

**Mixed forests in comparison to monocultures:  
Guarantee for a better forest conservation and higher species diversity?  
Macroheterocera (Lepidoptera) in forests of European beech and Norway spruce**

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**Zusammenfassung:** Mischwälder im Vergleich zu Monokulturen: Eine Garantie für besseren Forstschutz und höhere Artendiversität? Makroheterocera (Lepidoptera) in Buchen- und Fichtenwäldern sowie Buchen/Fichten-Mischwäldern.

Die vorliegende Untersuchung stellt Ergebnisse aus einer vierjährigen Studie über die Nachtfalterfauna in Buchen- (*Fagus sylvatica*) und Fichtenreinbeständen (*Picea abies*), sowie Buchen/Fichten-Mischwäldern des Sollings (südliches Niedersachsen, Deutschland) vor. Ein besonderes Augenmerk wurde auf das Vorkommen forstschutzrelevanter Schädlingsarten gelegt. Die Erfassung der Nachtfalter erfolgte durch den Einsatz von Lichtfallen.

Die Ergebnisse zeigen, dass die Buchenreinbestände die höchsten und die Fichtenmonokulturen die geringsten Falterzahlen aufwiesen. Ein Vergleich der vorgefundenen Artenzahlen ergibt in den Buchenreinbeständen und Buchen/Fichten-Mischbeständen gleich viele Arten, wohingegen in den Fichtenmonokulturen eine etwas geringe Artenzahl festgestellt wurde. Vermutungen, dass die Mischbestände die höchste Artenzahl aufweisen, konnte nicht bestätigt werden.

Eine Aufstellung der Artendominanzen verdeutlicht, dass die hohe Anzahl der Nachtfalter innerhalb der Buchenreinbestände hauptsächlich auf das Individuenreiche Auftreten der beiden Arten *Calliteara pudibunda* L. und *Colocasia coryli* L. beruhte. Innerhalb der Fichtenmonokultur war der Fichtenschädling *Lymantria monacha* L. und im Buchenreinbestand der Buchenschädling *C. pudibunda* mit sehr hohen Individuendichten auffällig gewesen – ein Zeichen für die potentielle Gefährdung dieser Waldtypen durch Kahlfraß dieser beiden Schadfalterarten.

Resümierend kann zusammengefasst werden, dass Buchen/Fichten-Mischwälder die Artendiversität nicht erhöhen (dies gilt für Falterarten, die mit Lichtfallen erfasst werden können), aber aus Sicht des Forstschutzes bzgl. des Buchenschädlings *C. pudibunda* und des Fichtenschädlings *L. monacha* das Risiko von Kalamitäten verringern können.

**Key words:** Macroheterocera, moths, light trap, species diversity, forest monoculture, mixed forest, pest, *Calliteara pudibunda*, *Lymantria monacha*

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The current forest policy in Germany is to change forest monocultures into mixed forests. This is based on the assumption that monocultures are less robust against climatic influences (e.g. storm, drought), more susceptible to pest organisms (JACTEL et al. 2002, WOODS 2003, BURTON et al. 1992) and are for several insect taxa known to show a lower species richness in comparison to mixed forests (YOUNG 1986, BARKMAN 1992, BURKHART & THAM 1992, DENNIS 1997, BRAGANCA et al. 1998). This investigation wanted to verify this thesis in forests consisting of European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*) and of both tree species. The area of investigation was in the Solling region, a large woodland in Lower Saxony (Germany).

The study focused on Macroheterocera (moths) for the following reasons: 1) high species richness in forests, 2) high numbers of individuals, 3) several species are known as pest insects, 4) or on the other hand are endangered.

The following questions should be answered: 1) in which forest type occurs the highest number of species and individuals, 2) does the mixed forest show lower species and individual numbers of pest species?

### Method

The investigation was carried out between 1999 and 2002, from March until the beginning of December. We probed forest monocultures of European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*) and mixed forests consisting of both tree species (four replications of each).

For catching the moths we used a light trap known as Minnesota type. The light trap consisted of a light source with an ultraviolet lamp (8 watt) and was equipped with a twilight switch. In every sample area we installed one of these light traps and took the sample in a weekly frequency.

Not every nocturnal Lepidoptera is attracted to light sources, this depends on species (SOUTHWOOD 1978, SUMMERVILLE et al. 2003). For this reason, it is not possible to detect with a light trap all species of a habitat. But for comparing different habitats it is a useful method (TAYLOR & CARTER 1961, INTACHAT et al. 1997).

### Results and discussion

During the four years of investigation in all forest types we caught circa 14700 moths, from 270 species.

In the beech forests we found the highest number of moths: In total 7200 specimen (100%), per sample about 17 individuals (Fig. 1: left graph). The spruce forest showed the least number of moths. Here we caught only 3000 moths (40%) and about 12 moths per sample. The individual numbers occurring in the mixed stands was in-between that of the pure beech and spruce stand (4500 insects = 62%).

In the beech stand and in the mixed forest we found on average the highest species numbers (each about 150 spec.). The lowest number we found in the spruce stand with an average of about 120 species (Fig. 1: right graph).

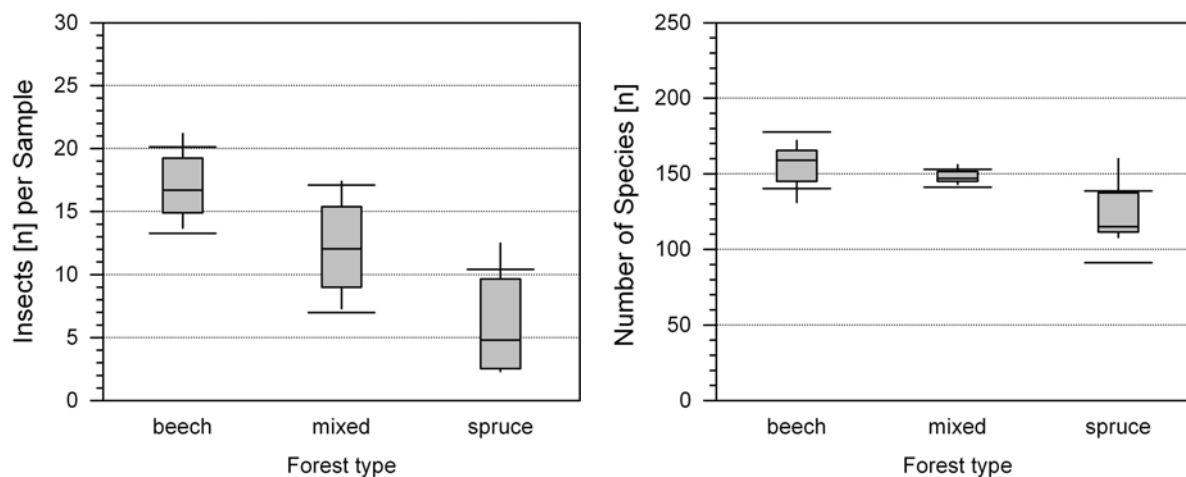


Fig. 1: The individual (left graph) and species numbers (right graph) of moths in the different forest types: comparison between pure beech, beech/spruce (mixed) and pure spruce (four replications of each).

Figure 2 shows the structure of dominance for the 20 most frequent species we found in the different forest types. The listed species are divided in different classes of dominance (see subtitle of Fig. 2).

Remarkable is that we found two eudominant species with very high values of dominances in the beech forest: *Colocasia coryli* L. (nut-tree tussock) and *Calliteara pudibunda* L. (pale tussock, Fig. 3). *C. coryli* was the only eudominant species in the mixed forest. In the spruce stand it was also a dominant species. However, *C. coryli* is not significant with regard to forest conservation. Of higher relevance in this regard is

*C. pudibunda*. The caterpillar of this moth feeds on different broad-leaved trees and is a potential pest of European beech (e.g. VITÉ & KLIEFOTH 1955, SCHWENKE 1978, SCHWERDTFEGER 1981). In the mixed forest this species showed a lower dominance as in the pure beech stand.

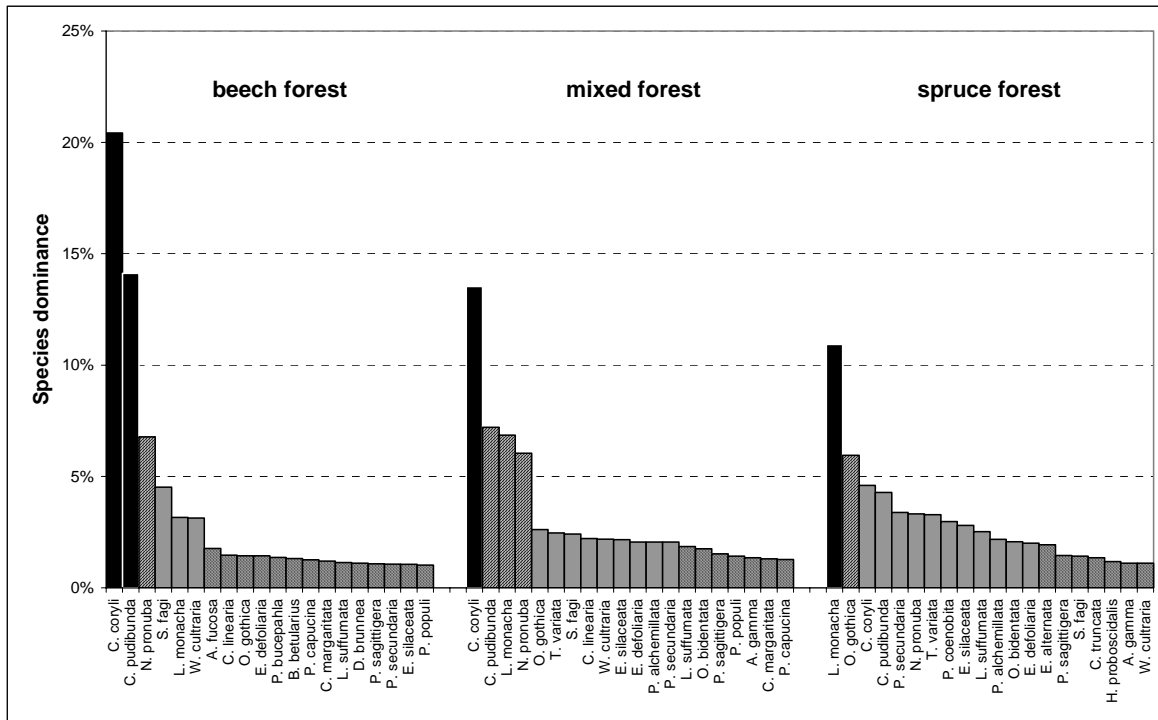


Fig. 2: Dominance structure of moths species in pure stands of spruce and beech and mixed stands of spruce / beech. The figure shows the most 20 frequent species of each forest type. Common classes of dominance are: Eudominant (>10%), dominant (5-10%), subdominant (2-5%) and recedent (1-2%).



Fig. 3: Adult moth and its larvae from *Calliteara pudibunda* L.

Another important pest we found in high density in the spruce forests was *Lymantria monacha* L. (nun moth). It is polyphagous on conifers and broad-leaved trees, but a well-known pest especially on Norway spruce (e.g. SORAUER 1925, GÄBLER 1955, JENSEN 1991). *L. monacha* occurred in all forest types without statistical differences (in terms of individual number) between the beech, spruce and mixed forests.

*C. pudibunda* was a very frequent species in the pure beech forests (Fig. 4). In mixed stands of beech and spruce we found only 28% of the individual numbers of the pure beech stand (beech: 100%).

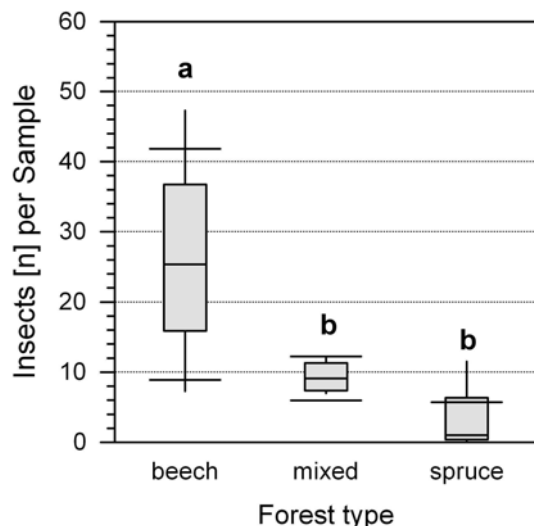


Fig. 4: Numbers of *C. pudibunda* per sample in comparison to forest types. Different letters on bars indicate significant statistical differences at  $P < 0.05$  ( $n=4$ ,  $F=5.62$ , one factorial anova).

### Conclusion

The mixed forest, consisting of both tree species European beech and Norway spruce, seems to be less susceptible to *C. pudibunda* (pest of beech) and *L. monacha* (pest of spruce). Especially *C. pudibunda* showed significantly lower individual numbers in the mixed forest as compared to the beech monoculture. In the spruce monoculture *L. monacha* was the only dominant species among the moths. This shows the potential for outbreaks of *L. monacha* in spruce forests. The lower individual numbers of this potential pest species in mixed forest could be explained by the resource disturbing hypothesis (PAIVINEN et al. 2003) or enemy hypothesis (JACTEL et al. 2002), that means in mixed forests, in comparison to monocultures, the abundance of predators and parasitism is higher (JÄKEL & ROTH 2005).

Considering the species richness we did not find the most species in the mixed forests as it was suggested. In the beech monoculture the number of species reached the same level. Only in the spruce monoculture we found a lower number of species.

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