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# Spatio-temporal factors influencing the occurrence of *Syngamus trachea* within release pens in the South West of England

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ABSTRACT

*Syngamus trachea* is a pathogenic tracheal nematode that causes syngamiasis in wild and game birds, especially when birds are managed at high densities. Despite its pathogenic nature, very little is known about its epidemiology and relationship with ambient temperature and humidity. The spatial and temporal modelling of disease was undertaken on two pheasant estates within the South West of England from April 2014 to August 2014. Significant differences between the mean numbers of eggs per gram of soil were identified between pens at both site 1 and site 2 but did not differ significantly between sites. Egg abundance was significantly associated with soil moisture content, with greater egg survival between years in pens with higher average volumetric soil moisture content. Previous years stocking density and pen age were also associated with greater egg survival between years with more eggs being recovered in pens with greater stocking densities, and pens that had been sited longer. The greatest model to explain the variation in the numbers of eggs per gram of soil per pen was a combination of soil moisture content, stocking density and pen age.

Larval recovery differed significantly between sites. Larval abundance was significantly and positively associated with temperature and relative humidity at site 1. Similarly, temperature and humidity were also positively and significantly associated with larval abundance at site 2. Rainfall did not influence larval recovery at either site 1 or site 2. The model with the greatest ability to explain larval abundance at both sites, was a combination of temperature, humidity and rainfall. Infection status (positive faecal egg counts) was significantly and positively associated with larval abundance at both sites, but rainfall was only positively associated at site 1. Temperature and humidity were positively associated with infection status at site 2, but not at site 1. The present study highlights the influence of climatic variables on both egg survival and larval abundance, and could therefore be used to develop more targeted treatment strategies around periods of higher disease risk. The frequent use of release pens is a clear factor in the epidemiology of syngamiasis, and it is recommended that pens be rested and/or rotated in order to reduce infection pressure in subsequent flocks.



## 1. Introduction

An understanding of the factors influencing infectious disease dynamics is fundamental to the control and

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prevention of disease (Pullan et al., 2012). Knowledge of these factors can potentially influence management decisions, leading to the development of alternative practices to promote sustainable disease control (Abbott et al., 2012; Morgan and van Dijk, 2012). With the development of drug resistance to anthelmintics in many animal species, sustainable disease control is a growing concept in agriculture (Morgan and Wall, 2009). It must be noted however, that drug resistance has not yet been identified within game birds, perhaps due to the lack of studies within this area. As only one anthelmintic, Flubenvet™, has been licensed for use in pheasants in the UK (Pennycott, 2000; NOAH, 2014), the need for alternative control methods could become a significant issue in the coming years. Other anthelmintics such as Fenbendazole (Panacur™) are available under the cascade, however, must be prescribed by a Veterinary Surgeon (NADIS, 2014).

In order to supplement wild populations of pheasants and maintain a large enough population to keep up with demand for shooting, it is common practice within many parts of Europe to rear pheasants in confined systems (Draycott et al., 2006; Goldova et al., 2006). It is estimated that approximately 12 million pheasants are harvested each year within the UK (Tapper, 1999). In order to maintain this increased demand for game shooting, around 25 million 6–8 week old pen-reared pheasants are released into the countryside every year (Tapper, 1999; Sage et al., 2003; Draycott et al., 2006). Within release pens, pheasants are commonly kept at stocking densities of ~1800 birds per hectare (Sage et al., 2005) and are commonly released at densities of 250 birds/km$^2$ (Aebischer, 2003). This high concentration of birds within release pens, combined with the increased density of parasitic and bacterial pathogens can lead to significant losses (Ruff, 1999; Goldova et al., 2006).

Pheasants (*Phasianus colchicus*) are susceptible to a number of parasitic nematodes (Ruff, 1999); *Syngamus trachea* in particular can cause significant production losses, poor weight gain and even mortality in heavily infected birds (Ruff, 1999; Krone et al., 2007; Atkinson et al., 2008). *S. trachea* is a parasitic strongylid nematode that causes syngamiasis in poultry and game birds (Krone et al., 2007; Atkinson et al., 2008), Generally, unembryonated eggs are deposited in the faeces and develop to the L3 stage within the egg, with development times generally decreasing at increasing temperatures (Barus, 1966a). The confinement of pheasants within pens prior to release is believed to be a major component in the epidemiology of syngamiasis, and as the same pens are frequently used between years, could facilitate the maintenance and propagation of disease within the environment (Ruff, 1999; Goldova et al., 2002; Draycott et al., 2006; Goldova et al., 2006). The added complication is *Syngamiasis* can be either direct or in-direct, and many invertebrate species can ingest *S. trachea* eggs, thus serving as paretenic hosts for disease, increasing its spatial distribution and increasing the longevity of infective stages (Clapham, 1934; Taylor, 1935; Nevarez et al., 2002; Atkinson et al., 2008; Holand et al., 2013).

Although the potential for disease is high within release pens, currently however, it is unclear how long eggs and larval stages of poultry parasites are able to remain viable in the environment, and thus contribute to disease between years (Clapham, 1934). It is suggested that the between and within-year variation in the abundance of free-living stages of parasites of veterinary importance is primarily weather dependent (Moss et al., 1993; O'Connor et al., 2006; Morgan and van Dijk, 2012), with temperature, humidity and rainfall being the most significant factors (Pullan et al., 2012; Dybing et al., 2013; Morgan and van Dijk, 2012; Formenti et al., 2013). It has also been suggested that soil moisture is important in governing egg longevity in parasites that have relatively high temperature thresholds for development (Guildford and Herrick, 1952; Khadijah et al., 2013a, 2013b). As *S. trachea* larvae are extremely susceptible to desiccation (Barus, 1966a), it is predicted that only low numbers of hatched larvae are able to survive the winter, although eggs are able to survive prolonged exposure to low temperatures when kept in water. In the natural environment, however, other factors such as humidity and soil moisture may be important for disease persistence (Guildford and Herrick, 1952), with the potential for discrete disease foci on estates (Kocan, 1969; Draycott et al., 2000; Goldova et al., 2006). In conjunction with environmental factors, the aggregated distribution of birds within estates, and the aggregated nature of faeces within release pens (Saunders et al., 2000) could explain the variation in infection pressure of all nematodes, not just *S. trachea*, which may provide an opportunity to manipulate disease risk spatially.

It is predicted that the potential for disease in release pens is high, with significant disease transmission occurring around communal sites such as feeders and water baths, with the potential transfer between species and the wider spatial distribution of disease among wild and penned birds. It is hypothesised that levels of disease of *S. trachea* are higher in pens that have not been relocated, and higher in pens with greater annual stocking densities. Here we report the results of a study investigating the influence of climatic variables on both egg survival and larval abundance, and speculate on how this could be used to reduce disease incidence in pheasant flocks.

## 2. Materials and methods

### 2.1. Selection of field sites

The two field sites were recruited subject to certain criteria. Field sites had to have a history of releasing pheasants continuously for a number of years (10) and have had some previous history of *S. trachea* infections. Due to anonymity requests, sites are only being referred to by approximate grid references. Site 1 was situated approximately at grid reference – SU 67340 48539 and consisted of seven release pens. Site 1 undertook Corvid control via the use of Larsen. Site 2 was situated approximately at grid reference – SU 17769 30326, and consisted of 13 release pens. Unlike site 1, site 2 did not undertake any Corvid control using Larsen traps. Both sites provided Flubendazole (Flubenvet™) in the feed as a prophylactic. One disused pen per site served as a control. No *S. trachea* eggs or larvae were found at any point during the study within control pens.