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Epidemiological role of birds in the transmission and maintenance of zoonoses

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Summary

The risk of zoonoses spreading from birds to humans is lower, quantitatively speaking, than the risk of transmission between other host groups, because the two taxonomic groups share fewer pathogens. Nevertheless, birds have a number of epidemiological characteristics that make them extremely important hosts in the transmission and maintenance of zoonoses, including their susceptibility to pathogens that are extremely hazardous to humans (such as highly pathogenic avian influenza virus, West Nile virus and *Chlamydia psittaci*) and their ability to travel long distances, especially in the case of migratory birds. The fact that the human diet includes poultry products (meat, eggs and their by-products) also means that most human cases of foodborne zoonoses are infections of avian origin. Lastly, close contact between humans and pet birds or urban birds leads to interactions of public health concern. This article sets out to describe the main factors that determine the role of birds in the epidemiology of zoonotic infections.

Keywords

Birds – Domestic – Epidemiology – Companion animal – Public health – Wild – Urban – Zoonosis.

Introduction

Birds are susceptible to fewer zoonotic agents than mammals, reflecting the evolutionary distance between birds and humans. A comparison of the class of birds (*Aves*) with the order of carnivores *(Carnivora)* shows that carnivores are susceptible to 43% of all zoonotic agents, compared with only 10.3% in the case of birds, although this percentage increases to 18.4% if the agents responsible for emerging zoonoses are also taken into account (1). The lower susceptibility of birds to zoonotic agents has to do with their higher body temperature, the specificity of strains and their excellent immune system (2). Birds posing the highest risk of excreting pathogens are therefore those with a compromised immune system, young birds, birds farmed intensively under forced production systems and those caught recently in the wild.

Despite their lower susceptibility, birds participate effectively in the transmission and spread of zoonoses, even over great distances, by acting as natural hosts, reservoirs and amplifying or liaison hosts for zoonotic agents because of their ability to fly. The emergence in 1997 of a new variant of the highly pathogenic avian influenza (HPAI) virus − H5N1 − in humans in China (3) emphasised the epidemiological importance of birds, especially migratory waterfowl, in relation to emerging zoonoses. Furthermore, birds are the reservoir of the most widely reported classical foodborne zoonotic agents in developed countries (campylobacteriosis and salmonellosis). This review sets out to describe the main factors that determine the role of birds in the epidemiology of zoonoses. In order to facilitate description of these factors for each group, the article is divided into sections in accordance with bird categories: farmed poultry, free-living birds (especially migratory or urban birds) and ornamental birds (companion animals, many of exotic origin). These divisions are not clear-cut, as some infections may be common to several strata and some bird species may belong to more than one of these categories.

Intensive poultry farming and risk factors for zoonoses: from salmonellosis to highly pathogenic avian influenza

Rapid world population growth has increased demand for animal protein, which is changing traditional animal production systems in terms of intensification, the introduction of new species and disruption of the ecological environment, all of which have promoted the emergence of zoonoses. The World Organisation for Animal Health (OIE) therefore prioritises the relationship between food-producing animals and zoonoses in its approach to notifiable diseases (4). Even though poultry farming is one of the pillars of animal production for human consumption, the epidemiological determinants in traditional poultry production systems and modern intensive poultry farming differ. In Europe, poultry farming focuses mainly on the species *Gallus gallus* (laying hens and broilers) and, to a lesser extent, other species (such as turkeys, ducks, geese, partridges and quails) reared mainly under intensive farming systems using acceptable biosecurity systems. This differs from other regions of the world, such as Southeast Asia, where waterfowl production (primarily ducks) predominates, under more basic production systems, which is a risk factor for the emergence of new HPAI virus strains.

As intensive poultry farming makes such a major contribution to human nutrition, the two most commonly diagnosed zoonoses in humans (salmonellosis and campylobacteriosis) are mostly avian in origin and are foodborne. A report published by the European Food Safety Authority (EFSA) in 2014 (5) showed that cases of salmonellosis and campylobacteriosis in the European Union in 2012 accounted for 28.6% and 9.3% of all foodborne disease outbreaks in humans, respectively. As both diseases are foodborne, their impact on individual countries is determined more by their inhabitants' eating habits than on the bird population. According to a 2012 EFSA report (6), there were 1.623 billion individuals of the species *Gallus gallus,* including broilers and layers, in the 15 European Union Member States that provided data. The report pointed out that a single country (Poland) accounted for 40% of this total, which, when added to the share of a further three countries (Czech Republic, Romania and Spain) made up 80% of all stock. However, the rates of human cases of salmonellosis and campylobacteriosis in these four countries in relation to the average number of cases published by EFSA do not allow a direct link to be established between the prevalence of these diseases and the size of the poultry population (6).

Infection with *S. enteritidis* (avian origin) is the main foodborne zoonosis in the European Union in terms of the number of outbreaks caused (5, 6). The two species of salmonella adapted to birds (*S. pullorum* and *S. gallinarum*) are not considered a public health risk, although they have been linked to salmonellosis in children. While many other animal species contract salmonellosis, virtually all serotypes infecting humans also infect birds, with the result that birds are considered to be one of the main reservoirs of salmonella. In adult birds, salmonella infection tends to be asymptomatic and some birds remain carriers. While some serotypes may be transmitted vertically (transovarial transmission), faecal contamination is the main mechanism of transmission and the eggshell becomes contaminated when salmonella of faecal origin cross the cloaca. In addition, the resistance of salmonella to environmental factors (weeks or months under favourable humidity, temperature and pH conditions) (7) amplifies the faecal transmission impact of carrier birds. A programme to control salmonellosis in Europe's poultry sector has been underway since 2010. It is mandatory for all European Union Member States and has led to a decline in the occurrence of this disease in both birds and humans in recent years (5, 6).

In the European Union, campylobacteriosis is the second most important zoonosis in terms of the number of outbreaks caused (and the leading zoonosis in terms of the total number of human cases) (5, 6). In the case of *Campylobacter jejuni*, poultry are the natural reservoir of infection, heavily influenced by the expansion of industrial poultry farming. Contamination of carcasses (chiefly chicken meat) during slaughter at the slaughterhouse is the main risk factor for human infection with *C. jejuni*, as the bacteria are transmitted to cuts of broiler meat (8). Furthermore, such cuts can cross-contaminate other foods, which pose even more of a risk when eaten raw (such as salads). In spite of this evidence, and unlike what has happened in the case of salmonellosis, there is still no European strategy to reduce the prevalence of *C. jejuni* in poultry farms, with the result that the number of human cases has remained constant or fallen only slightly (5).

In Southeast Asia, the conditions under which poultry (mainly chickens and ducks) are farmed and traded are risk factors for HPAI serotype H5N1, a zoonosis that has caused few human cases to date but has had a significant impact both politically and social and across the media because of its future potential to evolve into a pandemic, with unforeseeable consequences, or to be used as a biological weapon. In Southeast Asia, markets selling live broiler poultry (mainly chickens and ducks) are therefore considered a key factor in the epidemiology of avian influenza, as Hong Kong's bird markets are believed to have been the source of the H5N1 outbreak in 1997 (9). Lastly, migratory waterfowl also play a key role in the spread of influenza virus strains from Southeast Asia to parts of Africa and Europe, although the large-scale transport of poultry (industrial poultry farming) cannot be ruled out as a factor contributing to the spread of these new strains (10). According to data from the World Health Organization (11), between 2003 and December 2014, a total of 676 human cases of H5N1 infection were recorded across 16 countries, with a fatality rate of 59%. In spite of this alarm bell for the authorities, some researchers have minimised their importance, claiming that the data were biased because they related to hospitalised cases. Instead they have argued that most human infections do not have a severe clinical impact, demonstrating that 1–2% of 12,677 participants from 20 studies had seroevidence of prior H5N1 infection (12).

Although different types of influenza A virus can cause severe outbreaks of respiratory disease in a wide variety of hosts (humans, horses, marine mammals and pigs), domestic and wild birds have been the main subject of epidemiological studies of HPAI. The emergence of a number of new strains of the influenza A virus has been linked with various human pandemics causing high morbidity and mortality. In most hosts, influenza A virus infections are limited to a few combinations of subtypes N (neuraminidase) and H (haemagglutinin). However, all subtypes and most combinations have been isolated in birds, which can be asymptomatic and excrete virus for prolonged periods (12). In addition, genetic studies have shown waterfowl to be the most likely source of all influenza A virus strains affecting other species − in other words, all mammalian influenza viruses come from an avian reservoir. While the respiratory tropism of influenza means that respiratory, nasal and oral secretions contain the virus, excretion through the faeces is a noteworthy feature (10), with the result that faecal transmission is the main mechanism of virus spread, especially among waterfowl (particularly healthy carriers) (9, 13). The mechanism by which influenza viruses pass from one bird to another is extremely complex and not fully understood. Determinants modifying it include virus strain, avian species and other environmental factors (10).

In Southeast Asia, mass production of waterfowl (ducks and geese), the epidemiological characteristics of the markets where such animals are purchased live, and close contact in the home environment between these species and humans (as well as pigs) form the epidemiological basis for the emergence of new cases in this region. This has been demonstrated, once again, with subtype H7N9 of the influenza A virus, whose outbreak in China in 2013 caused the first human case of H7N9 infection. This new virus belongs to the AH7 group of influenza viruses, which normally circulate among birds and had already caused cases (H7N2, H7N3 and H7N7) in Canada, Italy, Mexico, the Netherlands, the United Kingdom and the United States of America, mostly related to influenza outbreaks in poultry. Infected humans presented with conjunctivitis and respiratory symptoms, with the exception of one fatality in the Netherlands (14).

Finally, the debate on avian influenza gathered momentum in 2012 when the authorities in the USA censored the publication of articles submitted to the journals *Nature* and *Science*, respectively, describing the molecular mechanisms needed to create mutant strains of HPAI (H5N1) with the ability to spread aerogenically among humans (15, 16). As regards the most deadly types of influenza virus (H5 and H7) circulating among birds, the OIE has maintained a database (17) since 2003 containing official information on HPAI outbreaks (H5N1 and other serotypes).

Emerging diseases, migratory movements and the role of wild birds in the spread of zoonoses

Periodic movements of migratory birds make them potential spreaders of pathogens, some of public health concern. Seasonal bird migration, one of nature's most spectacular phenomena, leads millions of birds to travel each autumn from northern and eastern Europe to southern Europe and Africa, and from North America to Central and South America, a process that is repeated in reverse each spring. The stress of migration can lead to immunosuppression and increased disease susceptibility, as well as reactivation of latent infections (13). A notable source of HPAI (H5N1) risk is when migrating birds from Asia and northern Europe congregate in sub-Saharan Africa. Migratory birds also interact with populations of domestic and free-living sedentary birds at stopover sites (for resting or feeding) or at the end of their journey. This makes concentration points along migration corridors (such as the Straits of Gibraltar, Messina, Bosphorus and Sinai Peninsula) especially important. Key biosecurity measures include preventing the access of wild birds to domestic birds by means of special mesh fencing and mortality monitoring of both bird populations.

Apart from acting as a reservoir of zoonotic agents, migratory birds can be infested with arthropod vectors, which in turn transmit pathogens that can be carried by birds over long distances and may be responsible for diseases of major importance. Borreliosis, or Lyme disease, is the most prevalent vector-borne zoonosis in humans in the

Northern Hemisphere, which, a few decades ago, occurred on only an occasional and localised basis (18, 19, 20, 21). Caused by several spirochete species of the *Borrelia burgdorferi* sensu lato complex, in humans the symptoms of Lyme disease vary widely and can take non-specific clinical forms that are hard to diagnose, even by experienced physicians (20). Infection is transmitted by the bite of an *Ixodes* tick whose pre-adult stages feed on small mammals (rodents and birds) and whose adult stages prefer larger animals (deer, sheep, cattle, etc.) (7). Seabirds act as natural reservoirs (18). The epidemiological role of birds in transmitting this infection has been emphasised, as they can become infected by the bacterium and, even when not infected, can carry it for long distances inside *Ixodes* spp. ticks during their migratory movements (13). The natural reservoirs of *B. burgdorferi* sensu lato are birds, small mammals and reptiles (lizards), with seabirds (particularly guillemots parasitised by *Ixodes uriae*) playing a key role in the spread and spatial distribution of *Borrelia* (as amplifying and liaison hosts), owing to the migratory and reproductive behaviour of guillemots in massive colonies (13, 18).

Another prominent epidemiological role of birds, especially wild ones, is to act as liaison hosts, or even amplifying hosts, for some arboviruses (arthropod-borne viruses). They include arboviruses caused by flaviviruses antigenically related to Japanese encephalitis, which often cause acute clinical symptoms (encephalitis) in horses and humans. In addition to the classic forms of equine encephalomyelitis in this complex found in the Americas, there is West Nile fever, caused by West Nile virus (WNV), an emerging mosquito-borne disease. Many birds can contract WNV infection. While symptoms are more severe in corvids, birds of other species present few symptoms but maintain the infection until immunity develops. Birds are therefore essential to the cycle of infection transmission as amplifying and liaison hosts that transport the virus over long distances (13). An outbreak in humans in Long Island (New York State) in the USA in 1999 sparked an unprecedented epidemic of WNV. In the years that followed, the virus spread massively, peaking at 15,000 equine cases in 2002 − the year when it reached the West Coast (22). The origin of the first WNV outbreak in the USA has been linked to the arrival of infected birds after a transatlantic migration (gulls or waterfowl) and to the fact that birds spread the infection throughout the country. Over the past decade, reports of human and equine cases have increased in Europe and countries bordering the Mediterranean Sea, just as they have in the USA. This resurgence has been explained by interactions between migratory bird populations, sedentary local bird populations and overwintering mosquitos (23). Another flavivirus, the Usutu virus, which behaves much like WNV and is also transmitted by mosquitos, emerged in Europe in 2001 and has been found in several countries, including Austria, Germany, Hungary, Italy, Spain and Switzerland. The Usutu virus has been found not only to cause human clinical cases but also to circulate in wild birds, mosquitos and sentinel animals (horses and chickens) (24).

The role of urban birds and exotic pet birds in the spread of zoonoses

Wild birds also interact with humans in cities, to the extent where they can sometimes become a pest. In addition to pigeons, there are vast urban populations of starlings, gulls, corvids (jackdaws) and even released or escaped exotic birds, such as the monk parakeet and other psittacines. In parks and gardens, these birds interact with some of the most susceptible humans (elderly people and children). What is more, some birds, including gulls and storks, have adapted to feed in rubbish dumps, posing an additional challenge for public health, especially when they alternate their visits between rubbish dumps and wetlands (lakes, marshes, river estuaries, etc.) that are used for swimming and other leisure activities, or even to provide human drinking water (fortunately the birds visit these wetlands before the water is treated). An important point of note is that gulls are a major reservoir for salmonella. In addition, the fact that some bacteria (*Salmonella* spp., *Campylobacter* spp. and *Enterococcus* spp.) isolated from the droppings of free-living birds (gulls and other species) proved to be resistant to antibiotics and, in some cases, were multidrug-resistant (13), further substantiates the epidemiological role of urban birds in public health and makes it necessary to establish control measures, where appropriate.

Human contact with birds that nest in human habitations is a further factor to be considered. For instance, pigeon droppings, in dovecotes, attics and other nearby locations, pose a risk of spreading fungi, such as *Cryptococcus neoformans*, to immunocompromised people. Although other bird species may also be involved, old pigeon droppings are a reservoir for *C. neoformans*, where it can persist for over two years and, when droppings turn to dust, the fungus can be spread by inhalation (25). Although healthy humans are not very susceptible, some immunocompromised individuals may develop severe symptoms. For instance, cryptococcosis is the commonest cause of fatal meningitis in patients with acquired immunodeficiency syndrome (AIDS) (26). This makes it necessary to avoid repeated contact between immunocompromised individuals and pigeons or their droppings. In addition, before removing droppings from places such as cornices, sills and dovecotes, these sites must be decontaminated using liquid chemicals (not aerosols). A mask must always be worn during decontamination.

Just like henhouses or dovecotes, the nests of urban birds harbour various ectoparasite species, especially red mites, ticks and fleas (see Table I). Not only can such ectoparasites induce lesions in people, they are also potential vectors of zoonotic infections (e.g. *Ixodes* spp. can transmit *B. burgdorferi*; *Dermanyssus gallinae* can play a role in the spread of *Chlamydia psittaci)*. The thigmotactic diurnal behaviour of *D. gallinae (*and ticks of the *Argasidae* family) is the key to the increased zoonotic risk they pose after birds have abandoned their nests or nesting places (henhouses, dovecotes, etc.) because, when such ectoparasites no longer have access to a host on which to feed, they may attack humans (27, 28).

Another group of birds of zoonotic concern is pets, in particular those of exotic origin, exposure to which is compounded by closer proximity to people in a home setting, especially children (who may have laxer hygiene habits) and sick people (who may have a weakened immune system). Even though salmonellosis is most likely to be foodborne, the risk of salmonella transmission to humans through contact with the droppings of pets (exotic birds, ducklings and chicks)

(2, 29) should therefore not be ruled out, particularly when the contaminated surface is wet or in contact with water (waterers, pet baths, etc.) and the required hygiene standards are not met (28).

Since the 1980s, imports of exotic birds from tropical countries, mainly into Europe and North America, have increased, in many cases illegally or without the relevant animal health guarantees, which is a risk factor for the introduction of zoonoses into homes and for ecological balance. Vietnam is one of the countries with the longest tradition of trading wild birds and the country that has reported the highest number of HPAI (H5N1) outbreaks. In this context, 25% of the most commonly traded bird species were found to be susceptible to HPAI (H5N1) (30). The stress and resulting immunosuppression suffered by captured free-living birds are factors that increase the risk of pathogen excretion by reactivating sub-clinical or latent infections. In addition, pet stores, bird shows and exotic bird markets are very busy places, which favours transmission. This risk increases when children are involved in such contact, as they tend to take fewer hygiene precautions (28).

One of the commonest avian zoonoses in humans is caused by *Chlamydia psittaci*, characteristic of, but not exclusive to, birds of the order Psittaciformes (cockatoos, parrots, parakeets, budgerigars, etc.), particularly those used as pets. Apart from psittacines, domestic turkeys and hens are involved in maintaining infection, and the number of cases detected among urban pigeons has also increased. Infection in birds can be persistent and chlamydia excretion is reactivated in stress situations. Chlamydia is transmitted via the respiratory route from droppings, nasal secretions and contaminated tissues and feathers, the commonest route being inhalation of aerosolised particles from infected droppings (31). Therefore, in the interests of public health, persons responsible for cleaning psittacine cages and equipment are advised to wear protective masks and there should be adequate ventilation. As it is an occupational zoonosis, it affects such groups as veterinarians, pluckers, pigeon breeders, poultry farmers, laboratory personnel, and workers in pet stores, slaughterhouses and poultry processing plants. Despite all this, there appears to be no awareness of the zoonotic risk posed by pets, as demonstrated by a survey of 300 pet shops selling birds and other species in the United Kingdom in 2003, where 36% of respondents said that the zoonotic risk was zero and 11% were unaware of any such risk (32).

Table I shows the clinical and epidemiological characteristics of the major avian zoonoses and includes not only the diseases mentioned above but also avian zoonoses that are not discussed in this article because they are less important or have a lower incidence.

To conclude, it is clear that, despite the evolutionary distance between humans and birds, birds can become infected by a wide variety of zoonotic pathogens. The fact that the human diet includes poultry products, the ability of wild carriers to travel long distances, and contact between humans and poultry or pet birds are all factors that increase the zoonotic importance of birds. While the number of human cases of classical foodborne zoonoses (salmonellosis or campylobacteriosis) are falling or have levelled off in countries that implement control programmes, emerging zoonoses, such as HPAI (H5N1), Lyme disease or West Nile fever, require surveillance programmes to be redesigned in the light of new epidemiological findings.

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Table I
Clinical and epidemiological characteristics of the main avian zoonoses (2, 7, 26, 27, 28)

Disease/agent	Route of transmission	Clinical picture in humans	Clinical picture in birds	Risk factors
Virus				
Highly pathogenic avian influenza *Orthomixovirus*	Airborne. Secretions and faeces of sick birds or healthy carriers	Respiratory symptoms High fatality rate	High mortality in birds Asymptomatic in wild carriers	Wild reservoir (waterfowl) Intermingling of wild birds of different origins Live bird markets
West Nile fever Other: American forms of equine encephalomyelitis, Usutu virus, etc. *Flavivirus* (Japanese encephalitis virus group)	Percutaneous by mosquito bite (*Culex* spp., *Aedes* spp.)	Several neurological disorders (encephalitis)	Asymptomatic Occasionally severe symptoms with high mortality (corvids)	Mosquito breeding sites Sick or carrier wild birds
Newcastle disease *Paramyxovirus*	Direct or indirect contact (respiratory secretions or droppings)	Minor zoonosis Mild and self-limited conjunctivitis	Usually respiratory symptoms Takes mild, moderate and very virulent forms	Direct contact with sick or carrier birds Live vaccines
Bacterium				
Ornithosis/psittacosis *Chlamydia psittaci*	Respiratory (dried and aerosolised faeces)	Pneumonia, flu-like and other symptoms	Gastrointestinal and respiratory symptoms	Companion animals (Psittacines) Occupational zoonosis
Lyme disease (borreliosis) *Borrelia burgdorferi* sensu lato	Percutaneous (tick bite)	Skin, neurological, joint or cardiac symptoms	Mainly asymptomatic	Migratory birds with *Ixodes*: geographical spread of *Borrelia burgdorferi*

Salmonellosis *Salmonella enteritidis* *S. typhimurium* *S.* spp.	Foodborne, faecal contamination in the surroundings of companion animals	Fever, gastroenteritis, abdominal pain	Young birds: diarrhoea and mortality Adult birds: inapparent Healthy carriers	Contamination of eggs, poultry meat and their by-products. Lack of hygiene in food preparation. Little risk with companion animals
Campylobacteriosis *Campylobacter jejuni*	Foodborne	Acute gastrointestinal symptoms Self-limiting infection	Diarrhoea in young birds Inapparent in adults Healthy carriers	High prevalence in poultry farms Cross-contamination of chicken carcasses Lack of hygiene in food preparation
Tuberculosis *Mycobacterium avium* *M. tuberculosis*	Faecal Airborne	Gastrointestinal tuberculosis Respiratory transmission	Gastrointestinal tuberculosis Respiratory transmission	Respiratory secretions Contaminated water, soil and dust Immunocompromised individuals
Yersiniosis *Yersinia enterlocolitica* *Y. pseudotuberculosis*	Faecal	Acute abdominal symptoms (appendicitis) Arthritis	Gastroenteritis	Wild bird carriers
Q fever *Coxiella burnetii*	Airborne	Fever, atypical pneumonia, hepatitis, chronic endocarditis	Asymptomatic	Faecal bird carriers of *C. burnetii* Birds in contact with infected ruminants
Fungi				
Cryptococcosis *Cryptococcus neoformans*	Airborne	Severe symptoms (immunocompromised individuals) Respiratory symptoms (asymptomatic) Meningitis/meningoencephalitis	Asymptomatic. Grows in the faeces of pigeons and other bird species	Aerosolised droppings
– Histoplasmosis *Histoplasma capsulatum*	Airborne	Asymptomatic Respiratory or generalised symptoms	Asymptomatic Grows in faeces	Immunocompromised individuals Caves, guano

Aspergilosis *Aspergillus fumigatus*	Airborne	Pulmonary symptoms Localised or invasive	Asymptomatic Respiratory and gastrointestinal	Immunocompromised individuals Telluric reservoir
Protozoa				
Microsporidiosis *Encephalitozoon hellem*	Faecal Airborne	Asymptomatic; diarrhoea Severe systemic infection in immunocompromised individuals	Occasional (psittacines) Faecal carriers	Lack of hygiene in bird equipment, water and feeders
Giardiasis *Giardia* spp.	Faecal	Asymptomatic Diarrhoea	Asymptomatic Diarrhoea	Lack of hygiene in bird equipment, water and feeders
Cryptosporidiosis *Cryptosporidium spp.*	Faecal	Asymptomatic; diarrhoea Extraintestinal manifestations (liver and lung)	Asymptomatic; diarrhoea Respiratory symptoms	Lack of hygiene in bird equipment, water and feeders
Trematodes				
Cercarial dermatitis Larvae of trematodes (*Schistosomatidae)*	Percutaneous	Accidental host Swimmer's itch	Intestinal symptoms	Bathing in water contaminated with waterfowl droppings that is home to snails and other intermediate hosts
Ectoparasites				
Dermatitis caused by mites *Dermanyssus gallinae*	Direct or indirect contact	Pruritic dermatitis	Dermatitis	Thigmotactic diurnal behaviour Cages, facilities, henhouses, dovecotes, nests, etc. Mayor risk following abandonment of nests by birds
Dermatitis caused by ticks: *Argas* spp.; *Ixodes* spp.	Direct or indirect contact	Described anaphylactic reactions to *Argas reflexus* bites	Dermatitis	Thigmotactic diurnal behaviour of Argasidae

Dermatitis caused by fleas: *Ceratophyllus gallinae; C. columbae; C. fringillae; C. garei; Dasypsyllus gallinulae*	Direct or indirect contact	Pruritic dermatitis	Dermatitis	Preferred host: domestic hen Other bird species (pigeon, pheasant, turkey, sparrow, etc.)