Endoparasites in the annual cycle of feral Greylag Geese *Anser anser*

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Abstract

The monthly occurrence of endoparasites in feral Greylag Geese *Anser anser* near Stuttgart, southwest Germany was studied in 2007 and 2008. Seven genera of parasites were found in the faecal samples. Nematode ova were most prevalent, followed by protozoan oocysts, whereas only a few cestode ova were recovered. The level of parasite infestation varied regionally and seasonally. More birds were found to have parasites in winter than in summer, which was reflected by a negative correlation between mean monthly temperature and the percentage of geese with parasites. Parasite loads were low and there was no measurable negative effect of parasites on the body condition of the geese.

Key words: Abdominal profile, Cestoda, *Eimeria*, Nematodes, temperature.

Endoparasites are common in wild birds and rarely lead to the death of an individual (Wobeser 1997). However, when animals are infected with another disease or become stressed, parasites may become more problematic, leading not only to death but in some cases may have a negative impact at the population level (Toft 1991). Parasites therefore may have the potential to have a significant influence on the evolution of their host species (Price 1991).

The endoparasite load in wildfowl can be high, especially in urban environments (Fallacara *et al.* 2001). Birds may become infected through drinking, feeding or when taking grit. Endoparasites may have a negative effect on an individual's ability to compete for food, nesting sites and mates (Hudson & Dobson 1991), for instance by taking nutrients directly, by reducing the bird's appetite, or by impairing their ability to absorb ingested food (Eckert *et al.* 2005). The risk of parasitic infection varies with habitat, presence of intermediate hosts such as water snails or worms, accessibility of a site, climate and feeding behaviour (Wobeser 1997; Marcogliese 2004; Schnieder *et al.* 2006; Dolnik *et al.* 2010).

Studies on the occurrence of endoparasites in living wild birds are rare, and most are based on *post mortem* examination of shot or oiled individuals (*e.g.*

Thieltges *et al.* 2006). Even rarer are studies demonstrating an effect at an individual level. In this paper, results from a two-year study of a feral Greylag Goose *Anser anser* population near Stuttgart, southwest Germany, are described. The aim was to determine: 1) the taxa of endoparasites that occurred in that population; 2) whether birds using parks in the city differed from those in more rural habitats in their parasite loads; 3) whether the occurrence of parasites varied during the annual cycle; 4) whether climatic variables such as rainfall, humidity or temperature had an effect; and 5) if parasites influenced the body condition of a goose, measured as the amount of fat on its abdomen (*i.e.* its abdominal profile index).

The study population

In the 1980s, feral Greylag Geese became established in and around the city of Stuttgart, southwest Germany (Woog *et al.* 2008). Numbers vary throughout the year, with the largest aggregations occurring in June, when geese from outside the city limits join local flocks during moult (Woog *et al.* 2008). By 2010, the maximum number of geese observed within the city had increased to 282 individuals (Schwarz 2010). Resightings of ringed birds have shown that individuals may move considerably, with some of the Stuttgart-ringed birds identified up to 80 km from their ringing site. The geese often come into close contact with humans in city parks, but during the breeding season they move to more natural areas to nest on gravel pit islands and reed-beds. Failed breeders and family groups often return to the city after the goslings have fledged, to feed on short, lush grass in the parks (Käßmann & Woog 2007, 2008). Feeding on aquatic vegetation is rare in this population. Between 2002 and 2010, 359 Greylag Geese have been caught and marked with a Vogelwarte Radolfzell metal ring and a blue plastic leg ring with white lettering during the annual moult, so that individual birds can be identified to monitor their movements and breeding success.

Endoparasites

Various endoparasites have been described from geese; most are specific to their host and are not harmful to humans. The majority live in the intestinal tract, but some also occur in the respiratory tract. Infection is usually via the oral route. Brief overviews of the commoner species, found in this study, are as follows:

Amidostomum anseris is specific to true geese (Anserinae; Enigk & Dey Hazra 1968). It draws blood from the gizzard, causing an inflammation of the mucous membrane. Adults often carry this parasite and it may also infect goslings, leading to death of the latter if heavily infested. Eggs are frost-resistant but need higher temperatures to develop. Birds may be infected by ingesting worm eggs attached to food. Additionally, larvae of *A. anseris* can penetrate the skin and migrate to the lungs and trachea prior to invading the gizzard linings (Fedynich & Thomas 2008).

Trichostrongylus is found in the caecae and small intestine, infection is through ingestion, the eggs don't survive frost.

Capillaria is a nematode living in the intestinal tract and other organs. When heavily infected, birds may die. Infection is by the oral route. Eggs need moist and warm conditions to develop.

The gape worms *Synangemus trachea* and *Cyathostoma bronchialis* live in the respiratory tract and are taken up orally. *C. bronchialis* have been reported from a number of wildfowl (McDonald 1969). Affected birds gasp and show respiratory distress (Griffiths *et al.* 1954). Adult cestodes live in the intestines and shed eggs only irregularly, making detection difficult.

Eimeria is a protozoon that survives in the epithelial cells of the intestinal tract. In response, the gut may become enlarged and inflamed; diarrhoea, which may become bloody in severe cases, is the primary symptom and birds become extremely thin. Infection is by the oral route through ingestion of eggs. Coccidiosis due to *Eimeria* may result in mortality in captive waterfowl, although wild birds apparently carry infections without harm (Wobeser 1997). *Eimeria* also causes renal coccidiosis in geese, a common condition which can cause high mortality rates, especially in goslings (M. Brown, pers. comm.).

Methods

Study area

Field work was carried out in three regions in and around Stuttgart, southwest Germany (48°46'N, 9°10'E): 1) parks around the inner city where birds are often fed by people, 2) a lake 7 km to the north along the river Neckar (Max-Eyth-Lake, MES, the catching site where geese aggregate to moult; Woog *et al.* 2007) and 3) sites to the north and south of the city where Greylag Geese use more rural habitats (Fig. 1).

Faecal sampling & analysis of parasites

Between February 2007 and February 2009 a fresh faecal sample was taken from 80–100 individuals in the three regions on a monthly basis. The same randomly-chosen individuals, identified by their ring codes, were targeted each month. On occasions when it was not possible to obtain sufficient samples from the target group, additional birds were also sampled. Sampling was carried out by observing an individual defecate and collecting the faecal sample immediately. Sampling was more difficult at rural sites because the birds were shyer in these areas. Identification of the parasites, at least to genus level, was carried out at the "Chemisches und Veterinäruntersuchungsamt" (CVUA) laboratory in Stuttgart, using the combined sedimentation-flotation method, with NaCl/ZnCl as flotation medium to identify ova and oocystes (Schnieder *et al.* 2006; Eckert *et al.* 2005). The faecal sample was put into 200 ml of water, stirred, then allowed to settle into a sediment for at least 10 mins. The supernatant was discarded and the remainder (9ml) put into a vial, which was filled to 12 ml with water, then centrifuged for 5 min at 1,500 RPM. The supernatant was again removed, leaving only 1 ml liquid above the sediment pellet. The pellet was dissolved in 12 ml NaCl/ZnCl solution with a specific gravity of 1.3 and centrifuged for 5 min at 1,500 RPM. Oocystes and ova have a lower specific weight than the NaCl/ZnCl solution and

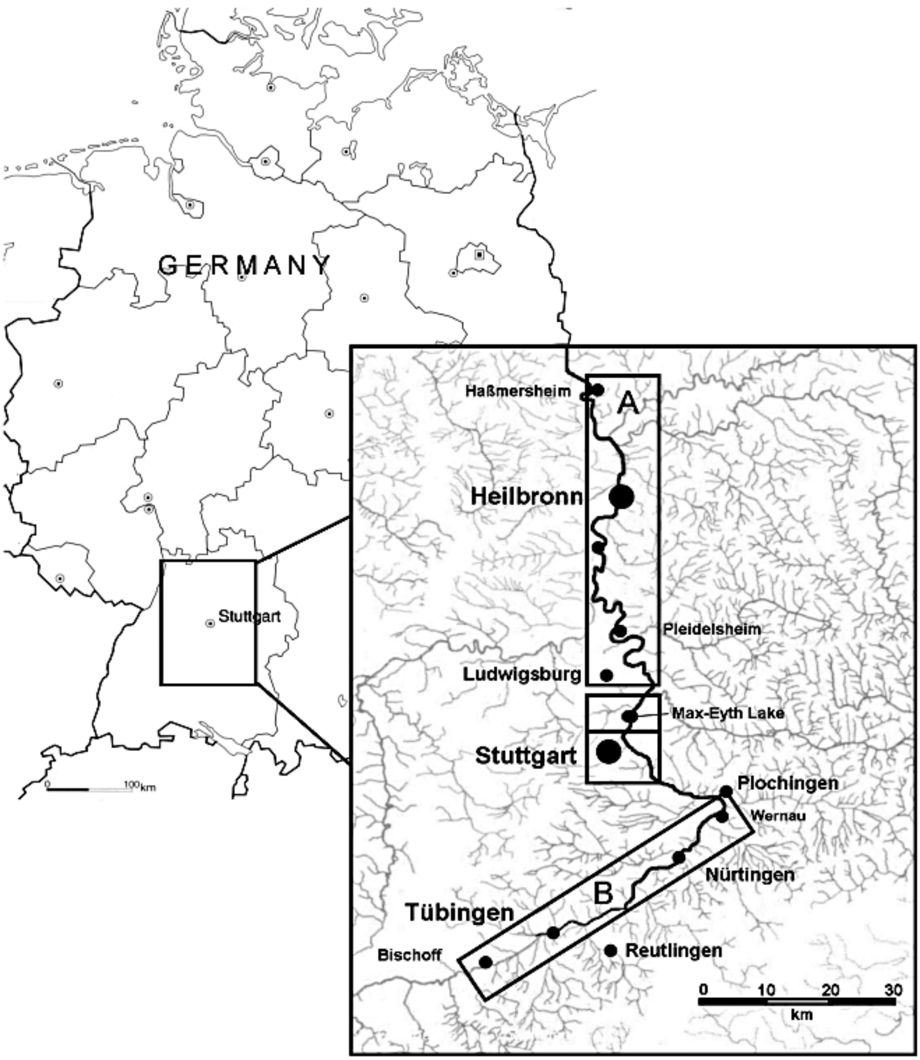

Figure 1. Map of the Stuttgart Greylag Goose study areas in the central Neckar valley, southwest Germany. Map modified from Hölzinger (1981). In the Stuttgart and Max-Eyth Lake areas, geese mainly use mowed lawns in park settings for grazing; in the areas A (north) and B (south) they used more rural settings, such as pastures and fields close to gravel pits.

therefore float to the surface. A standard quantity was taken using a platinum loop (5 mm in diameter; two loops taken per pellet sample) from the centre of the surface where the ova and oocystes were concentrated. The sample was placed on a slide and the type of nematode ova recorded for each slide under 100 × magnification.

Parasite load for nematode ova, recorded for each bird on each sampling occasion, was categorised semi-quantitatively by estimating the number of ova for the entire slide in relation to one of four classes: 1–10, 11–30, 31–100 and > 100 ova. For *Eimeria* oocystes, a different classification was used (1–3, 4–20, 21–100 and > 200 oocystes), and numbers only in the field of view (rather than the entire slide) were counted to determine *Eimeria* infestation levels.

Body condition

According to Toft (1991), a heavy parasite load may reduce body weight of a bird. In addition to the parasite assessment at the three different locations, we therefore tested whether the occurrence of parasites was associated with poorer body condition. Body condition for birds included in the study was assessed by recording the abdominal profile (AP) of each individual, viewed in the field, on a weekly basis (Zillich & Black 2002). The abdominal profiles (APs) of the geese were recorded over 21 weeks, between 10 October 2007 and 27 February 2008, and a monthly mean AP value was calculated for each individual.

Weather data

Daily precipitation, mean daily temperature and humidity for the Stuttgart area were made available by the Environmental Office ("Amt für Umweltschutz") in Stuttgart. Because the occurrence of parasites was determined monthly, daily precipitation records were summed to provide total monthly rainfall, and mean monthly temperature and humidity were calculated from the daily mean values.

Statistics

Seasons were defined as winter (January–March), spring (April–June), summer (July–September) and autumn (October–December). Chi-squared tests were carried out to analyse variation in the number of geese with and without parasites in different years, months, seasons and at different locations. Age, sex and breeding status was not included in the analysis because most of the geese were adult non-breeders, and an earlier study found that age and breeding status were not significantly associated with parasite levels in the geese near Stuttgart (Lehmann 2008). To test the effect of parasites on body condition (APs), Mann-Whitney U tests and Kruskal-Wallis tests were used to investigate the effect of month on APs of parasitised and unparasitised geese. Pearson correlation coefficient tested for simple effects of rainfall, temperature and relative humidity on the arcsine proportion of geese with parasites. Tests were carried out using Minitab software (Ryan *et al.* 2005, Release 16.1.0).

Results

Types of endoparasites

Between 29 January 2007 and 22 December 2008 a total of 2,157 faeces were sampled from a total of 200 individually-marked Greylag Geese; 148 individuals in 2007 and 166 individuals in 2008. Seven different endoparasite taxa were found (Nematoda: *Amidostomum anseris*, *Trichostrongylus, Capillaria, Cyathostoma, Syngamus trachea*;

Table 1. Number of faecal samples collected for Greylag Geese in the Stuttgart region, without and with various taxa of endoparasites, in 2007 and 2008.

	2007	2008
No parasites	642	617
Amidostomum	217	352
Eimeria	60	65
Trichostrongylus	12	41
Capillaria	6	6
Cestoda	3	0
Syngamus	1	0
Amidostomum & *Eimeria*	25	42
Amidostomum & *Trichostrongylus*	8	19
Amidostomum & *Capillaria*	4	11
Trichostrongylus & *Eimeria*	2	4
Trichostrongylus & *Capillaria*	1	1
Capillaria & *Eimeria*	–	1
Amidostomum & *Trichostrongylus* & *Eimeria*	1	10
Amidostomum & *Capillaria* & *Eimeria*	1	2
Amidostomum & *Capillaria* & *Trichostrongylus*	–	1
Cyathostoma & *Trichostrongylus* & *Eimeria*	1	–
Amidostomum & *Trichostrongylus* & *Eimeria* & *Capillaria*	–	1
TOTAL SAMPLES	**984**	**1,173**

Cestoda: *Cestodea*; Protozoa: *Eimeria*; Table 1). Identification to species level was rarely possible. In most cases, the geese were free of parasites (2007: 65%; 2008: 52.6%), followed by infestation of only one detectable type of endoparasite (2007: 30.4%; 2008: 39.6%), two types (2007: 4.1%, 2008: 6.7%) and three types (2007: 0.3%; 2008 1.1%). The observation that a higher proportion of the geese were free of parasites in 2007 was statistically significant ($\chi^2_1 = 5.26$; $P = 0.02$). Only one goose had four different types of endoparasite. Of the birds with nematodes, most had very low parasite loads (1–10 ova): 94.6% in 2007 and 92.9% in 2008 (Table 2). In 2007, 76% of

Table 2. Occurrence of ova (Nematodes) and oocystes (*Eimeria*) in faecal samples collected for Greylag Geese each month in 2007 and 2008. If a sample had more than one type of parasite, the occurrence of each parasite was included. Total* = the number of faeces with at least one parasite; some may have more than one type of nematode.

	No. of faecal samples with each parasite (*n*)	Percentage samples with 1–10 ova	Percentage samples with 11–30 ova	Percentage samples with 31–100 ova	Percentage samples with > 100 ova
2007					
Amidostomum	255	94.5	5.1	0.4	
Capillaria	12	100			
Cyathostoma	1		100		
Syngamus	1	100			
Trichostrongylus	25	96.0	4.0		
Total*	278	94.6	5.1	0.3	
2008					
Amidostomum	435	91.7	7.1	0.9	0.2
Capillaria	23	100			
Trichostrongylus	76	97.4	2.6		
Total*	496	92.9	6.2	0.8	0.2
Eimeria		**1–3 oocystes**	**4 – 20 oocystes**	**21 – 100 oocystes**	**>200 oocystes**
2007	90	75.6	20.0	4.4	
2008	124	71.8	19.4	7.3	1.6

the birds parasitised by *Eimeria* had 1–3 oocystes and 4% had ≥ 21 oocystes, compared with 72% and 8.9% in 2008 (Table 2). The occurrence of parasites in the monthly faecal samples varied between years 2007 and 2008 (χ^2_{11} = 35.11; P < 0.0001). Data from the two years therefore were considered separately in subsequent analyses. Variation between years was also found at the taxon level for *Amidostomum* (χ^2_{11} = 52.4, P < 0.0001). For the other taxa, monthly sample sizes were too small for statistical analysis.

Regional variation in parasite occurrence

In both years, parasite occurrence varied by region (χ^2_2 = 8.7, P < 0.02 in 2007; χ^2_2 = 17.7, P < 0.0001 in 2008; Fig. 2 a, b). This was due to a higher occurrence of parasites at Max-Eyth Lake in comparison with the inner city (χ^2_1 = 8.7, P < 0.003 in 2007; χ^2_1 = 17.7, P < 0.0001 in 2008). Parasite occurrence in the rural areas was similar to that of the inner city (χ^2_1 = 1.09, n.s. in 2007; χ^2_1 = 2.52, n.s. in 2008) and there was also no difference in parasite levels for geese caught at Max-Eyth Lake and the rural areas (χ^2_1 = 0.58, n.s. in 2007; χ^2_1 = 0.53, n.s. in 2008).

Seasonal occurrence of parasites

In 2007 and 2008, the monthly occurrence of endoparasites varied throughout the year (2007: χ^2_{11} = 70.18, P < 0.0001, 2008: χ^2_{11} = 106.12, P < 0.0001; Fig. 3). On a taxon level, the number and types of endoparasites found also varied considerably throughout the year (*Amidostomum*: 2007: χ^2_{11} = 73.53, P < 0.0001, 2008: χ^2_{11} = 137.2, P < 0.0001;

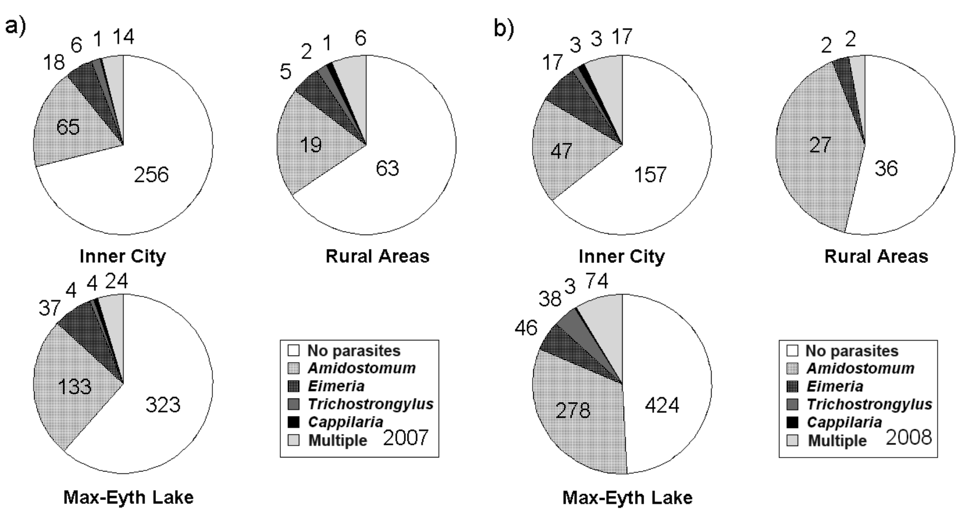

Figure 2. Regional variation in percentage parasite occurrence based on faecal samples from Greylag Geese sampled in the Stuttgart study area by region (Inner City, Max-Eyth Lake and rural areas) in: a) 2007 (left) and b) 2008 (right). "Multiple" indicates cases with more than one parasite species present.

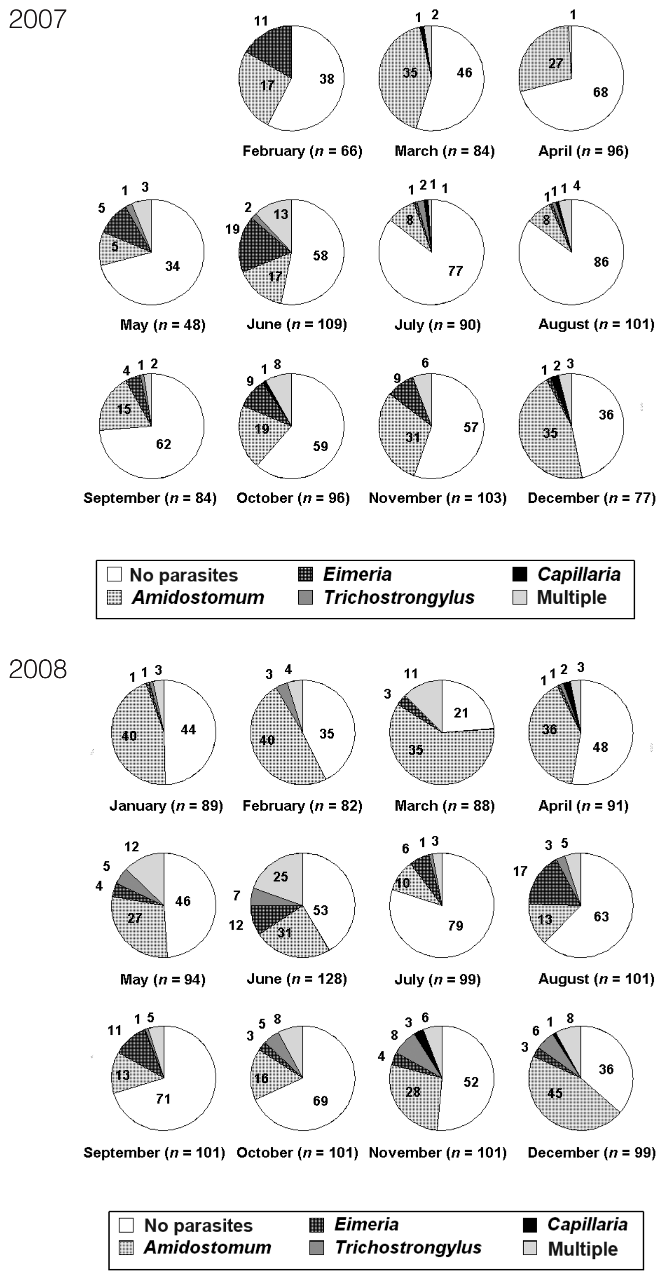

Figure 3. Monthly parasite occurrence in Greylag Geese based on faecal samples from Greylag Geese sampled in the Stuttgart study area in: 2007 (top) and 2008 (bottom). The numbers indicate number of individual geese sampled.

Trichostrongylus: 2007: χ^2_{11} = 41.1, P < 0.0001, 2008: χ^2_{11} = 43.14, P < 0.0001; *Eimeria*: 2007: χ^2_{11} = 79.9, P < 0.0001, 2008: χ^2_{11} = 51.85, P < 0.0001; Fig. 3, Fig. 4). In both years, *Amidostomum* peaked in March and in December, whereas there was no evidence of a repeating pattern amongst the other parasites.

In both years, the percentage of parasitised geese was low in summer (July–September; Fig. 5) and higher in autumn and winter (2007: χ^2_1 = 48.13, P < 0.0001, 2008: χ^2_1 = 48.85, P < 0.0001). The degree of parasitisation in spring 2007 was much lower than in spring 2008 (χ^2_1 = 14.93, P < 0.0001), for a possible explanation see results on the effect of climatic variables. In both years, during their annual moult in June, more geese had parasites than in the following, warmer summer months July, August and September (2007: χ^2_1 = 33.0, P < 0.0001, 2008: χ^2_1 = 40.73, P < 0.0001).

Effect of rainfall, temperature and relative humidity

Analysis of the effects of weather conditions, irrespective of the year in which the data were collected, found no association between monthly rainfall on the occurrence of parasites in each month (2007 and 2008 data pooled: Pearson correlation R_{23} = –0.135, P = 0.53, n.s.).

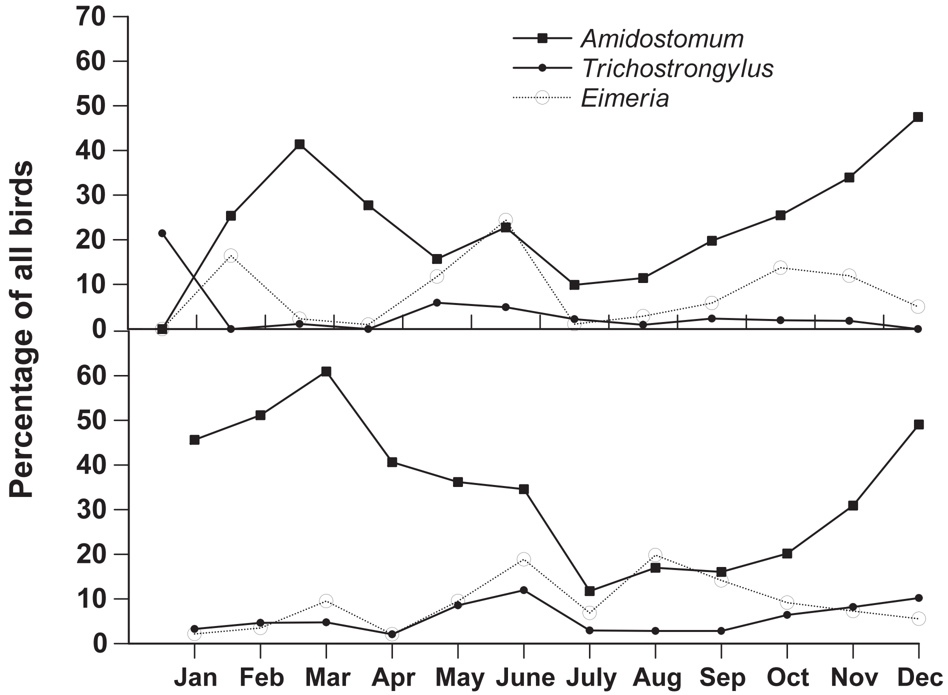

Figure 4. Monthly occurrence of *Amidostomum*, *Trichostrongylus* and *Eimeria* in 2007 (top) and 2008 (bottom). Numbers are expressed as the percentage of all samples taken.

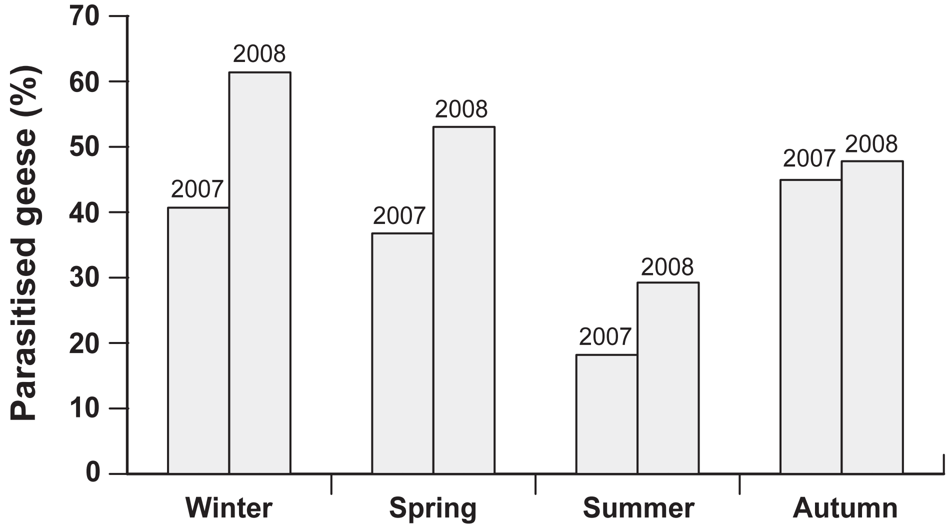

Figure 5. The percentage of parasitised geese, determined from faecal samples collected for Greylag Geese in the Stuttgart study area, varied with season (2007: $\chi^2_3 = 49.21$, $P < 0.0001$; 2008: $\chi^2_3 = 64.17$, $P < 0.0001$).

April 2007 was very dry, however, with only 1.41 mm of rainfall, in contrast to April 2008 which had 68.58 mm of precipitation.

There was a significant correlation between temperature and the proportion of geese with parasites, with fewer geese having parasites in warmer months (Pearson correlation: $R_{23} = -0.53$, $P = 0.008$ on including both 2007 and 2008 data; Fig. 6). Although there was some indication that the number of geese with parasites increased with humidity, this was not significant (Pearson correlation: $R_{19} = 0.25$, $P = 0.245$, n.s.; both 2007 and 2008 data included; Fig. 7).

Abdominal Profile and Endoparasites

Overall, the abdominal profiles of parasitised geese were not significantly lower than those of non-parasitised individuals (Mann-Whitney U test: $W = 120642$; $P = 0.14$, n.s.; Fig. 8). Similarly, there was no significant difference between the mean abdominal profiles recorded for geese with and without parasites on considering each month separately (Mann-Whitney U tests: $W = 6285$, $P = 0.93$ for October; $W = 4530$, $P = 0.11$ for November; $W = 4056$, P = 0.76 for December; $W = 6658$, $P = 0.28$ for January; and $W = 2662$, $P = 0.17$ for February; n.s. in each case).

There was significant variation between winter months (October–February) in the body condition of geese with parasites (Kruskal-Wallis test: $H_4 = 106.0$, $P < 0.0001$) but also for those without parasites ($H_4 = 47.21$, $P < 0.0001$; Fig. 8).

Geese had a much lower abdominal profile in January and February than in October and November (Mann-Whitney

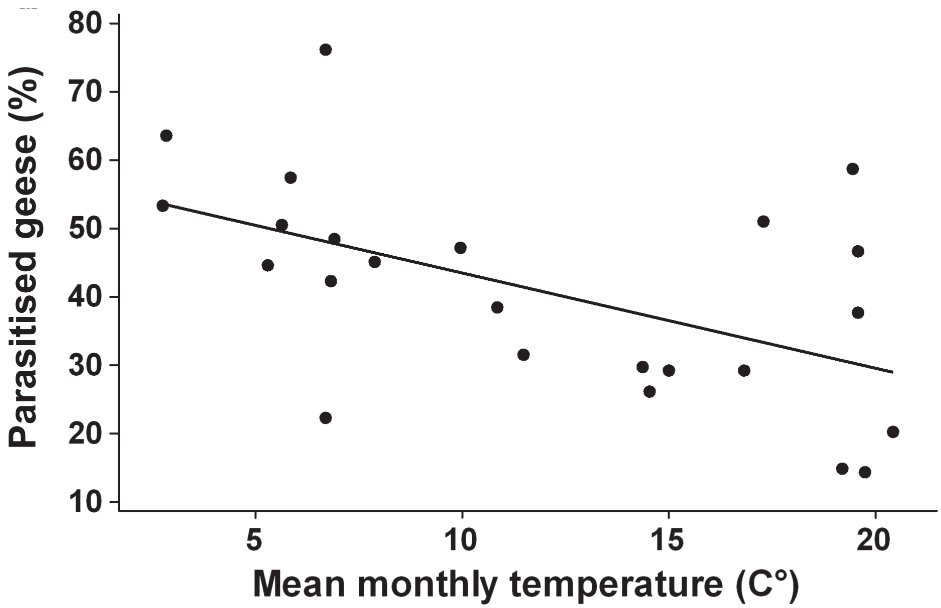

Figure 6. Correlation between mean monthly temperatures (calculated from daily means) and the monthly percentage of parasitised Greylag Geese in the Stuttgart study area in 2007 and 2008.

U tests: $W = 22011$, $P < 0.00001$ for geese with parasites; $W = 26269$, $P < 0.00001$ for those without parasites; Fig. 8).

Discussion

Seven different endoparasite taxa (Nematoda: *Amidostomum anseris*, *Trichostrongylus, Capillaria, Cyathostoma, Syngamus trachea*; Cestoda: *Cestodea*; Protozoa: *Eimeria)* were found in Greylag Goose faeces during the study. The level of infestation with parasites was low and no mortality was caused by parasitic infestation.

The occurrence of parasites in Greylag Geese varied regionally and seasonally. The region with the highest occurrence of parasites in the birds was Max-Eyth Lake. During the moulting season, geese aggregate there in large numbers when they are flightless and therefore largely confined to the water. This aggregation and confinement may increase chances for the spread of parasites. Moult is energetically demanding and, in passerines, a reduced immune response was associated with moult (*e.g.* Martin 2005; Sanz *et al.* 2004). Endoparasite infection could be facilitated through this reduced immune response, but this needs to be studied further.

Seasonal differences in endoparasite occurrence may (in addition to the moult phenomena) be at least partly explained by the prevailing climate (Anderson 1992). During hot and dry summer months, fewer parasites were found compared to periods with lower temperatures. Hudson & Dobson (1991) found that the first larval

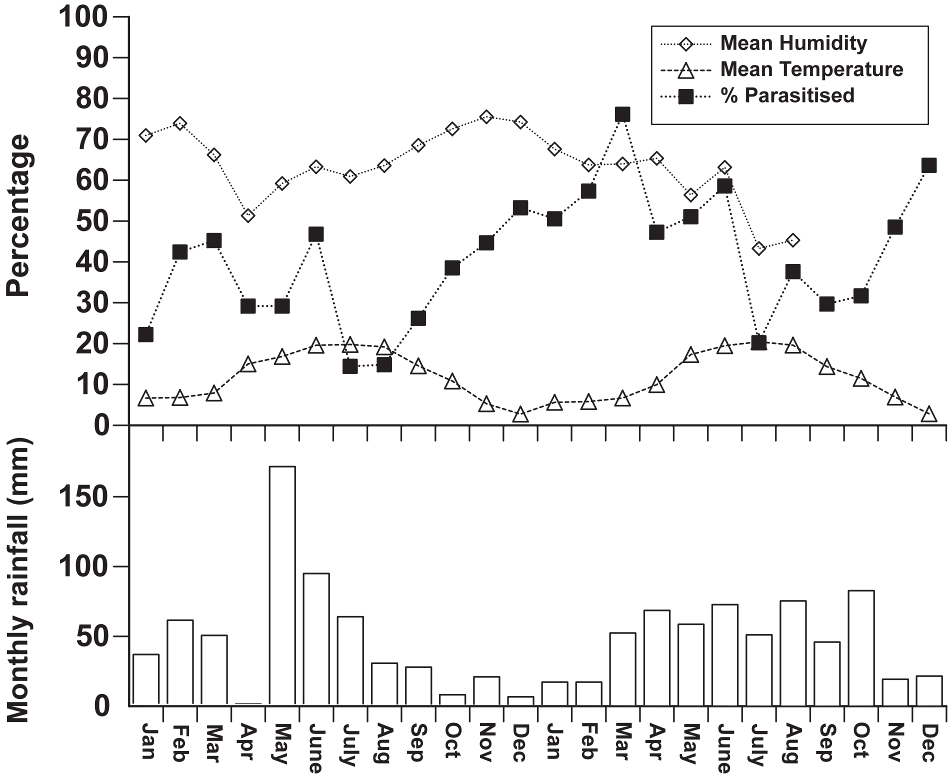

Figure 7: Monthly mean humidity and mean temperature in relation to the percentage of parasitised Greylag Geese in the Stuttgart study area (above) and monthly rainfall, from January 2007 through to December 2008.

stadia of *Trichostrongylus tenuis* survive only 24 hours in dry conditions. Data for other parasite taxa are scarce but may be similar to that of *Trichostrongylus,* potentially explaining low parasite prevalence in summer. The lower occurrence of parasites in April 2007 and the following months in comparison to 2008 may be explained by the almost complete lack of rainfall in April 2007 and unseasonally high temperatures (Fig. 7).

The larvae of *Amidostomum* hatch at temperatures above 6°C, *Trichostrongylus* at 4–7°C, so during mild periods parasites can flourish even in winter (Schnieder *et al.* 2006).

The higher *Amidostomum* occurrence in winter may be due to the poorer body condition of the geese, a result of lower food availability (Käßmann & Woog 2007), which may in turn exacerbate poor body condition. The annual variation in the occurrence of endoparasite taxa may also reflect differences in development cycles in these taxa. Monthly sampling may not be sufficient to mirror these patterns, because endoparasites may shed eggs in periods that

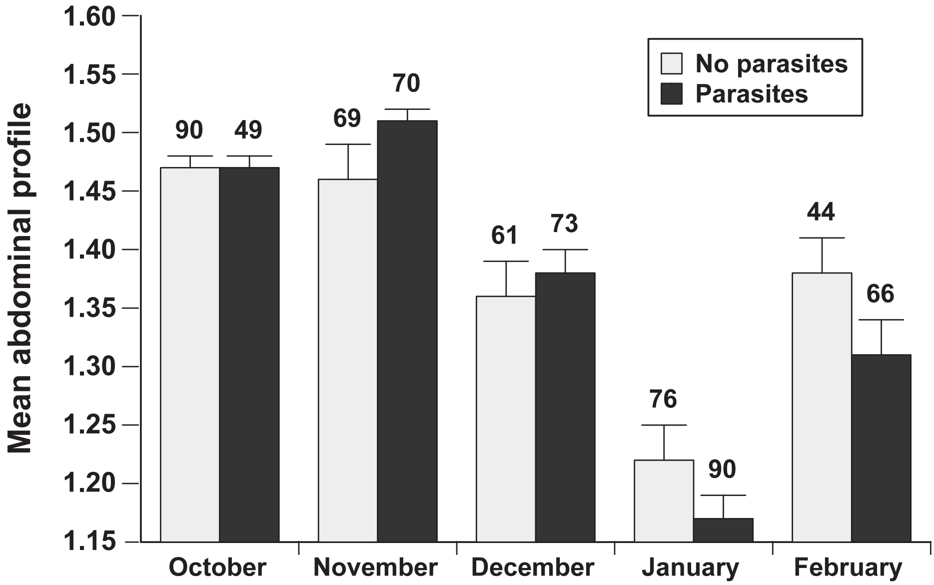

Figure 8: Mean abdominal profile of geese with and without parasites, based on faecal samples from Greylag Geese in the Stuttgart study area.

were not sampled. The seasonal differences may also reflect differences in their ability to survive frost, the reproductive biology of the endoparasites and the timing of infection in the geese. There were two peak periods in prevalence of *Amidostomum anseris* (in March and December), similar to patterns of *Trichostrongylus tenuis* infestation in Red Grouse *Lagopus lagopus scotica*, except that the two main infestation periods for the latter were in July–September and in late winter (Hudson & Dobson 1991).

Anderson (1992) points out that *Trichostrongylus tenuis* occurs in different stadia throughout the year and that this causes differences in the number of ova shed by the parasite. Unfortunately, we found little information on these cycles in the literature, especially concerning seasonal patterns in a wild setting.

The geese sampled at Max-Eyth Lake were more frequently found to have parasites than those sampled from the inner city parks. Goose numbers at Max-Eyth Lake were often much higher than in the inner city area and, furthermore, geese at Max-Eyth Lake often took refuge within a small conservation zone from disturbance caused by leisure activities, where they aggregated in large densities.

Contrary to Hudson & Dobson (1991), there was no evidence for parasite loads affecting goose body condition in this study. George & Bolen (1975) also found no correlation between physical condition and parasite load amongst Black-bellied Whistling Ducks *Dendrocygna autumnalis* although, as in our study, their parasite loads were rather low, possibly contributing to the lack of an effect.

In conclusion, this study described some patterns of parasite occurrence in the annual cycle of Greylag Geese but more detailed studies are needed. Measuring the effects of parasites on their hosts in the wild remains a challenge. Further investigation could be carried out for captive birds by treating some individuals to remove their parasites, then recording the effect on their body condition and subsequent reproductive success.

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