Prevalence of coleopteran species in the litter of commercially reared birds

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Abstract:

Numerous species of insects have been recorded from various types of manure in commercially reared birds from different parts of the world. This study was carried out to determine parasitic beetle populations in commercial rearing house litter from different regions of the West Azerbaijan province in Iran. A total of 60 samples of litter were collected from June 2008 to November 2009 from 20 poultry farms. The samples were examined parasitologically to detect and identify species of beetles (Coleoptera). Collected beetles belonged to three different species, of which *Alphitobius diaperinus* was the dominant species, with larvae and adults collected from 27 of the litter samples (45.0%). *Dermestes maculatus* larvae were found in 10 of the samples (16.6%), while *Carcinops pumilio* was collected from two samples (3.3%). Significant differences ($p<0.05$) were observed between the prevalence of *A. diaperinus*, *D. maculatus* and *C. pumilio* found in broiler houses and breeder houses. Although different beetle species, especially *A. diaperinus*, are vectors and reservoirs for various poultry pathogens, no standard field control strategies for beetles have been developed so far. Further studies are required about their prevalence and insecticide resistance profile in other parts of the country.

Introduction

The need to produce large amounts of food has necessitated the search for more intensive forms of production. One of the alternatives to increase food production of animal origin was the intensive management through confinement. But confinement also increased the concentration of animal excrement, creating in these places artificial ecosystems propitious to arthropod proliferation. Therefore, some species of beetles (Coleoptera) became synantropic and because some of them are vectors of pathogens they are of great medical-veterinary importance (Francisco, 1996).

The diversity of arthropods found in accumulated dung in places where domestic birds are maintained is very large and these arthropods are mainly Coleoptera, flies (Diptera), and mites (Acari) (Axtell and Arends, 1990). The study of the species that occur in environments modified by man assumes not only ecological but also sanitary importance because these species can be associated with many pathogenic organisms (Mascarini, 1995).

The lesser mealworm, *Alphitobius diaperinus*, is the most abundant beetle inhabiting litter in poultry houses. Litter temperature in the chicken houses (between 25°C and 30°C) and the chicken growth interval (nearly 50 days) permit the concurrent development of a full life cycle of the mealworm during the completion of hatching to adult of a grow-out of chickens (Erichsen and Jespersen, 1997; Salin et al., 2000).

Darkling beetles (*Tenebrionidae*) are known vectors and reservoirs for a number of serious poultry disease agents (Marek's disease virus, Newcastle disease virus, Infectious Bursal Disease Virus, Fowl pox virus, Reoviruses, Enteroviruses, Avian leucosis Virus, and Turkey Enterovirus) and can act as intermediate hosts for caecal nematodes, tapeworms and protozoa. In addition, they can transmit a number of food-borne diseases such as *Escherichia coli* and *Salmonella typhimurium*, and have been recently implicated in the transmission of Campylobacter species. Thus, the large populations of the pest that are prevalent in most broiler houses are a threat to the welfare of the flock and the production of safe food (Axtell and Arends, 1990; Despins et al., 1994; McAllister et al., 1994, 1996; Watson et al., 2001, Elowni and Elbihari, 1979; Goodwin and Waltman, 1996; Strother et al., 2005). The loss of chicken feed that is consumed by the pest animals increases production costs, while chickens feeding on lesser mealworms instead of feed receive lower nutrition. In addition, feeding on beetle larvae directly increases the likelihood of ingesting disease organisms or parasites (Despins and Axtell, 1995, McGoldrick, 2004).

Hide beetles (*Dermestes maculatus*, family *Dermestidae*) feed on bird carcasses, skins, hides, feathers, and dead insects. Broken eggs and dead birds in the manure enhance beetle populations, although large beetle populations may develop even with good sanitation. Larvae bore into wood posts, beams, paneling, drywall, and insulation to create a protected pupation chamber (Axtell, 1999).

The histerid beetle (*Carcinops pumilio*) of the family Histeridae occurs naturally in poultry house manure and is an important predator of house fly eggs and larvae (Geden and Axtell 1988; Wilhoit et al., 1991). *C. pumilio* has also been shown to be a competent reservoir of *Salmonella* enteritidis (Gray et al., 1999).

There are no data available on the occurrence and abundance of Coleoptera in broiler, layer and broiler breeder houses in Iran. The objective of the present research was to estimate the prevalence of Coleoptera in poultry house litter in the Urmia region of Iran.

Materials and Methods

This research was conducted from June 2008 to November 2009 in 20 poultry farms (14 broiler farms, 4 breeder farms, 2 layer farms) rearing chickens in Urmia, West Azerbaijan province, Iran. The litter samples were taken from 60 poultry houses (36 broilers, 20 breeders, 4 layers). The samples were collected from the top 5-10 cm layer of accumulated litter, since insects were observed to occur mostly in this upper layer. Each sample was a composite of eight sub samples from various sub habits in a house (near walls, feeders, drinkers and open center) and were thoroughly mixed (Rueda and Axtell, 1997; Safrit and Axtell, 1984). The samples were examined in the parasitology laboratory of the Faculty of Veterinary Medicine at Urmia University to detect beetles. The insects were identified with the aid of literature (Pfeiffer and Axtell, 1980; Dunford, 2000; Dunford et al., 2005). Statistical analysis of data was performed using SPSS statistical software (Version 17, Chicago, USA). Values of $P < 0.05$ in Fisher's exact test were considered significant.

Results

Insects collected from poultry farms (broiler, broiler breeder and layer farms) belonged to three families (*Tenebrionidae*, *Dermestidae*, *Histeridae*) within the order Coleoptera, of which *A. diaperinus* was the dominant species, with larvae and adults collected from 27 litter samples (45%). Larvae of *D. maculatus* were found in 10 samples (16.6%), while *C. pumilio* was collected from two samples (3.3%) (Fig. 1).

In broiler farms, larvae and adults *A. diaperinus* were collected from 13 farms (92.8%) and from 20 samples (55.5%). Specimens of *D. maculatus* were

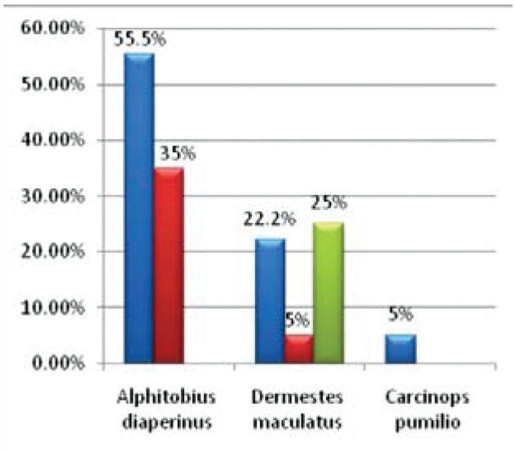

Figure 1: Number of positive litter samples for three Coleoptera species from broiler, broiler breeder, and layer houses in Urmia, Iran. Broiler farms Broiler breeder Farms Egg layer farms

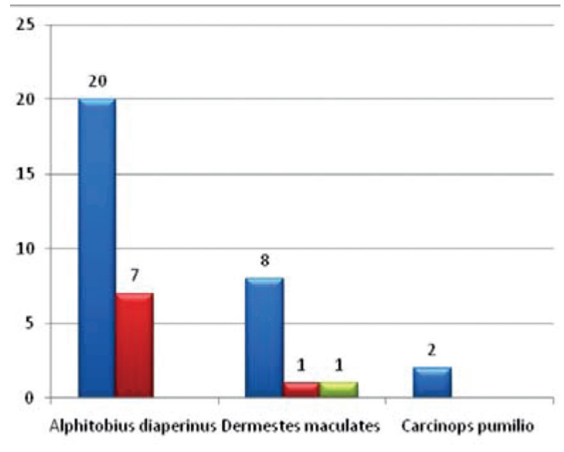

Figure 1: Percentage of Coleoptera species collected from broiler, broiler breeder, and layer houses in Urmia, Iran.
Broiler farms Broiler breeder Farms Egg layer farms

found in five farms (35.7%) and in eight samples (22.2%) (Table 1). Adults of *C. pumilio* were present in one litter farm (7.1%) and in two litter samples (5.5%) (Fig. 2).

The most frequently recovered Coleoptera in the broiler breeder farm litter samples were *A. diaperinus* (Table 1). The larvae and adults of the lesser mealworm occurred in three farms (75%) and in seven samples (35%). The beetle *D. maculatus* was collected from one farm (25%) and from one sample (5%) (Fig. 2). The larval stage of *D. maculatus* was also collected from one layer litter sample (25%) (Table 1, Fig. 2). With regard to the relative frequency of infestations, significant differences ($p<0.05$) were found between *A. diaperinus*, *D. maculatus* and *C. pumilio* infestations in broiler and breeder houses (Table 1).

Discussion

Among the observed beetle fauna, *A. diaperinus* was the dominant species in litter samples from 80% of farms. Similar results were obtained by Fernandes (1995), who found *A. diaperinus* to be the most abundant coleopteran species in an investigated farm in Brazil, and by Rueda and Axtell (1997), who recorded this species in 93.36% of all captured Coleoptera. However, Pfeiffer and Axtell (1980) described *A. diaperinus* as only the second most abundant species of Coleoptera species captured in farms from three regions of North Carolina, USA.

Although this beetle occasionally preys on eggs of filth flies, it is considered a major pest in commercial poultry houses (Axtell and Arends, 1990) rather than a beneficial species.

Lesser mealworms are important vectors of a number of poultry pathogens and parasites, such as the viruses of leucosis, Marek's disease, Gumboro disease (Falomo 1986), Turkey Coronavirus (Calibeo, 2002; Watson et al., 2000); Newcastle disease, Avian Influenza (Hosen et al., 2004); bacteria such as *Salmonella typhimurium*, *E. coli*, and *Staphylococcus ssp*. (Chernaki-Leffer, 2002; De Las Casas et al., 1968; Harein et al., 1970; McAllister et al., 1996); protozoans such as *Eimeria ssp*. that cause Coccidiosis (Goodwin and Waltman, 1996; Hosen et al., 2004); fungal *Aspergillus ssp*. (De Las Casas et al., 1972; Eugenio et al., 1970); helminths such as the nematode *Subulura brumpti* (Karunamoorthy et al., 1994); and fowl cestodes (Elowni and Elbihari, 1979). Both adults and larvae of *A. diaperinus* can cause intestinal obstruction in poultry for slaughter since these birds lack chitinases (enzymes to digest chitin) (Elowni and Elbihari, 1979). This may eventually cause microscopic lesions along the bird's intestinal wall.

Lesser mealworms can also cause structural damage in poultry houses. Energy costs in beetle-damaged broiler houses are reported to be 67% higher than in houses without beetle damage (Geden and

Table 1: Comparison of the relative frequency of Coleoptera species detected from litter collected in broiler, broiler breeder, and layer houses in Urmia, Iran. Uppercase letters (a-c) indicate statistically different ($p < 0.05$) values.

		Broiler	Breeder	Layer
	No. of observation	36	20	4
Alphitobius diaperinus	Relative frequency (%)^{a}	55.5 ^{a}	35^{a}	0
Dermestes maculatus	Relative frequency (%)	22.2 ^{b}	4 ^{b}	25
Carcinops pumilio	Relative frequency	5.5 ^{c}	3.5 ^{bc}	0

Hogsette, 2001). However, lesser mealworm populations in high-rise caged layer houses may actually perform some beneficial functions. When beetle activity is intense, manure may be aerated and dried, and the beetles may become facultative predators of fly larvae (Geden and Hogsette, 1994).

Each of the three poultry facility types principally used in poultry production in Iran (caged-layer, broiler, and breeder houses) has unique pest management needs. Caged-layer houses are widely used for commercial egg production and present the greatest breeding potential for flies and darkling beetles. Broiler houses are wide-span structures with litter (wood shavings) covering the floor, where the birds run free. High populations of beetles may occur in the litter. Breeder or broiler-breeder houses are also wide-span structures with free-running birds on a litter or slat-litter floor (the outer two-thirds of the house have a slatted floor two to three feet above ground level, with a litter-covered floor in the center third of the house). Our results indicated that Coleoptera were abundant in both broiler farms and in broiler and layer farms, respectively.

Although different beetle species, especially *A. diaperinus*, are vectors and reservoirs for numerous poultry disease agents, no standardized field strategies have been developed for their control, thus resulting in low long-term success in controlling the pest. In Australia, the meat chicken industry has become concerned in recent years over the inadequacies of current control practices, i.e., regular applications of insecticides to the floors and lower walls of broiler houses, and for this reason commissioned research to develop acceptable control strategies for the darkling beetle. However, research has shown that the current standard industry insecticide is not effective when applied to broiler house floors, a situation exacerbated by strong and widespread insecticide resistance occurring in beetle populations in broiler houses (Lambkin, 2001). To our knowledge, this is the first report about the prevalence of Coleoptera species of commercial birds litters in Iran, suggesting further studies on the prevalence in other parts of the country, and on economical effects of Coleoptera species and their transmission of disease agents.

Conclusion: The results of this study show that beetle species are common on all types of poultry facilities (broiler, broiler breeder and commercial layer houses) that are principally used in poultry production in Iran. Some species of Coleoptera infesting poultry houses can cause serious structural damage to the poultry house insulation and serve as reservoir of many avian pathogens. Therefore, further attention should be focused on prevention and control of these pests in poultry farms.

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References

1. Axtell, R.C., Arends, J.J. (1990) Ecology and management of arthropod pests of poultry. Annu. Rev. Entomol. Palo Alto. 35:101-126.
2. Axtell, R.C. (1999) Poultry integrated pest management: status and future. Integrated Pest Manag. Rev. 4: 43-73.
3. Calibeo, D.R. (2002) Role and mitigation of two vectors of turkey coronavirus, Musca domestica L. and *Alphitobius diaperinus* (Panzer). Thesis, North Carolina State University. p. 217.
4. Chernaki, A.M., Almeida, L.M. (2001a) Morfologia dos estágios imaturos e do adulto de *Alphitobius diaperinus* (Panzer) (Coleoptera: *Tenebrionidae*). Revta. Bras. Zool. 18:351-363.
5. Chernaki, A.M., Almeida, L.M. (2001b) Exigências térmicas, período de desenvolvimento e sobrevivência de imaturos de *Alphitobius diaperinus* (Panzer) (Coleoptera: *Tenebrionidae*). Neotropical. Entomol. 30:365-368.
6. Chernaki-Leffer, A.M., Biesdorf, S.M., De Almeida, L.M., Leffer, E.V. B., Vigne, P. (2002) Isolation of enteric and litter organisms from *Alphitobius diaperinus* in brooder chicken houses in West of Parana State, Brazil. Revista Brasileira de Ciencia Avicola. 4:243-247.
7. De Las Casas, E., Harein, P.K., Pomeroy, B.S. (1972) Bacteria and fungi within the mealworm collected from poultry brooder houses. Environ. Entomol. 1:27-30.
8. De Las Casas, E., Pomeroy, B.H., Harein, P.K. (1968) Infection and quantitative recovery of *Salmonella typhimurium* and *Escherichia coli* from within the lesser mealworm, *Alphitobius diaperinus*. Poult. Sci. 48:1871-1875.
9. Despins, J.L., Axtell R.C., Rives, D.V., Guy, J.S., Ficken, M.D. (1994) Transmission of enteric pathogens of turkeys by darkling beetle larvae (*Alphitobius diaperinus*). J. Appl. Poult. Res. 3:61-65.
10. Despins, J.L., Axtell, R.C. (1995) Feeding behavior and growth of broiler chicks fed larvae of the darkling beetle, *Alphitobius diaperinus*. Poult. Sci. 74:331-336.
11. Dunford, J.C. (2000) The darkling beetles of Wisconsin (Coleoptera: *Tenebrionidae*): taxonomy, natural history, and distributions. Thesis, University of Wisconsin-Madison. p. 291.
12. Dunford, J.C., Thomas, M.T., Choate Jr, P.M. (2005) The darkling beetles of Florida and the eastern United States (Coleoptera: *Tenebrionidae*). http://entnemdept.ifas.ufl.edu/teneb/index.htm(7th January 2006).
13. Elowni, E.E., Elbihari, S. (1979) Natural and experimental infection of the beetle, *Alphitobius diaperinus* (Coleoptera: *Tenebrionidae*) with Choanotaenia infundibulum and other chicken tapeworms. Vet. Sci. Commun. 3:171-173.
14. Erichsen, LD., Jespersen, J.B. (1997) Behaviour and population dynamics of litter beetles in broiler houses. Danish Pest Infestation Laboratory Annual Report, 71. In Lambkin, TA. Investigations into the management of darkling beetle. Website: http://www.rirdc.gov.au.
15. Eugenio, C., De Las Casas, E., Harein, P.K., Mirochia, C.J. (1970) Detection of the mycotoxin F-2 in the confused flour beetle and lesser mealworm. J. Econ Entomol. 63:412-415.
16. Falomo, A.A. (1986) The Pheromone Biology of the Lesser Mealworm *Alphitobius diaperinus* (Panzer), (Coleoptera: *Tenebrionidae*). Thesis, University of Wisconsin-Madison. pp 197.
17. Fernandes, M.A. (1995) Ocorrência de artrópodes no esterco acumulado em uma granja de galinhas poedeiras. Anais da Sociedade Entomológica Brasileira, Londrina. 24:649-654.
18. Francisco, O. (1996) *Alphitobius diaperinus* (Panzer) (Coleoptera: *Tenebrionidae*) associado a esterco em granjas de aves poedeiras: fenologia, estrutura etária e parasitismo. Dissertação (Mestrado em Entomologia) - Universidade Estadual de Campinas. p. 116.
19. Geden, C.J., Axtell, R.C. (1988) Predation by *Carcinops pumilio* (Coleoptera: Histcridae) and Macroclieles muscaedomesticoe (Acarina: Macrochclidae)

on the house fly (Diptera: Muscidae): functional response, effects of temperature, and availability of alternative prey. Environ. Entomol. 17:739-744.

20. Geden, C. J., Hogsette, J. A. (2001) Research and extension needs for integrated pest management for arthropods of veterinary importance. Center for Medical, Agricultural, and Veterinary Entomology USDA-ARS Workshop Proceedings, Lincoln, Nebraska. http://www.ars.usda.gov/Services/docs. htm?docid= 10139 (21st March 2006).
21. Goodwin, M.A., Waltman, W.D. (1996) Transmission of Eimeria, viruses, and bacteria to chicks: darkling beetles (*Alphitobius diaperinus*) as vectors of pathogens. J. Appl. Poult. Res. 5:51-55.
22. Gray, J.P., Maddox, C.W., Tobin P.C., Gummo, J.D., Pitts, C.W. (1999) Reservoir competence of *Carcinops pumilio* for *Salmonella enteritidis* (*Eubacteriales: Enterobacteriaceae*) J. Med. Entomol. 36:888-891.
23. Harein, P.K., De Las Casas, E., Pomeroy, B.S., York, M. D. (1970) *Salmonella* ssp. and serotypes of *Escherichia coli* isolated form the lesser mealworm collected in poultry brooder houses. J. Econ. Entomol. 63:80-81.
24. Hosen, M., Khan, A.R., Hossain, M. (2004) Growth and development of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: *Tenebrionidae*) on cereal flours. Pak. J. Biol. Sci. 7:1505-1508.
25. Karunamoorthy, G., Chellappa, D.J., Anandari, R. (1994) The life history of *Subulura brumpti* in the beetle *Alphitobius diaperinus*. Indian. Vet. J. 71:12-15.
26. Lambkin, T. A. (2001) Investigations into the management of the darkling beetle. A report for the Rural Industries Research and Development Corporation. RIRDC, publication number 01/151 online. November 2001.
27. McAllister, J.C., Steelman, D.D., Skeeles, J.K. (1994) Reservoir competence of the lesser mealworm (Coleoptera: *Tenebrionidae*) for *Salmonella typhimurium* (Eubacteriales: Enterobacteriaceae). J. Med. Entomol. 31:369-372.
28. McAllister, J. C., Steelman, C. D., Steeles, J. K., Newberry, L.A., Gbur, E.E. (1996) Reservoir competence of *Alphitobius diaperinus* (Coleoptera: *Tenebrionidae*) for *Escherichia coli* (Enterobacteriales: Enterobacteriaciae). J. Med. Entomol. 33:983-987.
29. McGoldrick, S. (2004) Litter beetles - what is the economic impact? p. 179-187. In Proceedings, Poultry Information Exchange, 18th-21st April 2004, Surfers Paradise, Australia. PIX Association Inc, Caboolture, Queensland, Australia.
30. Mascarini, L.M. (1995) Aspectos biológicos de Muscina stabulans (Fallén, 1817) em condições de laboratório. Dissertação (Mestrado em Entomologia) - Unicamp, Campinas, SP. p. 68.
31. Pfeiffer, D.G., Axtell, R.C. (1980) Coleoptera of poultry manure in caged-layer houses in North Carolina. Environ. Entomol. 9:21-28.
32. Rueda, L.M., Axtell, R.C. (1997) Arthropods in the litter of poultry (Broiler chicken and turkey) houses. J. Agric. Entomol. 14:81-91.
33. Safrit, R.D., Axtell, R.C. (1984) Evaluations of sampling methods for darkling beetles (*Alphitobius diaperinus*) in the litter of turkey and broiler houses. Poult. Sci. 63:2368-2375.
34. Salin, C., Delettre, Y.R., Cannavacciuolo, M., Vernon, P. (2000) Spatial distribution of *Alphitobius diaperinus* (Panzer) (Coleoptera: *Tenebrionidae*) in the soil of a poultry house along a breeding cycle. Eur. J. Soil Biol. 36:107-115.
35. Stafford, K.C., CollIson, C.H. (1987) Manure pit temperatures and relative humidity of Pennsylvania high-rise poultry houses and their relationship to arthropod population development. Poult. Sci. 66:1603-1611.
36. Skewes, P.A., Munroe, J.L. (1991) Research note: The effects of darkling beetles on broiler performance. Poult. Sci. 70:1034-1036.
37. Strother, K.O., Steelman, C.D., Gbur, E.E. (2005) Reservoir competence of lesser mealworm (Coleoptera: *Tenebrionidae*) for Campylobacter jejuni (Campylobacterales: Campylobacteraceae). J. Med. Entomol. 42:42-47.
38. Turner, E.C. (1986) Structural and litter pests. Poult.

Sci. 65:644-648.

39. Vaughan, J.A., Turner, E.C., Ruszler, P.L. (1984) Infestation and damage of poultry house insulation by the lesser mealworm, *Alphitobius diaperinus* (Panzer). Poult. Sci. 63:1094-1100.
40. Watson, D.W., Guy, J.S., Stringham, S.M. (2000) Limited transmission of turkey coronavirus (TCV) in young turkeys by adult darkling beetles, *Alphitobius diaperinus* Panzer (*Tenebrionidae*). J. Med. Entomol. 37:480-483.
41. Watson, D.W., Calibeo, D.R., Stringham, S.M., Guy, J. (2001) Role of Flies and Beetles in Disease. Virginia Poultry Health and Management Seminar. Virginia Cooperative Extension, VPI, Blacksburg, VA. April 17th-18th.pp. 83-85.
42. Wilhoit, L.R., Stinner, R.E., Axtell, R.C. (1991) A stimulation model for *Carcinops pumilio* (Coleoptera: Histcridae) population dynamics and predation on immature stage of house flies (Diptera: Muscidae). Environ. Entomol. 20:1079-1088.