HUMANS-DOGS (AND DOGS-HUMANS) RELATIONSHIP: EMERGING PROBLEMS IN URBAN AREAS

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The origins of the domestic dog

The dog family or Canidae is a biologically cohesive group of carnivores that is divided into 38 species, including the domestic dog, *Canis familiaris* (1). Although the members of this family share a number of ethological features (especially those related to social behaviour), the dog was the only *Canidae* species (and also the first animal specie) to be fully domesticated by humankind.

Since before Charles Darwin, the hypothesis on the origin of the domestic dog from the wolf (Canis lupus) or the golden jackal (Canis aureus) elicited a fervent debate. In the 1868s, with regard to the origins of the numerous domesticated varieties of the dog from a single wild species or from several species, Darwin wrote: "We shall probably never be able to ascertain their origin with certainty" (2). A long time later, Konrad Lorenz popularized the idea that some modern breeds of dog were originated from the wolf, but the others instead were derived from the jackal (3). However, afterwards Lorenz invalidated this hypothesis, especially on the basis of the complexity of the jackal's howling repertoire, which is quite unlike to that of the dog or wolf (4). Recent results, deriving from a combination of studies of ethology, morphology and molecular genetic, indicate that the principal, if not the only, ancestor of the domestic dog is the wolf (1).

Humans perhaps domesticated the wild dog ancestor more than once, and domestication was an event that took place independently in different geographical areas. Indeed, from as early as the Middle Pleistocene period, the bones of wolves have been found in association with those of early hominids in different archaeological sites dated between 400,000 and 150,000 years BP (Before Present; see 1). Examples include the site of Zhoukoudian in North China (5), the cave of Lazeret near Nice in the south of France (6), and the site of Boxgrove in Kent, England (1). These archaeological discoveries demonstrate that the sites of occupation and hunting activities of humans and wolves must often have overlapped.

However, the first evidence of dog domestication come from archaeological records that date back to about 14,000 years ago, during the cultural period known as the Epipaleolithic or Natufian. In particular, of special value has been the discovery in the Natufian site of Ein Mallaha in Israel (12,000 years BP), of the burial of an elderly human with a puppy (a tamed wolf or "dog") of about 4-5 months of age. The human skeleton lay in a flexed position, with its hand on the thorax of the puppy (7).

It is likely that dog domestication corresponded to a change in hunting strategy by a few human populations. Indeed, during the Natufian, humans developed the practice of the long-distance hunting by using new tools such as the microliths (arrows armed with tiny stone blades). The success of these long-distance projectiles would have been enhanced by the new partnership with dog, which could help to track down, immobilize and carry back wounded animals. Such a cooperative hunting technique would thus have resulted in greater hunting efficiency (8).

Undoubtedly, the dog domestication represented an advantage to humans' evolution. Indeed, once tamed, dog became not only an efficient partner in hunting practice, but also an ideal guardian and an incomparable companion "pet" animal, being able to elicit attachment and engaging in complex communicative interaction with its human partner.

The human-dog relationship

People always describe the human-dog relationship as a partnership, a dyadic symbiosis, a reciprocal special bond sealed by a cross-specific imprinting, or as the result of a combination of both biological and zooanthropological factors. Certainly, domestication has enriched the dog natural behavioural repertoire, providing this animal with new behavioural modules (or, more likely, a selection process magnifying pre-existent behavioural items), which, in turn, have facilitated the communicative interactions with the human beings. Thus, domestication might have reinforced the reciprocal emphatic bond in the dyad human-dog by enhancing the dyad skill known as the "reciprocal mind reading", namely the reciprocal ability to read and modify emotions without sharing an articulate language.

Recent evidence from ethological studies confirms that the domestic dogs are unusually skilled at reading human social and communicative behaviour – even more so than both wolves who were raised by humans and chimpanzees who are more closely related to human phylogenetically (9-12). For example, they use human social and communicative behaviour (e.g. a pointing gesture or gaze cues) to find hidden food, and they know what the human can and cannot see in various situations (9, 10). These social-communicative skills seem to be a dog specie-specific feature, and represent a case of convergent evolution with humans, manly due to adaptation to human forms of cooperation and communication. Comparative studies between canid species, and in particular studies on foxes, *Vulpes vulpes*, experimentally domesticated, suggest that these unusual human-like social skills have a heritable component and initially evolved during domestication as a result of selection on systems mediating fear and aggression towards humans (10, 13-19).

Changes in the human-dog relationship and emerging problems in the urban areas: the case of the "dangerous dogs"

Since its domestication the dog has mainly had a functional role within the human rural communities, being used in hunting practices and to protect the human family, the house or the livestock. However, the socio-economical progress and urbanization of the Italian population following the end of the Second World War have changed the traditional human-dog (and dog-human) relationship, leading to management problems. Indeed, keeping dogs of any kind of breed or size as pets has become increasingly popular. As reported by the Italian Ministry of Health (Ministero della Salute), Italian families kept about 5.35 million of dogs as pets between 2005 and 2006 (20). However, the urban domestic environments are quite different from the rural environments, where these animals can more easily develop and maintain a cognitive and affective independence. Furthermore, some people have an overwhelming tendency to "personify" dogs, limiting or actively repressing the expression of their natural behavioural repertoire.

Adopting dog as pet requires to the human family the ability to face management problems, which, when not adequately managed, might eventually change the relationship with this pet, compromising its psycho-physical welfare while increasing the risk for regrettable incidents mainly related to excessive aggressive reactions. In reference to this, the case of the "dangerous

dogs" represents an issue of topical interest and very often an example of inadequate management of the dogs by their owners.

A study performed by the Department of Health and Human Service of the Centers for Disease Control and Prevention (USA; 21), reports that in 2001, an estimated 368,245 persons were treated for dog bite-related injuries in the United States (rate: 129.3 per 100,000 population). The injury rate was highest for children aged 5-9 years and decreased with increasing age. Approximately 154,625 (42.0%) dog bites occurred among children aged ≤14 years; the rate was significantly higher for boys (293.2 per 100,000 population) than for girls (216.7). For persons aged ≥15 years, the difference between the rate for males (102.9) and females (88.0) was not statistically significant. The number of cases increased slightly during April-September, with a peak in July (11.1%). For injured persons of all ages, approximately 16,526 (4.5%) dog bite injuries were work-related (e.g., occurred to persons who were delivering mail, packages, or food; working at an animal clinic or shelter; or doing home repair work or installations). For person aged ≥16 years, approximately 16,476 (7.9%) dog bite injuries were work-related (21).

Data collected by searching for news accounts and by use of The Humane Society of the United States' registry databank indicate that from 1979 through 1998, dog attacks resulted in more than 300 human dog bite-related fatalities (DBRF) in the United States (22). Most victims were children. At least 25 breeds of dogs have been involved in 238 human DBRF reported during this 20-year period. Pitt bull-type dogs and Rottweilers have been responsible for 66 and 39 human deceases respectively (22). However, although fatal attacks to humans appear to be a breed-specific problem, other breeds may bite and dangerously injure persons at higher rates. Indeed, fatal aggressions represent a small proportion of dog bite injuries to human, constituting less than 0.00001% of all dog bites annually (22).

With regard to Italy, up until today, very few and scattered studies have been focused on dog bite attacks towards humans and DBRF. Data mainly from non-official sources, such as newspapers and reports published on the web, indicate an estimation of 400-700 cases per year of persons incurring in nonfatal dog bite-related injuries, and 1-2 cases of deaths related to dog attacks per year. Most victims are children and elderly. However, cases of human dog bite-related injuries are most probably underestimated. Indeed, bite related incidents often are not denounced to authorities, injured persons and dogs' owners deciding amicably to negotiate the event, especially if bites do not result in serious injuries.

Episodes of canine aggressions on persons occurring in the last years - often also markedly pointed out by mass media - have become a serious problem of epidemic proportion, engaging on the front line the Italian Minister of Health to control this public health concern. In particular, the question on breeds of dogs that might result "dangerous" to humans has been a topic fervently debated by public opinion, and on September 2003 the Minister of Health has enacted breed-specific restrictions by an ordinance, listing 93 breeds of dogs as potentially "dangerous" to public heath (23). However, on October 17th 2003, the Consiglio Superiore della Sanità has rejected the list of "dangerous" dogs, indicating that "dangerous" breeds *per se* do not exist. As a consequence, the list of "dangerous" dogs has been modified and initially restricted to 18 breeds (24), and, more recently, further shortened to 17 breeds, Neapolitan mastiff being cancelled from the official list (25).

Clearly, genetic history can influence aggressiveness of breeds and individual dogs, selective breeding increasing or decreasing these tendencies. However, it is very important to keep in mind that levels of dog aggressiveness are mostly influenced by several environmental variables, including the extent of dog socialization to people (especially children), its training, the quality of its psycho-physical welfare, and the owner's ability to prevent and manage contexts that might induce dog excessive aggressive reactions. Thus, an increased knowledge of

dog's ethology can help people to avoid unpleasant incidents and improve the quality of the relationship with this pet.

Dog communicative signals: the language of body postures and facial expressions in social interactions

Notwithstanding the process of domestication, most of the ethological features related to dog social behaviour have not changed, and therefore they closely resemble those characterising the dog wild ancestor, the wolf.

Wild wolves are carnivores living in packs. The pack usually consists of the *alpha* individuals (the breeding pair) and their offspring. The *alpha* individuals actively try to suppress mating in the rest of the pack by agonistic behaviour (26,27). Two parallel hierarchies can be detected in the pack, a male and a female one. Both are essentially pyramidal in structure, since rank differences are most obvious between high-ranking individuals, and are less distinct between middle-ranking adults and between pups. There is generally a close relationship between age and rank, the oldest animals occupying the top of the hierarchy. Cross-sex dominance relationships between males and females of similar rank are weak or non-existent. The *alpha* female is highly aggressive towards other females in her pack before and during the mating season, apparently in order to prevent them from breeding. The *alpha* male tends to be highly aggressive towards intruders, but not to other pack members. A *beta* male can sometimes be distinguished, and an individual with this rank will often be the most aggressive male in the pack, but will reserve aggression towards the *alpha* male for direct challenges to his leadership. Low-ranking wolves tend to be sociable both inside and outside the pack (26,27).

The domestic dog refers to its human family in a way resembling that of the wolf pack. Indeed, a dog identifies as its pack the human family (by which it has been "accepted"), and recognizes a human member of the family as the *alpha* individual. Moreover, during its social interactions with both conspecifics and non-conspecifics, dogs use communicative signals similar to those used by wild wolves to communicate to each other, namely body postures and facial expressions (3,28,29). For example, both dog and wolf communicate their dominant social status by an upright body posture with the head and tail held high and the ears pricked. An aggressive dominant animal couples this body posture with raised hackles, curled lips and bared teeth. In contrast, subordinate dogs or wolves hold their body low, the ears flat, and the tail held low and close to the body, creating the general impression of a smaller animal. Subordinates that display a fearful behaviour exaggerate these postures by cringing, tucking their tails between their legs and generally reducing the overall apparent body size. Subordinates often approach dominant individuals in an enthusiastic greeting with extreme wagging of the tail whilst maintaining a low general body posture (30). This behavioural pattern may also be associated with nuzzling and licking the face of the dominant animal; such behavioural pattern has been also observed among wolf pups directed towards other members of the pack and among dog pups directed towards their mother, in both cases facilitating/encouraging food regurgitation by the adult. Subordinate displaying the posture for passive submission rolls on its back exposing its inguinal region (submissive urination may also occur), a behaviour evoking pup posture when its mother rolls it on its back and licks its ano-genital region to stimulate pup urination and defecation. Dogs show a similar behavioural pattern also in the interaction with their human family, performing an "enthusiastic" greeting ritual to a family member returning home after a period of absence.

Also dog communicative signals associated to play solicitation behaviour are similar to those observed between young wolves. The more common signals, especially in dogs, include the play bow, pawing with a front foot, twisting jumps and open mouthed panting (31).

Unlike wolves, dogs use a complex tail-wagging repertoire to communicate a variety of moods related to a variety of contexts (30). Loose, free tail-wagging indicates general friendliness, and often extends to incorporate the entire rump in subordinate animals. More anxious or nervous dogs tend to wag their drooping tails more stiffly, seemingly as a pacification signal. Rapid, stiff, upright "flagging" of the tail indicates threat and possibility of aggression (30).

Recent ethological observations have demonstrated that dogs perform asymmetric tail-wagging behaviours in response to different emotive stimuli (32). In particular, stimuli that could be expected to elicit approach tendencies, such as seeing a dog's owner, are associated with higher amplitude of tail-wagging movements to the right side, while, stimuli that could be expected to elicit withdrawal tendencies, such as seeing a dominant unfamiliar dog, are associated with higher amplitude of tail-wagging movements to the left side (32).

Dog aggressive behaviour

As already explained in this paper, aggression is the most commonly reported category of behavioural problems in domestic dogs. However, it is important to keep in mind that both intra- and inter-specific aggressive behaviour are a natural feature of both wild canids and domestic dogs behavioural repertoire. In addition, under natural conditions, the aggression of wild canids is held in check by the set of body postures and facial expressions previously described in this paper, which clearly communicate to the opponent animal the aggression motivation or intent. Usually, aggressive encounters are rapidly ended when one individual displays the "cut-off" behaviour, such as submissive postures and infantile vocalizations (whining, yelping; 33,34). Biting is a key component of the predatory behaviour in canids (predatory aggression; see Table 1). However, there are other contexts in which a dog, if not adequately trained by its owner, might display aggression by attacking and biting persons. Table 1 reports a schematic description of dog aggression contexts/circumstances.

Table 1. Contexts and circumstances of dog aggressions

Aggression	Context/Circumstances
Competitive	Attempt to acquire hierarchical privileges: control of space, sleeping area (bed, furniture, place on the carpet, etc.), social or sexual partners
Irritation	Frustration, hunger, pain
Maternal	Defence of the offspring
Fear	Inescapable and dangerous situations
Predatory	Hunting and capture of prey
Territorial	Attempt to avoid intrusion of invaders into (a part of) the pack territory

For example, dogs showing "competitive aggression" (also known as "dominance aggression" or "dominance-related aggression") tend to react aggressively to apparent challenges to their positions within the social hierarchy. These circumstances include those in which the owner is apparently treated as a competitor for resource (e.g. food, space, sleeping position, etc.) or in response to supposedly "dominant" gestures by the owner, such as holding,

petting, grooming, restraining, punishing or pushing past the animal, staring or yelling at it, or even leaning over it (35).

Commonly, competitive aggression is characterised by threats or attacks directed at the owner or a member of its human family rather than strangers. This form of aggression is also more commonly reported in intact males and neutered females, and it is one of the most frequent problems described by behaviour therapists and trainers (36-39).

Extreme "territorial aggression" represents another common behavioural problem in dogs. Like wolves, many dogs, especially those of guarding breeds, display a natural tendency to react aggressively to unfamiliar intruders (people and animals both conspecifics and non-conspecifics) within their home ranges. Home range or territory usually includes the immediate vicinity of the owner's home, but may also include other areas where the dog is regularly walked or confined. However, training the dog to bark without attack and bite an intruder invading the territory could prevent behavioural problem related to extreme territorial aggression. In reference to this, it had better train the animal to "control" its aggression towards intruders ever since its puppyhood.

Finally, social isolation (especially at puppyhood), restraint (such as chaining and the constriction in restricted spaces limiting dog performance of kinetic activities), and, more in general, all those life conditions preventing the expression of the dog natural behavioural repertoire, might lead it to experience fear, boredom, deprivation and frustration, with consequent excessive aggressive reactions towards people.

As previously reported, levels of aggressiveness may be affected by genetic factors. However, increasing evidence from ethological studies indicate that both social environment and events experienced during particular periods of the dog development can have more important effects than genetic influence on levels of aggressiveness at adulthood.

The development of dog social behaviour

A variety of studies on both human and animal models indicate that early social events, experienced during the so-called "critical periods" of the development, can induce long-term effects on social behaviour, predisposing to behavioural disturbances at adulthood.

As shown in Figure 1, among domestic dog pups, primary socialization period runs from about the third to the twelfth week after bird, with a peak of sensitivity between 6 and 8 weeks (35,40).

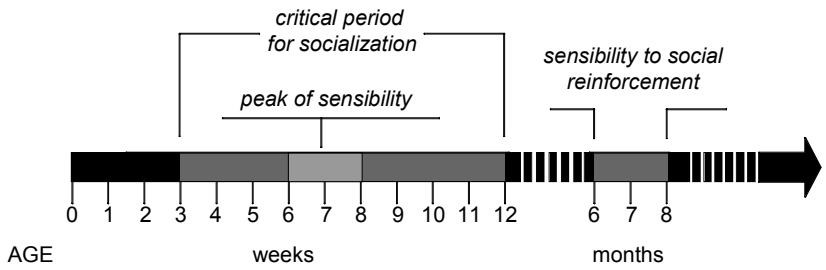

Figure 1. Critical developmental period for dog socialization ranges between 3 and 12 weeks of life, with an optimum between 6 and 8 weeks, and a period of sensibility to social reinforcement ranging between 6 and 8 months of life. Early social experiences, periodically repeated until about 8 months of age, favour attachment relationships with both conspecific and non-conspecific, determining the young dog's future social partners

Indeed, below 3 weeks of age, puppies' central nervous system seems too immature to permit socialization, and beyond 12 weeks their growing tendency to react fearfully to novel persons or situations could represent a limit for further socialization. However, between 6 and 8 weeks pup's social motivation to approach and make contact with unfamiliar persons or animals prevails over its natural diffidence towards novelty. Thus, this period represents the optimum time for socialization (35,40).

Among wild wolf pups, primary socialization ensures that the young animals consolidate social attachment relationship with their littermates, parents, and the other pack members. For what concerns the domestic dog, pups exposure to an adequate socialization during the developmental sensitive period allows they to form attachment relationship not only with conspecifics, but also with those non-conspecifics encountered in this period (41). Indeed, cross-fostering experiments demonstrate that dog puppies raised throughout the socialization period with only kitten littermates, as adults show a marked tendency to engage social interactions with cats and kittens, while the they tend to avoid conspecifics (42). Thus, the feature of the socialization experience not only determines the young animal's future social partners but also defines the species to which it effectively belongs. In addition, during the sensitive period for socialization, puppies also form the so-called "site attachment", namely the attachment for particular places. Therefore, during this developmental period, both the social and physical environment seem play a crucial role in determining pups attachments to both the living and non-living components of their rearing environment (40).

Ethological studies indicate that dogs reared in socially and physically impoverished environments from weaning until around 12-14 weeks of age as adults tend to exhibit neophobia when placed in unfamiliar situations, showing fearful and avoidant responses to anything novel or unfamiliar (35,43). However, in the absence of periodic social reinforcement until the age of 6-8 months, both young wolves and dogs, which were well socialized at 3 months, could, nevertheless, regress and become fearful again (see Figure 1).

Therefore, experiences, especially during the socialization period and later, between 6-8 months of age, plays a major part in determining which fears are acquired and how strongly they are expressed in adult life (see also 44). As a consequence, the provision of an enriched social, and stimulating physical, environment, by both breeders and owners, during the first 8 months of dog's life, may reduce the incidence of aggression-related behavioural problems, improving therefore both dog welfare and the quality of the dog/human relationship.

Conclusions

Among the different species of companion animals, the dog is the most preferred and desired pet by people, especially children. Certainly, many behavioural patterns displayed by dogs elicit a special attachment in the human partner. However, life together a dog requires diligence and a sense of responsibility from the human family.

Before adopting a dog, it should be opportune to consult a professional (e.g. veterinarian, dog behaviourist, or responsible breeder) to choose a suitable dog breed, sex, age, and temperament on the basis of the family's lifestyle and both the physical and social environment where the dog will live. Moreover, family members should spent time with dog before adopting it, especially in the case of families with children. In reference to this, it is advisable for parents to be sensitive to cues that a child is fearful or apprehensive about a dog: in this case it is important to delay the adoption of a dog. However, parents never should leave infants or young children alone with any dog. Children, in turn, should be educated for basic safety around dog.

Aggressive behaviour is a natural component of the dog's behavioural repertoire, which could become dangerous for persons because owners are often unable to adequately train their animals, or they are unable to prevent and/or manage those contexts eliciting responses excessively aggressive by their dogs. Often, owner's management mistakes are related to a poor knowledge of dog's ethology. Therefore, owner's education represents the only strategy to reducing unpleasant incidents due to canine aggressions. Indeed, an increased knowledge of dog's ethology can improve its psycho-physical welfare, reducing the misunderstanding risks with its human partner.

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