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When cats' ways of life interact with their viruses: A study in 15 natural populations of owned and unowned cats (*Felis silvestris catus*)

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ABSTRACT

In natural populations, virus circulation is influenced by host behavior and physiological characteristics. Cat populations exhibit a great variability in social and spatial structure, the existence of different ways of life within a same population may also result in different epidemiological patterns. To test this hypothesis, we used a logistic regression to analyze the risk factors of Feline immunodeficiency virus (FIV), feline herpes virus (FHV), feline calicivirus (FCV), and feline parvovirus (FPV) infection in owned (fed and sheltered) and unowned (neither fed nor sheltered, unsocialized) cats living in a rural environment in the North Eastern part of France. A serological survey was carried out in 492 non-vaccinated and non-sterilized individuals from 15 populations living in the same area. The prevalence of feline leukemia virus (FeLV) was also studied, but too few were infected to analyze the risk factors of this virus. For each virus, the epidemiological pattern was different in owned and unowned cats. Unowned cats were more frequently infected by directly transmitted viruses like FIV, FHV and FCV (21.22%, 67.66%, 86.52% in unowned cats *vs* 9.55%, 53.88%, 77.18% in owned cats, respectively), a difference that may be explained by a more solitary and more aggressive behavior in unowned adults, and/or possibly by a higher sensitivity related to a more stressful life. On the contrary, owned cats were more frequently infected with FPV (36.41% in owned cats *vs* 15.61% in unowned cats), possibly as a result of their concentration around human settlements. The present study showed that owned and unowned cats living in a same area have behavioral and physiological characteristics sufficiently different to influence virus circulation. Pooling different types of cats in a single sample without taking it into account could give a wrong picture of the epidemiology of their viruses. The conclusion of this work can be extended to any epidemiological studies led in wildlife species with flexible behavior as any variations in social or spatial structure, between or within populations, could result in different virus circulation.

1. Introduction

The domestic cat (*Felis silvestris catus*) is the natural host of several viruses that infect the feline population worldwide, as well as wild felids and sometimes other wild carnivores (Nishimura et al., 1999; Driciru et al., 2006). The most important viruses of cats are feline immunodeficiency virus (FIV), feline leukemia virus (FeLV), feline herpesvirus (FHV), feline calicivirus (FCV) and feline parvovirus virus (FPV). FIV and FeLV, two retroviruses, are major non-traumatic causes of death in adult cats, and are associated with immunosuppression causing secondary infection (Courchamp and Pontier, 1994; Lutz et al., 2009). These retroviruses can infect other felids, most of which are

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threatened or endangered species e.g. the European wildcat (*F. s. silvestris*) (Courchamp and Pontier, 1994; Ostrowski et al., 2003; Troyer et al., 2005) or the Iberian lynx (Meli et al., 2010). FHV and FCV are responsible of upper respiratory tract disease, of concern in veterinary medicine (Radford et al., 2009; Thiry et al., 2009). FPV infects all felids, as well as other carnivores (Steinel et al., 2001), and FPV infection may be fatal especially in kittens (Truyen et al., 2009). Although these viruses have been extensively studied, little is known about their prevalence and risk factors in natural cat populations. Most of the studies focused on multiple households, catteries or shelters and on cats visiting veterinary clinics (e.g. Ishida et al., 1989; Tenorio et al., 1991; Binns et al., 2000; Bannasch and Foley, 2005; Helps et al., 2005; Coyne et al., 2006; Blanco et al., 2009; Murray et al., 2009; Ueland and Lutz, 2010). However, the behavior of domestic cats is extremely flexible and contrasted social organizations are observed depending on the characteristics of the environment (Liberg et al., 2000). As the risks of infection are often linked to behavior and social structure (Pontier et al., 2009), different epidemiological patterns are expected from one population type to another.

Within rural populations of domestic cats, two ways of life coexist. On the one hand, owned cats are free to roam and hunt preys but are dependent on food and shelter provided by the owner. They can thus be considered as "semi-dependent" on human beings in regard to trophic resources. On the other hand, rural unowned cats are usually unsocialized and mainly live on hunted preys (mostly rodents, lagomorphs, birds; Liberg, 1980). They can be considered as "independent" on human beings for trophic resources, although they may opportunistically access cat food, garbage or road kill they may find around villages. They are therefore continuously exposed to the spatial and temporal fluctuations of their resources and climatic conditions. Hence, owned and unowned cats differ in their access to food resources and shelters. This exposition to different constraints may result in variations of behavior and expression of energetic trade-offs, even if they are living in the same area. We expect unowned cats to allocate more energy to foraging and thermoregulation than owned cats, at the expense of some other functions, including immunity. Unowned cats could also be more aggressive than their owned fellows, as suggested by Liberg (1980), and more solitary, as suggested by previous studies on cats living in rural or wild areas feeding entirely on natural prey (Corbett, 1979; Say et al., 2002). In addition, unowned cats may have larger home ranges as they may need to compensate for variations in the abundance of small rodents (Liberg, 1980), contrary to owned cats who can easily find food and shelters in human habitations to ensure their security and energetic requirements (Dards, 1978; Macdonald and Apps, 1978; Liberg, 1980). Indeed, as for other carnivores, the size of cats' home range depends on the spatial and temporal availability of their prey (Macdonald, 1983; Liberg and Sandell, 1986). According to previous studies, the spatial distribution of owned domestic cats could actually be determined by the structure of human housing (Pontier, 1993), with home ranges centered on farms (Germain et al., 2008) and cats of the same group having overlapping ranges (Macdonald and Apps, 1978; Corbett, 1979; Liberg, 1980; Izawa et al., 1982).

Factors predisposing individuals to infectious diseases are usually of behavioral or physiological nature. These differences in social and spatial behavior as well as possible variations in energetic trade-offs between owned and unowned cats may therefore lead to different prevalence and risk factors for the main viruses. The relative roles of behavior and physiology depend probably on the transmission mode and characteristics of the viruses. We propose to study the effect of four factors linked to cat behavior: sex, age, orange phenotype and body mass, in unowned and owned cats living in the same area. Sex and orange phenotype are likely to influence agonistic behaviors as males are known to be more aggressive (Liberg and Sandell, 1986), such are also suspected orange cats (Pontier et al., 1995, 1998), whereas age and body mass may influence any social interaction (Courchamp et al., 1998; Natoli et al., 2005). The five viruses listed previously are particularly interesting to study in this context because their transmission modes and characteristics are different. FIV is mainly transmitted by bites, through a direct horizontal mode (Sparger, 1993). Within domestic cat populations, the virus is principally transmitted during aggressive or sexual contacts (review in Courchamp and Pontier, 1994; Bendinelli et al., 1995). On the contrary, FeLV, FHV and FCV are transmitted through 'amicable' contacts. FeLV is transmitted by the saliva or blood mainly during licking and grooming (Francis et al., 1977), and more rarely by bite (Hoover and Mullins, 1991). FHV and FCV are transmitted by oral, nasal and ocular secretions during close interactions (Povey and Johnson, 1970; Gaskell and Povey, 1982). FHV infected cats become asymptomatic carriers, but the latent infection can be reactivated by a stress (i.e. change of habitat, lactation or fights between males; Gaskell and Povey, 1977). As for FPV, it is transiently excreted in feces, urine, saliva and vomiting and its high resistance in the environment (still infectious after 13 months at 4–25 °C; Csiza et al., 1971) makes indirect transmission through feces and feces-contaminated premises or fomites largely predominant (Reif, 1976). After infection by FIV, FCV, FHV or FPV, contamination seroconversion is usually observed, and antibodies may persist for months or years. FIV infection leads to lifelong seropositivity; FHV antibodies may persist for several months after primo-infection or reactivation of latent infection (H. Poulet, personal communication); FCV antibodies for several months or years (H. Poulet, personal communication); FPV antibodies for several years (Csiza et al., 1971).

In this paper, we analyzed the risk factors of the five viruses in owned and unowned cats living in a rural environment in the North Eastern part of France. Considering the modes of transmission of the five viruses, we expect the risk factors of FCV, FHV and FeLV to be similar, but different from those of FIV and FPV. In addition, the epidemiological patterns of those infections should reveal differences in behavior and physiology between owned and unowned cats. The impact of not distinguishing between owned and unowned cats will be investigated by pooling them in the same analysis.