Title: Breeding success of barn owls reflects risk of hantavirus infection.

Can grave and formal pass for wise, When Men the solemn Owl despise? (Benjamin Franklin)

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Sir:

Hantaviruses (genus *Hantavirus*, family *Bunyaviridae*) are carried worldwide by rodents, bats and insectivores. In Europe, hemorrhagic fever with renal syndrome (HFRS) may be caused by infection with Dobrava virus (DOBV), carried by *Apodemus flavicollis* (yellow-necked mouse). A milder form of HFRS –nephropathia epidemica- may be caused by infection with Puumala virus (PUUV), carried by *Myodes glareolus* (bank vole). Hundreds of DOBV caused infections and thousands of PUUV caused infections occur in Europe each year. In Belgium, only Puumala virus (PUUV) infections occur (Heyman et al. 2009). We already identified domestic dogs and cats as sentinels for hantavirus occurrence (Dobly et al., 2010), but it is clear that in the complicated system that nature is, many factors may give additional indications for the risk of acquiring hantavirus infection.

Despite of this constant threat, hantavirus infections in humans show cyclic variations and many biotic and a-biotic parameters influence the occurrence of these infections over time. The likeness of a virus-human encounter is correlated to the amount of virus in the environment and thus to the number of virus-shedding rodents (Heyman et al. 2009). As rodent population dynamics in Western Europe are driven by food availability (fruits, seeds, insects, etc), their mammal and avian predators depend on their abundance for their own survival, breeding success and litter size. The abundance of predator species that prey on rodents may thus give indications for the risk for hantavirus infections in humans.

The Barn Owl (*Tyto alba,* family *Tytonidae*) is the most widely distributed owl species in Europe. The bird feeds primarily on small vertebrates, particularly rodents. Rodents, especially voles (*Arvicolidae*), make up at least 70% of the biomass eaten by the Barn Owl. An individual Barn Owl consumes one to five rodents per night and a nesting pair with four young eats approximately 1,500 rodents per year (De Bruijn, 1994; Smets and Lefebvre, 2002, 2003, 2004, 2005).

When the population of a rodent species (belonging to the *Muridae*, *Cricetidae* or *Arvicolinae* family) peaks, the Barn Owl tend to specialize on this species and it may become its main prey (Klok and De Roos, 2007). It was established that the Barn Owl's diet is also subject to change depending on habitat and geographical location (Libois et al., 1983; Barbosa et al., 1992; De Bruijn, 1994; Almzatos and Goutner, 1999). In Western Europe the Barn Owl normally hunts rodents that have their habitat in grassland e.g. the field vole (*Microtus arvalis*). Small rodent population dynamics however display interspecific synchrony (Huitu et al., 2004; Liebhold et al., 2004)**.** The breeding success of the Barn Owl due to peaking *Microtus* populations also reflects the population density of other Microtine rodent species like *Myodes glareolus*, the vector for Puumala hantavirus (Carslake et al. 2010; Hansski et al. 2001, Lambin et al. 2006). *Moreover,* Barn Owl population dynamics are –similarly to that of its prey- regulated by r-selection (Stenseth, 1978; Altwegg et al. 2007).

Besides the natural population fluctuations due to adverse climatic conditions or food scarcity, the dramatic Bam Owl population decrease mid-twentieth century was attributed to factors such as deaths by human intervention (hunting, trapping, being caged), the direct or indirect effect of pesticides, increase in road kills and the loss of breeding sites mainly due to modernisation of buildings. It is only recently that signs of partial and local population recovery have been noted, mainly due to the help of protective measures by conservationist organisations.

For this study we analyzed the data provided by the "Kerkuilwerkgroep Vlaanderen" (http://www.kerkuilwerkgroep.be/), a division of Vogelbescherming Vlaanderen (http://www.vogelbescherming.be/) and the human hantavirus infection data provided by the National Reference laboratory for Hantavirus infections, Brussels, Belgium.

In the late '70ties, the Barn Owl appeared on the RED List of endangered species in Belgium. The Kerkuilwerkgroep Vlaanderen initiated surveillance and support for the Barn Owl population by informing the public, providing nesting facilities and eliminating adverse factors for the survival of the Barn Owl in general. The available surveillance data (Table 1) focus on breeding pairs per year.

Although the time series are relatively short (1982-2009, i.e. 27 years), a correlation is present between the number of hantavirus infections in a certain year and the breeding success of the

Barn Owl (number of breeding pairs) (Figure 1, panels A and B). The comparison between the number of hantavirus infections (dependant variable) and the number of the breeding success of the Barn Owl (number of breeding pairs) and the year (independent variables) was assessed by a multivariate negative binomial regression (because of extra-binomial variability). It appears that the number of breeding success is positively correlated with the number of hantavirus ($P<0.0001$). Before 1993, a negative correlation is observed ($P<0.05$). Between 1993 and 2004, the same observation is worth ($P<0.001$), except for the years 1993, 1996 and 1999 (positive correlation). From 2005 until 2009, the correlation was always positive ($P<0.001$).

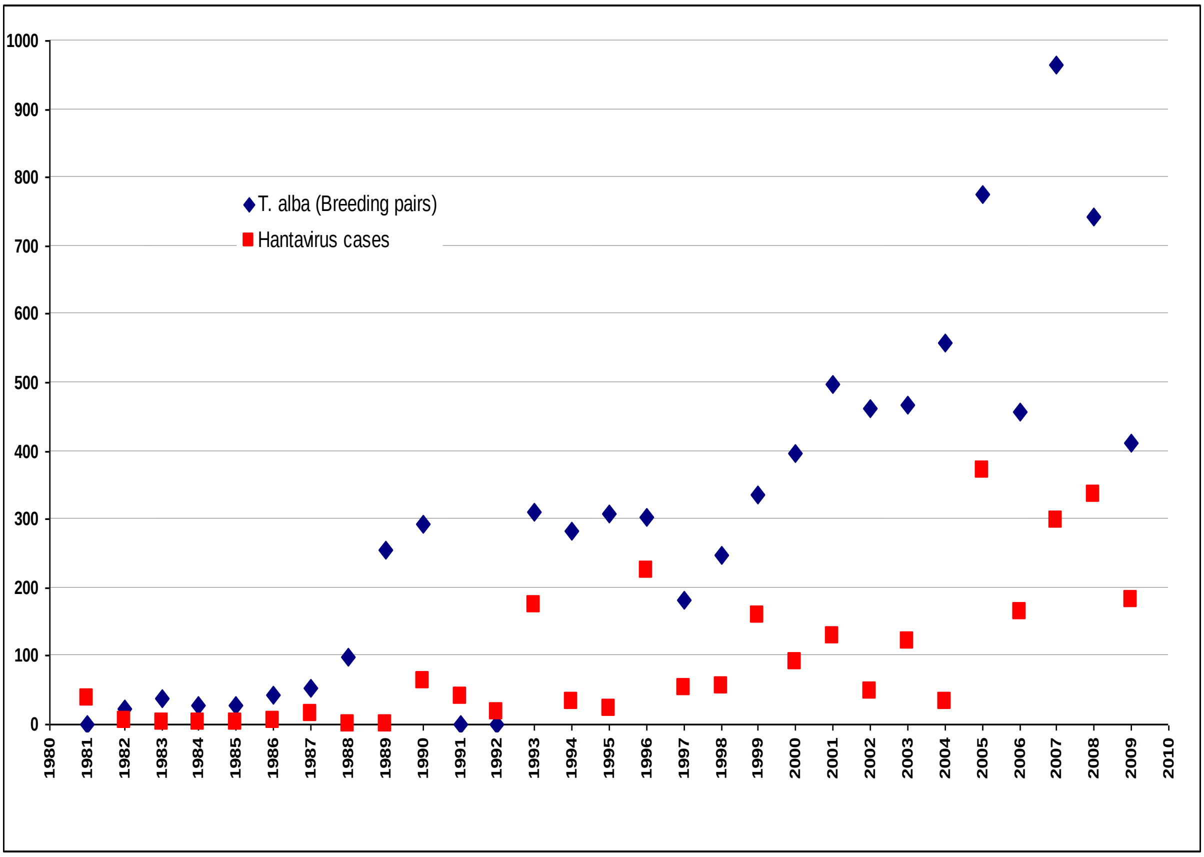
According to our data the Barn Owl breeding success is related to rodent population density. Rodents carry and transmit hantaviruses to humans and the relation between their population density and human hantavirus infections was firmly established in Belgium. Monitoring the Barn Owl populations can thus be beneficial as a sentinel marker for predicting the risk of hantavirus infection in the human population.

Table 1. Number of Barn Owl breeding pairs (Source: Kerkuilnieuws, Nieuwsbrief van de Kerkuilwerkgroep Vlaanderen - afdeling van Vogelbescherming Vlaanderen vzw. 12de Jaargang, july 2010, and human cases of hantavirus infection (Source: National Reference Laboratory, Queen Astrid Military Hospital, Brussels, Belgium), 1981-2009

Year	*T. alba* (Breeding pairs)	Hantavirus cases
1981	0	39
1982	23	4
1983	39	3
1984	29	3
1985	28	3
1986	43	4
1987	54	14
1988	99	0
1989	256	1
1990	292	62
1991	204	40
1992	240	18
1993	311	174
1994	282	32
1995	309	22
1996	303	224
1997	182	52
1998	247	55
1999	336	159
2000	397	91
2001	497	129
2002	461	48
2003	468	122
2004	558	34
2005	776	372
2006	458	163
2007	964	298
2008	742	336
2009	441	182

Figure 1. Breeding pairs of *T. alba* versus human hantavirus (HTV) cases.

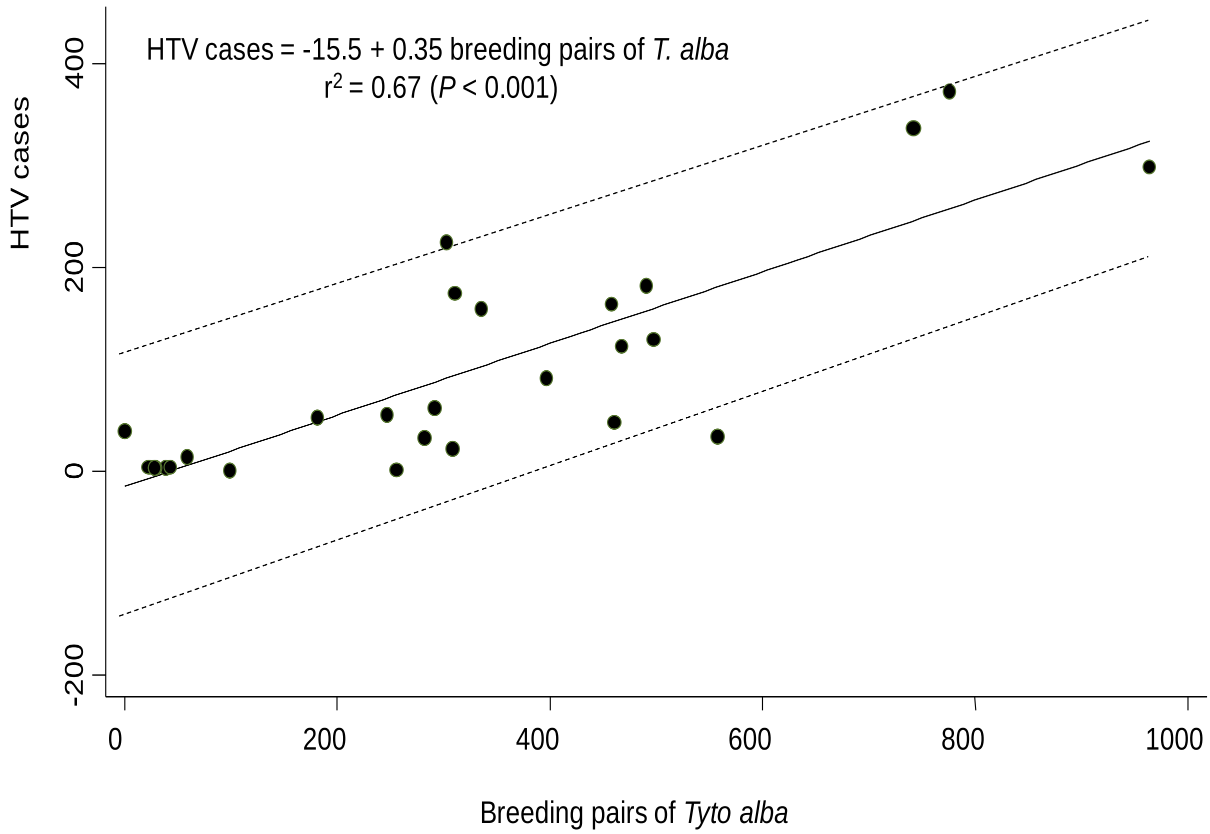
Panel [A]. Breeding pairs and HTV cases in function of time



<u>Legend</u>: X-axis: Year; Y-axis: ◆ represent the number of breeding pairs of *T. alba* by year and ■ represent the number of HTV cases by year.

Figure 1. Breeding pairs of *T. alba* versus human hantavirus (HTV) cases.

Panel [B]. Relation between breeding pairs and HTV cases



Legend: ● represent the number of HTV cases; ——— represent the fitted values and ---- represent the upper and the lower limits of the 95% confidence interval of the fitted values based on standard error of residual.

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