Chapter 5

Welfare of Pet Birds and Potential Zoonoses

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Abstract

The human-animal interaction had long been established and currently emerged in multiple aspects including housing of animals for food and as pets. The "pet birds" are the wild or exotic birds having high genetic value and are housed under captivity as companions or for ornamental purposes. The commonly housed pet birds are either passeriformes or psittaciformes. These birds are housed under conditions to meet standard requirements for welfare of pet birds. Besides the pet birds and human relationship, these birds are potential carriers or transmitters of several pathogens considered responsible for zoonotic diseases. The range of the zoonotic diseases consisted of bacterial, viral, parasitic and fungal diseases. The mode of transmission is also an important entity for understanding the spread mechanism of zoonotic diseases. The transmission and spread is predominantly through the direct contact and in the few conditions through the vectors; termed as vector-borne transmission. Altogether, in this chapter, the authors have discussed different aspects of welfare of pet birds, categories of zoonotic diseases along with mode of transmission and spread of zoonoses. At the last, few aspects of welfare of pet birds and prevention and control guidelines of zoonoses are suggested for the personal biosafety and public health.

Keywords: welfare of pet birds, Zoonosis, exotic birds, biosafety, public health

1. Introduction

The term "pet birds" employs on every bird which feeds on different plant seeds or grains and could be kept legally under captivity which could spent all or some time in cages. The increased

popularity of "pet birds" particularly during last few decades has highlighted the significance of pet bird zoonoses and pet bird medicine throughout the world [1]. Further, the relationship among humans and birds is diverse that existed since centuries. Humans are using wild birds for different purposes i.e. meat, eggs, skins and feathers as food or for ornamental purposes. The relation has emerged from historical sport hunting to companion or pet birds which are currently considered as "family members" in several regions of the world [2]. The majority of pet birds are originated from either passeriformes (canaries and finches etc.) or psittaciformes (budgerigars, parrots and parakeets etc.) [3]. These birds particularly the psittaciformes are naturally wild inhabitants and are now domesticated to be kept as companions or for ornamental purposes, among all the birds, parrots are the best pets which have been domesticated since the times of Alexander the Great and ancient Egyptians [4]. Further, the pigeons are among the first domesticated birds which are being reared for meat, racing and historically were used as courier pigeons particularly during wartimes [2]. Similarly, there are many factors which influence the owners to select an appropriate species of a bird to be housed as pet bird i.e. size of the birds, color, average age, sound and interaction of birds with humans. The strong relationship of owners with their pet birds increases liabilities to provide sufficient housing conditions, clean food and water as well as this relation also poses the risk of transmission and spread of zoonotic diseases. The main zoonotic diseases include bacterial (chlamydophilosis, salmonellosis and tuberculosis), viral (influenza virus infection, West Nile fever and new castle disease), parasitic (*Cryptosporidium* infection) and fungal (aspergillosis) diseases [5]. The main transmission and spread is through direct contact with carrier or sick pet birds, however the indirect transmission is also important for some viral infections, for example, the transmission of West Nile Fever virus (WNF virus) through mosquitoes [6]. With an increased trend in pet bird housing, remarkable increase in veterinary diagnostic was noticed throughout the world [7]. Collectively, in this chapter, the authors have discussed different categories of zoonotic diseases of pet birds, the transmission and spread of zoonoses along with few prevention and control guidelines.

2. Welfare of pet birds

The urge to have exotic pets or pet birds for ornamental purposes is prehistoric which must be governed by some of the regulations. For example, in East Asian or American regions, the pet bird keeping is quite popular [8, 9]. To assure certain welfare rules for pets, the Convention on International Trade in Endangered Species (CITES), is an international agreement that deals as licensing and governing system for the trade of animals. Exotic pet birds are obtained from the wild, born in captivity from wild parents and then reared and bred in captivity [10]. While keeping the exotic or wild birds under captivity, certain standards must be followed which includes

- Proper housing having sufficient space according to the breeding requirements
- Free access to clean water and food

- Disease control by following regular vaccinations and proper treatment strategies
- Freedom from discomfort and distress etc.

3. Zoonotic diseases of pet birds

The zoonotic diseases of pet birds are mainly divided into bacterial, viral, parasitic and fungal diseases as outlined in **Figure 1**. These zoonotic diseases have significant impact on biosafety and human health [3].

3.1. Bacterial diseases

The important bacterial diseases are:

i. Chlamydophilosis (also termed as ornithosis, psittacosis or parrot fever) is most threatening zoonotic disease caused by a bacterium *Chlamydophila psittaci*. Psittaciformes birds are highly susceptible to *Chlamydophila* in comparison to passeriformes birds [11–13]. The clinical signs and symptoms in humans ranged from mild respiratory signs to severe pneumonia along with diarrhea, conjunctivitis, arthritis and genital organ infection. Veterinarian and pet birds breeders are first susceptible hosts for chlamydophilosis [14–16]. The zoonotic *Chlamydophila* cloud also contribute to antibiotic resistant in humans [16].

ii. Salmonella species are frequently isolated from many pet birds including both passeriformes and psittaciformes. The disease cloud be classified as asymptomatic carriers to birds having severe clinical symptoms including diarrhea, septicaemia, osteomyelitis, depression, crop stasis, dehydration, anorexia [17]. Salmonella is potential zoonotic pathogen

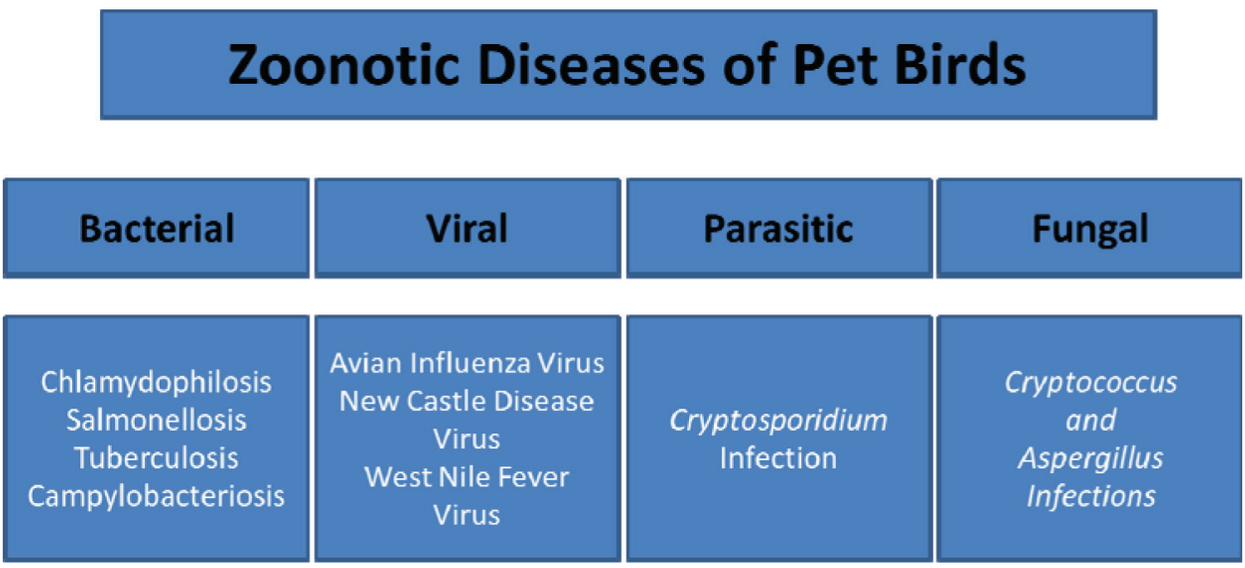

Figure 1. Categories of zoonotic diseases of pet birds.

associated with human transmission particularly from passeriformes birds [18]. The incidence of human salmonellosis could be severe along with severe clinical signs including vomiting and diarrhea [19].

iii. Tuberculosis caused by Mycobacterium species is also believed to be transmitted by pet birds particularly psittaciformes. The commonly isolated species are *Mycobacterium genavense* and *Mycobacterium avium*, respectively [17]. However, the major human pathogen *Mycobacterium tuberculosis* is rarely reported in birds as potentially zoonotic agent.

iv. Campylobacteriosis caused by *Campylobacter jejuni* is primarily responsible for food borne infections including gastro enteritis (diarrhea, vomiting), headaches, and depression, leading sometimes to death. The condition was reported as potentially zoonotic [20, 21].

v. Some other bacterial pathogens associated with pet birds which are considered as zoonotic include Pasteurella, Klebsiella, Yersinia, Pseudomonas and *Escherichia coli* [22]. Highly pathogenic *E. coli* O157:H7 is most fatal strains transmitted from wild passeriformes to cattles followed by its introduction into the food chain which has been reported in several studies [22, 23]. Even the toxigenic strains of *E. coli* are reported in pet birds which are responsible for zoonoses [24]. Collectively, the bacterial pathogens are important for owners and breeders of pet birds.

3.2. Viral diseases

The viral pathogens associated with pet birds zoonoses includes Avian Influenza virus (AI virus), West Nile Fever virus (WNF virus) and New Castle Disease virus (ND virus). Among these AI virus is a major risk to breeders and owners of the pet birds, particularly avian influenza A is global public health threat. In one of the recent studies AI virus (H9N2) was characterized in samples originated from pet birds and the potential role of pet birds was observed in transmission and spread [25]. International pet trading also increases the risk of transmission and spread of highly pathogenic zoonotic AI viruses, for example the highly pathogenic H9N2 strain was identified from parakeets which were imported to Japan from Pakistan [26]. The significant morbidity and mortality rates are reported recently in humans due to influenza virus infections [27]. Further, the role of wild migratory birds is considered important for transmitting the pathogen in several regions of the world. The virus also spread from endemic countries to other locations through international trade of exotic and pet birds [28]. However, the commercial markets of pet birds are still a greater risk for zoonotic transmission and spread of highly pathogenic AI viruses [29]. Secondly, the zoonotic transmission and spread of different arboviruses (*Flaviviruses*) could not be neglected including WNF virus which is an emerging vector-borne zoonotic disease [30]. The pet birds are also involved in transmission and spread of WNF virus as described in recent study, further, the international routes of wild migratory birds also served as potential reservoirs for zoonotic transmission and spread as described in recent cross sectional study [6]. Mostly, the birds are infected exhibiting sub clinical course of the disease, however, birds may develop a clinical form of the disease with ocular and neurological symptoms. At the last, Newcastle disease which is caused by Avian *Paramyxovirus* is also described in pet birds and transmission to humans is possible with mild

clinical signs and symptoms which includes mild conjunctivitis [17]. Concludingly, AI and WNF viruses are potentially zoonotic having significant impact on public health whereas ND virus is less important zoonotic pathogen.

3.3. Parasitic diseases

The parasitic disease are rarely contracted and are considered as least zoonotic as compared to bacterial or viral pathogens. However, one important disease in birds is caused by *Cryptosporidium* which is characterized by intestinal and nephrotic symptoms which leads to sever diarrhea in humans [30]. The condition is usually caused by either *C. meleagridis* or *C. baylei* which are considered as zoonotic [30–32]. The prevalence of zoonotic *C. ubiquitum* in different birds (Alexandrine parakeets, Atlantic canary, budgerigar, cockatiel, crested myna, rock dove, and silky fowl, Fischer's lovebird and rosy-faced lovebird) is considered significantly important for public health [32]. Similarly, Toxoplasmosis caused by *Toxoplasma gondii* is reported in 3 out of 140 pet birds in Fujian, China [33]. Toxoplasma was also isolated in love birds [34]. However, the main role of pet birds in transmission and spread is not well characterized. Finally, the risk of transmission and spread of parasitic infection is only important among young children who are closely associated with pet birds and are unaware of hygienic handling [17].

3.4. Fungal diseases

The pet birds are continuous source of different fungal infections which are transmissible to human, the main pathogens include *Cryptococcus* and *Aspergillus*, the former is considered as an opportunistic pathogen for humans [35], whereas later is more frequently isolated fungi from pet birds [17]. In both of the fungal pathogens, the zoonoses is considered as less important as the humans could contract the clinical disease or few clinical symptoms from environmental or other sources. In one of the previous studies, cryptococcal meningitis was reported in a female with exposure to a pet magpie that was confirmed genetically by identifying the isolates from the cerebrospinal fluid of the patient and fecal material of the bird [36]. Unfortunately, there is dearth of data with regard to aspergillosis in pet birds. *Aspergillus* spp. are isolated from pet birds from acute as well as chronic cases which is considered as less zoonotic threat [7]. Collectively, among young children and immunocompromised patients the risk of transmission of fungal pathogens from pet birds could not be neglected.

4. Route of transmission

The possible route for transmission and spread of zoonoses among breeders or owners of pet birds includes direct or vector-borne transmission.

4.1. Direct transmission

Passeriformes and psittaciformes are commonly housed pet birds as companion or for ornamental purposes. This is also quite natural that the owners or breeders of pet birds have very

close contact with their birds, thereby probability of disease contraction increases. The direct contact also involves the shedding of zoonotic pathogen in drinking water that normally comes in contact with breeders or owners of pet birds [25]. The range of direct transmission varies from allergic alveolitis to sever chlamydophilosis. The respiratory or inhalation route may result in psittacosis, allergic alveolitis or asthma among owners or breeders of pet birds [37, 38]. The contact with drinking water and foods of pet birds is also associated with transmission and spread of zoonotic diseases [37]. There is an increased numbers of different pet birds particularly at shop facilities or markets which indirectly increases the risk of transmission and spread of different diseases particularly salmonellosis and chlamydophilosis [39]. One of the another aspects is "kitchen-housing" of pet birds that also has an impact on zoonotic transmission and spread of several infections to the owners of the pet birds. Different meetings or gatherings of pet birds by the owners in different pet bird exhibitions or pet bird shows also increases the risk of transmission and spread of various pathogens. Therefore, unusual close contact with pet birds should be avoided to control direct transmission of infectious pathogens.

4.2. Vector-borne transmission

The vector-borne zoonootic diseases are also a major problem for breeders and owners of pet birds. For example, different species of mosquitoes are responsible for transmission of *Flaviviruses* like WNF virus [40]. Mosquitoes (Culex, Anopheles and Culiseta) play an important role in transmission and spread of WNF virus, therefore, it is important to control the mosquitoes population in the surroundings of pet birds [41, 42]. Normally, the mosquitoes acquire infection while feeding on infected pet birds or other animals, therefore mosquito-borne infections also resulted in an outbreak form in a particular region [43]. Similarly, ticks (particularly genus *Ixodes*) also play role in transmission and spread of several pathogens which include *Borrelia burgdorferi* which is causative agent of Lyme disease [44]. The role of tick infestation was found among European songbirds and further transmission to humans [45]. The presence of ticks was also demonstrated on migratory birds in Iceland [46]. Even the large birds or zoo birds also have an incidence of tick infestation as recently observed in captive Emu at Healesville sanctuary, Victoria, Australia [47]. Some species of mites are also reported to suck the blood of pet birds including *Dermanyssus gallinae*, this is a nocturnal ectoparasite and found on pet birds as well as on the surroundings which may involve in the transmission and spread of *Coxiella burnetii*, *Salmonella* and *Listeria monocytogenes* infections [48–50]. Altogether, the transmission and spread of zoonotic diseases which are caused by either mosquitoes, ticks or mites could be well controlled by regular cleanliness of pet birds and surroundings of pet birds [48, 51].

5. Guidelines for welfare of pet birds and for prevention of potential zoonotic diseases

To control the transmission and spread of potential zoonoses, at least the below mentioned precautionary measure should be adopted [10, 11]:

- Free access to water and food for good health of pet birds
- Good housing facility which protects from harsh environment conditions
- Sufficient space to maintain the natural behavior
- Careful handling
- Prevention and control of diseases of pet birds
- Cleanliness of clothing and shoes following contact with other birds
- Washing of hands before and after handling birds
- Regular cleanliness of cages, food and water
- Discard the remaining food (fruits and vegetables) regularly
- Regular washing and cleanliness of cages at least once a week
- Storage of food in clean and sealed containers
- Cleanliness and disinfection of cages before use
- Quarantine of the sick or newly introduced pet birds
- Restricted access of persons having their own pet birds
- Follow the rules for import or export of pet birds
- It is also recommended that breeders or pet shop owners should control the transmission and spread of zoonotic diseases [39].

Usually, sellers or breeders of pet bird are well aware of the precautions; however, the risk of zoonoses is higher in the cases of housing the pet birds for the first time particularly when children or their parents are not informed and guided properly.

6. Conclusion

In conclusion the pet birds must have free access to clean food and water, freedom from discomfort, distress, pain, injury and several diseases. At the end, the relation of pet birds and humans is an interesting entity which cannot be neglected as potential source of zoonoses. A good strategy could be isolation of new pet birds for first few days from the existing pet birds for control of potential diseases. The understanding of natural behavior of pet birds, zoonotic disease and different routes of transmission and spread along with basic information with regard to potential zoonotic disease could minimize the risk of zoonoses to the owners and breeders of pet birds, ultimately providing good care to pet birds.

Conflict of Interest

The authors declare no 'conflict of interest'.

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References

[1] Veladiano IA, Banzato T, Bellini L, Montani A, Catania S, Zotti A. Normal computed tomographic features and reference values for the coelomic cavity in pet parrots. BMC Veterinary Research. 2016;**512**:182. DOI: 10.1186/s12917-016-0821-6

[2] Anderson PK. Human–bird interactions. In: Duncan I, Hawkins P, editors. The Welfare of Domestic Fowl and Other Captive Birds. Animal Welfare. Vol. 9. Dordrecht: Springer; 2010. pp. 17-51. DOI: 10.1007/978-90-481-3650-6_2

[3] Boseret G, Losson B, Mainil JG, Thiry E, Saegerman C. Zoonoses in pet birds: Review and perspectives. Veterinary Research. 2013;**44**:36. DOI: 10.1186/1297-9716-44-36

[4] Hess L. Parrots: Appropriate pets or best not bred? Journal of Avian Medicine and Surgery. 2016;**30**:286-297. DOI: 10.1647/1082-6742-30.3.286

[5] Contreras A, Gómez-Martín A, Paterna A, Tatay-Dualde J, Prats-Van Der Ham M, Corrales JC, De La Fe C, Sánchez A. Epidemiological role of birds in the transmission and maintenance of zoonoses. Revue Scientifique et Technique. 2016;**35**:845-862. DOI: 10.20506/rst.35.3.2574

[6] Hacioglu S, Dincer E, Isler CT, Karapinar Z, Ataseven VS, Ozkul A, Ergunay K. A snapshot avian surveillance reveals West Nile virus and evidence of wild birds participating in Toscana virus circulation. Vector Borne and Zoonotic Diseases. 2017;**17**:698-708. DOI: 10.1089/vbz.2017.2138

[7] Cray C. Infectious and zoonotic disease testing in pet birds. Clinics in Laboratory Medicine. 2011;**31**:71-85. DOI: 10.1016/j.cll.2010.10.008

[8] Alves R, Nogueira EEG, Araujo HEP, Brooks SE. Bird-keeping in the Caatinga, NE Brazil. Human Ecology. 2010;**38**:147-156 Doi.org/10.1007/s10745-009-9295-5

[9] Kuhnen VV, Remor JO, Lima REM. Breeding and trade of wildlife in Santa Catarina state, Brazil. Brazilian Journal of Biology. 2012;**72**:59-64 Doi.org/10.1590/S1519-69842012000100007

[10] Haitao S, Parham JF, Zhiyong F, Meiling H, Feng Y. Evidence for the massive scale of turtle farming in China. Oryx. 2008;**42**:147-150 Doi.org/10.1017/S0030605308000562

[11] Balsamo G, Maxted AM, Midla JW, Murphy JM, Wohrle R, Edling TM, Fish PH, Flammer K, Hyde D, Kutty PK, Kobayashi M, Helm B, Oiulfstad B, Ritchie BW, Stobierski MG, Ehnert K, Tully TN Jr. Compendium of measures to control *Chlamydia psittaci* infection among humans (psittacosis) and pet birds (avian Chlamydiosis), 2017. Journal of Avian Medicine and Surgery. 2017;**31**:262-282. DOI: 10.1647/217-265

[12] Circella E, Pugliese N, Todisco G, Cafiero MA, Sparagano OAE, Camarda A. Chlamydia psittaci infection in canaries heavily infested by *Dermanyssus gallinae*. Experimental and Applied Acarology. 2011;**55**:329-338. DOI: 10.1007/s10493-011-9478-9

[13] Dorrestein GM. Bacterial and parasitic diseases of passerines. The veterinary clinics of North America. Exotic Animal Practice. 2009;**12**:433-451. DOI: 10.1016/j.cvex.2009.07.005

[14] Alcaraz LD, Hernández AM, Peimbert M. Exploring the cockatiel (*Nymphicus hollandicus*) fecal microbiome, bacterial inhabitants of a worldwide pet. PeerJ. 2016;**22**(4):e2837. DOI: 10.7717/peerj.2837

[15] Van Droogenbroeck C, Beeckman DSA, Verminnen K, Marien M, Nauwynck H, Boesinghe LT, Vanrompay D. Simultaneous zoonotic transmission of *Chlamydophila psittaci* genotypes D, F and E/B to a veterinary scientist. Veterinary Microbiology. 2009;**135**:78-81. DOI: 10.1016/j.vetmic.2008.09.047

[16] Vanrompay D, Harkinezhad T, Van De Walle M, Beeckman D, Van Droogenbroeck C, Verminnen K, Leten R, Martel A, Cauwerts K. *Chlamydophila psittaci* transmission from pet birds to humans. Emerging Infectious Diseases. 2007;**13**:1108-1110. DOI: 10.3201/eid1307.070074

[17] Evans EE. Zoonotic diseases of common pet birds: Psittacine, passerine, and columbiform species. The veterinary clinics of North America. Exotic Animal Practice. 2011;**14**:457-476. DOI: 10.1016/j.cvex.2011.05.001

[18] Joseph V. Infectious and parasitic diseases of captive passerines. Journal of Exotic Pet Medicine. 2003;**12**:21-28. DOI: 10.1053/saep.2003.127878

[19] Cavallo SJ, Daly ER, Seiferth J, Nadeau AM, Mahoney J, Finnigan J, Wikoff P, Kiebler CA, Simmons L. Human outbreak of *Salmonella typhimurium* associated with exposure to locally made chicken jerky pet treats, New Hampshire, 2013. Foodborne Pathogens and Disease. 2015;**12**:441-446. DOI: 10.1089/fpd.2014.1889

[20] Wedderkopp A, Madsen AM, Jørgensen PH. Incidence of *Campylobacter* species in hobby birds. Veterinary Record. 2003;**152**:179-180. DOI: 10.1136/vr.152.6.179

[21] Shitaye EJ, Grymova V, Grym M, Halouzka R, Horvathova A, Moravkova M, Beran V, Svobodova J, Dvorska-Bartosova L, Pavlik I. *Mycobacterium avium* subsp. hominissuis infection in a pet parrot. Emerging Infectious Diseases. 2009;**15**:617-619. DOI: 10.3201/eid1504.081003

[22] Williams ML, Pearl DL, LeJeune JT. Multiple-locus variable-nucleotide tandem repeat subtype analysis implicates European starlings as biological vectors for *Escherichia coli* O157:H7 in Ohio, USA. Journal of Applied Microbiology. 2011;**111**:982-988. DOI: 10.1111/j.1365-2672.2011.05102.x

[23] McIntyre KM, Setzkorn C, Wardeh M, Hepworth PJ, Radford AD, Baylis M. Using open-access taxonomic and spatial information to create a comprehensive database for the study of mammalian and avian livestock and pet infections. Preventive Veterinary Medicine. 2014;**116**:325-335. DOI: 10.1016/j.prevetmed.2013.07.002

[24] Gioia-Di Chiacchio RM, Cunha MP, Sturn RM, Moreno LZ, Moreno AM, Pereira CB, Martins FH, Franzolin MR, Piazza RM, Knöbl T. Shiga toxin-producing *Escherichia coli* (STEC): Zoonotic risks associated with psittacine pet birds in home environments. Veterinary Microbiology. 2016;**184**:27-30. DOI: 10.1016/j.vetmic.2016.01.004

[25] Lenny BJ, Shanmuganatham K, Sonnberg S, Feeroz MM, Alam SM, Hasan MK, Jones-Engel L, McKenzie P, Krauss S, Webster RG, Jones JC. Replication capacity of avian influenza a(H9N2) virus in pet birds and mammals, Bangladesh. Emerging Infectious Diseases. 2015;**21**:2174-2177. DOI: 10.3201/eid2112.151152

[26] Mase M, Imada T, Sanada Y, Etoh M, Sanada N, Tsukamoto K, Kawaoka Y, Yamaguchi S. Imported parakeets harbor H9N2 influenza a viruses that are genetically closely related to those transmitted to humans in Hong Kong. Journal of Virology. 2001;**75**:3490-3494. DOI: 10.1128/JVI.75.7.3490-3494.2001

[27] Wu S, Wei Z, Greene CM, Yang P, Su J, Song Y, Iuliano AD, Wang Q. Mortality burden from seasonal influenza and 2009 H1N1 pandemic influenza in Beijing, China, 2007-2013. Influenza and Other Respiratory Viruses. 2017;**12**:88-97. DOI: 10.1111/irv.12515

[28] Van Borm S, Thomas I, Hanquet G, Lambrecht B, Boschmans M, Dupont G, Decaestecker M, Snacken R, Van Den Berg T. Highly pathogenic H5N1 influenza virus in smuggled Thai eagles, Belgium. Emerging Infectious Diseases. 2005;**11**:702-705. DOI: 10.3201/eid1105.050211

[29] Amonsin A, Choatrakol C, Lapkuntod J, Tantilertcharoen R, Thanawongnuwech R, Suradhat S, Suwannakarn K, Theamboonlers A, Poovorawan Y. Influenza virus (H5N1) in live bird markets and food markets, Thailand. Emerging Infectious Diseases. 2008;**14**:1739-1742. DOI: 10.3201/eid1411.080683

[30] Zhang XX, Zhang NZ, Zhao GH, Zhao Q, Zhu XQ. Prevalence and genotyping of *Cryptosporidium* infection in pet parrots in North China. BioMed Research International. 2015;**2015**:549798. DOI: 10.1155/2015/549798

[31] Joachim A. Human cryptosporidiosis: An update with special emphasis on the situation in Europe. Journal of Veterinary Medicine Series B. 2004;**51**:251-259. DOI: 10.1111/j.1439-0450.2004.00765.x

[32] Li Q, Li L, Tao W, Jiang Y, Wan Q, Lin Y, Li W. Molecular investigation of *Cryptosporidium* in small caged pets in Northeast China: Host specificity and zoonotic implications. Parasitology Research. 2016;**115**:2905-2911. DOI: 10.1007/s00436-016-5076-4

[33] Chen R, Lin X, Hu L, Chen X, Tang Y, Zhang J, Chen M, Wang S, Huang C. Genetic characterization of *Toxoplasma gondii* from zoo wildlife and pet birds in Fujian, China. Iranian Journal of Parasitology. 2015;**10**:663-668

[34] Cooper MK, Šlapeta J, Donahoe SL, Phalen DN. Toxoplasmosis in a pet peach-faced lovebird (*Agapornis roseicollis*). The Korean Journal of Parasitology. 2015;**53**:749-753. DOI: 10.3347/kjp.2015.53.6.749

[35] Wu Y, Du PC, Li WG, Lu JX. Identification and molecular analysis of pathogenic yeasts in droppings of domestic pigeons in Beijing, China. Mycopathologia. 2012;**174**:203-214. DOI: 10.1007/s11046-012-9536-9

[36] Lagrou K, Van Eldere J, Keuleers S, Hagen F, Merckx R, Verhaegen J, Peetermans WE, Boekhout T. Zoonotic transmission of *Cryptococcus neoformans* from a magpie to an immunocompetent patient. Journal of Internal Medicine. 2005;**257**:385-388. DOI: 10.1111/j.1365-2796.2005.01466.x

[37] Gorman J, Cook A, Ferguson C, van Buynder P, Fenwick S, Weinstein P. Pet birds and risks of respiratory disease in Australia: A review. Australian and Newzealand Journal of Public Health. 2009;**33**:167-172. DOI: 10.1111/j.1753-6405.2009.00365.x

[38] Elmberg J, Berg C, Lerner H, Waldenström J, Hessel R. Potential disease transmission from wild geese and swans to livestock, poultry and humans: A review of the scientific literature from a one health perspective. Infection Ecology and Epidemiology. 2017;**7**:1300450. DOI: 10.1080/20008686.2017

[39] Halsby KD, Walsh AL, Campbell C, Hewitt K, Morgan D. Healthy animals, healthy people: Zoonosis risk from animal contact in pet shops, a systematic review of the literature. PLoS One. 2014;**9**:e89309. DOI: 10.1371/journal.pone.0089309

[40] Ciota AT. West Nile virus and its vectors. Current Opinion in Insect Science. 2017;**22**:28-36. DOI: 10.1016/j.cois.2017.05.002

[41] Rudolf I, Betášová L, Blažejová H, Venclíková K, Straková P, Šebesta O, Mendel J, Bakonyi T, Schaffner F, Nowotny N, Hubálek Z. West Nile virus in overwintering mosquitoes, Central Europe. Parasites & Vectors. 2017;**10**:452. DOI: 10.1186/s13071-017-2399-7

[42] Giordano BV, Kaur S, Hunter FF. West Nile virus in Ontario, Canada: A twelve-year analysis of human case prevalence, mosquito surveillance, and climate data. PLoS One. 2017;**12**:e0183568. DOI: 10.1371/journal.pone.0183568

[43] Paternina LE, Rodas JD. Sampling design and mosquito trapping for surveillance of Arboviral activity. Methods in Molecular Biology. 2018;**1604**:89-100. DOI: 10.1007/978-1-4939-6981-4_6

[44] Comstedt P, Bergström S, Olsen B, Garpmo U, Marjavaara L, Mejlon H, Barbour AG, Bunikis J. Migratory passerine birds as reservoirs of *Lyme borreliosis* in Europe. Emerging Infectious Diseases. 2006;**12**:1087-1095. DOI: 10.3201/eid1207.060127

[45] Heylen D, Fonville M, Docters van Leeuwen A, Stroo A, Duisterwinkel M, van Wieren S, Diuk-Wasser M, de Bruin A, Sprong H. Pathogen communities of songbird-derived ticks in Europe's low countries. Parasites & Vectors. 2017;**10**:497. DOI: 10.1186/s13071-017-2423-y

[46] Alfredsson M, Olafsson E, Eydal M, Unnsteinsdottir ER, Hansford K, Wint W, Alexander N, Medlock JM. Surveillance of *Ixodes ricinus* ticks (Acari: Ixodidae) in Iceland. Parasites & Vectors. 2017;**10**:466. DOI: 10.1186/s13071-017-2375-2

[47] Kwak ML, Madden C. The first record of infestation by a native tick (Acari: Ixodidae) on the Australian emu (*Dromaius novaehollandiae*) and a review of tick paralysis in Australian birds. Experimental and Applied Acarology. 2017;**73**:103-107. DOI: 10.1007/s10493-017-0168-0

[48] Valiente Moro C, Chauve C, Zenner L. Vectorial role of some dermanyssoid mites (Acari, Mesostigmata, Dermanyssoidea). Parasite. 2005;**12**:99-109. DOI: 10.1051/parasite/2005122099

[49] Valiente Moro C, Chauve C, Zenner L. Experimental infection of *Salmonella enteritidis* by the poultry red mite, *Dermanyssus gallinae*. Veterinary Parasitology. 2007;**146**:329-336. DOI: 10.1016/j.vetpar.2007.02.024

[50] Valiente Moro C, Desloire S, Chauve C, Zenner L. Detection of *Salmonella* sp. in *Dermanyssus gallinae* using an FTA® filter-based polymerase chain reaction. Medical and Veterinary Entomology. 2007;**21**:148-152. DOI: 10.1111/j.1365-2915.2007.00684.x

[51] Dubey JP. A review of toxoplasmosis in wild birds. Veterinary Parasitology. 2002;**106**: 121-153. DOI: 10.1016/S0304-4017(02)00034-1