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Authors: Krone, Oliver, Altenkamp, Rainer, and Kenntner, Norbert

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PREVALENCE OF *TRICHOMONAS GALLINAE* IN NORTHERN GOSHAWKS FROM THE BERLIN AREA OF NORTHEASTERN GERMANY

Oliver Krone,[1,3] Rainer Altenkamp,[2] and Norbert Kenntner[1]

[1] Institute for Zoo and Wildlife Research, PF 601103, D-10252 Berlin, Germany
[2] Fehmarner Str. 18, D-13353 Berlin, Germany
[3] Corresponding author (email: krone@izw-berlin.de)

ABSTRACT: In recent years, the northern goshawk (*Accipiter gentilis*) has colonized suburban and urban areas in Berlin, Germany, and elsewhere in Europe. Because of the high proportion of feral pigeons (*Columba livia f. domestica*) in their diet, urban goshawks are suspected to have a high infection rate with *Trichomonas gallinae.* Therefore, from 1998 to 2001, we examined 269 nestlings from 90 nests for infection with *T. gallinae* by culture of swabs taken from the oropharynx and checked their oropharynx for the presence of caseous lesions indicative of trichomonosis. In 80% of the nest sites (n=90), at least one nestling was infected. The nestling infection rate with *T. gallinae* was 69.7% (n=33) in 1998, 73.0% (n=89) in 1999, 55.8% (n=77) in 2000, and 62.9% (n=70) in 2001. In total, 65.1% of the northern goshawk nestlings were culture positive for *T. gallinae.* Prevalence increased with the age of nestlings (χ^2=12.4, n=269, df=5, P=0.03) and tended to increase with brood size (χ^2=9.345, n=269, df=4, P=0.053). Caseous lesions were present in 12 nestlings (4.5%), but only 10 of these were culture positive for *T. gallinae.* Two nestlings (0.7%) had large caseous lesions (diameter>1 cm) characteristic of late-stage trichomonosis and died shortly after examination. It is suggested that the combination of a high prevalence of *T. gallinae* with a low rate of pathologicic changes is the result of an evolutionary-adapted parasite-host relationship.

Key words: *Accipiter gentilis,* Berlin, Germany, infectious diseases, mortality, northern goshawk, *Trichomonas gallinae,* trichomonosis.

INTRODUCTION

The northern goshawk (*Accipiter gentilis*) is a common raptor in the forests of the Holarctic (Cramp and Simmons, 1980; Fischer, 1983). In Central and Northern Europe, the northern goshawk inhabits all forest types (boreo-montaneous, temperate, mediterranean) and even agricultural landscapes with only patchy forest distribution (Cramp and Simmons, 1980; Glutz von Blotzheim et al., 1989; Bijlsma and Sulkava, 1997). In recent years, the northern goshawk has colonized suburban and urban areas in Germany (Behncke and Müller, 1991; Würfels, 1994; Altenkamp and Herold, 2001; Rutz, 2001; Altenkamp, 2002) and elsewhere in Europe, for example in Riga, Latvia; Wroclaw, Poland (Wieliczko et al., 2003) and Moscow, Russia (Galushin cit. in Love and Bird, 2000). In Berlin, Germany, about 70 breeding territories of northern goshawks were known in 1999, situated in urban forest areas as well as in graveyards and public parks. The colonization of Berlin and other European cities is probably favored by the high abundance of prey, especially feral pigeons (*Columba livia f. domestica*) throughout the year, the lack of human persecution, and the goshawk's habituation to intense human activities (Altenkamp and Herold, 2001; Rutz, 2001, 2003).

The protozoan flagellate *Trichomonas gallinae* is the causative agent for the potentially lethal avian disease trichomonosis. In general, *T. gallinae* inhabits the upper digestive tract of its host. Pigeons and doves of the family Columbidae are the most common hosts of *T. gallinae,* with prevalences up to 100% (Stabler, 1954; Stabler, 1969). Experimental studies reveal marked differences in pathogenicity and virulence among different strains of *T. gallinae* (Kocan and Knisley, 1970; Stabler, 1977; Stabler and Braun, 1979). Cross-infection with *T. gallinae* between different bird orders and families proved the ubiquitous infection potential but with differences among taxa (Levine et al., 1941).

Avivorous raptors, such as the northern goshawk, are directly exposed to the causative agent of trichomonosis by foraging on infected prey. There is also evidence for vertical transmission from the raptorial parents to their offspring either by feeding the nestlings with small pieces of meat with adherent flagellates or by direct bill-to-bill contact (Stabler, 1969; Stone and Janes, 1969; Cooper and Petty, 1988). In European, free-ranging birds of prey, *T. gallinae* was described in northern goshawks from Germany (Trommer, 1964; Link, 1986; Looft and Busche, 1990) and Great Britain (Cooper and Petty, 1988), and in Bonelli's eagle (*Hieraaetus fasciatus*) from Spain (Real et al., 2000) and Portugal (Hoefle et al., 2000). Trichomonosis, known as "frounce," has been a severe threat to falconry birds for centuries, and there is a high prevalence of disease in captive birds in the Middle East (Cooper, 1985; Krone and Cooper, 2002; Samour et al., 1995). It is also the most important infectious disease in free-ranging birds of prey in general (Keymer, 1972).

Boal et al. (1998) and Boal and Mannan (1999) reported a very high prevalence of *T. gallinae* and very high nestling mortality due to trichomonosis in Cooper's hawks (*Accipiter cooperi*) from urban areas of Arizona. Boal et al. (1998) concluded that the urban environment is a low-quality habitat for this species. One aim of this study was to investigate if the same is true for northern goshawks in an urban area of central Europe. Therefore, we examined the prevalence of *T. gallinae* and the mortality caused by trichomonosis in nestlings of northern goshawks in the Berlin area.

MATERIAL AND METHODS

The capital Berlin covers 890 km^2, is located in northeastern Germany, and has a human population of 3.4 million. The study area of 701 km^2 comprised the eastern half of Berlin and its proximate eastern surroundings in the federal state of Brandenburg (52°22′N–52°42′N, 13°21′E–13°48′E). In this study area, population dynamics and breeding success of northern goshawks were monitored from 1986 onwards (Altenkamp, 2002). Nests are inspected annually to determine the number and sex of nestlings and for banding them. To study the prevalence of *T. gallinae,* we sampled all nestlings from 90 nests from up to 37 different breeding territories between 1998 and 2001. In 1998, 55% of all nestlings in the study area were sampled (n=60), 90% (n=99) in 1999, and 100% in 2000 (n=77) and 2001 (n=70). The oropharynx of the nestlings was examined macroscopically for the presence of white, caseous lesions or stomatitis as an indicator for trichomonosis. Then we collected an oropharyngeal swab in culture medium to test for the presence of *T. gallinae.* Swabbing was performed carefully for about five sec with medium-saturated, cotton-tipped swabs on the mucosal surface of the oral cavity using the tongue as longitudinal center, ensuring the upper esophagus was included. The swab was immediately transferred into culture medium (Trichomonas-Medium, Hain Diagnostika GmbH, Nehren, Germany) and incubated at 37 C. Aliquots of each culture medium were examined using a light microscope at 100× and 400× magnification. If *T. gallinae* was not identified within 72 hr incubation, the sample was considered negative for the presence of the flagellate.

To determine sex and age of chicks, we measured wing cord length and weight of all nestlings. Age to the nearest day was determined after Bijlsma (1997), who measured nestlings daily. The northern goshawk is highly dimorphic, therefore sex determination of nestlings is reliable from the 12th day onwards (Bijlsma, 1993, 1997). Age was categorized and ranked at intervals of five day. We used chi-square and Fisher's exact probability test to check for differences between sexes, age groups, brood sizes, and sampling years (Sokal and Rohlf, 1995). Statistical tests were performed using SPSS 11.5; the significance level was set at $P \leq 0.05$.

RESULTS

In 80% of the nests (n=90), at least one nestling was infected. The nestling infection rate with *T. gallinae* was 69.7% (n=33) in the year 1998, 73.0% (n=89) in 1999, 55.8% (n=77) in 2000, and 62.9% (n=70) in 2001, respectively. Prevalence did not differ among years (χ^2=5.827, n=269, df=3, P=0.12). In total, 65.1% of the northern goshawk nestlings were culture positive for *T. gallinae.*

No differences were found between the sexes (n=269). Prevalence tended to increase with brood size (χ^2=9.345, n=269,

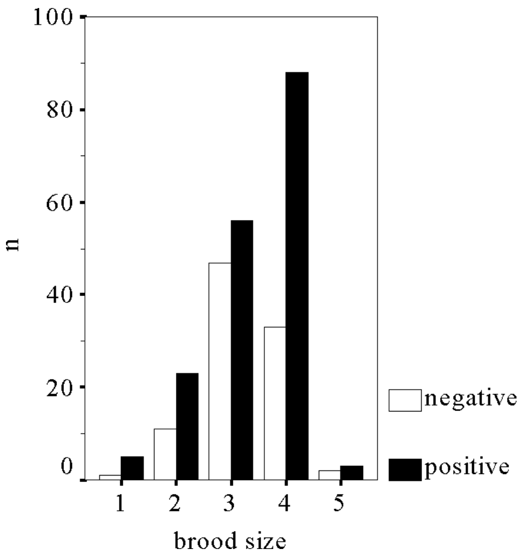

FIGURE 1. Northern goshawks (*Accipiter gentilis*) infection rate of *Trichomonas gallinae* versus brood size in the Berlin area from 1998 to 2001.

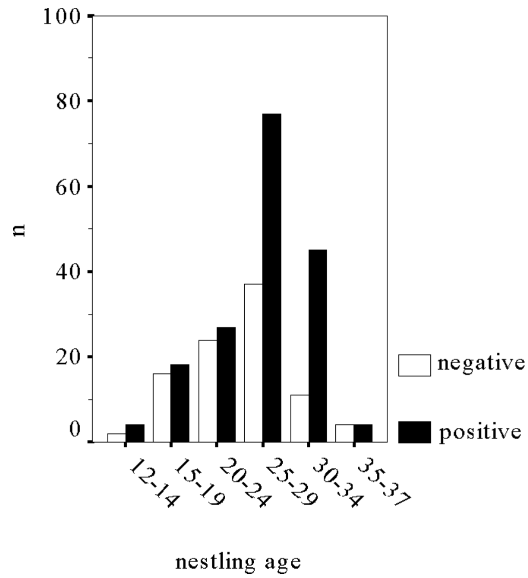

FIGURE 2. Prevalence of *Trichomonas gallinae* in different age classes of northern goshawk (*Accipiter gentilis*) nestlings (n=269) from the Berlin area.

df=4, P=0.053; Fig. 1). Prevalence was not randomly distributed over six age-groups (χ^2=12.4, n=269, df=5, P=0.03) indicating increasing prevalence with age (Fig. 2). None of the nest sites examined in two (n=9), three (n=13), or four (n=6) consecutive breeding seasons were without nestlings infected with *T. gallinae.*

Among 269 nestlings, 12 (4.5%) had caseous lesions in their oropharynx, of which 10 cases (83%) were culture positive for *T. gallinae.* Two (0.7%) nestlings with large, caseous lesions (diameter>1 cm), pathognomonic for late-stage trichomonosis died shortly after examination.

DISCUSSION

During the breeding season, pigeons and doves (Columbidae) form an important part of the goshawk's diet in our study area. In the breeding seasons 1999–2001, feral pigeons (*Columba livia f. domestica*) accounted for 29.2% of the prey (n=2,083) (Altenkamp and Herold, 2001), and they are assumed to be a reservoir host for *T. gallinae.* Quantitative data about the prevalence of *T. gallinae* in pigeons from our area does not exist. However, a mean prevalence of 65.1% in goshawk nestlings proved high exposure of the avivorous goshawk to *T. gallinae* in this area. Obviously, there is a continuous risk for infection with *T. gallinae* throughout the nestling stage, resulting in an increasing proportion of infected nestlings with increasing age. This also was shown for goshawks near Wroclaw in southwestern Poland. There, Wieliczko et al. (2003) found a prevalence of 35% (n=33) in up to 14-day-old nestlings, increasing to a prevalence of 100% (n=28) in the same nestlings when these had reached an assumed age of 35–40 day. However, as young goshawks older than 35 day regularly jump from the nest when disturbed (Altenkamp, pers. obs.) and details about age-determination are not given by Wieliczko et al. (2003), we doubt that all nestlings studied by the authors were indeed 35–40 day old at the second examination. Nevertheless, prevalence in the second age group was higher than in any age group of our study area, indicating a higher risk of infection compared with the Berlin area. This is in accordance with the higher proportion of feral pigeons in the diet of goshawks near Wroclaw, reaching 50.9% (n=1,166) in 1982–94 (Drazny and Adamski, 1996).

Furthermore, in our study area, there seems to be an increasing risk for *T. gallinae* infection for nestlings with increasing brood size. This could be explained by the higher number of prey deliveries by adult birds raising the risk of encountering infected prey items, but further research concerning this phenomenon is needed.

In our study, 12 nestlings showed clinical signs of trichomonosis (4.5%). Again, this rate was much higher near Wroclaw (22.2%) (Wieliczko et al., 2003). In our study, we could only confirm the presence of *T. gallinae* in 10 of the 12 nestlings that had lesions compatible with trichomonosis. Stomatitis due to other causes (e.g., capillariasis, vitamin A deficiency, pox and fungal infections) can be confused with trichomonosis, especially in the early stages, and may account for the two culture-negative birds. The same may be true for the study of Wieliczko et al. (2003). Only two chicks in our study were severely infected (<1%). These birds had large oropharyngeal lesions including deformations of the cranio-mandibular apparatus, which probably lead to impaired food intake followed by marked loss of body condition of the nestlings, resulting in their death shortly after examination. Wieliczko et al. (2003) did not report mortalities of nestlings from Wroclaw. Other quantitative data concerning mortality of nestlings caused by trichomonosis in Central Europe is not available, but the low mortality rates found in this study and near Wroclaw correspond well with anecdotal reports from rural areas of Germany (e.g., Looft and Busche, 1990). Obviously, in Central Europe, the northern goshawk has become well adapted to *T. gallinae.* The low mortality rate could also be caused by strains with low pathogenicity, which would produce and support protective immunity of northern goshawks to infections with highly virulent strains (Stabler, 1969). But, given the consistently high prevalence and the low mortality over the four study yr, variation in virulence of *T. gallinae*-strains seems to be low.

In Great Britain, mortality of northern goshawk nestlings caused by trichomonosis was much higher than in our study. Cooper and Petty (1988) reported a mortality rate of 10.5% for goshawk nestlings (n=134) from 46 nests examined from 1972 to 1985. They discussed this result as either a seasonal, highly virulent strain of *T. gallinae* (improbable from our view, given the long duration of the study) or as a result of inbreeding depression, as well as a nonadaptive genotype of northern goshawks. The present northern goshawk population in Great Britain derives solely from escaped or reintroduced birds used for falconry, following their import mainly from Finland. In the Scandinavian and Finnish taiga, feral pigeons are absent, and the proportion of pigeons in the diet of goshawks is much lower than in central Europe (e.g., Höglund, 1964; Marquiss, 1981; Tornberg, 1997). Therefore, the British population of goshawks may be less well adapted to *T. gallinae.*

Compared with urban Cooper's hawks in Arizona, urban goshawks in the Berlin area face minor problems with *T. gallinae.* Boal et al. (1998) reported a prevalence of 85% of *T. gallinae* in nestlings of Cooper's hawk from Tucson, Arizona (USA). Before fledging, 51% of the nestlings (n=283) died. Of these mortalities, 79.9% were caused by trichomonosis. The prevalence for *T. gallinae* in nestlings from an exurban study area was only 9%, and none of the nestlings died due to trichomonosis (Boal et al., 1998; Boal and Mannan, 1999). Very probably, the high *T. gallinae*–induced mortality reported by Boal and Mannan (1999) is the result of a very recent confrontation of a raptor population with this disease, and not a sign of low quality of the urban area itself, as stated by the authors. As there is a strong selective pressure, we may assume that this mortality rate will decrease rapidly. Indeed, further studies on *T. gallinae* infection in Cooper's hawk in three distinct study areas of North America, including urban and rural nest sites, revealed a prevalence of only 2.7% (n=110) without mortality attributed to trichomonosis even after fledging (Rosenfield et al., 2002).

Additional quantitative data about the prevalence of *T. gallinae* in raptors is scarce. In a survey of 39 Bonelli's eagle nestlings from Spain in 1993, 14 eaglets (36%) were positive for *T. gallinae,* including one nestling that died due to trichomonosis. However, only two chicks had lesions attributed to *T. gallinae* infection. In a previous study from 1986 to 1993, four of 179 macroscopically examined eaglets (2%) died due to trichomonosis (Real et al., 2000). Hoefle et al. (2000) reported a high prevalence of trichomonosis in Bonelli's eagle nestlings from southern Portugal. In 1997, 14 of 16 examined eaglets (87.5%) had oropharyngeal or esophageal lesions. However, these may (at least partly) be caused by diseases other than *T. gallinae* (see above). Indeed, in 1998, Hoefle et al. (2000) examined another 12 nestlings both macroscopically and by culture. Of these, only six were infected with *T. gallinae,* but ten eaglets had macroscopic lesions in the oropharynx. Both studies explained the high prevalence of *T. gallinae* with an increase of feral pigeons in the eaglet's diet and a decrease of the traditional prey, e.g., Lagomorpha and Galliformes (Real et al., 2000; Hoefle et al., 2000).

Considering the low mortality of nestlings because of trichomonosis, the high breeding success, and the steadily increasing population in our study area (Altenkamp, 2002), we conclude that trichomonosis has little demographic impact on the population. This was also proved for the urban goshawk population in Hamburg (C. Rutz, pers. comm.). However, it would be interesting to survey the mortality due to trichomonosis during the postfledging period and the prevalence of *T. gallinae* infections in immature and adult northern goshawks and other avivorous raptors in Berlin and elsewhere. Further research is needed to investigate the incidence of *T. gallinae* infections in Columbidae and the virulence of observed strains in Berlin as well as in Germany.

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