

# Scavenging Hypothesis: Lack of evidence for Dog Domestication on the Waste Dump

Christoph Jung<sup>1</sup>, Daniela Pörtl<sup>2</sup>

<sup>1</sup> *Petwatch, Halle, Germany,*

<sup>2</sup> *Psychiatric department, Saale-Unstrut Klinikum, teaching hospital Leipzig and Jena Universities, Naumburg, Germany*

**Abstract:** In the debate on canine domestication, researchers have identified a lot of valid information regarding the time, the region and the ancestor of the dog. But researchers are still figuring out, why and how this process started. The scavenging hypothesis, first proposed 2001 by Ray and Lorna Coppinger, proclaims the first human waste dumps as the ecological niche for the self-domestication-process of dogs. Many scientists refer to that model, sometimes partly modified. The scavenging hypothesis is broadcasted by most public media as the commonly accepted model of dog's domestication. Thus, we have to deal with that popular model. Based on a broad multi-disciplinary approach like human evolution, archaeology, palaeogenetics, psychology and neurobiology, we will look for evidence. Investigating nine assumptions of the scavenging hypothesis we did not find any evidence. Dog's domestication started thousands of years before the advent of food waste dumps. The scavenging hypothesis cannot explain why only wolves and never foxes nor jackals have been domesticated. Paleolithic people and ancient wolves were living together closely in the same ecological niche hunting the same prey with the same cooperative methods. It is likely that they met very often and knew each other very well. We have some hints, that ancient wolves and people treated each other with respect cooperatively. We have hints for an active cooperation from humans and dogs starting in the Upper Paleolithic period long before it would have even been possible scavenging human waste. We have hints for emotional bonds between ancient people and dogs. Emotional bonds would have been unlikely for an animal hanging around human settlements while scavenging carrion and feces, like the scavenging hypothesis describes. Looking at recent dogs and humans we have evidence for strong unique similarities in the psychological and neurobiological structures eventually allowing interspecific bonding, communication and working. Interspecific cooperation decreased the level of the stress axis of both species in the Paleolithic period and even does so today, what improves our social and cognitive abilities. We propose that dogs domestication could be understood as an active social process of both sides. Further investigations need a closely networked multidisciplinary approach.

**Key Words:** dog, wolf, domestication; scavenging hypothesis; stress-axis; coevolution.

\* *Corresponding Author:* jung@petwatch.de

## Introduction

Dogs (*Canis lupus familiaris*) are called our best friends. They are living in close proximity with us round over the world in quite all cultures during each historical period. But it is still an open question, how and why dog derived. Ray and Lorna Coppinger proposed a process of self-domestication as scavengers on the first human waste dumps (Coppinger & Coppinger, 2001; 2016). They observed recent dog populations in special ecological niches like on Pemba Island (Tanzania) or on the Mexico City waste dump. Those dogs are living primarily on and from human waste. Coppingers argue, that those dogs would be the original dog type. When human started the epoch of agriculture and permanent settlement, they produced first food waste dumps. These dumps have been a new ecological niche for wolves (*Canis lupus*). While scavenging and hanging around on the dumps, wolves with a temperament allowing them to approach humans showed higher reproductive success. Over the time specimens more tolerant to humans have been selected naturally. Thus, dog should have been derived. Many scientists refer to that hypothesis in their papers and even public media like BBC (2011) or New York Times (2017) are broadcasting this version. Therefore, it is worth looking for evidence supporting that popular model.

In the early two thousands dogs were making a comeback in science. Especially in the last years, a lot of valid research from several disciplines e.g. human evolution, archaeology, paleozoology, palaeogenetics, biology, psychology and particularly neurobiology has been published, providing hints and evidence for a better insight to understand how dog evolved. Thus searching for evidence of the scavenging hypothesis, we have to take a multi-disciplinary point of view. First, we will explore nine basic assumptions of this special dog domestication model.

### 1. *The time range dog domestication started*

The scavenging model envisages dogs coming up around 8,000 years ago (Coppinger, 2016, p.220), when human started the epoch of agriculture and permanent settlement in the region of the Fertile Crescent. Those human settlements produced first food waste dumps, which should have provided the new ecological niche where dog derived from wolf. However, there is clear evidence of much older dogs, pushing their origin back into an epoch at least 15,000 years ago when our ancestors were still hunting and gathering (Botiqué et al., 2017; Thalmann et al., 2013; Ovodov et al., 2011). Today it is commonly accepted, that dog derived in the Paleolithic period, thousands of years before the epoch of settled agriculture started, perhaps more than once, but especially in the area of the former Eurasian cold steppe, where we found the most remains of early dogs or protodogs, advent of agriculture started at first thousands of years later. As commonly accepted dog-remains in that region are much older (Germonpré et al., 2009, 2015; Losey et al., 2013; Janssens et al., 2018).

### 2. *Paleolithic people did not produce food waste dumps*

The Paleolithic Homo sapiens did not build any slaughter or kitchen dumps (Havlíček, 2015; Havlíček & Kuca, 2017). Even when they lived as nomads with regularly summer and winter camps they did not produce any dumps containing food. Nevertheless, it is quite unlikely, that butchering place and camping place have been at the same site. Butchering places were separated. They did not want to alert predators to their camps and they could not shoulder a killed mammoth. Nevertheless, our ancestors sometimes had a problem with waste. Archeologists describe four dump types during the Paleolithic period:

- a) Archeologists have found several stone tool factories with a lot of stone tool waste (Havlíček, 2015; Rust, 1948).
- b) In some caves burned bone dumps have been found (Jelínek, 1977; Boscha, 2012).
- c) And archeologists have found a lot of shell midden which did not have any potential benefit neither as construction material nor as fuel and surely not as wolf-food (Gutiérrez-Zugasti et al., 2011; Havlíček, 2015).
- d) Archeologists even found mammoth-bone accumulations, but without any tracks of bites from wolves or dogs. These mammoth-bone dumps served as a store of construction material or fuel (Boscha, 2012). In the cold steppe there was not enough construction- or firewood. Thus bones, fat and quite all other remains of the prey were used in daily life.

In sum Paleolithic people used the entirety of the carcasses for eating, clothing, warming or as tools or fuel. First waste dumps regularly containing food first appeared in the Neolithic period.

### 3. *And never enough*

Coppingers schedules the new ecological niche starting with the advent of settled agriculture. Other scholars, promoting this model, are pushing the timeline back to the period of hunters and gatherers. "First a founder group of less-fearful wolves would have been pulled

toward nomadic encampments to scavenge kills or perhaps salvage wounded escapees from the hunt.” (Driscoll et al. 2009) But, even if nomadic hunters might have temporarily produced food remains, it could never have been enough to feed a founder group of wolves. Paleolithic hunter clans consisted only of 20 to 50 individuals (Groeneveld, 2016). Nomadic hunters in the Eurasian cold steppe were permanently following the big herds of bovids or mammoths (Amkreutz et al., 2018). Even if they lived in temporarily camps producing food waste, it would have been never nearly enough to feed a founder population. Archaeologists argue: “When wastes accumulated, nomadic people would simply move to another location.” (Pichtel, 2005). To establish the new wolf-population shaping dogs, the Coppingers calculated, a dump size should provide food for 20 specimens, because 20 specimens were needed for a reproductive population to found a new wolf-type from which dogs could have been derived (Coppinger & Coppinger, 2016). The Coppingers further calculated that one dog needs the waste and feces of 14 people to survive (Coppinger & Coppinger, 2016). Therefore, we would need the waste and feces of at least 280 people for only one wolf-dog founder population. That is at least six-times too much for the real *Homo sapiens* living in that period – even if he would have produced food waste dumps. Paleolithic (temporarily) settlements simply could not have been big enough to provide a wolf-dog-founder population even if they would have produced feces and food remains.

#### 4. *Adaptation to starch-rich diet started long after*

The scavenging hypothesis proclaims: “The dog is a shape that evolved to a new niche that was created when people switched from hunting and gathering to growing grain. The waste products of that activity created a food supply that supports village dogs”. (Coppinger, 2016) Some authors are going on to say, that: “Only a time-machine would allow us to determine which scenario occurred, and quite possibly both processes played a role. However, independently of which pathway dogs took during domestication, the feeding niche of today’s wolves and dogs is remarkably different from each other and likely has been since the advent of cultivation” (Marshall-Pescini et al., 2015). Today’s dogs are living together with humans and they are used to human food as nutrition for thousands of years before the advent of settled agriculture. During the time range humans were living as hunters together with their dogs – a time range quite longer than the time range of settled agriculture – meat has been used as dog’s main or only diet, sometimes maybe a special meat diet. From the Gravettian site of Predmostí I, 25-27,000 years old, we have evidence, that protodogs had a high proportion of reindeer and muskox in their specific diet (Bocherens et al., 2014). At the beginning of settled agriculture, dogs had been slowly and only partly adapted to starch-rich diet (Axelsson et al., 2013), starting 7,000 years before present (Ollivier et al., 2016). Diet adaptation in dog even reflects the spread of pre-historic agriculture. Thus Nordic dog breeds are showing very little adaptation to starch-rich food till today (Arendt et al., 2016) and some breeds e.g. Laiki are still hunting small game for their own food (Beregovoy, 2001). On the other side some recent wolf populations are adapted to marine dietary niches (Darimont et al., 2014). Therefore, today’s food habits cannot create any explanation for domestication much more than 10,000 years ago. Domestication of plants as the basic feature of agriculture (settled or not) started less than 12.000 years bp (Meyer & Purugganan, 2013). Dogs derived many thousands of years before that period and especially before grain became a regular ingredient of dog’s diet.

#### 5. *Why wolves and not foxes?*

The scavenging hypothesis argues, that it was only the wolf which occupied the new ecological niche provided by human food waste. Scavenging and hanging around human settlements wolves with a temperament allowing them to approach these dumps showed higher reproduc-

tive success which favored their self-domestication. From generation to generation, they were genetically selected to be more tolerant to humans. Thus, dogs derived. Actually, it is commonly accepted that an ancient subspecies of the wolf was the only ancestor of recent dogs (Skoglund, 2015; Fan et al., 2016; Freedman et al., 2014; Thalmann et al., 2013). However, why wolves and not hyenas, bears, badgers, jackals, coyotes or foxes have been domesticated? They all were living in that period in the proximity to *Homo sapiens*. Many predators scavenging at least occasionally were living in the Paleolithic cold steppe, even *Homo sapiens* himself. Foxes (*Vulpes vulpes*) like scavenging on waste dumps (Hewson, 1983; Young, 2015). Foxes can be tamed very well as demonstrated in the Farm-fox experiment (Trut, 1999). They are smaller than wolves and, living near or inside the camps, they would have been no potential risk for death of clan members, especially toddlers (Kubinyi et al., 2007). Foxes like scavenging even downtown in big cities like Berlin (Hewson, 1983; Young, 2015). If scavenging and hanging around human settlements would have been the crucial impact of domestication, foxes or jackals would have been much better candidates for a self-domestication process on the waste dump. But it is likely, that neither foxes nor jackals were ever been domesticated in any culture or at any time. The scavenging hypothesis cannot explain why only the wolf, a potential dangerous and direct competitor, living in the same ecological niche, hunting the same game, should have been domesticated.

## 6. Evidence for pre-historic working dogs

We have evidence for dogs specialized in polar bear hunting and also special sled dog “breeds” (something like breeds) working together with hunter-gatherers 8,000 years ago (Pitulko & Kasparov, 2017). On Zhokhov Island in the far north of Siberia humans always lived in hunter groups. They never built any permanent settlements. Since the beginning of the Neolithic period, we have growing evidence for dogs as specialized working partners for hunting, herding, sledding, guarding in many regions (Guagnin et al., 2018; Pitulko & Kasparov, 2017; Perri, 2016; Jung, 2011). We know cave paintings and rock art from northern-Africa or the Arabian Peninsula showing man and dog hunting or herding together thousands of years before advent of settled agriculture in these regions (Guagnin et al., 2018; Coulson & Campbell, 2001; Holl, 2004). A dog, able to work together with humans, an already specialized dog, maybe something like an early dog breed, could not derive just from scavenging and hanging around on waste dumps. “Breed” dogs when fossilized are only the late, visual result, not the (practical) beginning of an active partnership. The early onset of specialized working “breeds” (fossilized) means a much older working-together-culture.

## 7. Honor for a scavenger?

Archaeologists have found a lot of Paleolithic graves containing dogs or dogs and humans together all over the world e.g. in the Green County, Illinois, USA, 8,500 years old, a human-dog grave in Israel 12,000 years old and in Oberkassel, Germany, 14,200 years old (Morey & Wiant, 1992; Morey, 1994; Janssens et al., 2018). It surely was a hard work to scoop out a grave with stone tools. The corpses had been buried carefully, partly provided with food for a life after death. From a psychological point of view, we can assess such burials as an honor. It seems very unlikely, that so much respect had been shown just for a scavenger hanging around. We further might argue that such dogs were ceremonially buried to serve as guards or to help a dead hunter in the afterlife. And this would have been an honor for the dogs as well. Both options do not fit to an animal characterized as a scavenger, hanging around, eating carrion and feces. Careful analysis of the remains of the oldest human-dog grave in Oberkassel gives us an impression about dogs emotional relationship to Paleolithic people (Janssens et al., 2018). The grave in Oberkassel contained two humans and in addition the remains of two dogs, an older one and a

puppy. The pup died at an age of seven months. An analysis of its bones and teeth revealed that it likely had a serious case of morbillivirus and it likely contracted the disease at around three to four months of age. It probably suffered from two or three periods of serious illness. Without special care, this young dog would have died very shortly after contracting it the first time. But it received intensive human care. “Without adequate care, a dog with a serious case of distemper will die in less than three weeks”, lead-researcher Janssens explains (Janssens, 2018). This dog was clearly seriously ill but it survived a further eight weeks, which would only be possible if it had been well cared for. Janssens goes on to say: “That would mean keeping it warm and clean and giving it food and water, even though, while it was sick, the dog would not have been of any practical use as a working animal. This, together with the fact that the dogs were buried with people who we may assume were their owners, suggests that there was a unique relationship of care between humans and dogs as long as 14,000 years ago.” (Janssens, 2018) Working and living together, not side by side, leads to interspecific emotional bonds, to reputation and honor. Would have people shown so much care just for a scavenger?

### 8. Cooperation or competition

Recent European and North American cultures produce an image of the human-wolf relationship as a hostile rivalry and the wolf is seen only as a competitor (Fogg & Pierotti, 2017). In all regions of Europe wolves have been strongly hunted for hundreds of years. Wolves have been exterminated in wide areas, from Europe over Asia up to North America since a long time. To survive gray wolves have to become very timid. Their recent behavior is the result of a strong selection favoring the shyest and least human socialize able specimen (Boitani, 1995). Thus, recent wolves have strongly internalized to avoid any human contact. But not all wild wolves do so. The Arctic wolves on Ellesmere or Baffin Islands in the far north of America do not fear humans as much. Arctic wolves (*Canis lupus arctos*) have never been hunted in large scale. They are interested to contact humans (Mech, 1997; Marshall Thomas, 2000; DeLallo, 2011). It is documented, that human lived with Arctic wolf packs over several month, even allowed to look after the pups in the den when the pack was hunting (Fogg & Pierotti, 2017). Those Arctic wolves accepted human individuals as a kind of pack members.

### 9. Wolf as a friend in Native cultures

Indigenous peoples use to describe wolves are brother, grandfather, relative, companion, teacher and even creator (Schlesier, 1987; Marshall 1995; Fogg et al., 2015). From hunters of Siberia to Native Americans wolves and dogs are seen with much respect, mostly as friends or companions. In the pre-Christian religions and mythologies wolf is described in a similar way and regularly as a divinity or a companion of a divinity (Oeser, 2007). It is quite rarely that the wolf is mainly described as an aggressive animal or only as a competitor. But the Wolf is never described as scavenger nor hanging around human settlements (Fogg & Pierotti, 2017).

## Discussion

In these nine issues, we did not find any evidence for the basic assumptions of the scavenging hypotheses neither from an archaeological, nor from an evolutionary, paleozoological, biological or cultural point of view. The fundamental assumption of the scavenging hypotheses in all variations is, that the ecology of wolves, characterized by “Group-hunting of ungulates” should have been changed to a new ecology of dogs characterized by “Human refuse scavenging” (Marshall-Pescini et al., 2015). These models proclaim that the domestication process of dogs would

have been based fundamentally on a scavenging niche provided by humans and scavenging would be the real nature of dogs until today. Coppingers assume: “The message of this chapter is, those look-a-like dogs, in the same way as look-a-like pigeons, have evolved right there in their niche and are uniquely adapted to this niche. They are not escapees from irresponsible dog (or pigeon) owners. They are a natural species that lives close to humans, finds its own food, and mates perfectly well without human control” (Coppinger & Coppinger, 2016). We have demonstrated that it is quite unlikely, that a sufficient scavenging niche existed during the time range dog originated. It is unlikely as well, that the scavenging hypothesis should be the main evolutionary story for a non-human animal, called human’s “best friend”, closely living and cooperatively working with humans.

### *Interspecific emotional bonding*

Unfortunately, we do not have a time machine, but scientists from many disciplines are collecting hints and even evidence to fill out the dog domestication mosaic. Step by step, we are getting a more accurate approach to the time range when the domestication of the wolf began (Theofanopoulou et al., 2017). The grave in Oberkassel e.g. gives as a serious hint about dog’s emotional relationship to the Paleolithic people, like basically all burials of dogs in that period. In addition, we have many psychological and neurobiological arguments not only to explain reliably such emotional bonds in the Paleolithic period. Emotional bonds and common graves are indicating that both species had shared their lifetime. Humans and dogs had lived together, not side by side like animals hanging around as scavengers on hypothetic waste dumps. Human associated wolves and hunter-gatherers became familiar, behavioral cultures were formed (Wayne, 2014; Foote et al., 2016; Filatova et al., 2015; Avital & Jablonka, 2000). It is likely that humans and dogs were working together and that dogs had been selected therefore which had been started in the Upper Paleolithic period (Wang, 2013; Jung, 2011). Man and dog hunted together in the Eurasian cold steppe (Shipman 2015; Coulson & Campbell, 2001; Holl, 2004) as well as in many other regions e.g. Persia (Hole, 2007), Japan (Perri, 2016) or the Arabian Peninsula (Guagnin et al., 2018). Lead researcher Guagnin (2017) goes on to resume: “Hunting scenes depicted in the rock art illustrate dog-assisted hunting strategies from the 7<sup>th</sup> and possibly the 8<sup>th</sup> millennium BC, predating the spread of pastoralism.” Working together with dogs must have been an essential condition for humans to keep wild goats starting the era of livestock farming. Man and dog protected each other to avert danger. Dogs are used for transportation for at least 9,000 years (Pitulko & Kasparov, 2017). Pitulko & Kasparov assume: “It can be hypothesized that dog teams might have been used in Siberia as early as 15,000 years ago.” It is a long way to develop the ability to herd, hunt and transport together as an interspecific team. Even the tamest wolf would never be interested in herding, sledding, or hunting together. Dogs are actively interested in working together with their people. This trait is commonly called “will-to-please”. If we have specialized dogs as herding, hunting, sledding partners since thousands of years. Hence, dogs must have been evolved completely and segregated from their wild ancestors. This segregation should have been primarily based on mental skills (Saetre et al., 2014; Pörtl & Jung, 2015, 2017; Fogg & Pierotti, 2017). *Canis lupus* really provided all basic requirements to evolve such abilities of cooperation with humans as later seen in dogs.

### *Why foxes cannot become dogs*

Foxes do not provide these basic requirements, although they are also canid hunters and scavengers. They like human waste dumps. Foxes use to steal chicken in the middle of human settlements and do not have any fear of living close to humans even downtown in the biggest cities with much traffic (Plumer, 2014). Therefore, they should have been the fittest candidates

for a domestication process as scavenger on human waste dumps. Nevertheless, foxes have never been domesticated naturally. Foxes are loner, whereas wolves are highly social. That is one of the crucial differences. Jackals (*Canis aureus*) are socially living in family groups. They are scavengers and hunters. However, they are hunting only small game, mainly rodents, and mostly alone (Lanszki & Heltai, 2002). Hunter and gatherer in the Paleolithic period preferred big game like mammoth or bison. They were hunting collectively. Human and wolf hunted the same big mammals with the same cooperative methods in exactly the same ecological niche. Arriving in the Paleolithic cold steppe at least 40,000 years ago, our human ancestors did not have any practice how to hunt a mammoth (Shipman, 2015; Fogg & Pierotti, 2017). Wolves already lived there for many thousands of years well used to hunt big dangerous prey very successfully. It is not unlikely that the first Homo sapiens observed wolf packs hunting big prey and so learned better how to do it by himself. Native American people claim to have learned to hunt from wolves (Schlesier, 1987; Marshall, 1995; Fogg et al., 2015). Native people in Northern America used to hunt bison with a wolf mask (Marshall, 1995; Fogg & Pierotti, 2017).

### *The crucial role of the HPAaxis...*

The Siberian Farm-fox-experiment demonstrates that modulations of the Hypothalamic-pituitary-adrenal (HPA) stress axis are playing a key role in domestication (Hekman et al., 2018). Domestication includes decreased aggression and decreased flight distance concerning to humans (Benecke, 1994; Hare et al., 2012). Thus, a decrease of HPAaxis activity is fundamental in dog's domestication process (Pörtl & Jung, 2017). Regulation of HPAaxis is inherited epigenetically and thus operates very quickly during evolution (Pörtl & Jung, 2017; Ahmed et al., 2014; Trut et al., 2009; Buschdorf & Meaney, 2015). Due to increased interspecific pro-social contacts between wolves and humans epigenetically based down regulation of HPAaxis promoted better executive functions and improved social learning capability in both species (Miklosi et al., 2003; Hare et al., 2005). Thus, tamed wolves became domestic dogs by integrating themselves into human social structures. And humans increased their social and cultural practice also described as human self-domestication syndrome (Hare, 2012).

### *... and social similarities.*

It is commonly accepted, that humans and wolves period lived in similar structured highly social family groups during the Paleolithic (Mech, 1999, Page et al., 2017). They reared their offspring collectively (Page et al., 2017). Both hunted in-group cooperatively in exactly the same ecological niche (Shipman, 2015). They must have seen, smelled, heard and felt each other very intensively. Thus, individual bonding was enabled (Bartal et al., 2011; Romero et al., 2014; Joly-Mascheroni et al., 2008). Sharing the same ecological niche and the same behavior leads to similar experience. Hence creating an enlarged interspecific resonance space facilitating empathy. We have to deal with those social traits to identify the neurobiological reasons for the wolf's self-domestication and the deriving cooperation abilities.

### *Behavioral cultures for cooperation*

In the today's western culture, the wolf is seen only as a competitor (Fogg & Pierotti, 2017). Recent Arctic wolves, mythologies all over the world and the cultural heritage of native Nordic peoples report an alternate role (Fogg & Pierotti, 2017). The wolf is described as a cooperation partner, as a teacher, a friend like described above. Wolves and dogs have never been addressed as scavengers hanging around humans – neither in mythologies nor from Native Peoples. Recent Arctic wolves are actively interested in contact with humans, even joining to them. There-

fore, it seems not to be unlikely that some Paleolithic hunter clans and some wolf packs once established a loose tradition of cooperation. Both species are able to form behavioral cultures for interspecific cooperation and to pass them on from generation to generation (Heinrich, 1999; Wayne, 2013). Later on as result: Better hunting success and more power to defend the carcass against third predators could have been some of the direct advantages of this cooperation. Nevertheless, the main impact might have been on the mental site.

### *Neurobiological requirements for cooperation*

Scientific research of different disciplines like neurosciences and psychology validates increased evidence for similar social functions of dogs and humans (Spunt et al., 2017; MacLean et al., 2017b). Research of brain activities demonstrate very similar mental functions (Ledoux, 2012; Gimpl & Fahrenholz, 2001; Reep et al., 2007) which enabled both of them to interact and communicate with each other (Heberlein et al., 2016; Darwin, 1910). fMRI pictures and movies demonstrate nearly same activities of brain regions in dogs and humans (Desmet et al., 2017; Andics et al., 2014; Berns et al., 2012; Berns, 2015, 2017) like EEG transients as well (Iotchev et al., 2017). We can measure basically the same release of neurohormones in both species (MacLean et al., 2017a; Berns, 2015, 2017). We have reliable evidence concerning interspecific functions like mirror neurons, joint attention and even empathy (Romero et al., 2013; Szánthó et al., 2017). Dogs are able to discriminate and recognize the emotion of a human face simply by using parts of human faces (Huber et al., 2013; Albuquerque et al., 2016). Dogs show emotional contagion with other dogs, but also with humans (D'Aniello et al., 2018; Takaoka et al., 2015; Custance & Meyer, 2012; Yong & Ruffman, 2014; Huber et al., 2006). Dogs understand a lot of communicative signals like odor, expressions, gazing or pointing and even some of our intentions (Kaminsky et al., 2013; Kujala et al., 2017; Schwab & Huber, 2017). Eventually we have preliminary evidence for interspecific Theory of Mind in dogs in relation to humans (Müller et al., 2015). Last but not least we have to deal with very interesting facts due to modulations of neurotransmitters and stress axis functions, where we see significant similarities in functions and epigenetic modulations (Meaney & Szyf, 2005; Kis et al., 2017; Cimarelli et al., 2017; Hekman et al., 2018). In sum we have reliable evidence for similar social skills of human and dog due to similar brain functions. These similarities are much stronger than similarities with our closed genetic relatives under the non-human animal kingdom.

Today's evidence for similar social skills are at least reliable hints at social skills of Paleolithic humans and their evolving dogs (Theofanopoulou et al., 2017). To sum up, with archaeological, paleogenetical and paleozoological findings we got a powerful framework to understand the mental and social conditions of dog domestication. Therefore, we get a growing foundation to understand the inner processes that turn a wolf into a dog. 40.000 years ago, the invasive Homo sapiens, capturing the Eurasian cold steppe, really created a new ecological niche: himself. The nature of this new niche was not mainly or even only waste. Our hypothesis states, that it must have been essentially a broad social process. The engine promoting this special domestication process must have been much more than only a simple genetically selection for tameness. It must have been an active socially based process on both sides driven by epigenetic features.

## Conclusions

The scavenging hypothesis describes the first human waste dumps as the new ecological niche for dog's domestication initiating genetic selection for tameness. Genetic selection for the ability "to eat in the presence of people" (Coppinger & Coppinger, 2016) should have been the only or at least the main factor in this self-domestication process. Eventually dogs should to be

characterized as scavengers, wolves as hunters (Coppinger, 2001, 2016; Marshall-Pescini et al., 2015). In our review we have summarized that these models are unlikely and should have been dropped.

The variety of disciplines, we have studied, do not provide any reliable evidence for human waste dumps as a hypothetical ecological niche for dog's domestication. Nevertheless, it is likely that scavenging carcasses would have been one of the sites humans and wolves met each other. And there should have been much more options to meet and to get known, eventually becoming familiar with each other e.g. while hunting or camping, while defending killed prey against thirds or rearing a lonely wolf pup. We think it is much more helpful to look at the psychological factors allowing a wild wolf to live voluntary within human societies without stress on both sides, without leashes and eventually working cooperatively with humans. We suggest genetic selection as a necessary prediction but not a sufficient explanation of dog's domestication pathway (Jensen, 2015).

We are proposing the hypothesis of the "Active Social Domestication" of dog (Pörtl & Jung, 2013, 2015, 2017). As the name already implies, this model describes dog's self-domestication as an active socially based process concerning both species. This unique kind of domestication was primarily an interspecific social process. Prosocial interactions reduce the activity of the stress axis via epigenetic modulations (Oliva et al., 2016; Meany, 2001; Weaver et al., 2004). The wolf integrated himself into the way of life of Paleolithic hunters. It was an active process on both sides. Evolutionary continuity of mammalian brains enabled both, human and wolf, mutual interactions which reduced stress on both sides and eventually favored what we call domestication (Ledoux, 2012; Gimpl & Fahrenholz, 2001; Reep et al., 2007; Spunt et al., 2017). Both of them wanted to cooperate, to live together and to work with each other (Pörtl & Jung, 2015, 2017). Advantages are known on both sides but not primarily in immediate effects like better hunting success, protecting, watching or warming. Lower permanent stress levels promote the frontal brain functions, contributing to better executive functions and improving social learning capabilities in both species (Hare et al., 2012). This allowed human associated wolves to grow into domestic dogs. We suggest, that modulations of the HPA axis are playing a key role (Hekman et al., 2018).

During the last 150 years most dogs turned from a role in human production to one in our mental welfare (Jung, 2011; Jung & Pörtl, 2015). But this role is neither new nor less important. Dogs have been – and still are – our social bonding partners for thousands of years. Even today we have some preliminary evidence, that dogs provide a general healthy influence (Mubanga et al., 2017) and specially a healthy influence on human stress system (O'Haire & Rodriguez, 2018; Julius et al. 2014; Beetz et al., 2012). Dogs improve our social and cognitive abilities. In addition, dogs feel like us as shown by neurobiological investigations (Berns, 2017).

For a better understanding of the metamorphism from the wild wolf to our family dogs, it is indispensable to take a multi-disciplinary approach. Co-Evolution of men and wolf resp. dog is a unique phenomenon in nature. It is an important part of our culture, social history and economic development. To understand dogs we have to understand humans. Dog's evolution is very closely linked to human evolution and history. It is an archaeological and paleogenetical issue and particularly a unique psychological and neurobiological challenge still today. Further research should deal with psychology, neurosciences, epigenetics and further disciplines in a broad and close multidisciplinary way.

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Daniela Pörtl and Christoph Jung contributed equally to this work.

Correspondence and requests for materials should be addressed to Christoph Jung. Obschuetzerstrasse 17. D-06667 Weissenfels. Germany Email jung@petwatch.de Phone +49 17656859000 Fax +49 321 21206281.

L'ipotesi della domesticazione attraverso il commensalismo (ipotesi "scavenging"): non esistono evidenze scientifiche di una domesticazione del cane nelle discariche

Christoph Jung<sup>1</sup>, Daniela Pörtl<sup>2</sup>

<sup>1</sup> *Petwatch,*

<sup>2</sup> *Psychiatric department, Saale-Unstrut Klinikum, teaching hospital Leipzig and Jena Universities, Naumburg, Germany*

### *Sintesi*

Nel dibattito sulla domesticazione dei cani i ricercatori hanno identificato molte informazioni riguardanti il tempo, la regione e l'antenato del cane. Ma i ricercatori stanno ancora cercando di capire perché e come sia iniziato questo processo. La "scavenging" ipotesi, proposta per la prima volta nel 2001 da Ray e Lorna Coppinger, sostiene che le prime discariche di rifiuti umani siano state la nicchia ecologica per il processo di auto-domesticazione dei cani. Molti ricercatori si riferiscono a quel modello, a volte parzialmente modificato. L'ipotesi di scavenging è diffusa dalla maggior parte dei media pubblici come il modello comunemente accettato di domesticazione del cane. Quindi dobbiamo occuparci di quel modello popolare. Basandoci su un ampio approccio multidisciplinare come evoluzione umana, archeologia, paleogenetica, psicologia e neurobiologia, cercheremo di trovare le prove esitenti.

Indagando su nove ipotesi dell'ipotesi di "scavenging", non abbiamo trovato alcuna prova. La domesticazione del cane iniziò migliaia di anni prima dell'avvento delle discariche di rifiuti alimentari. L'ipotesi di "scavenging" non può spiegare perché solo i lupi e non le volpi e gli sciacalli siano stati addomesticati.

I popoli paleolitici e i lupi vivevano insieme nella stessa nicchia ecologica, cacciando le stesse prede con gli stessi metodi cooperativi. È probabile che si siano incontrati molto spesso e si conoscessero molto bene. Esistono alcuni indizi che i lupi e le persone si siano trattati con rispetto in modo cooperativo e che vi sia stata una cooperazione attiva tra uomini e cani a partire dal Paleolitico superiore, molto prima che fosse possibile nutrirsi di rifiuti umani. Esistono prove di legami emotivi tra l'uomo preistorico e cani. I legami emotivi sarebbero stati improbabili per un animale che gironzolava attorno agli insediamenti umani mentre scavava carogne e feci, come descrivono le ipotesi di "scavenging". Guardando i cani e gli esseri umani attuali abbiamo prove di forti somiglianze uniche nelle strutture psicologiche e neurobiologiche che consentono un legame interspecifico, la comunicazione e il lavoro.

La cooperazione interspecifica ha ridotto l'attività dell'asse ipotalamo-ipofisi e surrene di entrambe le specie nel periodo Paleolitico e lo fa anche oggi e ciò migliora le nostre capacità sociali e cognitive. In questa review si propone che l'addomesticamento dei cani possa essere inteso come un processo sociale attivo di entrambe le parti. Ulteriori indagini richiedono un approccio multidisciplinare strettamente connesso.