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House Flies (*Musca domestica*) as Possible Vectors of *Campylobacter fetus* subsp. *jejuni*

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A total of 161 strains of *Campylobacter fetus* subsp. *jejuni* were isolated from house flies (*Musca domestica*). The carrier rates detected were 50.7% in flies captured on a chicken farm and 43.2% in flies from a piggery. The relative prevalences of *Campylobacter coli*, *C. jejuni*, and nalidixic acid-resistant thermophilic campylobacters were 90.1, 6.2, and 3.7%, respectively. The results indicate that flies may play a linking role in the epidemiology of *Campylobacter* infection in humans by transmitting campylobacters from animals to human food.

Campylobacter fetus subsp. *jejuni* is frequently encountered as either a commensal or a pathogen in the intestinal tract of many avian and mammalian species (2, 23, 30). In medical microbiology, these bacteria have attracted interest during the past decade due to an increasing frequency of isolations from human clinical specimens. *C. fetus* subsp. *jejuni* is now recognized as an important causal agent of human enteritis (2, 30). The available data suggest an alimentary route of infection. Unpasteurized milk (1, 5, 13, 15, 25, 28) and drinking water (9, 26) have been implicated as the source of infection in several outbreaks of campylobacteriosis, some of which have involved thousands of people. Both milk and meat products (especially poultry) probably serve as a vehicle for *C. fetus* subsp. *jejuni* (3, 10, 12, 19, 22, 24).

Adult house flies (*Musca domestica*) are important agents in the dissemination of numerous infectious diseases (29). The flies get onto and into almost everything humans eat or drink, and the flies visit every conceivable form of excreta and other filth (29). Although they are rarely the dominant transmitting agent in any epidemic disease, flies represent a considerable hazard to health wherever they have access to both feces and human food. Moreover, hibernating flies, flies reared from infected larvae, and dead flies may also harbor pathogens.

The present study was undertaken to assess the ability of house flies to act as a vector of *C. fetus* subsp. *jejuni*.

MATERIALS AND METHODS

Samples. A total of 608 adult house flies were examined for the presence of *C. fetus* subsp. *jejuni*. The flies were identified as *M. domestica* according to standard criteria by use of taxonomic keys. All flies were collected in the counties of Østfold and Akershus in southeastern Norway. In a pilot study conducted in July 1981, 90 flies were captured in a piggery by using insect nets. These flies were divided into pooled samples, with three live flies in each pool. The presence of *C. fetus* subsp. *jejuni* in several of these samples prompted a more comprehensive study to determine the exact incidence of campylobacters in flies in different environments. Hence, a total of 518 house flies were captured and examined individually. During September 1981, collections were made from four different habitats, comprising one cattle barn (100 flies), one turkey farm (103 flies), one piggery (169 flies), and one chicken farm (146 flies) (Table 1). Flies were captured individually by means of glass tubes containing campylobacter enrichment broth (see below).

Cultivation and isolation. Cultivation was performed within four h of collection. The flies were transported and cultivated in tubes with cotton wool plugs containing 5 ml of campylobacter enrichment broth (16). This medium consists of peptone (Difco Laboratories, Detroit, Mich.) (10 g/liter), Lab-Lemco powder (Oxoid Ltd., Hampshire, England) (8 g/liter), yeast extract (Oxoid) (1 g/liter), sodium chloride (5 g/liter), rezasurin solution (0.025% wt/vol) (16 ml/liter), vancomycin (Vancocin; Eli Lilly & Co., Indianapolis, Ind.) (10 μg/ml), trimethoprim lactate (Burroughs-Wellcome Co., London, England) (5 μg/ml), and polymyxin B (Burroughs-Wellcome) (2.5 IU/ml). Before incubation, the flies were crushed with a sterile glass rod to expose any bacteria in the intestinal tract. The tubes were incubated at 42 to 43°C in a microaerobic atmosphere by using the GasPak system (BBL Microbiology Systems, Cockeysville, Md.) without a catalyst. After 48 h, subcultures were made on a selective agar medium which consisted of gonococci agar base (11), defibrinated horse blood (70 ml/liter), IsoVitaleX enrichment (BBL) (10 ml/liter), and the antimicrobial agents colistin (Colimycin; Lundbeck & Co., Copenhagen, Denmark) (10 IU/ml), cefalotin (Keflin; Lilly) (15 μg/ml)

TABLE 1. Isolation of *C. fetus* subsp. *jejuni* from house flies

Habitat	No. of flies	Flies carrying campylobacters	
		No.	%[a]
Chicken farm	146	74	50.7
Piggery	169	73	43.2
Cattle barn	100	0	
Turkey farm	103	0	

[a] Total for all flies = 28.4%.

and nystatin (Mycostatin; E. R. Squibb & Sons Ltd., Twickenham, Middlesex, England) (25 IU/ml). The plates were incubated in a microaerobic atmosphere as described above, and examined after 48 and 72 h. Plates showing no growth were incubated further and read after 1 week.

C. fetus subsp. *jejuni* was identified on the basis of morphological, cultural, and biochemical characteristics as described in the accompanying paper (6). The isolates were subsequently tested for their ability to hydrolyze hippurate (4, 21) and for susceptibility to nalidixic acid (6, 21). These parameters formed the basis for allocation to *Campylobacter jejuni*, *Campylobacter coli*, and nalidixic-acid resistant campylobacters (NARTC), as proposed by Skirrow and Benjamin (21).

RESULTS

C. fetus subsp. *jejuni* was isolated from 11 of 30 pooled samples, each consisting of three live house flies captured in a piggery. A total of 518 flies were examined individually. Of these, 147 (28.4%) were found to harbor *C. fetus* subsp. *jejuni* (Table 1). Isolations were made from 74 (50.7%) of 146 flies captured on a chicken farm and from 73 (43.2%) of 169 flies inhabiting a piggery. No strains were isolated from 100 flies from a cattle barn or from 103 flies from a turkey farm.

Three biochemically distinct taxa (21) were recognized among the 161 strains isolated. The relative prevalences of these taxa are shown in Table 2. *C. coli* constituted 98.8% of the strains recovered from flies captured in the two piggeries examined and 80.5% of the isolates from flies living on the chicken farm. Ten (13.0%) of the strains obtained from the chicken farm were *C. jejuni*, whereas no such strains were found in the piggeries. Flies from both habitats harbored NARTC (21), but the prevalence was relatively low (Table 1). Three flies harbored two biochemically distinct strains (*C. jejuni* and NARTC).

TABLE 2. Relative prevalence of *C. jejuni*, *C. coli*, and NARTC occurring in house flies from different habitats[a]

Habitat	No. of isolates (%)			
	Total	*C. jejuni*	*C. coli*	NARTC
Chicken farm	77[b]	10 (13.0)	62 (80.5)	5 (6.5)
Piggery	84	0	83 (98.8)	1 (1.2)

[a] Species were identified by the method of Skirrow and Benjamin (21). Total percent recoveries were as follows: *C. jejuni*, 6.2%; *C. coli*, 90.1%; NARTC, 3.7%.

[b] Three flies harbored two biochemically distinct strains (*C. jejuni* and NARTC).

DISCUSSION

There are essentially four different ways in which house flies may transmit infectious microorganisms (29): (i) on the hairs and surface of its body, (ii) on the glandular hairs on its feet, (iii) by regurgitation of vomitus, and (iv) by passage through the alimentary tract. Hence, either the fly may function as a temporary mechanical vector, or the pathogen concerned may survive for a longer period of time within the fly's body, in many instances with no adverse effect upon the carrier host. This latter possibility provides an opportunity for multiplication of the pathogen. In the present study, no attempt was made to discriminate between superficial contamination and infection of the alimentary tract. However, both situations may lead to bacterial contamination of human food. Flies have, for example, been observed to defecate at intervals of 4 to 5 min all day long (29). Ullmann and Kischkel (27) found that all three campylobacter strains that they examined survived for at least 7 days on completely desiccated swabs. This observation indicates that campylobacters may remain viable for several days on the body surface and in the fly's discharges after the latter have become desiccated.

Milk has been recognized as an important vehicle for *C. fetus* subsp. *jejuni* (1, 5, 13, 15, 25, 28). The infective dose in milk is low (14). Hence, the possibility exists that humans may contract the infection by drinking milk in which flies have drowned. Moreover, house flies are known to be persistent feeders at the external apertures of the teats of the bovine udder and often visit other teats of the same or a second cow within a short span of time. Lander and Gill (7) were able to produce a fairly severe clinical mastitis by experimental infection of bovine udders with *C. fetus* subsp. *jejuni*. Large numbers of campylobacters were excreted in the milk during the early stages of the syndrome, enabling effective dissemination of the pathogen to consumers of unpasteurized milk. The small size of the inoculum required to provoke mastitis suggests that this situation may occur under natural conditions. Flies or bovine feces are potential sources of infection.

Avian wildlife constitutes an extensive reservoir of *C. fetus* subsp. *jejuni* (6, 8, 20). House flies represent a significant food resource for several species of insectivorous birds, and the pathogen may thus be transmitted from fly to predator.

C. jejuni and, to a lesser degree, *C. coli*, have been associated with human campylobacteriosis (20). In our study, both *C. jejuni* and *C. coli* were isolated from flies inhabiting piggeries and a chicken farm. Similar strains have previously been recovered from feces of pigs and poultry in Norway (17, 18, 18a). Although this by no means proves that the bacteria isolated from flies originated from the pigs and poultry concerned, it is strongly suggestive thereof. Hence, it is possible that house flies may function as an epidemiological link between humans and domestic animals.

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