Arthropods in a hospital and their potential significance in the epidemiology of hospital infections

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Key words: arthropods, hospital, epidemiology, microbes

Abstract. Synanthropic and other arthropods were collected and examined for microbes in the summer seasons of 1988 and 1990. The collection was performed in a Prague hospital with departments situated in separate buildings, each surrounded by a park. In 1988, the most attention was given to flies (35 species collected) found outside between the buildings. In 1990, all arthropods found inside the buildings (particularly in the departments of dermatology and urology) were studied. A total of 30 taxa were identified. The microbes found on the bodies of arthropods were isolated in both seasons. In 1990, the hospital environment and biological material from patients (urine, pus) were also examined for the presence of microbes. Altogether 108 strains (21 species) and 116 strains (25 species) were isolated from the arthropods’ bodies in 1988 and 1990, respectively. The ecological characterization of the arthropods and results of microbiological studies show that synanthropic arthropods play a significant role in the epidemiology of hospital infections.

The occurrence of potentially pathogenic microbes on the body surface of synanthropic flies and some other insects (common cockroach, German cockroach, wasp), or their passage through the digestive tract of these arthropods, is generally known, and the importance of arthropods in mechanical transmission of microbes has been widely reported (Roth and Willis 1957, Greenberg 1965, 1971–73, Weber 1980). Data concerning the presence of synanthropic arthropods in hospitals and their possible significance in the origin and propagation of hospital infections is not documented in the available literature.

This problem was studied in two stages. In 1988 synanthropic flies were collected from the open spaces between the various buildings of a Prague hospital and their bodies were examined for microbes (Daniel et al. 1990). The positive results obtained served as an impetus for further studies at the same hospital in 1990. The goals of the second stage of investigation were as follows: 1) identification of all arthropods (even the exoanthropic ones which occur randomly) in the hospital buildings; 2) biochemical characterization, serotyping and sensitivity to antibiotics of all microbial strains isolated from the arthropod bodies; 3) comparison of the
microbial flora found on the arthropods with that isolated in the hospital environment or in the biological material.

The results of the arthropod collection are reported in this paper; microbiological and epidemiological studies will be reported separately (Šrámová et al. 1992).

MATERIALS AND METHODS

The arthropods were collected from a Prague hospital with departments situated in separate buildings, each surrounded by a park in the summer (June–September) of 1988 and 1990.

The studies in 1988 primarily concerned synanthropic flies. Due to their relatively low frequency, it was necessary to collect them at places where they concentrated, fed and could get contaminated, and from where they could spread into adjacent buildings. These three conditions were fulfilled by the location of waste cans or garbage containers which were not completely sealed in front of individual buildings. The flies were caught on June 27, August 2, and September 14 in order to record the seasonal changes in their species composition as well as in climate related activity. Silon nets (as described lower) were used for this purpose because standard traps with bait might have become a source of microbial contamination. Ants (Lasius emarginatus (Olivier)), which incidentally swarmed out into the operating room at the surgery department on June 27, were caught in the nets too. The experiment also included wasps (Paravespula vulgaris (L.)) which were abundant in the whole hospital area throughout August.

The second part of the investigation (July–September 1990) dealt, firstly with the occurrence of arthropods inside the departments of dermatology, urology and infection enabling the collection of synanthropic arthropods, and, secondly the penetration of exoanthropic species (especially those flying into lighted windows in the evening). Most insects were caught in the rooms (treatment rooms, operating rooms, out-patient rooms, wards, kitchens, nurses’ rooms), but adjacent areas, i.e. paths, corridors and attics were dealt with as well.

A sterile entomological net was used for each collection, and the insects were transferred by sterile exhauster into vessels with a solid phase medium used for the microbes (commercial product of Hygicult TPC – Orion Diagnostica Espoo Finland). During the first collection (June 27), 10 flies were put into each vessel, but during the next two collections (August 2–September 14) only 5 specimens were placed together. In 1990, this number was lowered yet again, and sometimes individual arthropods were examined.

The arthropods were sealed in the vessels for 2 hours to provide perfect contact with the plate covered with culture medium and to let them defecate. Then they were allowed to fly into the net, killed by ether, and fixed in 70% alcohol for an exact species determination.

The details of microbiological processing (isolation, inoculation on selective media, biochemical examination, serotyping, and disk diffuse method for the detection of the resistance to antibiotics) are described in a paper by Šrámová et al. (1992). Bacterial strains obtained from the hospital rooms (departments of surgery and dermatology) and from biological materials (pus and urine) from patients of the two departments were processed in a similar way.

RESULTS

The first stage of the research (1988) revealed a wide spectrum of flies found in the hospital and its surroundings situated in the residential part of the town (Table 1). A total of 500 flies belonging to 35 species were caught and used for 90 microbiological isolation experiments. The most successful collections came from
Table 1. List of flies caught in the free space between the hospital buildings – results from 1988. (The species are arranged according to their frequency.)

| Species                        | Date of collection | Total |
|                               | 27. 6. | 2. 8. | 14. 9. |       |
|                               | ♀      | ♂      | ♀      | ♂      |       |
| 1 Drosophila melanogaster     | 43     | 48     | 2      | 5      | 62    | 76    | 138   |
| 2 Protophora terraenovae      | 51     | 2      | 20     | 7      | 11    | 2     | 93    |
| 3 Lucilia sericata            | 5      | 13     | 5      | 4      | 2     | 4     | 24    |
| 4 Musca domestica             | 1      | 2      | 2      | 7      | 1     | 6     | 19    |
| 5 Muscina stabulans           | 8      | 2      | 6      | 1      | 2     | 17    |
| 6 Hydrotæa aerescens          | 2      | 9      | 1      | 3      | 7     | 3     | 15    |
| 7 Sarcophagidae gen. sp.      | 7      | 3      | 1      | 2      | 2     | 2     | 10    |
| 8 Coproica sp. 1              | 5      | 1      | 2      | 2      | 1     | 10    |
| 9 Fannia sp.                  | 1      | 3      | 3      | 1      | 5     | 6     |
| 10 Muscidae gen. sp.          | 1      | 3      | 3      | 1      | 5     | 6     |
| 11 Calliphora vicina          | 2      | 1      | 2      | 1      | 5     | 5     |
| 12 Lucilia caesar             | 2      | 1      | 2      | 1      | 5     | 5     |
| 13 Drosophila immigrans       | 2      | 1      | 2      | 1      | 5     | 5     |
| 14 Hydrotæa ignava            | 2      | 1      | 2      | 1      | 5     | 5     |
| 15 Lucilia ampullacea         | 2      | 1      | 2      | 1      | 5     | 5     |
| 16 Drosophila fumbris         | 2      | 1      | 2      | 1      | 5     | 5     |
| 17 Coproica ferruginata       | 2      | 1      | 2      | 1      | 5     | 5     |
| 18 Syritta pipiens            | 2      | 1      | 2      | 1      | 5     | 5     |
| 19 Limosina sp.               | 2      | 1      | 2      | 1      | 5     | 5     |
| 20 Sphaeroceridae gen. sp.    | 2      | 1      | 2      | 1      | 5     | 5     |
| 21 Anthomyiidae gen. sp.      | 2      | 1      | 2      | 1      | 5     | 5     |
| 22 Drosophila busckii         | 2      | 1      | 2      | 1      | 5     | 5     |
| 23 Sphaerocea sp.             | 2      | 1      | 2      | 1      | 5     | 5     |
| 24 Leptocera sp. 1            | 2      | 1      | 2      | 1      | 5     | 5     |
| 25 Leptocera sp. 2            | 2      | 1      | 2      | 1      | 5     | 5     |
| 26 Trachypella sp.            | 2      | 1      | 2      | 1      | 5     | 5     |
| 27 Sepsis violacea            | 2      | 1      | 2      | 1      | 5     | 5     |
| 28 Coproica vagans            | 2      | 1      | 2      | 1      | 5     | 5     |
| 29 Coproica sp. 2             | 2      | 1      | 2      | 1      | 5     | 5     |
| 30 Liopiophila varipes         | 2      | 1      | 2      | 1      | 5     | 5     |
| 31 Mycetaulus bipunctatus      | 2      | 1      | 2      | 1      | 5     | 5     |
| 32 Muscina pabolorum           | 2      | 1      | 2      | 1      | 5     | 5     |
| 33 Hydrotæa (Ophyra) sp.       | 2      | 1      | 2      | 1      | 5     | 5     |
| 34 Stomoxys calcitrans         | 2      | 1      | 2      | 1      | 5     | 5     |
| 35 Tachinidae                  | 2      | 1      | 2      | 1      | 5     | 5     |
| Total                         | 2      | 1      | 2      | 1      | 5     | 5     | 492   |
Table 2. Results of microbiological isolation tests from the body surface of flies and other insects caught in the areas between the hospital buildings (June–September 1988)

<table>
<thead>
<tr>
<th>Microbe (Arranged according to the number of isolated strains)</th>
<th>Number of isolated strains</th>
<th>Date</th>
<th>Total</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteus vulgaris</td>
<td></td>
<td>27. 6.</td>
<td>2. 8.</td>
<td>14. 9.</td>
</tr>
<tr>
<td>Proteus mirabilis</td>
<td></td>
<td>7</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td></td>
<td>6</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td></td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Bacillus sp.</td>
<td></td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Providencia alcalifaciens</td>
<td></td>
<td>1</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Proteus sp.</td>
<td></td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Providencia rettgeri</td>
<td></td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Enterobacter aerogenes</td>
<td></td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Staphylococcus xylosus</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Enterobacter agglomerans</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Klebsiella oxytoca</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Providencia stuartii</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Providencia sp.</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Morganella morganii</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>48</td>
<td>31</td>
<td>29</td>
</tr>
</tbody>
</table>

The possible significance of individual species in the epidemiology can be deduced from Table 1. Only the first four species reach numbers representing 5% and more of the total number of flies caught. Moreover, this group can be regarded (according to Gregor's classification 1989) as a group of eusynanthropic species which, with the exception of Protophormia terraenovae (Robineau-Désvoidy), are endophilic (i.e. occurring inside buildings). However, even among the species with a lower frequency (1–4%) there are some classified as eusynanthropic (Nos. 5–15 in the Table 1, e.g. Muscina stabulans (Fallén), Calliphora vicina (Robineau-Désvoidy), Hydrotaea aenesescens (Wiedemann)) whose presence must be considered from this viewpoint.
Table 3. List of arthropods according to their localization in the hospital – collections on July 9 and September 19, 1990

<table>
<thead>
<tr>
<th>ARTHROPODA</th>
<th>Free Space</th>
<th>Dept. of dermatology</th>
<th>Dept. of urology</th>
<th>Dept. of infection</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARACHNIDA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steatoda bipunctata</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tegenaria domestica</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Nuctenea umbratica</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Araneus sp.</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Miolopus morio</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>INSECTA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blattella germanica</td>
<td>49</td>
<td></td>
<td>17</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>Hemiptera</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Aphidoidea gen. sp.</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Chrysopa sp.</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Tenebrio molitor</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Coccinella septempunctata</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Athous niger</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Meligethes sp.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Nitidulidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Musca domestica</td>
<td>1</td>
<td></td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Fannia canicularis</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Fannia scalaris</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sarcophagidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Piophilidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tachinidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lauxaniidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Drosophila melanogaster</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Drosophila sp.</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Culex pipiens molestus</td>
<td></td>
<td></td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Chironomidae gen. sp.</td>
<td></td>
<td></td>
<td>1</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Agrotis exclamationis</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Nemapogon cloacellus</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lasius niger</td>
<td></td>
<td></td>
<td>11</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Lasius emarginatus</td>
<td></td>
<td></td>
<td>13</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Paravespula vulgaris</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>58</td>
<td>54</td>
<td>19</td>
<td>161</td>
</tr>
</tbody>
</table>

During the first stage of research, 108 strains of 21 microbe species were isolated from the flies (Table 2).

In 1990, all arthropods found in the hospital were studied. The 161 specimens caught belonged to 30 taxons of the classes Arachnida and Insecta (Table 3), and 116 strains of 25 microbe species were isolated from their body surface (Table 4).
Table 4. Results of microbiological isolation experiments from the body surface of arthropods caught inside hospital buildings in July–September 1990 (numbers of isolated strains)

<table>
<thead>
<tr>
<th>Microbe</th>
<th>Parasites</th>
<th>Eusynanthropic species</th>
<th>Hemisynanthropic species</th>
<th>Exoanthropic species</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus haemolyticus</em></td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td><em>Staphylococcus hominis</em></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><em>Enterococcus sp.</em></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Enterobacter aerogenes</em></td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td><em>Enterobacter agglomerans</em></td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td><em>Enterobacter cloacae</em></td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td><em>Enterobacter intermedius</em></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Klebsiella ozaenae</em></td>
<td></td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><em>Klebsiella pneumoniae</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Klebsiella oxytoca</em></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td><em>Citrobacter diversus</em></td>
<td></td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td><em>Citrobacter freundii</em></td>
<td></td>
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<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Citrobacter amalonaticus</em></td>
<td></td>
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<tr>
<td><em>Hafnia alvei</em></td>
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<td>1</td>
<td>1</td>
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<td>3</td>
</tr>
<tr>
<td><em>Serratia marcescens</em></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td><em>Serratia fonticola</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Providencia rettgeri</em></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><em>Morganella morganii</em></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td></td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td><em>Pseudomonas cepacia</em></td>
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<td></td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><em>Pseudomonas fluorescens</em></td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td><em>Acinetobacter calcoaceticus</em></td>
<td>3</td>
<td>11</td>
<td>1</td>
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<td>21</td>
</tr>
<tr>
<td><em>Flavobacter sp.</em></td>
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<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><em>Corynebacterium sp.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sporulating microbes</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Fungi</td>
<td>5</td>
<td></td>
<td></td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
<td><strong>68</strong></td>
<td><strong>19</strong></td>
<td><strong>22</strong></td>
<td><strong>116</strong></td>
</tr>
<tr>
<td>Department of urology</td>
<td>Treatment rooms (including endoscopy)</td>
<td>Preparation room of the operating room</td>
<td>Operating room</td>
<td>Sterilization room</td>
<td>Wards</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culex pipiens</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Musca domestica</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Family Calliphoridae</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Family Stenopinae</td>
<td>12</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Family Drosophilidae</td>
<td>8</td>
<td>1</td>
<td>4</td>
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<td>1</td>
</tr>
<tr>
<td>Nectria umbilicata</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pseudognaphasilium</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Athous sp.</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Coccinella</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cheirotypa sp.</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Aphodioidea gen. sp.</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hemiptera gen. sp.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Araneus sp.</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nucella unguiculata</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Segestria domensis</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Techina molitar</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sarcoptiphilus gen. sp.</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Caloneura cognitabres</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This set can be classified into 4 categories and evaluated according to the relation to man and his living environment (Tables 5 and 6): 1. parasites, 2. eusynanthropic species, 3. hemisynanthropic species, and 4. exoanthropic species (which occasionally fly into lighted rooms etc.).

Table 6. Localization of arthropods in the department of dermatology. (1 – parasites; 2–7 eusynanthropic; 8 – exoanthropic species)

<table>
<thead>
<tr>
<th>Department of dermatology</th>
<th>Culex pipiens molestus</th>
<th>Blatella germanica</th>
<th>Musca domestica</th>
<th>Sarcophagidae gen. sp.</th>
<th>Piophilidae gen. sp.</th>
<th>Drosophila melanogaster</th>
<th>Drosophila sp.</th>
<th>Chironomidae gen. sp.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 3</td>
</tr>
<tr>
<td>Wards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 4</td>
</tr>
<tr>
<td>Small kitchen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>49 51</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 49 2 1 1 1 1 1 1 58</td>
</tr>
</tbody>
</table>

The first group consists of a single species, the mosquito *Culex pipiens molestus* Forskal. Its complete synanthropy is beyond question; it develops in the boiler rooms of central heating, water distribution pipes and in all basement rooms with sufficient temperature and small pools of water. The mosquito penetrates from these spaces into the upper floors where it attacks people. This was evidenced not only by the statement of the patients but also by the fact that the caught females were engorged with fresh blood.

In contrast to previous observations, the species spectrum of synanthropic arthropods was much wider. Besides the flies, the German cockroach (*Blatella germanica* (L.)), particularly, was an important eusynanthropic species in the epidemiology of hospital infections. Not even the beetles *Tenebrio molitor* L. can be underestimated. The group of hemisynanthropic species mostly included spiders; some of them (*Tegenaria domestica* (Clerck), and partly also the *Steatoda bipunctata* (L.)) are sometimes considered eusynanthropic (Sacher 1983). Their importance for the mechanical transmission of pathogens is mentioned in the discussion which follows.
Our collection also contained a wide spectrum of exoanthropic species, which are not usually related to people and their living environment. When they do become part of the living environment, however, they may participate in the mechanical spreading of potential pathogens, as was indicated by microbiological studies.

In addition to this general ecological classification, the arthropods can be classified according to their location in the buildings (Tables 5 and 6).

DISCUSSION

The problem of synanthropic arthropods which serve as the vectors of hospital infections depends on 1) their species composition and ecological features (entomological); and 2) the character of the detected microbial flora on the surface of arthropod bodies (microbiological).

The classification of arthropods shown in Tables 5 and 6, and the previous text, shows their possible relations with man. This is, of course, dependent on their location in individual parts of the hospital. The wards where the patients spend the majority of their stay, are repeatedly invaded by blood-sucking insects (in our case, *C. pipiens molestus*) and by synanthropic flies which can have direct contact with the patients. Such a case was observed, e.g., at the department of dermatology, where one fly (*Musca domestica* L.) repeatedly landed on the bandage covering the skin lesion of a patient. The bacterial strain *Morganella morganii*, resistant to tetracycline, ampicillin, cotrimoxazol, kanamycin, and polymyxin was isolated from the body surface of the fly. The flies also land on the foods and their remnants kept in the vicinity of beds.

Although the flies hatch outside the hospital, they can easily penetrate inside the rooms through the open windows in summer, thus creating an "air bridge" with the outer environment where they are often contaminated in the waste containers. The synanthropic flies, which are more endophilic (such as *M. domestica*), may disseminate the microbes in all rooms and their furnishings. This role can also be partly played by other arthropods (even exoanthropic species, especially flying insects such as non-biting midges and others).

What is of importance, is the presence of arthropods in the rooms which serve as the place for treatment of patients, including the operating room and adjacent rooms where the surgical material and instruments can be contaminated. It was surprising to find there, for example, synanthropic *Tenebrio molitor* and other exoanthropic species (Table 5). The arthropods evidently penetrated there through the windows which were in bad condition. The arthropods (e.g. *T. molitor*) arrived not only from the outside but also from the loft located immediately above the operating room. An examination of the loft (which was being reconstructed) revealed remnants of pigeon nests, faeces and dead bodies of pigeons (see Table 5). The existence of this "air bridge" was confirmed by the observations of the personnel.

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It is necessary to also mention the small kitchens in individual departments which can be permanently inhabited by large populations of the German cockroach (*B. germanica*) and thus become a source of food contamination for all patients. Our observations at the department of dermatology revealed several shelters below the tiles on the walls, where these insects penetrated around the opening of the waste pipe.

**Table 7.** Epidemiological relationship of bacterial strains isolated from the body surface of arthropods, from the environment or from the patients.

(Antibiotics tested: streptomycin, chloramphenikol, gentamycin, tetracyklin, ampicilin, carbenicilin, nitrofurantoin, cotrimoxazol, kanamycin, polymyxin, neomycin, ceftazin, tikarcilin, amikacin, augmentin, netilmicin, ofloxacin)

<table>
<thead>
<tr>
<th>Isolation place and species</th>
<th>Bacterial strain</th>
<th>Resistance to antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Department of dermatology</strong></td>
<td><strong>German cockroach</strong></td>
<td><strong>Klebsiella pneumoniae</strong></td>
</tr>
<tr>
<td><strong>Blattella germanica</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Small kitchen – side-table</strong></td>
<td><strong>Klebsiella pneumoniae</strong></td>
<td>TET, AMP, CAR, FUR, TIC</td>
</tr>
<tr>
<td><strong>Department of urology</strong></td>
<td><strong>Spider Araneus sp.</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
</tr>
<tr>
<td><strong>Preparation room of the surgery</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC, TET, ERY, COT, OXA</td>
</tr>
<tr>
<td><strong>Ward – cutlery basket</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC, CMP, TET, COT, OXA</td>
</tr>
<tr>
<td><strong>Surface of patient's table</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC, CMP, TET, ERY</td>
</tr>
<tr>
<td><strong>Patient's urine</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC, TET</td>
</tr>
<tr>
<td><strong>Operation room (instruments)</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC</td>
</tr>
<tr>
<td><strong>Operation room (shelves)</strong></td>
<td><strong>Staphylococcus haemolyticus</strong></td>
<td>PNC</td>
</tr>
</tbody>
</table>

However, all our entomological observations would have remained at the level of enumeration of the found species and speculations about the possible significance of the results, if a microbiological evaluation had not been made. This was already
done in the first year of our investigation. A large number of strains (see Table 2) were isolated, but the conclusion could be only provisional, since the results only gave evidence of the presence of some potential pathogenic microbes on the bodies of synanthropic flies, but did not show the relation of these microbes to the environment of the hospital and, particularly, to the patients.

This problem was solved only in 1990, when the microbial flora found on the arthropod bodies was compared with that found in the hospital rooms and biological material (pus and urine) of patients at the department of dermatology and urology. Biochemical examinations, serotyping and detection of the resistance to antibiotics were carried out on the isolated bacterial strains. Detailed results are published elsewhere (Šrámová et al. 1992), but some of the conclusions supporting the importance of the entomological studies are given below.

The susceptibility tests of microbes to 17 antibiotics revealed that 37% of strains (n = 90) isolated from the arthropods were resistant to more than three antibiotics. This fact itself shows how dangerous these resistant strains of potential pathogens are for patients already weakened by other diseases.

The epidemiological relationship of bacterial strains – which were found on the arthropods to the environment of the hospital and directly on the patients, is evident from Table 7. The relationship was found in the strain *Klebsiella pneumoniae* (on the bodies of German cockroaches and in the small kitchen at the department of dermatology – the two strains exhibited the same resistance) and in the strain *Staphylococcus haemolyticus* (found on a spider’s body, in the hospital environment, and in a patient at the department of urology – all exhibited the same resistance to antibiotics, particularly to penicillin and tetracyclin).

Although we are aware of the fact that the identity of bacterial strains can be confirmed only on the basis of the genetical relationship of ribonucleic acids, the above results confirming the bacterial resistance are so significant that they show the role of synanthropic arthropods in the epidemiology of hospital infections. In our opinion, the presence of insects and other arthropods in hospitals is so important that it deserves permanent and detailed attention.

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**REFERENCES**


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