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Insect succession and carrion decomposition in selected forests of Central Europe. Part 2: Composition and residency patterns of carrion fauna

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ABSTRACT

The insect fauna of pig carcasses was monitored in different seasons and forests of Western Poland (Central Europe). The composition of carrion fauna and selected features of residency in carrion in adults and larvae of particular taxa were analysed. A total of 131 adult and 36 larval necrophilous taxa were collected. Only 51 adult species and 24 larval taxa were minimally abundant ($\geq$10 specimens) at least on one carcass. As for the composition of carrion fauna, there were large differences between seasons, but no important differences between forest types.

In most species of Diptera, length of the presence period of adults was between 35 and 65% of the sampling interval, while in most species of Coleoptera, it was above 60%. Only in a few species (e.g., *Saprinus semistriatus*, *Necrodes littoralis* or *Creophilus maxillosus*) was the presence period shorter than 35% of the sampling interval. Interestingly, in some adult Coleoptera (e.g., *Necrobia violacea*) very long presence periods were recorded. In most taxa, the length of the presence period of larvae was between 40 and 65% of the sampling interval. Only *Calliphora vomitoria*, *Phormia regina*, *Hydrotaea dentipes*, *N. littoralis* and *C. maxillosus* had shorter presence periods of larvae.

As a rule, residency of adults was broken, whereas residency of larvae was unbroken. Moreover, in adults, two distinct residency patterns were observed; with breaks clumped in the final part of the presence period and with breaks evenly distributed inside the presence period.

Almost in all taxa, the time of appearance showed the closest relationship to the onset of bloating. The relationship was significant, positive and strong in adults of *P. regina*, *Fannia manicata*, *Hydrotaea ignava*, *Stearibia nigriceps*, *S. semistriatus*, *N. littoralis* and *C. maxillosus* as well as larvae of *P. regina*, *H. dentipes*, *H. ignava*, *S. nigriceps*, *N. littoralis*, *Oiceoptoma thoracicum*, *Thanatophilus* sp., *C. maxillosus* and *Philonthus* sp. Interestingly, in some forensically significant taxa (e.g., adults of *N. violacea* or *Thanatophilus rugosus*), we found no significant relationship between the time of their appearance and the onset of any decompositional process.

Implications for the succession-based post-mortem interval (PMI) estimation, determination of the carcass movement and the season of death are discussed.

In a classical method of succession-based post-mortem interval (PMI) estimation, an estimate is based on the presence of two definitive taxa on human remains [1]. A definitive taxon is that which defines lower (minimal) or upper (maximal) PMI in a given case [1]. To choose definitive taxa, experts use a proper model of succession originating usually from forensically oriented field experiments regarding the succession of local carrion insects [1,2]. Then, a decision referring to minimal and maximal PMI must be made. Such a decision is based on the model of succession, context of the case and expert experience [1,2]. The last step is to evaluate the correspondence between the estimated PMI and the presence of non-definitive taxa [1].

Necessary prerequisites to use this method are proper models of succession. Such models are created in forensically oriented experiments regarding the succession of local carrion insects. Experiments of this kind usually generate large inventories of taxa, as in the studies by Early and Goff [3] and Matuszewski et al. [4], for instance. However, as many carrion insects are of little or no use for forensic purposes, the question as to which taxa to include in the model becomes crucial. Forensic literature lacks the criteria that

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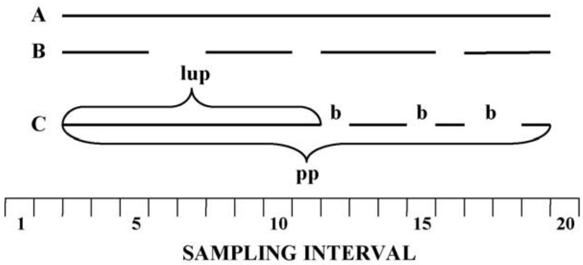

Fig. 1. The residency patterns in carrion insects. A – a nonreoccurring taxon, B – a reoccurring taxon with breaks evenly distributed, C – a reoccurring taxon with breaks clumped, b – a break in the presence period, lup – the longest unbroken period, pp – the presence period.

could be used to compare the forensic usefulness of carrion insects and that consequently could help to choose taxa for the model.

An early step towards rating of carrion insects was the recognition of reoccurring taxa [5]. The reoccurring taxon was defined as that which appears, leaves and reappears on a carcass, as opposed to the non-reoccurring taxon, which persists on a carcass over a single time interval [5]. In other words, reoccurring taxon can be defined as that whose presence period has break (or breaks) inside and non-reoccurring taxon as that whose presence period is unbroken (Fig. 1). To quantify this feature of residency, one can count breaks in the presence period. However, not only the number of breaks are important, but also their location inside the presence period. In fact, two taxa can have the same number of breaks, but due to different location of breaks (evenly distributed or clumped), their general pattern of residency may differ (Fig. 1). The evenness with which breaks are distributed inside the presence period can be evaluated by the measurement of the longest unbroken interval.

Length of the presence period is another feature of residency, which may be useful in the comparison of carrion insects. First of all, its measurement can help in identifying taxa, which are present during the entire decomposition. It can also help to assess the usefulness of taxa, which are present during the limited time in decomposition. In fact, the length of the presence period of definitive taxa is negatively related to the accuracy of PMI estimate (Fig. 2). So, with two taxa, which have in common all the aspects of residency except the length of the presence period, the one with shorter presence period is more useful, as it narrows the width of the PMI estimate [6] and consequently makes this estimate more accurate.

Another important feature of residency is the relationship between a given taxon presence and a particular state of the carcass. Carrion experiments revealed substantial variation in decompositional variables between different seasons as well as within the same season and between the same seasons in different years [7–9]. We think that only these taxa, which respond consistently to this variation, can be used as PMI indicators. To evaluate this consistency for particular taxa, one can measure

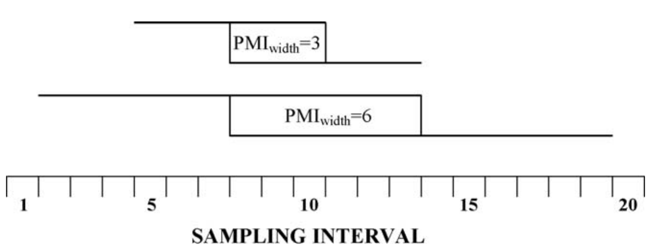

Fig. 2. The relationship between the length of the presence period of definitive taxa and the accuracy of PMI estimate (expressed as PMI width). Cases shown differ only in the length of the presence period of definitive taxa. All the other features of residency (e.g., the degree to which presence periods overlap) are the same. In the upper case the PMI estimate is more accurate than in the lower case.

significance and strength of the relationship between certain decompositional variables and time of appearance on carrion. We included in this analysis the appearance time (the first day when specimens of a given taxon are present on a carcass), as it is one of two variables, which are used in a classical method of PMI estimation from successional data [1]. As for decompositional variables, we chose onsets of decompositional processes (bloating, active and advanced decay), as they are well defined and easy observable landmarks in decomposition, which are subjected to substantial seasonal variation [9].

The abundance of a taxon and the repeatability of its occurrence on carrion in a given habitat are also forensically important. The abundance is important, because it is closely related to the probability of a taxon collection at the death scene. In taxa of very low abundance, this probability is close to 0, which precludes in practice their usefulness for forensic purposes. For this reason, prior to the taxon inclusion in the model, some evaluation of its abundance is needed. The repeatability of occurrence on carrion in a given habitat is also of importance, as it indicates whether an absence of a given taxon can be used in PMI estimation. On the one hand, in taxa, which repeatedly occur on carcasses in a given habitat, inferring PMI from their absence is possible. On the other hand, in taxa, which have low repeatability of occurrence on carrion in a given habitat, such inference is too risky.

In the current article, we used the above-mentioned criteria to select insects of forensic use in forests of Central Europe and to compare their usefulness for succession-based PMI estimation. This analysis was based on the results of a large scale, forensically oriented experiment on insect succession and pig carrion decomposition in selected forests of Central Europe. In this article, only the composition of carrion fauna and the residency of particular taxa are considered.

1. Materials and methods

1.1. Experimental design and independent variables

We used a complete factorial design with two factors (season and forest type) and four replications. Both factors were considered at three levels. In case of seasons, they were spring, summer and autumn, and in case of the forest type, they were pine-oak forest, hornbeam-oak forest and alder forest. Spring part started in the second half of April, summer part in the second half of July and autumn part in the second half of September. The experiment was conducted in Western Poland in the forests of the Biedrusko military range (52°31′N, 16°54′E) in 2006 and 2007. In both years of the experiment, two carcasses were used in each treatment. A detailed description of independent variables and design of the experiment was presented in Matuszewski et al. [9].

1.2. Carcasses

We used 36 domestic pig (*Sus scrofa domestica*) carcasses of similar weight (mean = 25.8 kg). For details on the way in which carcasses were handled, see Matuszewski et al. [9].

1.3. On-site procedure

Until the end of active decay (the day when masses of feeding larvae were no more present) carcasses were examined daily and at less frequent occasions afterwards. The spring part lasted 88 days in 2006 and 105 days in 2007, the summer part 49 days in both years and the autumn part 94 days in 2006 and 105 days in 2007. Examinations were usually conducted between 10:00 and 14:00 h. The inspection of a single carcass was performed by two persons and lasted about 30 min.

Insects were collected using pitfall traps, aerial sweep net and manual sampling. Two traps (plastic containers 16 cm in diameter and 17 cm in height) filled with 50% ethylene glycol solution were buried next to the carcass: one dorsally and one ventrally. Flying insects were collected using a large aerial sweep net (Ø65 cm). We used a swatting technique, in which a researcher approaches insects (resting on a substrate) while holding the tail of the net and swats the substrate with the net to collect specimens. This technique was performed twice. Manual sampling (with forceps or fingers) was always done by two individuals and lasted about 10 min. Insects were collected mainly from the carcass surface and from soil under and near the carcass. Specimens were preserved in 70% ethanol. Some of the larval Diptera (mainly 3rd instars of Calliphoridae and Muscidae) were kept alive and reared in the laboratory (about 20 °C, plastic containers with soil).