing different consistent patterns in their hunting sequence. In this way the behavioural

analysis could focus on different hunting strategies and behavioural variations within the same species, providing a sample divided in coherent classes.

Results

The data obtained from the observation of Pointing dogs, resulted in a set of recorded observations, which were then compared to assess which patterns appeared to be more commonly displayed in each phase and which could have been the possible variations, allowing the production of the ethogram. The description of every phase of the predatory behaviour sequence was then organised in three different levels:

Level 1: Provides a general description of what is observed during the phase, including the possible triggers for such phase to begin, its duration, the focus of attention and hypothetical functions of the phase. This observation does not aim to specify how each step the sequence is manifested; it is instead limited to the simple recording of what is observed.

Level 2: Describes the locomotion of the animal during the whole phase and the different postures that can be observed, therefore the subject of the description is the whole body of the animal, with no specific descriptions for individual body parts.

Level 3: Describes the movements of single parts of the animal body, including sensory orientation, specific motion patterns and other peculiar behaviour.

This organisation allowed us to produce an extensive description of consistent locomotory patterns and specific postures related to each phase, allowing us to record how each phase of the predatory sequence was manifested and which variations in terms of frequency and duration could appear, with an increasing degree of specificity as the level increases. Some of such patterns related to postures and movements were often displayed among Pointing dogs, therefore it was decided to provide a standardized definition for each of them for the purpose to harmonize the descriptions provided by the observers.

Centered Balance: the body weight of the dog is equally distributed between the fore and hind limbs, while both front and hind limbs are perpendicular to its body below its shoulders and hips.

Forward Balance: the forelimbs are supporting much of the body weight of the dog as they held in a roughly perpendicular position below or behind the shoulders, with an armpit angle of 90° or slightly less, while one or both hindlimbs are stretched back.

High center of gravity: the dog presents an extension of all limbs, so that the height of the dog at withers is the same as when it is standing in a standard quadrupedal position.

Low center of gravity: the dog presents a flexion of all limbs, so that the distance between its withers and the ground is less than when the dog is standing in a standard quadrupedal position. It can range from a light flexion of the elbow/knee to a nearly complete flexion that brings the body very close to the ground, almost in a sternal decubitus position.
Ears neutral: ears are not moving, but rather they are relaxed. The neutral position of ears for dogs with pendulous ears is drop sideways. The neutral position of ears for dogs with pricked ears is characterized by the pinna facing forward.
Ears forward: the ears are turned or pushed rostrally. In dogs with pendulous ears the triangle formed by the pendulous part of the ear is brought forward, in such a way that the upper edge of that triangle tends to lie perpendicular to the longitudinal axis of the dog. In dogs with pricked ears the pinna become rigid and tense.
Ears lifted sideways: the ears are adducted, the base of both pinnae becomes closer together, by being pulled towards the head midline.
Ears backwards: the ears are pulled caudally, in the direction of the back of the head. In dogs with pendulous ears the triangle formed by the pendulous part of the ear is brought backwards, in such a way that the internal pinna is completely visible facing the dog from the front. In pricked ears, the pinna collapses into a flattened shape.

Searching Phase

Level 1

At the beginning of this phase, the dog moves quickly through space with a less precise directionality, often changing its direction and gait with the aim to cover larger areas of the hunting field. This pattern has a highly variable duration, as this process may end gradually or suddenly, according to how quickly the dog identifies the presumed location of the prey, both by sight and/or following the intercept of its olfactory trail. As the sensory orientation of the dog becomes more oriented towards the presumed location of the prey, the dog might transition to a subsequent pointing phase as its movements become slower and its directionality is more precise.

Level 2

During the entire searching phase, the balance is centred, and the trunk is straight and parallel to the ground. The head may be held higher or lower than the trunk line, depending on where the scent is located and on the characteristics of the environment in where the dog is searching, such as the

presence of physical obstacles preventing the dog to hold its head in one direction. The tail might be held along, under or above the trunk line, often presenting a very rapid and shallow tail wag of about 45 degrees amplitude, with lateral and/or circular movements. It is also possible to observe the mouth to be held open or closed for the entire duration of the phase, even though vocalizations are never emitted. At the beginning of the searching phase, as the dog scans larger portions of the environment, it tends to move with quick lateral movements, zigzagging in the area. During this locomotion pattern the dog tends to keep a higher centre of gravity, which in turn results on the extension of the limbs that leads to the performance of a gallop or canter gait. Each change of direction is initiated by the head, which dictates the orientation of the animal in the space. Usually at this stage the mouth of the dog is always open, with no evident signs of muscle tension. As the gradual localization of the prey leads the dog towards the following pointing phase, the range of lateral movements and their pace tend to progressively decrease, as the lowering of the centre of gravity induces a slight flexion of the limbs until the gait turns to trot or walk. At this point, the movements appear to be more straight forward, as the body is forming a single linear plane with the trunk. On the opposite, the head might still exhibit lateral zigzag movements, and the mouth might be closed. This transition to progressively slower and more controlled movements, seems to bring the dog to increase its focus on the prey and its body stiffness, even if no muscle tremors are yet evident.

Level 3

This phase is characterized by the presence of both visual and olfactory exploration of the environment, evident by lateral, upward and downward head movements accompanied by sniffing the air and/or the ground, sometimes showing nostril movements too. Ears are either relaxed or held backwards or sideways, but, as the dog decreases its pace and comes closer to the presumed location of the prey, they might begin to be held forward.

Such phase was not present in the literature related to Canis Familiaris Predatory Behaviour, so it has been added to the ethogram following the direct observations of the clips showing Pointing dogs. Among this group, this pattern appeared consistently as described in the first level of the ethogram and was displayed in most of the observations before the transition into a Pointing/Stalking phase. Such lack of consideration from previous studies might have been due to the high variability in its display and duration, which can be influenced by several factors like the presence of obstacles, noise or other dogs or humans in the hunting field. In fact, the movements of the body in relation to the head and the display of facial features such as eyes, ears and nostrils

movement might be performed following a visual, auditory or olfactory cue according to the position of the prey, whose detection may be strongly influenced by the factors stated above. As this phase when manifested in Pointing dogs is always followed by Pointing/ Stalking, which to be displayed requires the individuation of at least the presumed location of the prey, it is reasonable to infer that the prey location may be the purpose for the manifestation of this phase.

Pointing/Stalking Phase

Level 1

Pointing is characterized by an immobile stance of the dog while Stalking behaviour is a dynamic process, consisting in a slow, controlled locomotion. Both behaviours show a constant body orientation towards the presumed location of the prey, but their duration is highly variable and can range from a couple of seconds to several minutes, and, in the case of Stalking, from a single step to several. However, no external events or stimuli are evident to determine which are the reasons behind the onset of stalking after pointing and vice versa. This phase generally terminates, when the dog is sufficiently close to the prey, with the display of the subsequent chasing or biting phase.

Level 2

The postures characterizing either Pointing or Stalking appear to have low variability between the subjects observed among Pointing dogs. In the case of Pointing, the dog presents a quadrupedal, stationary, tense position and it does not initiate any movement, while during the Stalking phase, it moves toward the presumed location of the prey, by performing a 4-step gait raising one paw at a time and bringing it closer to the body before placing it down on the ground. Each movement of the limbs is followed by one of the contralateral limbs and can be initiated by both frontal and hind limbs. Therefore, if the movement is started from a frontal limb, the next step will be accomplished by the opposite hind limb and the sequence will be repeated with the alternation of the other frontal and hind limbs. This gait might appear at variable rate and the increase in the speed of such steps is associated with more frequent and larger head movements related to more evident instances of olfactory exploration. Moreover, the balance can be either centred or forward, as the centre of gravity can range from high to low, according to the degree of flexion of the limbs. The height of the posture manifested by the dog can be achieved at the first expression of either Pointing or Stalking and can remain constant throughout the whole phase after its first instances, although further lowering can be observed as the distance from the prey decreases. Even muscle tension

seems to increase as the dog approaches the prey, as suggested by tremors that might affect limbs, tail and the neck area. The head is generally immobile and is kept above or in line with the trunk, often extended forward according to the visual and olfactory orientation, although some exceptions can be observed as described in Level 3. The mouth is either closed, or open for a short time, during which the dog does not appear to be panting but rather shows very controlled rib cage movements. During the phase the dog does not emit any vocalizations. The tail is held along or higher than the trunk line and it is still and stiff. It is not uncommon to observe how tail, trunk, neck and head align to form a single linear plane, especially when the posture is lower. In case the posture is observed to be different at the beginning of the stalking phase, it is straightened as soon as the locomotion starts.

Level 3

This phase is characterized by the presence of constant sensory orientation towards the presumed location of the prey. Nostril movement generally occurs with the nose oriented in the direction of scent trail of the prey; it has a variable frequency, duration, and rate and it is mostly observed without any associated movement of the head. However, the dog might perform quick, narrow, and controlled sideways or downwards head movements, which are always simultaneous to nostril movements. Hence, it seems this likely that this peculiar pattern is expressed when the dog has lost the scent trail and needs to re-intercept it. Eyes are usually turned in the direction of the prey, although brief and momentary diversions might occur if distractors such as other dogs, people or environmental noise are observed in the scene. Blinking rate seems to intensify when the dog looks away, and to decrease in frequency the closer it gets to the prey. Mouth is often closed but might show tonguing, while ears are either relaxed or held forward, and oriented toward the presumed prey location. Dogs with pendulous ears might show reduced mobility due to their hanging anatomy, therefore their ear mobility is more difficult to detect. When oriented toward the prey, the triangle formed by the pendulous part of the ear is brought forward, in such a way that the upper edge of that triangle tends to lie perpendicular to the longitudinal axis of the dog. During pointing, often the dog will hold a raised fore or hind limb. The raised fore limb can be abducted at variable distance from the body, ranging from being raised only a few centimeters off the ground, with sight flexion of the shoulder and elbow joints only, to being held very close to the trunk, with the elbow in line with the shoulder, and the wrist fully flexed so that the paw is close to the ulna. Similarly, the raised hind limb can be held from few cm off the ground, with slight flexion of the hip and knee joints, to full flexion of hip, knee, ankle and metatarsal-phalangeal joints.

This phase was presented by all the Pointing dogs, whose observations have been used for the writing of this catalogue, as the aim of this further selection was to provide an ethogram based on a sample showing a sequence as uniform as possible. Pointing and Stalking were considered as two different behavioural units in the literature about Canis Familiaris predatory behaviour, but in our observations such phases have been incorporated as they were showing showing a peculiar, alternated fashion and, apparently, the same purpose. Indeed, while Pointing might have been displayed at the beginning of the sequence or right after a Searching phase, Stalking was displayed only after a Pointing phase. Furthermore, it was not uncommon to observe a display of another Pointing phase after the onset of Stalking. Even though the reasons behind such alternated onset of was not evident, they appeared to manifest because of the sensory cues perceived by the dog, which could provide information about the positioning of the prey, thus leading the dog to either move towards it or to stand still according to its location, repeating this alternated pattern for a highly variable time while waiting for the right time to ambush it. Therefore, the maintenance of the height of the posture and its lowering following the reduction of distance with the prey, the lack of vocalizations, the extension of the head and tail and their lack of movement while forming a straight line during the performance of both Pointing and Stalking were interpreted as adjustments the dog needed to apply to its movement while performing this phase. Such modifications in the locomotion of the animal were easily correlated to the need to confirm the position of the prey while avoiding being noticed by it and/or to focusing on the target of the following phases, which appeared to be the ultimate purposes of this sequence. The performance of Pointing/Stalking phase, indeed, could inevitably affect the following phases of the sequence, as the way Chasing and Biting phases were manifested were highly related to how close the dog can get to the prey without being noticed.

Chasing Phase

Level 1

Chasing is characterized by the beginning of a locomotion or by an increase in the speed of the gait performed by the dog to reach a fleeing prey. This phase, indeed, appears to be elicited by a sudden movement of the prey, which either by running or flying away is able to cause the antecedent Pointing/Stalking phase to cease. Such phase shows a high variability in its appearance, as it is strongly influenced by the distance from the prey, a feature that relies on the performance of the previous Pointing/Stalking phase. Indeed, if the dog manages to get close enough to the prey in the

previous phase, it will perform a quick leap forward defined as Lunging, without an actual chase of the prey. Whenever the lunging is unsuccessful, or when the dog is too far for an ambush, the prey starts fleeing leading to the beginning of a proper chase of the prey. As a result, the duration of the chase and the presence of either chasing and/or lunging is highly variable. Chasing terminates with an extension of the neck and head towards the prey, as the dog prepares to grab it with its mouth.

Level 2

Chasing is characterized by an energetic locomotion, during which the dog quickly moves at gallop, accomplishing a 4-stroke jumping and tilting gait, consisting of three beats plus a suspension or two beats and two suspensions, in which both the front and hind groups contribute to the forward thrust. The centre of gravity is high to allow limbs to fully extend and flex rhythmically to support the gallop, while the balance follows the energetic movement during the chase and tends to shift forwards when the prey is close enough to attempt to grab it.

During chasing the trunk is straight and parallel to the ground; but can be adjusted depending on the behaviour of the prey and its distance from the dog. For instance, when a running prey is close enough, the dog may lean the trunk downwards, by flexing the front limbs. If the prey flies away or jumps and the dog is not too far away, it can display some upward leaps, characterized by the tilting of trunk back and hind limbs supporting full body weight. The position of the head follows the movement of the prey by stretching in its direction, while the tail can be kept along or below the trunk line, moving slightly up and down accordingly to the body movements during gallop. Lateral and/or circular tail movements can be observed in the moment of maximum proximity to the prey during a lunging or when sudden changes of direction occur. During the run the mouth can be either closed or open, according to the effort required for the dog to cope with physical effort, while it opens during lunging behaviour, anticipating the biting attempt. Furthermore, vocalizations are never emitted. No particular sign of muscle stiffness is visible in muscles that are not involved in the maintenance of the gait.

Level 3:

The attention of the dog during chasing is still fully and constantly kept on the moving prey, as the head is fully oriented in its direction and it runs directly towards it. The ears in Pointing dogs seems to be held in a relaxed, neutral position, and move in accordance with the run or are held backwards, although, sometimes is possible that during the first lunge towards the prey the ears are held forward and then they may be moved sideways or backwards.

Such behaviour, though highly variable, has been shown in most of the observations featuring Pointing dogs. The phase was displayed in the form of both Lunging and proper chasing, according to the distance between the observed dog and the prey, leading to a high variability in its performance. The features displayed appeared to be generally in line with what was present in literature as the main function of Chasing behaviour appeared to be the reduction of the distance between the dog and the prey, allowing the dog to grab the latter triggering the subsequent biting phase. Such behaviour appeared to be elicited by the sudden movement of the prey escaping, either by running or flying away, as the sequence is initiated only after the prey movement and during its whole display of the chase the dog appears to be focused exclusively on the prey. Lateral and/or circular tail movements can be observed in the moment of maximum proximity to the prey during a lunging or when sudden changes of direction occur. They could therefore represent an anticipation of the tail movement that will be expressed during the capture, or they could be dictated by the kinesis required to modify the run during a change of direction, an initial braking or a final lunge before the landing of the bite.

Biting Phase

Level 1:

Biting behaviour occurs when the dog is close enough to the prey to expect to catch it, usually following chasing or lunging behaviour. This capture bite aims to capture the prey and to land it still on the ground and it may or may not be followed by other types of bites, with different functions. The presence and successfulness of the capture bite depend largely on the behaviour of both the prey, and the dog, therefore the duration of this phase is very variable.

Level 2

Postures expressed during the early stage of the capture bite depend greatly on the behaviour of the prey. On one hand, if the prey is alive and fleeing the dog will bite while in movement and then change its posture to adjust its grasp to avoid letting the prey slip out of its mouth and finally landing it on the ground. As a result of these adjustments and depending on how the prey fights back, postures at the early stage of biting might highly variable. On the other hand, in the case the prey is motionless (Preys shot by a hunter, preys trying to hide or camouflaging), the movement and posture of the dog are in accordance with the braking that follows the chase or lunge, with the front part of the body stopping on the prey, while the rear is pivoting, following the chasing inertia. Once

the prey is on the ground, the trunk is straight or bent downwards to reach the prey as the dog adopts a centred balance. The head is lowered and aligned with the trunk, while hind limbs are generally more extended than the forelimbs, so that the caudal part is held higher than the front. The tail is kept in line with the trunk or higher and it can be both motionless, although not rigid, or it can move in a fast lateral and/or circular waggle. The mouth is clearly engaged in a firm bite and vocalizations are never emitted. Even though this sequence is pretty rich in variability there is no evidence of muscle tension other than that necessary to end the run and strike the bite.

Level 3

During the capture bite the attention of the dog was still directed towards the prey, always showing a clear and constant sensory orientation towards it and when the bite is landed it usually involved the middle or back part of the body.

The phase is displayed successfully by all the examined dogs, as it has been the main criteria for the selection of the observations in the course of the first sampling from the initial pool of videos. Its appearance is and manifestation are related to both the distance from the prey and its behaviour, for example the lowering of the head below the line of the trunk and the extension of the hindlimbs may be useful to help the dog immobilizing the prey by unloading its weight on its frontal part. Indeed, immobilization of the prey appears to be the main purpose for the performance of such phase, which once successfully accomplished can lead to the killing of the prey and its dissection or to its delivery to the master. An unsuccessful biting phase leads to the beginning of a new sequence, which might start with a Chasing phase in order to catch the prey a second time.

Discussion

A behavioural inventory includes descriptions of distinct units of behaviour. Details of what happens and the context in which that action is observed are necessary for understanding the "meaning" of that action or posture (Smith, 1977). The fact that Canis Familiaris is recognized as a pet animal or at least tolerated among almost all the cultures in the world, might be the reason why such inventory is not present in the case of its predatory behaviour. Indeed, instances of observations and literature on the topic are scarce and mostly considers such behaviour as a simple

derivative of the one displayed by Canis Lupus. In the constitution of a partial ethogram, the need to split the behavioural continuum into categories must be balanced against the need for generality (MacNulty, Mech & Smith, 2007), therefore assuming that behavioural sequence of the domestic dog is a simple derivative of the one displayed by the wolf just according to its taxonomy could result in a biased analysis that may leave out phases in the hunting sequence that might be exclusive to the domestic dog, resulting in a perfunctory way to analyse this species.

Sampling from the initial archive was performed according to the presence in the clips of a successful biting phase leading to the capture of the prey. The displayed predatory sequence did not need to be complete, as we tried to be as unconstrained as possible from the literature about the topic by following an empirical approach based on a qualitative design, which aimed to provide just a description of the behaviours observed in the clips. Such descriptions included the behaviours noted in the literature and in anecdotal descriptions, consisting of Pointing, Stalking, Chasing and Biting, but further modifications according to the results of the empirical observation were performed and led to an update of the sequence and to a creation of a sample pool including 20 videos. Such update in the sequence consisted in the addition of a Searching phase and in the incorporation of Pointing and Stalking phases in one referred as Pointing/Stalking. Each of the selected videos was then analysed by four independent observers, which were following a template specifically designed to record the timing of each phase, its duration and the postures and gaits assumed by the recorded animal, allowing to distinguish between the units of behaviour identified in the sequence and their manifestations. In the meanwhile, 19 hunting dogs were filmed by our observers that were able to collect data about their hunting sequence from a closer perspective, which allowed them to better evaluate facial expressions displayed during the hunting sequence, allowing to increase the instances of predatory behaviour observed and to convey information about signs of stress or sensory inspection of the surrounding by the dog. In this perspective, eye direction, blinking rate, movements of the nostrils, ears and mouth were often presented in all the steps of the sequence, while tongue presentation was rarely displayed.

Some of the observations showed dogs that were performing an evident Pointing/Stalking phase, while in other cases, such phase was not performed, leading to the manifestation of an uncomplete sequence in some dogs, which were presenting Chasing and Biting phases immediately following the Searching phase. It was therefore decided to perform a further sampling between the observations and to consider only the dogs that were performing the highest number of phases in the predatory sequence described in the behavioural analysis for the writing of the ethogram.

Such dogs were referred as “Pointing dogs”, as they were the only group that was always displaying a clearly defined Pointing/Stalking phase. The observations obtained from this group of dogs

showed that each of the identified phases in the predatory sequence followed a rigid sequential order, starting from Searching and being carried on through Pointing/Stalking, Chasing and Biting, generating a sequence that was not altered in any of the clips. Indeed, if one or more phases did not appear in the sequence, the following phase according to this order was then manifested, though such sequence could be stopped and restarted from the beginning at any phase. The transition from one phase to the subsequent ones might have been more or less clearly related to the sensory perception of the prey. It was indeed unclear how well the dog was able to discriminate among sensory cues for the location of the prey during the display of Searching, given the high variability in the coverage of the hunting field and in directionality of the visual and olfactory inspection. If we consider the following steps in the sequence, both the detection and intensification of an olfactory trail might lead the dog to switch from its Searching phase to the subsequent Pointing/Stalking phase, even though it is unclear what stimulus can cause the dog to exhibit pointing rather than stalking behavior, and vice versa. On the contrary, chasing behavior in the dog is clearly triggered by the movement of prey, as the increase of its distance from the dog needs to be overcome, until it is close enough to trigger the subsequent Biting phase towards the prey. Therefore, it is reasonable to think that the performance of the biting phase is related with the decrease in distance from the prey, as it is observed only when the dog is close enough to expect a successful bite to be landed.

Although useful to convey specific information about Predatory behaviour, this experimental design presented some issues relative to the performance of repetitive sampling from the same pool of observations. Indeed, in the course of the whole experimentation the initial sample size has been progressively reduced in order to obtain instances of Predatory behaviour showing an increased uniformity among the observations in the sample. However, this had the effect of reducing the generalization of the results as well as the statistical power of the analysis, due to the fact that, since the ethogram levels have been defined only according to the data obtained from Pointing dogs, the specificity of the results obtained was limited to the dog breeds that were showing that same behavioural sequence including Searching, Pointing/Stalking, Chasing and Biting. Since low statistical power, because of low sample size of studies, small effects or both, negatively affects the likelihood that a nominally statistically significant finding actually reflects a true effect (Button et al., 2013), a refinement for this project would be to identify other dog groups, showing similar predatory sequences in a consistent way among themselves, allowing to describe further interspecific variations among Canis Familiaris. Such method would be implemented more efficiently by increasing the sample size of the pool that would then undergo the behavioural analysis, paying attention to diversify as much as possible the breeds appearing in the clips. In this

way, the chance to witness variations in the predatory behaviour sequence are increased, as well as the probability to identify such new dog groups, leading to an improvement of the statistical power of the analysis.

Conclusions

The observation of online amateur videos has turned out to be an effective method to obtain valuable information related to how such predatory behaviour in Canis Familiaris can be displayed, as such videos are available from public sources, therefore are easy to collect, and might show different contexts and a wide individual variability among the subjects. Studies about the predatory behaviour of Canis Lupus and other wild canids might benefit from such design, given the difficulty to obtain this kind of visual information from live observation of wild specimens. Indeed, monitoring of wild canids might present some complications, as wild canids tend to hunt in packs, making focal animal sampling impractical because of the difficultly of continuously viewing the same individual at long distances, in variable terrain among the movements of other pack members and prey (MacNulty, Mech & Smith, 2007). Furthermore, such observation might also require monitoring of nearby prey populations, in order to provide a higher chance to record the predatory sequence. This would ultimately lead to extend the area in which the recording is taking place, thus, increasing time and resources needed for the whole set up of the behavioural analysis. Integration of clips taken from open sources website could be a valid method to exponentially increase the number of available observations for a behavioural analysis and might provide a new point of view for the observation of wild canids species. Indeed, as the number of people obtaining the footage is not restricted to academics but is widened to citizen scientists, the probability of capturing any given behaviour is dramatically increased (Nelson & Fijn, 2013). Moreover, information obtained from the observation of predatory behaviour in domestic dogs could be useful for the performance of comparative studies about Predatory behaviour in wild canids species, given their relatedness with Canis Familiaris, which might be relevant for some homologies or similarities in the manifestation of such behaviour. Domestic dog, indeed, is easily available for behavioural experimentation and its relative tameness makes it a suitable animal for such studies. The comparison between the ways in which predatory behaviour is displayed among different species of canids might allow to understand which could be the triggers, the deterrents and the possible variations for the manifestation of this sequence. Therefore, the knowledge derived from this ethogram could be of use for the improvement of the relationship between humans and wild canids, especially in the ecosystems they share and in which they might often collide. The validation of a partial ethogram

for dog predatory behaviour could also provide a valuable instrument for the assessment of differences among dog breeds by looking the way the predatory sequence is manifested. In this way the specificity of the ethogram would increase, as well as its relatability for the individual breeds, allowing to provide information of higher ecological value. In some cases, as it was witnessed at the beginning of our analysis, domestic dogs might display similar instances to the ones present in the predatory sequence in contexts that are unrelated to foraging, such as playing with conspecifics, humans or toys. Even though those playful behaviours were not considered for the performance of the behavioural analysis of the Predatory behaviour sequence, they are part of the behavioural repertoire of Canis Familiaris as well as all other canid species, therefore they could provide valuable information for future ecological and ethological studies as they are displayed in different contexts and with a high variability among subjects.

In the end, such catalogue could highly benefit the whole scientific community, as it would provide a standardized way to approach an important aspect of the behaviour of a precious animal subject, which due to its availability, adaptability, tameness and huge breed variety, could constitute an added value for further ethological analysis.

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