Papers

Survey of prevalence and control of ectoparasites in caged poultry in China

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To investigate the prevalence and control of ectoparasites in China, 1200 questionnaires were delivered to caged commercial layer or parent hen keepers. Of the 860 respondents, 785 (91.3 per cent) claimed they found suspected ectoparasites in their birds and 833 samples were received. Ectoparasites of the species *Dermanyssus gallinae*, *Ornithonyssus sylviarum* or *Menacanthuss stramineus* were found in 736 (88.4 per cent) samples. For caged commercial layers, *D gallinae* was the most common ectoparasite (64.1 per cent). For caged parent hens, *O sylviarum* was the most common ectoparasite (46.9 per cent). Most bird keepers (95.0 per cent of commercial layer keepers and 74.9 per cent of parent hen keepers) used pyrethroids, organophosphates or other insecticides or acaricides to control ectoparasites. However, 34.6 per cent of layer keepers and 25.7 per cent of parent hen keepers did not re-treat their birds with insecticides or acaricides within two weeks after the first treatment. Sanitation procedures, including cleaning, washing and disinfection, were conducted in empty houses between flocks and on most commercial layer farms and parent hen farms. However, insecticides or acaricides were used in empty houses between flocks only in 24.8 per cent of commercial layer farms and in 36.1 per cent of parent hen farms.

ECTOPARASITES, including mites, lice, bedbugs, fleas and ticks, are common in poultry and are found worldwide. Several species of mites are known to infest poultry, but the most common and economically deleterious ectoparasites affecting modern poultry production are the red mite (*Dermanyssus gallinae*) and the northern fowl mite (*Ornithonyssus sylviarum*) (Lemke and Kissam 1986, Hogsette and others 1991, Maurer and Baumgärtner 1992, Axtell 1999). These two mites are ectoparasites of domestic birds worldwide. It has been reported that poultry were infected by *D gallinae* in almost all parts of France (Chauve 1998) and, in England, 58.0 per cent of commercial layers were infected by the poultry red mite (Fiddes and others 2005). The northern fowl mite is considered to be one of the most important and common ectoparasites of poultry in North America (Levot 1992, Mullens and others 2009). The two types of mites are obligatory blood-feeding ectoparasites. They have direct negative effects on bird performance, including causing stress, anaemia, egg production losses and even death (Höglund and others 1995, Chauve 1998, Kilpinen 2000). Furthermore, the two mites can cause skin irritation such as dermatitis and urticaria in poultry workers (Auger and others 1979, Beck 1999). More importantly, the red mite is suspected to be a vector of several pathogenic agents, such as eastern equine encephalomyelitis, avian smallpox, avian cholera and *Salmonella enteritidis* (Zeman and others 1982, Durden and others 1992, Waladde and others 1993, Valiente-Moro and others 2007, 2009). Several species of lice are known to infest poultry, but the most common and important in modern poultry production facilities is the chicken body louse (*Menacanthuss stramineus*) (Price and Graham 1997). Other ectoparasites, for example, fleas and the fowl tick species *Argas persicus* and *Argas radiatus*, are frequently categorised as poultry ectoparasites but are rare in modern poultry production (Kohls and others 1970). Ectoparasites in poultry have most frequently been controlled with insecticides or acaricides, such as pyrethroids, organophosphates, organochlorines, carbamates and amitraz. The successful control of ectoparasites using chemicals depends not only on the selected types of insecticides or acaricides but also on the dosage regimens of the drugs. Axtell (1999) pointed out that the management of poultry flocks was a critical point for the control of ectoparasites in poultry, and the pest management strategy should be compatible with the poultry management and production requirements. In particular, cleaning and washing houses and spraying insecticides or acaricides in all crevices and corners between flocks is essential and very efficient in reducing, or even eliminating ectoparasites (Chauve 1998).

Poultry production is an important industry in China. More than 47.0 per cent of egg production and 15.5 per cent of broiler production is supplied by China (Axtell 1999). Unlike in the EU, where the use of traditional cages is reducing and will be banned for poultry birds by 2012 (Council of the EU [1999]), in China, cages are still used widely for commercial layers and parent hens. It is estimated that more than 85.0 per cent of laying hens and 70.0 per cent of parent hens are kept in cages in modern poultry production in China. The present study was conducted to investigate the prevalence of ectoparasites in caged commercial layers and parent hens in China and how they are controlled.

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Materials and methods

Distribution of questionnaires

Questionnaires were hand delivered to caged commercial layer (eggs sold in the market) or parent hen (eggs used as hatching eggs for commercial layers or broilers) keepers in China from January 2008 to September 2009 by 25 salesmen from Beijing Zhongnong Huawei Pharmaceutical and four researchers from China Agricultural University (CAU) or the Beijing General Station of Animal Husbandry and Veterinary Service. Poultry keepers in 11 provinces in China (Beijing, Jiangsu, Guangxi, Liaoning, Jilin, Hebei, Hunan, Shandong, Guangdong, Anhui and Henan) were asked to provide information on the stocking density of their birds, whether their birds were infested with ectoparasites, the sanitation practiced in empty houses (where no birds were currently present) between flocks, the insecticides or acaricides they used and whether they re-treated their birds within two weeks of the first treatment with insecticides or acaricides to control ectoparasites. Contact information for all participants was retained for follow-up. The 11 provinces cover more than 50 per cent of the total commercial layers (about 2.1 billion) and 60 per cent of the total parent hens (about 50 million) in China. The farms were selected randomly. Each investigator was responsible for several different counties in a province. During the period of the investigation, each farm was sent only one questionnaire.

TABLE1: Prevalence of ectoparasites on 833 caged poultry farms in China

Farm type	Number of farms	Number (%) of farms infested with each ectoparasite species *Dermanyssus gallinae*	*Ornithonyssus sylviarum*	*Menacanthuss stramineus*	Total
Commercial layer	597	350 (64.1)**	124 (22.7)**	72 (13.2)	546 (91.5)
Parent hen	236	70 (36.8)**	89 (46.9)**	31 (16.3)	190 (80.5)
Total	833	420 (57.1)**	213 (28.9)**	103 (14.0)	736 (88.4)

** Significant difference (P<0.01) between commercial layer farms and parent hen farms

TABLE 2: Compounds applied in the control of ectoparasites on 833 poultry farms in China

	Number (%) of premises using treatment		Number (%) using repeated treatment within two weeks of first treatment	
Applied compounds	Commercial layers	Parent hens	Commercial layers	Parent hens
Organophosphates alone	232 (38.3)	24 (9.4)	158 (68.1)	23 (95.8)**
Pyrethroids alone	239 (39.5)	36 (14.1)	170 (71.1)	35 (97.2)**
Avermectins alone	10 (1.7)	57 (22.4)	3 (30.0)	20 (35.1)
Organophosphates in combination with avermectins	9 (1.5)	49 (19.2)	3 (33.3)	31 (63.3)**
Pyrethroids in combination with avermectins	10 (1.7)	55 (21.6)	3 (30.0)	27 (49.1)**
Other pesticides	85 (14.0)	27 (10.6)	42 (49.4)	26 (96.2)**
No treatment	20 (3.3)	7 (2.7)	—	—
Total	605 (100.0)	255 (100.0)	379 (62.6)	162 (63.5)

** Significant difference (P<0.01) between commercial layer farms and parent hen farms

TABLE 3: Sanitation practiced in empty houses between flocks on 833 poultry farms in China

	Method used		Method not used	
Method of sanitation	Number (%) commercial layers	Number (%) parent hens	Number (%) commercial layers	Number (%) parent hens
Cleaning	415 (68.6)	233 (91.4)**	190 (31.4)	22 (8.6)
Washing	276 (45.6)	220 (86.3)**	329 (54.4)	35 (13.7)
Disinfection	487 (80.5)	248 (97.3)**	118 (19.5)	7 (2.7)
Spraying pesticides	150 (24.8)	92 (36.1)*	455 (75.2)	163 (63.9)
No treatment	70 (11.6)	3 (1.2)**	535 (88.4)	252 (98.8)

* Significant difference (P<0.05) between commercial layer farms and parent hen farms
** Significant difference (P<0.01) between commercial layer farms and parent hen farms

Sampling

Participants collected samples from sites of suspected infestation (for example, extracted feathers or dust from cracks or crevices in poultry house, or on cages and water pipes) and placed them in a self-sealing bag for postage to CAU where the ectoparasites were identified. The sample bags were kept in an incubator for approximately two hours at a temperature of 65°C to kill the ectoparasites before they were posted. Sample bags and prepaid envelopes were provided and participants were told that they would be informed of the results from their premises.

Identification of ectoparasites

Upon reaching the lab for veterinary parasitology in CAU, all contents in the self-sealing bags were transferred into a container. The contents were submerged in 10 per cent potassium hydroxide and brought to a transient boil. The resultant digest was then washed over a 400 sieve (aperture 40 μm) and the residue was collected into a Pasteur plate. Thirty ectoparasites from each sample (or all ectoparasites if there were fewer than 30) were examined under a microscope and identified on the basis of their morphology (Crystal 1985, Bhatia and others 2006).

Statistical analysis

The prevalence of ectoparasites, the percentage of premises where repeated treatments were applied within two weeks of the first treatment, and the percentage of premises where sanitation was practiced in empty houses between flocks was compared for caged commercial layer farms and parent hen farms using Chi-squared analysis with significance defined at a 95 per cent confidence level ($P<0.05$). All statistical analyses were performed using Graphpad v5.01.

Results

Of the 1200 questionnaires delivered, 860 were completed, giving a response rate of 71.7 per cent. Of the 860 respondents, 785 (91.3 per cent) claimed that they had found suspected ectoparasites on their premises. These 785 respondents included 574 (73.1 per cent) commercial layer keepers (representing a total of 5,536,300 birds) and 211 (26.9 per cent) parent hen keepers (representing a total of 4,238,900 birds).

A total of 833 samples, including 597 from commercial layer farms (representing a total of 6,360,200 birds) and 236 parent hen farms (representing a total of 5,534,300 birds), were received.

Mite prevalences

D gallinae, *O sylviarum* and *M stramineus* were the three most common ectoparasites found in caged birds. In total, 736 (88.4 per cent) samples were positive for at least one species of ectoparasite (Table 1). For caged commercial layers, *D gallinae* was the most common ectoparasite (64.1 per cent, 350 of 546 samples), followed by *O sylviarum* (22.7 per cent, 124 of 546 samples) and *M stramineus* (13.2 per cent, 72 of 546 samples). For caged parent hens, *O sylviarum* was the most common ectoparasite (46.9 per cent, 89 of 190 samples), followed by *D gallinae* (36.8 per cent, 70 of 190 samples) and *M stramineus* (16.3 per cent, 31 of 190 samples). The commercial layer farms had a significantly higher prevalence of *D gallinae* than the parent hen farms ($P<0.01$). However, the parent hen farms had a significantly higher prevalence of *O sylviarum* than the commercial layer farms ($P<0.01$). There was no significant difference in the prevalence of *M stramineus* between commercial layer farms (13.2 per cent) and parent hen farms (16.3 per cent).

Treatments used for control

The different compounds applied to the birds to control ectoparasites are shown in Table 2. Of the commercial layer keepers, 41.2 per cent used pyrethroids alone or in combination with avermectins, 39.8 per cent used organophosphates alone or in combination with avermectins and 14.0 per cent used other pesticides to control ectoparasites in caged poultry. For parent hen farms, these percentages were 35.7, 28.6 and 10.6, respectively.

A significant proportion of commercial layer keepers, ranging from 30.0 per cent of those who used avermectins alone to 71.1 per cent of those who used pyrethroids alone, re-treated their birds within two weeks of the first treatment with insecticides or acaricides. For parent hen farms, the percentages of birds re-treated ranged from 49.1 per cent of those on which pyrethroids in combination with avermectins were used, to 97.2 per cent of those on which pyrethroids were used alone. The difference between the percentages of commercial layers and parent hen farms that were re-treated was significant ($P<0.01$).

In total, 63.2 per cent of parent hen keepers and 4.9 per cent of commercial layer keepers used avermectins (abamectin or ivermectin) alone or in combination with insecticides or acaricides (pyrethroids or organophosphates).

The sanitation practiced in empty houses between flocks is shown in Table 3. Cleaning (removing waste and manure from the poultry house), washing (washing the house and cages with water after cleaning) and disinfection were carried out in 68.6, 45.6 and 80.5 per cent of commercial layer farms, respectively. For parent hen farms, the percentages were 91.4, 86.3 and 97.3 per cent, respectively. There was a significant difference between the values obtained from commercial layer farms compared with parent hen farms ($P<0.01$). Insecticides or acaricides were used in the empty houses between flocks only on 24.8 per cent of commercial layer farms and 36.1 per cent of parent hen farms. This difference was statistically significant ($P<0.05$).

Discussion

Data from the present study showed that there was infestation of ectoparasites in most of the poultry farms with cage systems. The estimated percentage of poultry farms with ectoparasites, based on questionnaire responses, was 91.3 per cent (785 of 860). Sample examination showed that 88.4 per cent (736 of 833) of samples were positive, indicating that ectoparasites are widespread in poultry farms in China.

D gallinae, *O sylviarum* and *M stramineus* were the three most common ectoparasites found in caged birds in this study. *D gallinae* was the most common ectoparasite found in commercial layers and *Osylviarum* was most common in parent hens. Sparagano and others (2009) reported that *D gallinae*, the poultry red mite, was widespread in caged birds in the EU; in their study, approximately 74.1 per cent of caged birds in Italy were infested. Data from Fiddes and others (2005) showed that 58.0 per cent of layers were infested by the red mite in England and, in a review article, Chauve (1998) reported that poultry in France were infested by the red mite in almost all parts of the country. However, in Sweden, only 6.0 per cent of farms in cage systems were affected (Höglund and others 1995). There are many factors that influence the prevalence of the red mite. Housing systems, temperature, control actions and the sanitation practiced in empty houses between flocks affect its survival (Nordenfors and Höglund 2000). Inadequate control actions and sanitation practiced on poultry farms in China may have contributed to the high prevalence of the red mite in this study.

The northern fowl mite, *O sylviarum*, inhabits temperate zones and is considered to be one of the most important and common pests of poultry in the USA (Levot 1992, Mullens and others 2009). Like the USA, the majority of China is located in a temperate zone and the present study showed that the northern fowl mite was also widespread in caged layers (22.7 per cent of farms) and parent hens (46.9 per cent of farms) in China.

The chicken body louse, *M stramineus*, which was most commonly encountered in caged layer flocks, but may also be a problem in breeder flocks (Axtell 1999), was found in both caged layers (13.2 per cent of farms) and parent hens (16.3 per cent of farms) in the present study. The prevalence of ectoparasites in poultry in China is therefore complicated by the presence of a number of different species.

In China, ectoparasites have most frequently been controlled with insecticides and acaricides. The present study showed that most commercial layer keepers (95.0 per cent) and parent hen keepers (74.9 per cent) used pyrethroids, organophosphates or other insecticides/acaricides alone to control ectoparasites in caged poultry. The successful control of ectoparasites by chemicals depends not only on the selected insecticides or acaricides but also on the dosage regimes used. Most insecticides and acaricides have no effect on the eggs of mites, which can hatch later and become a source of re-infection. Moreover, insecticides and acaricides applied within the housing system may result in poor exposure of the parasite to the control agent. Kilpinen (2000) showed that *D gallinae* would spend most of the day in the crevices of buildings and only visit birds during darkness to feed, and *O sylviarum* and *M stramineus* have been shown to avoid exposure by sheltering within feathers. Thus, ectoparasites often reoccur in affected poultry premises after treatment (Höglund and others 1995, Chauve 1998, Nordenfors and others 1999) and repeated treatments are often required within one to two weeks of the first (Meyer-Kuhling and others 2007). The present study showed that 34.6 per cent of commercial layer keepers and 25.7 per cent of parent hen keepers did not re-treat their birds within two weeks of the first treatment with insecticides or acaricides. This may be one of the main reasons why most bird keepers cannot successfully control ectoparasites in China.

Approximately 63.2 per cent of parent hen keepers and 4.9 per cent of commercial layer keepers used avermectins alone or in combination with other insecticides or acaricides to control ectoparasites. Most of them continuously added abamectin or ivermectin into bird feed for seven days at 1 to 2 ppm. It has been shown that ivermectin is effective against *D gallinae* only at high doses between 1.8 and 5.4 mg/kg, and effective doses are very close to those that cause toxicity (Zeman 1987, Ash and Oliver 1989). In addition, abamectin and ivermectin are not permitted for use in birds in China. It is therefore surprising that some bird keepers in the present study used abamectin or ivermectin, either alone or in combination with insecticides or acaricides, to control mites. Later inquiry on the telephone indicated that most users of these substances believed that they should be effective against poultry mites and lice because avermectins exhibited a high potency against mites and lice in other animals, such as pigs, rabbits, cattle and sheep. There is no systemic compound that can be used practically in the control of ectoparasites in poultry. Bird keepers should pay more attention to warnings that the off-label usage of avermectins in birds may cause serious problems, such as residue and possible toxicity.

As Chauve (1998) pointed out, good management of poultry flocks is critical for the control of pests in poultry, and the pest management strategy should be compatible with the poultry management and production requirements. Cleaning, washing the houses and spraying insecticides or acaricides in all crevices and corners between flocks are essential to reduce, or even eliminate, mites or lice in the houses. In the present study, although 91.4 per cent of parent hen keepers and 68.6 per cent of commercial layer keepers cleaned the poultry houses between flocks, only a very low proportion (less than 13.7 per cent) of parent hen keepers and a moderate proportion (54.4 per cent) of commercial layer keepers washed the houses, and only 36.1 per cent of parent hen keepers and 24.8 per cent of commercial layer keepers sprayed insecticides or acaricides. Inadequate cleaning measures in houses between flocks is likely to lead to the survival of mites or lice in the houses, even after periodic sanitation. It has been shown that red mites can survive sanitation periods and could be a source of infection for replacement birds (Kirkwood 1963, Nordenfors and others 1999). Unlike *O sylviarum,* which completes its entire life cycle on the host, *D gallinae* resides in cracks and crevices in nearby buildings during most of the day and only spends brief periods of time on birds when feeding. Therefore, sanitation practices in empty houses between flocks should be a more effective measure in controlling *D gallinae* than *O sylviarum*. Compared with commercial layer keepers, significantly more parent hen keepers cleaned, washed or sprayed insecticides or acaricides within the empty houses between flocks (Table 3). This may be one of the reasons for the lower prevalence of *D gallinae* on parent hen farms than on commercial layer farms (see Table 1).

The present study shows that ectoparasites are widespread on both commercial layer farms and parent hen farms with cage systems in China, and the three most common are *D gallinae*, *O sylviarum* and

M stramineus. Although insecticides and acaricides are used on most poultry farms to control ectoparasites in China, the dosage regimes of the insecticides and acaricides need to be improved. Bird keepers should also take more measures to reduce or eliminate the survival of ectoparasites in the empty houses between flocks and pay more attention to off-label usage of avermectins in birds.

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