House flies as mechanical vectors of pathogens

USEFUL REFERENCES

ASSOCIATION WITH VIRUSES

Calibeo-Hayes, D., S. S. Denning, S. M. Stringham, J. S. Guy, L. G.Smith, and D. W. Watson. 2003. Mechanical transmission of turkey coronavirus by domestic houseflies (Musca domestica Linnaeus). Avian Dis. 47:149–153.

Chakrabarti, S., D. J. King, C. Afonso, D. Swayne, C. J. Cardona, D. R, Kuney, A. C. Gerry. 2007. Detection and isolation of exotic Newcastle disease virus (ENDV) from field collected flies. Journal of Medical Entomology 44: 840-844. *(virus recovered from several filth fly species captured in the field)*

Chakrabarti, S., D. J. King, C. J. Cardona, A. C. Gerry. 2008. Persistence of exotic Newcastle disease virus (ENDV) in laboratory infected *Musca domestica* and *Fannia canicularis*. Avian Diseases 52: 375-379. *(virus did not amplify but persisted for several days at infectious levels primarily in the gut)*

Gregorio SB, Nakao JC, Beran GW. 1972. Human enteroviruses in animals and arthropods in central Philippines. Southeast Asian J Trop Med Pub Health 3: 45-51.

Millushev, I., G. Gerganov, and N. Shishkov. 1977. Role of house flies in the epizootiology of Newcastle disease. Vet. Med. Nauki 14:97–100.

Otake, S., S. A. Dee, R. D. Moon, K. D. Rossow, C. Trincado, C. Pijoan. 2004. Studies on the carriage and transmission of porcine reproductive and respiratory syndrome virus by individual houseflies (Musca domestica). Veterinary Record 154: 80-85. *(house flies can acquire virus after exposure to infected pig)*

Otake, S., S. A. Dee, R. D. Moon, K. D. Rossow, C. Trincado, M. Farnham C. Pijoan. 2003. Survival of porcine reproductive and respiratory syndrome virus in houseflies. Canadian Journal of Veterinary Research 67: 198-203. *(virus acquired from pig by flies remained infectious in fly gut for up to 12 hrs but did not persist long on external surface of flies)*

Schurrer, J. A., S. A. Dee, R. D. Moon, M. P. Murtaugh, C. P. Finnegan, J. Deen, S. B. Kleiboeker, C. B. J. Pijoan. 2005. Retention of ingested porcine reproductive and respiratory syndrome virus in houseflies. American Journal of Veterinary Research 66: 1517-1525. (*virus did not amplify and retention time depended upon initial concentration and temperature)*

Schurrer, J. A., S. A. Dee, R. D. Moon, K. D. Rossow, C. Mahlum, E. Mondaca, S. Otake, E. Fano, J. E. Collins, C. Pijoan. 2004. Spatial dispersal of porcine reproductive and respiratory syndrome virus-contaminated flies after contact with experimentally infected pigs. American Journal of Veterinary Research 65:1284-1292. *(flies acquired virus from pigs and transported infectious virus up to 1.7km from pig facility)*

Tan, S. W., K. L. Yap, and H. L. Lee. 1997. Mechanical transport of rotavirus by the legs and wings of *Musca domestica* (Diptera: Muscidae). Journal of Medical Entomology 34: 527-531.

Watson, D. W., E. L. Nino, K. Rochon, S. Denning, L. Smith, and J. S. Guy. 2007. Experimental evaluation of Musca domestica (Diptera: Muscidae) as a vector of Newcastle disease. Virus. J.

Med. Entomol. 44: 666–671. *(virus persisted for less time relative to Chakrabarti, also no amplification)*

ASSOCIATION WITH BACTERIA

Ahmad A, Nagaraja TG, Zurek L. 2007. Transmission of *Escherichia coli* O157:H7 to cattle by house flies. Prev Vet Med. 80:74-81. *(study actually showed transmission to animals following release of infected flies. About as close as these studies get to demonstrating potential of house flies as mechanical vector of pathogens)*

Ahmad, A., A. Ghosh, C. Schal, and L. Zurek. 2011. Insects in confined swine operations carry a large antibiotic resistant and potentially virulent enterococcal community. *BMC Microbiol.* 11: 23. *(more like this from the Zurek lab if you are interested)*

Chaiwong, T., T. Srivoramas, P. Sueabsamran, K. Sukontason, M. R. Sanford, K. L. Sukontason. 2014. The blow fly, Chrysomya megacephala, and the house fly, Musca domestica, as mechanical vectors of pathogenic bacteria in Northeast Thailand. TROPICAL BIOMEDICINE 31: 336-346. *(many different human pathogenic bacteria recovered on field collected flies from food preparation and garbage sites in Thailand – more articles like this from Thailand if you want to look for them)*

Doud, C. W., H. M. Scott, and L. Zurek. 2014. Role of House Flies in the Ecology of Enterococcus faecalis from Wastewater Treatment Facilities. MICROBIAL ECOLOGY 67: 380-391.

Elder, R.O., J.E. Keen, G.R. Siragusa, G.A. Barkocy-Gallagher, M. Koohmaraie, and W.W. Laegreid. 2000. Correlation of enterohemorrhagic *Escherichia coli* O157 prevalence in feces, hides, and carcasses of beef cattle during processing. PNAS 97: 2999-3003

Emerson, P. M., R. L Bailey, O. S. Mahdi, G. E. L. Walraven, and S. W. Lindsay. 2000. Transmission ecology of the fly *Musca sorbens*, a putative vector of trachoma. Transactions of the Royal Society of the Tropical Medicine and Hygiene 94: 28-32. *[article describes low incidence of house flies on eyes, M. sorbens more common on eyes and PCR detection of bacteria from this species)*

Fleming, A., H. V Kumar, C. Joyner, A. Reynolds, and D. Nayduch. 2014. Temporospatial fate of bacteria and immune effector expression in house flies fed GFP-Escherichia coli O157:H7. Medical and Veterinary Entomology 28: 364–371 *(lab study - bacteria persisted for approx. 12 h in crop and rectum)*

Forsey T, Darougar S. 1981. Transmission of chlamydiae by the housefly. Brit J Ophthalm. 65: 147-150.

Fotedar R, Banerjee U, Shriniwas SS Verma AK. 1992. The house fly (*Musca domestica*) as a carrier of pathogenic microorganisms in a hospital environment. J Hosp Inf. 20: 209-215.

Fotedar, R. 2001. Vector potential of houseflies (*Musca domestica*) in the transmission of *Vibrio cholerae* in India. Acta Tropica 78: 31-34.

Ghosh, A. M. Akhtar, C. Holderman, and L. Zurek. 2014. Significance and Survival of Enterococci During the House Fly Development. JOURNAL OF MEDICAL ENTOMOLOGY 5: 63-67 *(enterococci can persist through immature stages to colonize gut of teneral adult flies)*

Grubel, P., J. S. Hoffman, F. K. Chong, N. A. Burstein, C. Mepani, and D. R. Cave. 1997. Vector potential of houseflies (*Musca domestica*) for *Helicobacter pylori*. Journal of Clinical Microbiology 35: 1300-1303.

Levine O.S. and M.M. Levine. 1991. Houseflies (*Musca domestica*) as mechanical vectors of shigellosis. Rev Infect Dis. 13: 688-696.

Mian, L. S., H. Maag, and J. V. Tacal. 2002. Isolation of *Salmonella* from muscoid flies at commercial animal establishments in San Bernardino County, California. Journal of Vector Ecology 27: 82-85.

Moriya K, Fujibayashi T, Yoshihara T, Matsuda A, Sumi N, Umezaki N, Kurahashi H, Agui N, Wada A, Watanabe H. 1999. Verotoxin-producing *Escherichia coli* O157:H7 carried by the housefly in Japan J Med Vet Entomol. 13: 214-216.

Nichols G. Fly transmission of *Campylobacter*. 2005. Emerg Infect Dis. 11: 361-364.

Olsen A.R. and T. S. Hammack. 2000. Isolation of *Salmonella* spp. from the housefly, *Musca domestica* L., and the dump fly, *Hydrotaea aenescens* (Wiedemann) (Diptera: Muscidae) at caged-layer houses. J Food Prot. 63: 958-960.

Sasaki, T., M. Kobayashi, and N. Agui. 2000. Epidemiological potential of excretion and regurgitation by *Musca domestica* (Diptera: Muscidae) in the dissemination of *Escherichia coli* O157:H7 to food. Journal of Medical Entomology 37: 945-949.

Shane SM, Montrose MS, Harrington KS. 1985. Transmission of campylobacter jejuni by the housefly (Musca domestica). Avian Dis. 29: 384-391.

Soheyliniya, S., A. Barin. 2014. The role of house fly (*Musca domestica*) in transmission of pathogenic strains of *E. coli*. Journal of Veterinary Research 69: 9-15. *(72 h persistence of E. coli in digestive tract – compare to Fleming et al.)*

Talley JL, Wayadande AC, Wasala LP, Gerry AC, Fletcher J, DeSilva U, Gilliland SE. 2009. Association of *Escherichia coli* O157:H7 with filth flies (Muscidae and Calliphoridae) captured in leafy greens fields and experimental transmission of *E. coli* O157:H7 to spinach leaves by house flies (Diptera: Muscidae). J Food Prot. 72: 1547-1552.

Wei, T., K. Miyanaga, Y. Tanji. 2014. Persistence of antibiotic-resistant and -sensitive Proteus mirabilis strains in the digestive tract of the housefly (Musca domestica) and green bottle flies (Calliphoridae). APPLIED MICROBIOLOGY AND BIOTECHNOLOGY 98: 8357-8366. *(lab study - bacteria persisted for up to 3 days)*

Zurek, L., S. S. Denning, C. Schal, and D. W. Watson. 2001. Vector competence of *Musca domestica* (Diptera: Muscidae) for *Yersinia pseudotuberculosis*. Journal of Medical Entomology 38: 333-335.

ASSOCIATION WITH PARASITES

Balla, H. J., Y. Usman, A. Muhammad. 2014. The role of housefly (*Musca domestica*) in mechanical transmission of intestinal parasites in Maiduguri Metropolis, North Eastern Nigeria. Journal of Natural Sciences Research 4: 60-65. *(detection of nematodes on field collected flies)*

Doiz O, Clavel A, Morales S, Varea M, Castillo FJ, Rubio C, Gomex-Lus R. House fly (Musca domestica) as a transport vector of Giardia lamblia. Folia Parasitol. 2000;47:330-331.

Graczyk TK, Fayer R, Cranfield MR, Mhangami-Ruwende B, Knight R, Trout JM, Bixler H. House flies (*Musca domestica*) as transport hosts of Cryptosporidium parvum Am J Trop Med Hyg 1999;61:500-504.

Graczyk TK, Knight R, Tamang L. Mechanical transmission of human protozoan parasites by insects. *Clin Micro Rev.* 2005;18:128-132.

Khan AR, Huq F. 1978. Disease agents carried by flies in Dacca city. Bangladesh Med Res Council Bull. 4: 86-93.

Kasprzak W, Majewska A. Transmission of *Giardia* cysts. I. Role of flies and cockroaches. Wiad Parazytol. 1981;27:555-563.

Markus MB. 1980. Flies as natural transport hosts of *Sarcocystis* and other coccidia. J Parasitol. 66:361-362.

Szostakowska B, Kruminis-Lozowska W, Racewicz M, Knight R, Tamamang L, Myjak P, Graczyk TK. 2004. Cryptosporidium parvum and Giardia lamblia recovered from feral filth flies. Appl Environ Microbiol 70: 3742-3744.

Wallace GD. 1971. Experimental transmission of *Toxoplasma gondii* by filth-flies. Am J Trop Med Hyg. 20: 411-413.

FLY CONTROL ASSOCIATED WITH DISEASE REDUCTION

Chevasse, D. C., R. P. Shler, O. A. Murphy, S. R. A. Huttly, S. N. Cousens, and T. Akhtar. 1999. Impact of fly control on childhood diarrhoea in Pakistan: community randomised trial. Lancet 353: 22-25.

Cohen, D., M. Green, C. Block, R. Slepon, R. Ambar, S. S. Wasserman, and M. M. Levine. 1991. Reduction of transmission of shigellosis by control of houseflies (*Musca domestica*). Lancet 337: 993-997.

Emerson, P. M., S. W. Lindsay, G. E. L. Walraven, H. Faal, C. Bogh, K. Lowe, and R. L. Bailey. 1999. Effect of fly control on trachoma and diarrhea. Lancet. 353: 1401-1403.

Lindsay, D. R., W. H. Stewart, and J. Watt. 1953. Effect of fly control on diarrheal disease in an area of moderate morbidity. Public Health Reports 68: 361-367.

Watt, J., and D. R. Lindsay. 1948. Diarrheal disease control studies. I. Effect of fly control in a high morbidity area. Public Health Reports 63: 1319-1334.

REVIEW ARTICLES

Cirillo VJ. 2006. Winged sponges – houseflies as carriers of typhoid fever in 19th- and early 20th-century military camps. *Perspectives in Biology and Medicine.* 49:52-63.

Graczyk, T. K., R. Knight, R. H. Gilman, and M. R. Cran-field. 2001. The role of non-biting flies in the epidemiology of human infectious diseases. *Microbes Infect.* 3: 231–235.

Greenberg B. 1973. Flies and disease, Vol. II. Princeton Univ. Press, Princeton, NJ

OF SIGNIFICANCE TO THE ESA EBOLA DISCUSSION

Leroy EM, Gonzalez J-P, Baize S. 2011. Ebola and Marburg haemorrhagic fever viruses: major scientific advances, but a relatively minor public health threat for Africa. Clin. Microbiol. Infect. 17:964–76 *(detection of Ebola virus in fruit bats)*

Paessler, S., and D. H. Walker. 2013. Pathogenesis of the viral hemorrhagic fevers. Annual Review of Pathology 8: 411-440. *(general overview of Ebola epidemiology)*

Reiter, P., M. Turell, R. Coleman, et al. 1999. Field Investigations of an Outbreak of Ebola Hemorrhagic Fever, Kikwit, Democratic Republic of the Congo, 1995: Arthropod Studies. Journal of Infectious Disease 179: S148-S154. *(Ebola NOT found in captured blood feeding arthropods)*

Otake, S., S. A. Dee, K. D. Rossow, R. D Moon, C. Pijoan. 2002. Mechanical transmission of porcine reproductive and respiratory syndrome virus by mosquitoes, *Aedes vexans* (Meigen). Canadian Journal of Veterinary Research 66: 191-195. *(mechanical transmission of virus following interrupted feed on infected pig and subsequent feeding on uninfected pig)*

Swanepoel, R., P. A. Leman, F. J. Burt, et al. 1996. Experimental inoculation of plants and animals with Ebola virus. Emerging Infectious Diseases 2: 321-325 *(Ebola replicated only in bats and was recovered from feces of infected insectivorous bats. Few insects inoculated did NOT amplify Ebola.)*

Paweska, J. T., P. J. van Vuren, J. Masumu, P. A. Leman, A. A. Grobbelaar, M. Birkhead, S. Clift, R. Swanepoel, A Kemp. 2012. Virological and serological findings in Rousettus aegyptiacus experimentally inoculated with vero cells-adapted Hogan strain of Marburg virus. PLOS One 7:e45479 *(bats inoculated with virus did not shed virus in feces or urine, but virus persisted in blood and body tissues for 5 days)*

Turell, M. J., D. S. Bressler, and C. A. Rossi. 1996. Short report: lack of virus replication in arthropods after intrathoracic inoculation of Ebola reston virus. American Journal of Tropical Medicine and Hygiene. 55: 89-90. *(Neither mosquitoes nor a tick species supported replication of Ebola following IT inoculation)*

Ebola hemorrhagic fever (a Filovirus related to Marburg virus) is associated with person-person spread and inadequate protections during necropsy or handling of infected animals. Animal reservoirs are fruit bats and possibly non-human primates. Clinical manifestations include diarrhea and vomiting, particularly during the period when patients are most infective. Hemorrhagic lesions in many cases as well. Transmission to humans known principally by direct contact with skin of infected human or cadaver. At end stage, virus infects macrophages and endothelial cells. Virus thought to gain entry to human host through mucosal surfaces or injured skin.