Anthropogenic sources of mortality in the western whip snake, *Hierophis viridiflavus,* in a fragmented landscape in Western France.

ROGER MEEK

7 rue Georges Clemenceau, Chasnais, France 85400.
Rogermeek85@aol.com

ABSTRACT - Whip snakes (*Hierophis viridiflavus*) frequently enter urban areas and suffer mortalities as a consequence. Information collected over a seven year period in Vendée, Western France from 36 casualties indicated humans killed more snakes, particularly sub adults/hatchlings, than dogs or cats. Domestic cats killed only sub adults/hatchlings but dogs killed both size classes, mostly when they entered gardens. Adult snake mortalities occurred predominantly during May, which is the main period for reproduction; those of sub adults/hatchlings were more frequent during August/September, the period of dispersal from nest sites. Humans killed a little more than half of sub adults/hatchlings when they entered houses, frequently in the belief they were vipers (*Vipera aspis*). Snakes with total body lengths between 600 - 1000mm were killed in less than expected frequency compared to their frequency in a live sample whilst those of sub adults/hatchlings were greater than expected. However, questions of bias in the data base are likely for several reasons and this is discussed.

Mortality is a key factor in animal population dynamics affecting both abundance and population continuity and over extended time periods the evolution of anti-predator strategies, habitat selection and activity patterns occurs (Roff, 1992). Sources of mortality include predation, lack of nutrition, effects of injury and climate. Snakes also suffer mortalities from road vehicles in Europe and elsewhere (e.g. Bonnet et al., 1999; Andrews et al., 2006; Meek, 2009) with direct killing by humans, domestic dogs and cats adding to these numbers (Whitaker & Shine, 2000; Akani et al., 2002). In the bocage-dominated landscape of Western France where snakes have limited useable habitat, many species employ hedgerows as pathways for movement to reach prime habitat patches (Saint Girons, 1996). When these pathways are interrupted by urban structures snakes may be constrained to enter urban areas where, in addition to humans, they also encounter domestic animals increasing mortality risk (Rugerio & Luiselli, 2004). Mainly due to its wide foraging lifestyle (Coifi & Chelazzi, 1991; 1994, Arnold & Ovenden, 2002), the species most likely to enter urban environments in Western Europe is the whip snake *Hierophis viridiflavus* a habitat generalist attaining around two metres in length (Capula et al., 1997). Obtaining useful information on anthropogenic mortalities other than road-kill requires a data base with adequate sample size, but incidents are rarely reported. This paper presents information on anthropogenic related mortalities in *H. viridiflavus* in Western France.

MATERIALS AND METHODS

Data was collected between 2005 and 2011 in the Vendée region of Western France (46°27`N) and sourced from seven households where the owners reported snakes entering their properties. Five of these were situated close to the edge of or inside villages (St Denis-Du-Payre, Lairoux and La Brettoniere-La-Clay - see Meek, 2009 for map) with two households remotely situated between villages. Both of the latter had large ponds on their properties and were frequented by snakes, which included *H. viridiflavus*, grass snakes (*Natrix natrix*) and viperine snakes (*N. maura*). The study locality is a fragmented landscape consisting mostly of hedgerow bordered agricultural land linking small patches of woodland. When a report of mortality was received the snake was inspected and measured for total length (TL) and if possible sexed. Sub adult/hatchlings were defined as snakes with a maximum TL of 500 mm, the size when there is a change to adult pattern and colouration, which is attained around the 4 - 5th year (Arnold

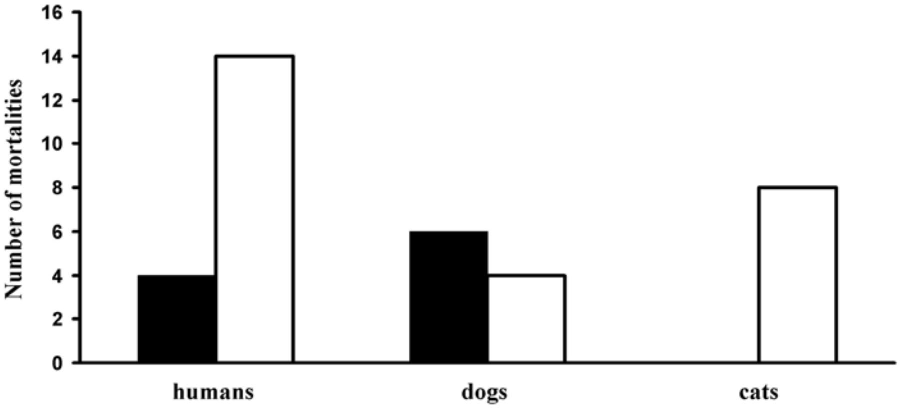

Figure 1. Sources of *H. viridiflavus* mortalities. Solid histograms represent adults, open histograms sub adults/ hatchlings.

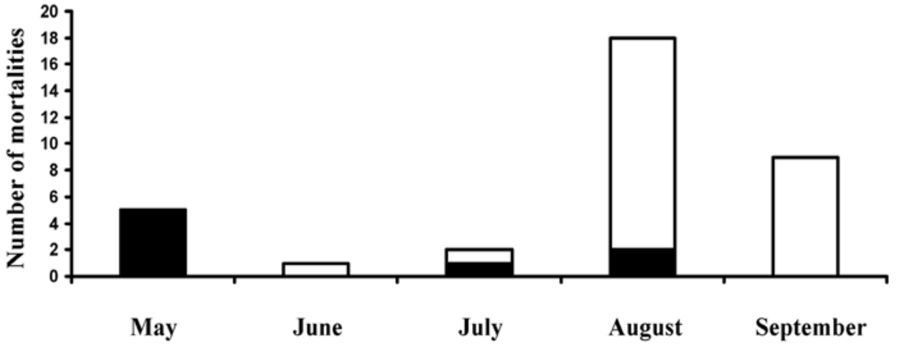

Figure 2. Seasonal distribution of mortalities indicating adult mortalities predominating in May and sub adult/ hatchlings mostly in August and September. Age class representations as in Fig 1.

& Ovenden, 2002). The date and nature of the mortality (i.e. from humans, dogs or cats) was noted and a photograph taken of the corpse and its injuries.

To test predictions of size class vulnerability to mortality the distribution was compared to the distribution of live snakes found in the study locality. The live sample included snakes crossing roads, moving in hedgerow corridors, basking at woodland edges and found under rocks etc. Capture of live snakes was not always possible so they were photographed first and their size estimated from some object in the immediate environment. After measurement all captured snakes were released at the point of capture but not marked. This means they could have been counted more than once but given the large area covered and time period involved, repeated capture or observation should have been minimal.

Statistical analysis. A Kolmogorov - Smirnov one sample test (designated D_{max}) was applied to monthly and annual mortalities to test for regularity. The test evaluates the degree the observed pattern of categorical frequencies differs from the expected under a null hypothesis. To test for monthly and

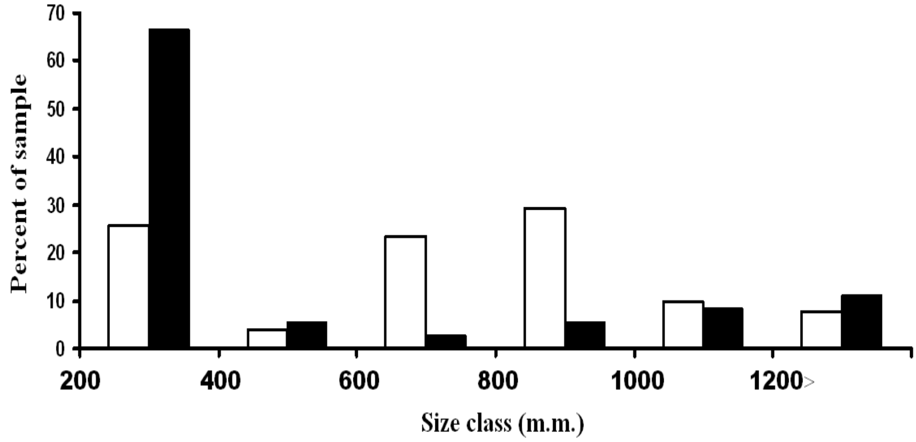

Figure 3. Size class distributions of observed frequencies of anthropogenic mortalities (n = 36) in relation to expected frequencies based on a live sample (n = 51). Solid and open histograms represent snake mortalities and live snakes respectively. See text for further details.

annual mortalities the null hypothesis was equal cell distribution. For size class related mortalities the live distribution (n = 51) was treated as the expected proportions with size class intervals set at 200mm increments. The major advantage of the Kolmogorov - Smirnov test over χ^2 is that it is not sensitive to cell size (i.e. <5) and for intermediate sample sizes is more powerful (e.g. Birnbaum & Tingey, 1951).

RESULTS

Between 2005 and 2011, 36 snakes (10 adults, 26 sub adults/hatchlings) were reported killed (Fig. 1). Mortalities ranged from 1-9 per annum (mean with standard deviation = 5.14±2.73) with no significant annual departures from regularity (D_{max} = 0.075, p > 0.05). Of the total found 18 (= 50% of which 11.1% were adults and 38.9% sub adults/hatchlings) were killed by humans, 10 (27.8%) by dogs and 8 (22.2%) by cats. Entry into houses (53.8%) was an important source of sub adult/hatchling mortality but reported on only one occasion in an adult. Cats killed or mortally injured sub adult/hatchlings mostly when they entered gardens (87.5% of casualties). Two snakes survived the initial cat attacks but succumbed within two days, despite no apparent surface wounds suggesting internal injury. Of 10 adults killed, 8 were males and 9 were killed at the remote households. The two largest snakes (males with TL`s 1320 & 1430mm) were shot by a landowner in the belief that they were persistently preying on ducklings at a farm pond. On only one occasion was there an attempt by either cat or dog to consume a freshly killed snake. This was by a Siberian Husky that killed a large male (TL = 1230m.m.). Mortalities from dogs and cats were usually caused by a deep penetrating single bite with no evidence of mastication.

Monthly mortalities deviated significantly from regularity (D_{max} = 0.371, p< 0.01; Fig. 2). August casualties were 154% greater than expected (mainly due to sub adult/hatchlings) but 85.7% and 71.4% less than expected during June and July respectively. Size class distribution of mortalities differed significantly from the distribution of live snakes (D_{max} = 0.429, p<0.01) with lower than expected mortalities in the 600 - 1000 size classes

(88.1 & 88.2% less than expected) but greater (161.4%) than expected for sub adults/hatchlings (Fig. 3).

DISCUSSION

Although insight is gained from this type of information there are questions of bias in the data base. For instance, only a limited number of households supplied information and hence only a subset of total mortalities recorded. Furthermore dogs and cats may inflict casualties out of view and domestic poultry that consume wall lizards (*Podarcis muralis*) are also capable of preying on small snakes. Despite these limitations size and seasonal differences in mortalities were identified. Large adults were found to be at risk from humans and dogs; cats were apparently only a threat to smaller snakes mostly when they entered gardens. Perhaps unexpected was the frequency that sub adult/hatchlings entered houses, where they were killed by local people on the assumption they were `vipers`. The extent of this practise is unknown but it is probably widespread and could impact on recruitment into the adult population.

Entering urban areas may be a non-optimal behaviour decision (Fahrig, 2007) but foraging movements alone do not explain the discrepancy between *H. viridiflavus* mortalities and those of sympatric *N. natrix* (n = 2) and *N. maura* (n = 0) both of which may also forage (Hailey & Davies, 1986; Nagy & Korsos, 1998; Wisler et al., 2008). Species abundance may partly explain the differences but anti-predator behaviour could also be relevant. Many snakes show hierarchical anti-predator behaviours but with crucial differences (for discussion see Duval et al., 1985). For instance, *H. viridiflavus* initially adopts passive defence such as flight followed by threat of bite. Striking out at the potential predator is a last resort but once this stage is reached aggressive defence persists in both adults and sub adult/hatchlings (pers. obs.). Confronted by a dog (or a cat in the case of small snakes) this is probably fatal since a strike or bite effectively decreases the distance between the snake and the predator and exposes key body areas to injury. Furthermore hedgerows provide limited escape opportunities with optimal movement possible in only two directions. The surrounding open habitat presents even greater predation risk. Both *Natrix* species resort to passive defence including death feigning or balling if flight is ineffective (e.g. Hailey & Davies 1987; Gregory et al., 2007; Gregory 2008), which may reduce predatory instinct in dogs or cats.

The results are in good agreement with a study in Italy where Rugiero & Luiselli (2004) found *H. viridiflavus* sustained injuries - mainly from cats, when they entered urban areas on the outskirts of Rome. Research on other species gave similar results. Around 50% of snake mortalities in towns and villages in tropical Africa were due to humans (Akani et al., 2002); in Australia venomous species were among the snakes killed by people and domestic cats in urban areas (Whitaker & Shine, 2000). Reading et al., (2010) have drawn attention to a possible global decline in snake populations whilst Dodd (1987) cites malicious killing as a significant conservation issue and hence mitigation to reduce any possible decline is needed. Mortalities from domestic animals are difficult to eliminate but direct killing by humans, especially due to misidentification or perceiving defensive displays as attacks requires mitigation to reduce snake mortalities. This could take the form of education in schools or posters in village halls identifying venomous and non-venomous species along with basic information on behaviour.

REFERENCES

Akani, G.C., Eyo, E. Odegbune, E., Eniang, E.A. & Luiselli, L. (2002). Ecological patterns of anthropogenic mortality of suburban snakes in an African Tropical region. *Israel J. Zool*. **48**, 1 -11.

Andrews, K.M., Gibbons, J.W. & Jochimson, D.M. (2006). *Literature Synthesis of the Effects of Roads and Vehicles on Reptiles and Amphibians*. Washington D.C. Federal Highway Administration (FHWA),US Department of Transportation, Report No FHWA-HEP-08-005.

Arnold, N & Ovenden, D. (2002). *Field Guide to Reptiles and Amphibians of Britain and Europe.* HarperCollins, London.

Birnbaum, Z.W. & Tingey, F.H., (1951). One sided confidence contours for probability distribution function. *Ann. Math. Stat.* **22**, 592-596.

Bonnet, X. Naulleau, G. & Shine, R. (1999). The dangers of leaving home: mortality and dispersal in snakes. *Biol. Conserv.* **89**, 39–50.

Capula, M., Filipi, E., Luiselli, L. & Jesus, V.T. (1997). The ecology of the western whip snake, *Coluber viridiflavus*, in Mediterranean Central Italy. *Herpetozoa* **10**, 65 - 79.

Coifi, C. & Chelazzi, G. (1991). Radio tracking of *Coluber viridiflavus* using external transmitters. *J. Herp.* **25**, 37 - 40.

Ciofi, C. & Chelazzi, G. (1994). Analysis of homing pattern in the colubrid snake *Coluber viridiflavus*. *J. Herp.* **28**, 477 – 484.

Dodd, K. (1987). Status, conservation and management. In, *Snakes. Ecology and Evolutionary Biology*. Seigel, R.A., Collins, J.T. & Novac, S. S. (Eds) pp 478 – 513. MacMillan, New York.

Duvall, D., King, M. B. & Gutzwiller, K. J. (1985) Behavioural ecology and ethology of the prairie rattlesnake. *Natl. Geogr. Res.* **1**, 80 - 111.

Fahrig, L. (2007). Non-optimal animal movement in human-altered landscapes. *Funct. Ecol.* **21**, 1003-1015.

Gregory, P. T. (2008). Bluffing and waiting: handling effects and post-release immobility in a death-feigning snake (*Natrix natrix*). *Ethology* **114**, 768 - 774.

Gregory, P. T., Isaac, L. A. & Griffiths, R. A (2007). Death feigning by grass snakes (*Natrix natrix*) in response to handling by human "predators." *J. Comp. Psychol.*, **121**, 123-129.

Hailey A. & Davies P. M. C. (1986). Diet and foraging behaviour of *Natrix maura*. *Herpetol. J.* **1**: 53-61.

Hailey, A. & Davies, P.M.C. (1987). Effects of size, sex, temperature and condition on activity metabolism and defence behaviour of the viperine snake *Natrix maura*. *J. Zool. Lond.* **208**, 541 - 558.

Meek, R. (2009). Patterns of reptile road-kills in the Vendée region of Western France. *Herpetol. J.* **19**, 135 – 142.

Nagy, Z. T. & Korsos, Z. (1998). Data on movements and thermal biology of grass snake (*Natrix natrix* L.) using telemetry. In *Current Studies in Herpetology* pp 339 – 343 Miaud, C. & Guetant, R. (Eds.). France (SEH 1998): Le Bourget du Lac.

Reading, C. J., Luiselli, L. M., Akani, G. C, Bonnet, X., Amori, G., Ballouard, J. M., Filipi, E., Naulleau, G., Pearson, D. & Rugiero, L. (2010). Are snakes in widespread decline? *Biology Letters* **6**, 777 - 780.

Roff, D. A. (1992). *The Evolution of Life Histories: Theory and Analysis.* Chapman and Hall, New York.

Rugiero, L. & Luiselli, L. (2004). Ecological notes on two colubrid snakes (*Coluber viridiflavus* and *Elaphe longissima*) in a suburban habitat (Rome, central Italy). *Herpetol. Bull.* **87**, 8 – 12.

Saint Girons, H. (1996). Structure et evolution d`une petite population de *Vipera aspis* (L) dans une region de bocage de l`ouest de la France. *Terre Vie-Rev. Ecol.* A **51**: 223 – 241.

Whitaker, P. B. & Shine, R. (2000). Sources of mortality of large elapid snakes in an agricultural landscape. *J. Herp.* **34**, 121 - 128.

Wisler, C. Hofer, U. & Arletta, R. (2008). Snakes and monocultures: habitat selection and movements of female grass snakes (*Natrix natrix* L) in an agricultural landscape. *J. Herp.* **42**: 337 – 346.