# The saprotrofic food chain in terrestrial ecosystems: Decomposition

**C : N ratio**

| | |
|---|---|
| In most plant tissues: | 40-80 : 1 |
| In microbial cells and animal tissues: | 10 : 1 |

To accumulate 11 g of biomass, a population of microorganisms needs to incorporate 1 g N !

**If C is available in excess** (due to input of matter with a high C:N ratio) additional N (not from the matter being decomposed) is acquired from the environment if available.

Consequence: All previously accessible **N is immobilized in the microbial biomass**. Leads to inhibition of plant growth due to lack of N.

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

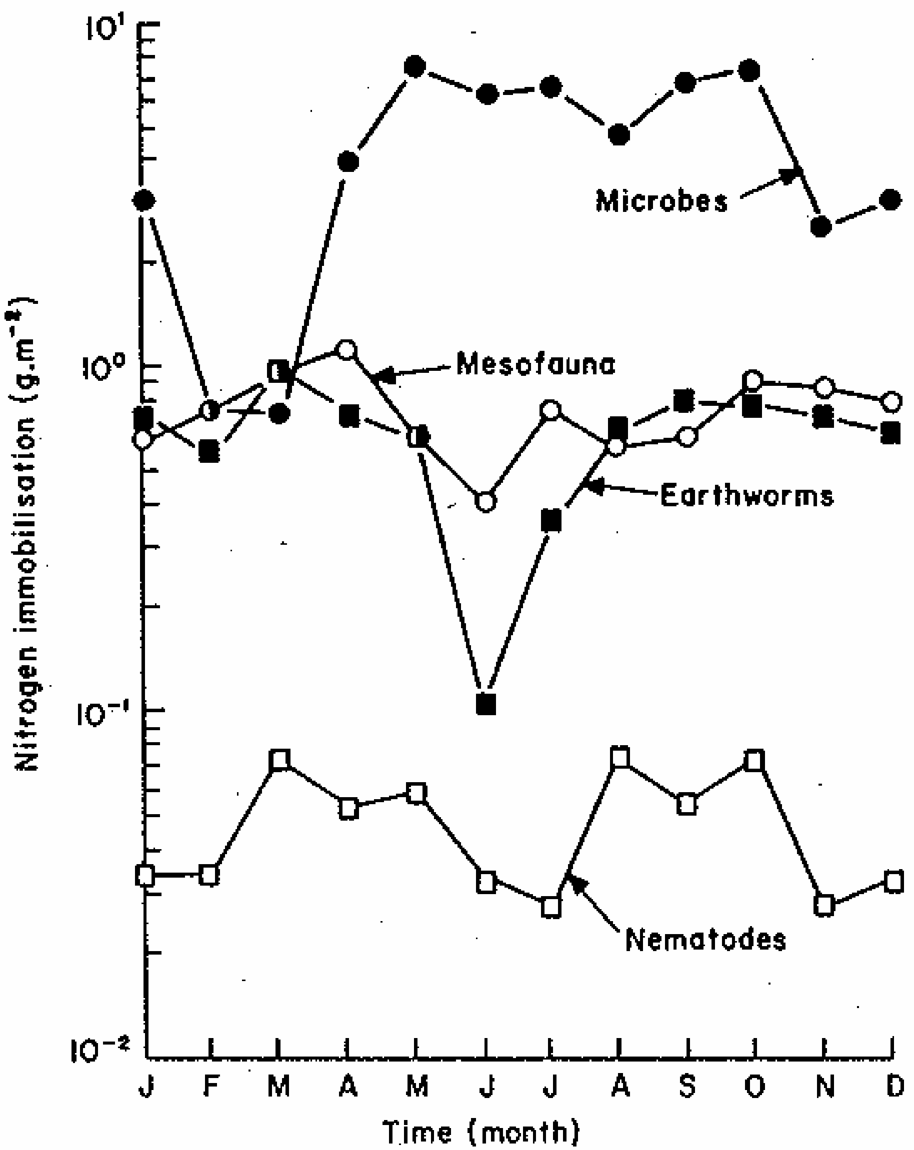



FIG. 3.15. Comparison of microbial nitrogen immobilisation with that of mesofaunal arthropods, earthworms, and nematodes. While microbial immobilisation is much greater than that of fauna, faunal immobilisation is much more constant through the year (after Ausmus, Edwards & Witkamp 1976).

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

The two major components of dead phytomass (leave litter, woody debris) are

- **cellulose**, and
- **lignin**.

Most **animal consumers** (saprophages, detritivores) are not able to utilize these compounds as they are

**lacking the required enzymes**.

**Cellulases** have been found only in few phytophages and saprophages:

- a few molluscs (including Helix pomatia)
- some larvae of Diptera
- a few earthworm species.

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

**Why are animals missing these enzymes?**

**Polymere structure** of cellulose and lignin, both consist of **C, H, and O**.

By **dissimilation** of C organisms gain **energy**.

**In contrast to nutrients as N and P, C is abundant** in the food resource.

To get the required amount of the scarcer elements, larger organisms **ingest a large amount of dead or live phytomass** and

**do not invest in a high efficiency of digestion of these structural compounds**.

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

**Better degradable parts of phytomass, e. g. fallen fruit.**

Fed on by many polyphages (omnivores): insects, birds, mammals.

Distinct microflora (as any type of resource), dominated by **yeasts**.

These yeasts and their metabolic products fed on by specialized species of ***Drosophila*** (Diptera: Brachycera).

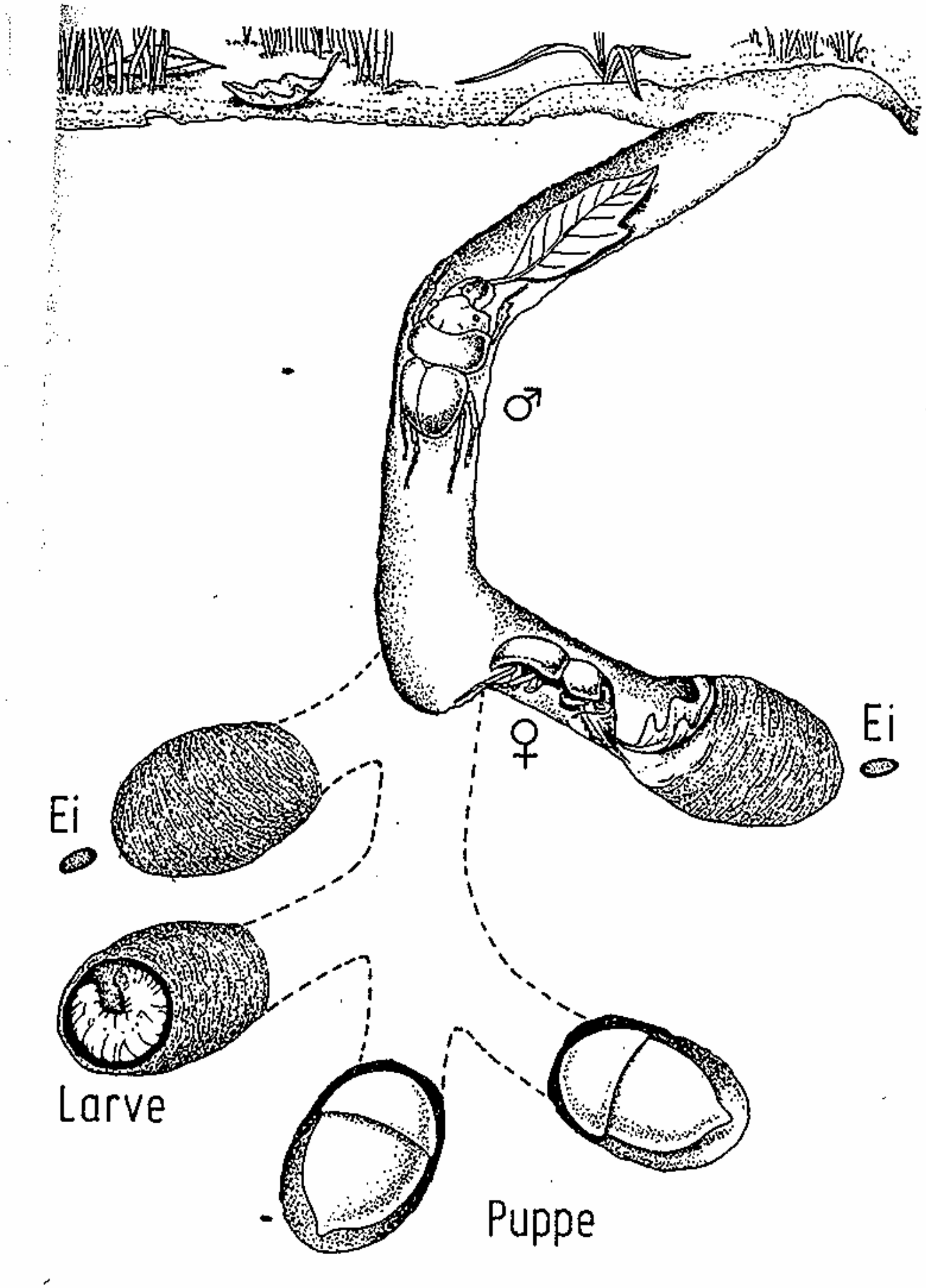
*Drosophila* have the enzyme **alcoholdehydrogenase** to break up ethanol (otherwise toxic).

Individual species specialized on individual species of decomposing fruit or vegetables (amongst others depending on amount of alcohol produced during decomposition – less in vegetables, more in fruits).

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

*Lethrus apterus*
(Coleoptera: Scarabeidae s.l.):

Fermented leaves of *Vitis vinifera*
are used to nourish the larvae.



# The saprotrofic food chain in terrestrial ecosystems: Decomposition

Various ways of cellulose decomposition / digestion

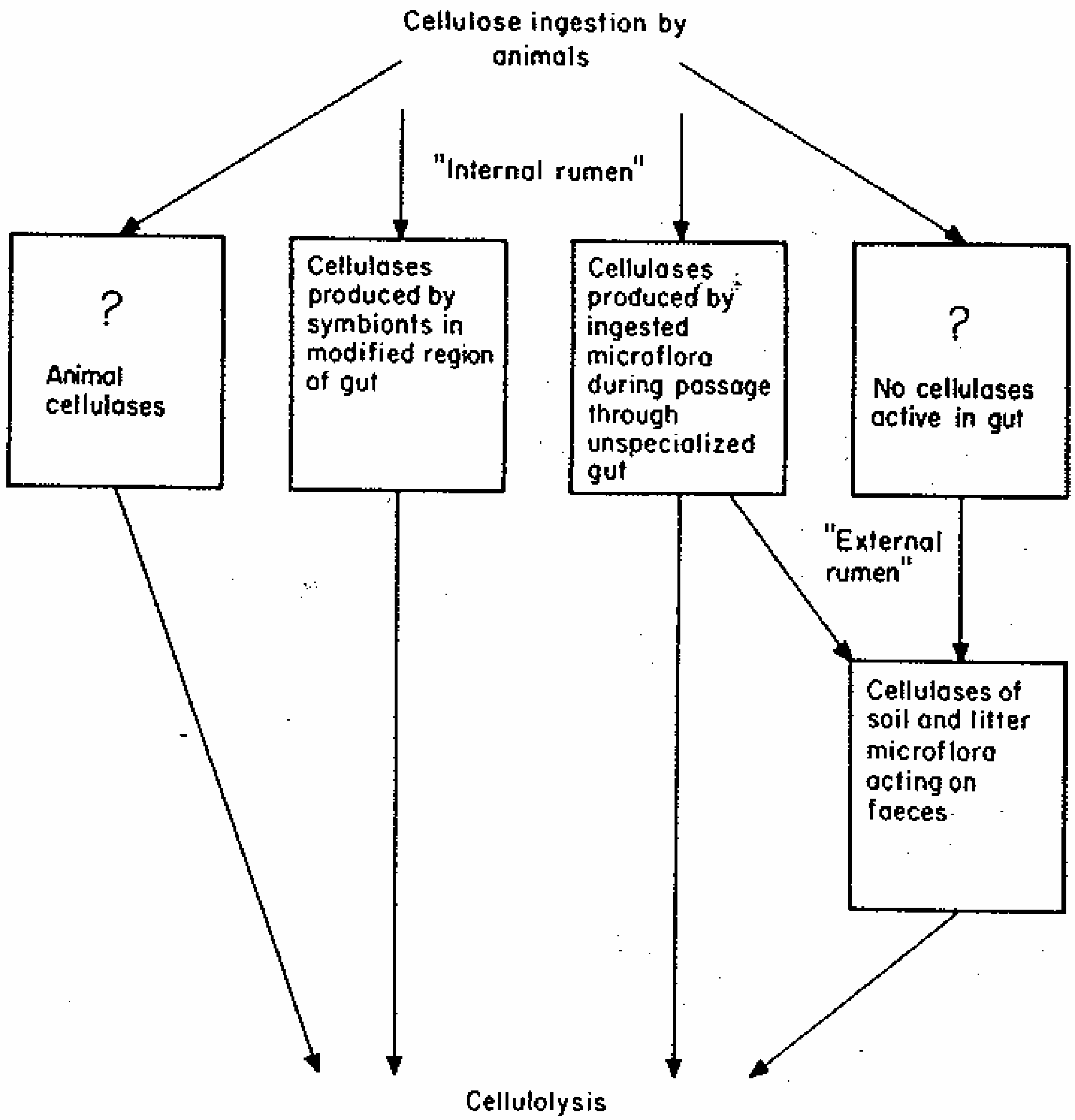



FIG. 3.12. The action and interaction of saprotrophic animals and micro-organisms in cellulose decomposition.

# The saprotrofic food chain in terrestrial ecosystems: Decomposition

**Symbiotic relationships – obligatory mutualism:**

Protozoans and bacteria in the gut of the more primitive termites and cockroaches (also in coprophagous beetles, e.g. Scarabidae, Geotrupidae).

*Eutermes* (Isoptera):
- protozoans in the hindgut (dilated to rectal pouch),
- protozoans take small woody particles as food,
- can make up for over 60 % of its body mass.

| | Content of wood: | Content of termite faeces: |
|---|---|---|
| cellulose | 55 % | 18 % |
| pentosan | 18 % | 8.5 % |
| lignin | 27 % | 75.5 % |

Some termites also digest lignin: **Reticuloformes**, reduce ligin content by over 80 %.

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

**Degradative succession**

**What is a succession?**

" A continuous process of change in vegetation which can be separated into a series of phases" (Tansley 1935)

" The non-seasonal, directional and continuous pattern of colonization and extinction on a site by species populations" (Begon et al. 1990)

" The directional change in vegetation during ecological time" (Krebs 1994)

All definitions imply that succession is different from random fluctuations in community structure; there is some sort of directionality.
Succession has also been used to described cyclical changes in communities.

Succession represents a sequence of populations that replace each other resulting in community change; this orderly progression of change is called a **SERE** and each of the communities characterizing succession represent seral stages

**Two types of succession:**

**PRIMARY** - sequence of species on newly exposed landforms that have not previously been influenced by a community, e.g., newly formed sand dunes, lava flows, areas exposed by glacial retreat.

**SECONDARY** - succession in which vegetation of an area has been partially or completely removed, but where well developed soil, seeds, and spores remain so that the resulting sequence of species is driven principally by interactions such as competition and herbivory, e.g., familiar old-field succession.

## The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

**CLIMAX COMMUNITY**

a more or less permanent and final stage of a particular succession, often characteristic of a restricted area.

> **Monoclimax** - Clements argued that there was only one true climax in any given climatic region which was the endpoint of all successions, regardless of starting point; i.e., succession on sand-dunes, old-fields, ponds filling in, and so on would eventually end in the same climax community.
>
> **Polyclimax** - Gleason, Tansley recognized that a local climax may be governed by a combination of climate, soil conditions, topography, fire, etc. A single climatic area could contain a variety of specific climax types.

**Degradative succession** is a succession in terms of the development of a sere of successional stages determined by the composition of the decomposed matter, climate (macro- and microclimate as humidity), soil / bedrock, etc. (but also on who comes first to collonize – decomposition path).
However, it **does not end in a climax but in the exhaustion of the resource, i.e. the decomposed material**.

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

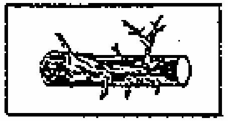
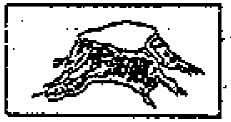
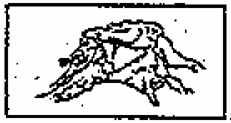
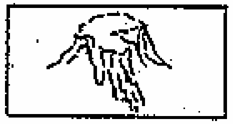
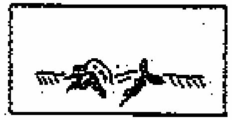
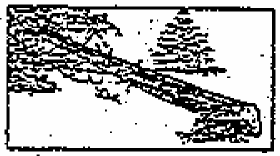
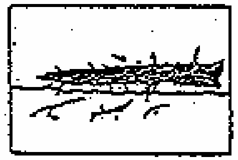
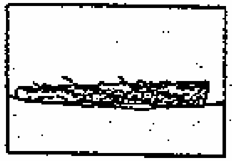
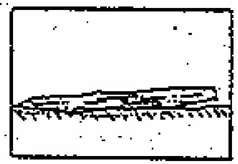
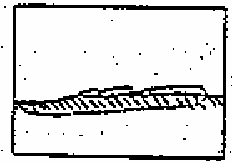
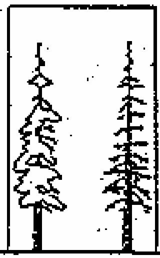
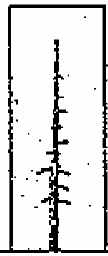
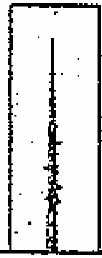
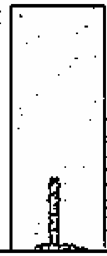
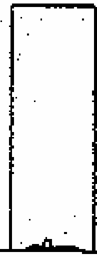
| Type of Dead Wood | TOTHOLZ-FORM | Decomposition Stage / ZERSETZUNGS-GRAD I | II | III | IV | V | ZEIT-Bedarf |
|---|---|---|---|---|---|---|---|
| | FEIN-REISIG | | | | | | > 10 J. |
| | ÄSTE | | | | | | > 20. J. |
| Logs | STAMMTEILE |  | |  | |  | > 30 J. |
| | HOCH-STUBBEN | | | | | | > 50 J. |
| Stumps from logging | HOLZERNTE-STUBBEN |  |  |  |  |  | > 15 J. |
| | KRONENTEILE | | | | | | > 20. J. |
| | WURZELTELLER | | | | | | > 30 J. |
| Entire lying trunks | ganze BÄUME liegend |  |  |  |  |  | > 80 J. |
| Entire standing trees | ganze BÄUME stehend |  |  |  |  |  | > 150 J. |

*Abb. 2: Totholzformen in Wirtschaftswäldern und deren Veränderung im Laufe der Zersetzung. Die Angaben des Zeitbedarfs geben grobe Richtwerte an, die je nach Standort, Baumart und Umwelteinflüssen stark variieren können.*

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

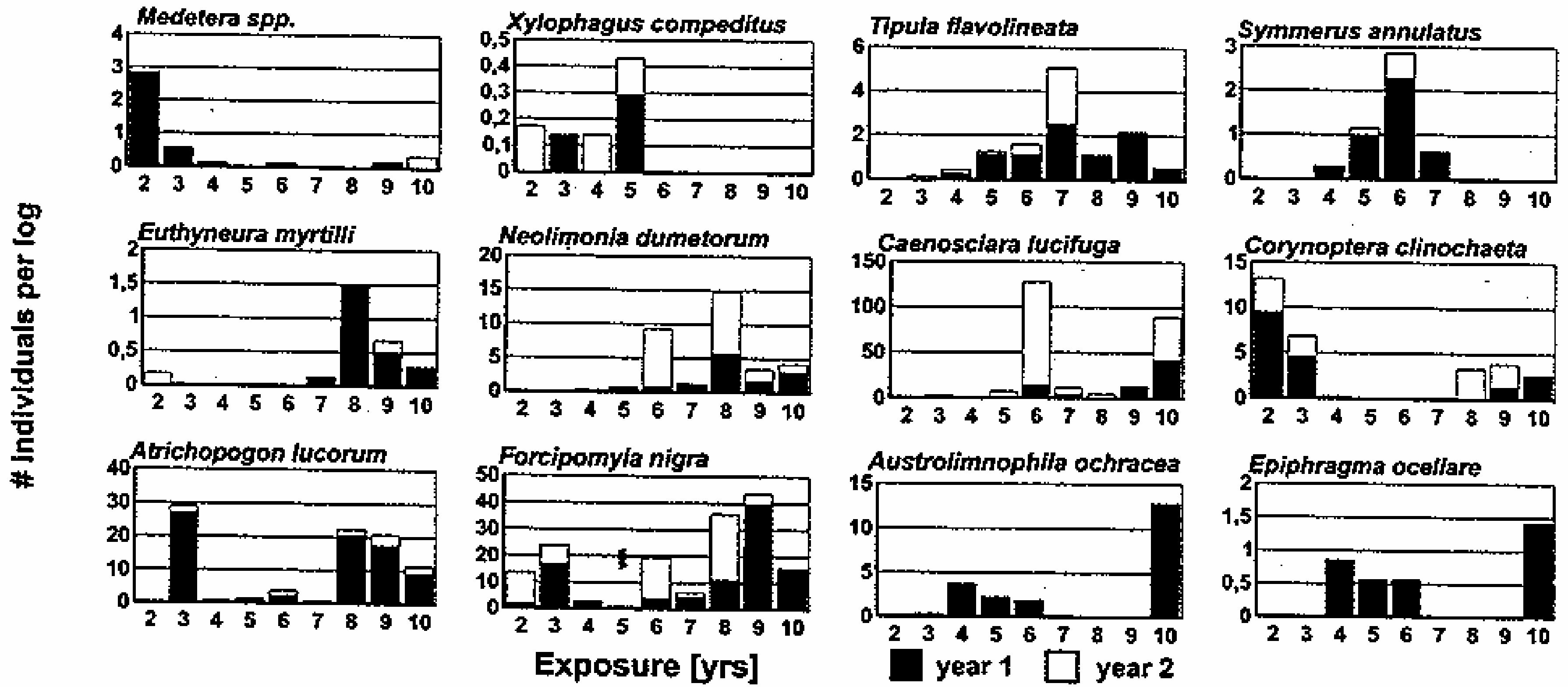



**Fig. 3.** Mean emergence abundances of selected dipteran species in the course of succession. Catches from "year 1" and "year 2" (see Materials and Methods) are indicated by different shadings

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

Changes in the properties of dead wood, i. e. beech branches (environmental factors for saproxylic organisms) with time

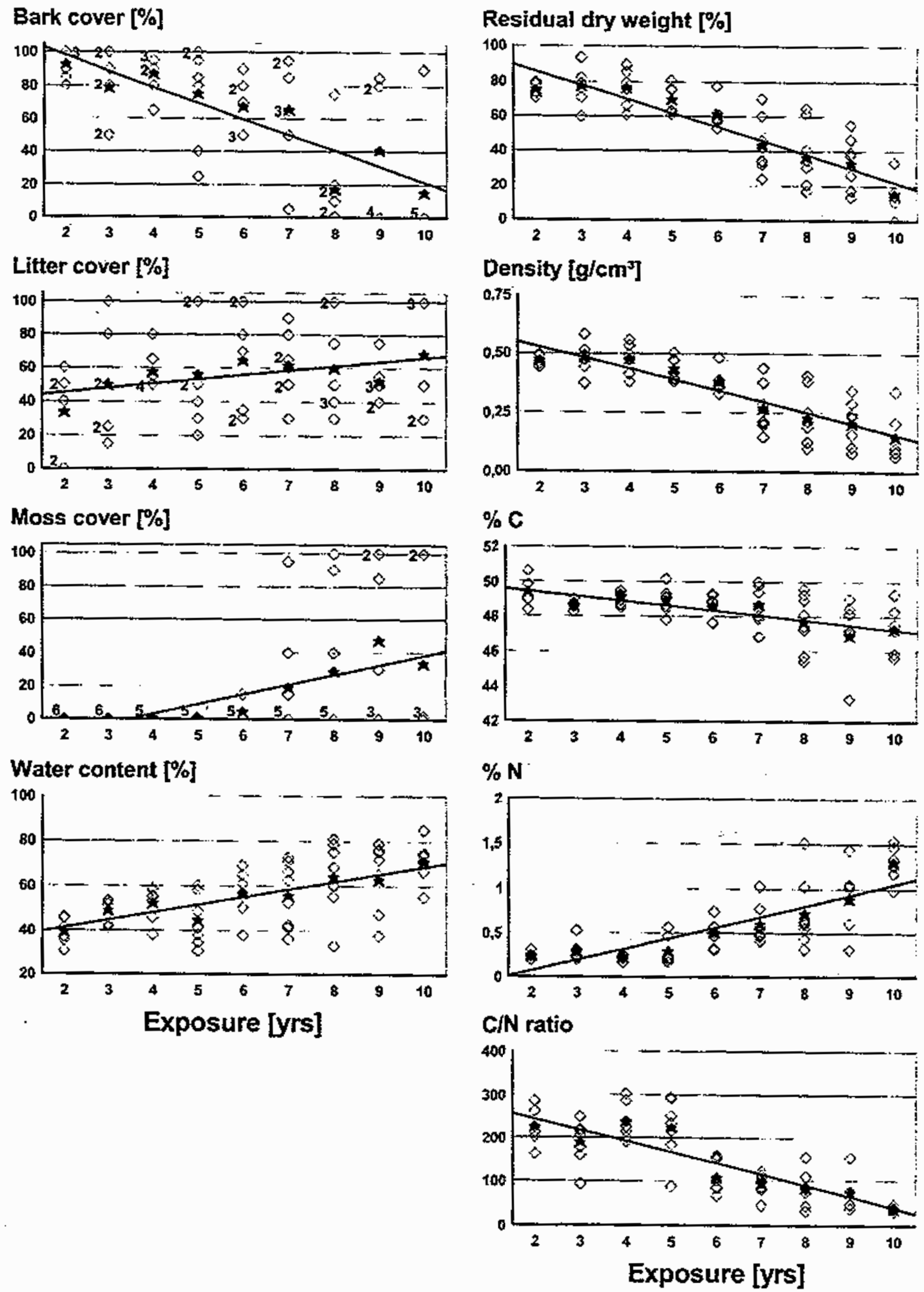
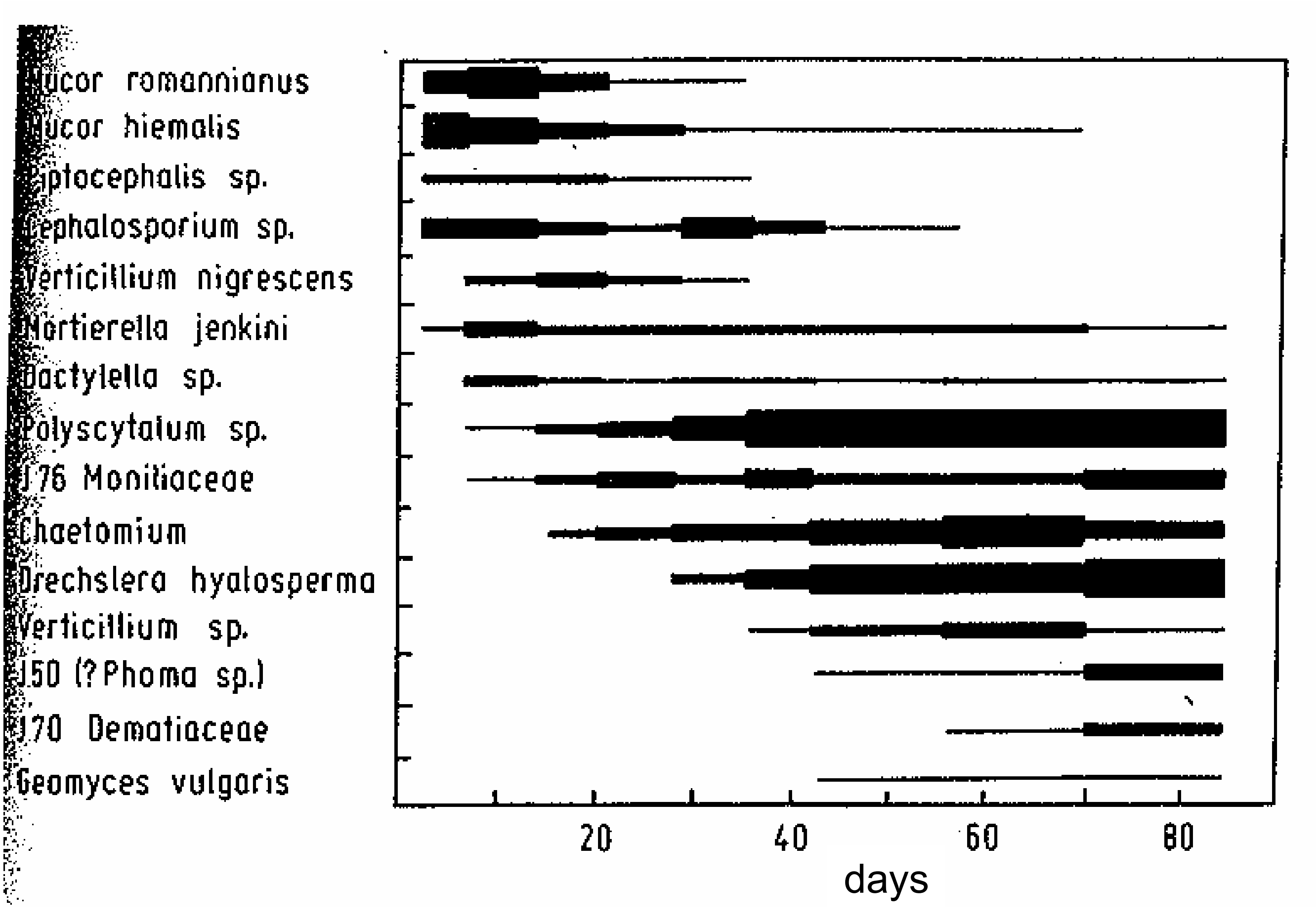



**Fig. 2.** Changes in environmental factors with time of exposure. Diamonds represent individual logs (identical values are indicated by numbers) and asterisks cohort means. Lines indicating trends are linear regressions for cohort means and significant ($p<0.05$) in all cases excepting litter cover

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition




Succession of fungal species on faecal pallets of Glomeris (Diplopoda); height of bars indicates the percentage abundance of the species in the assemblage.

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

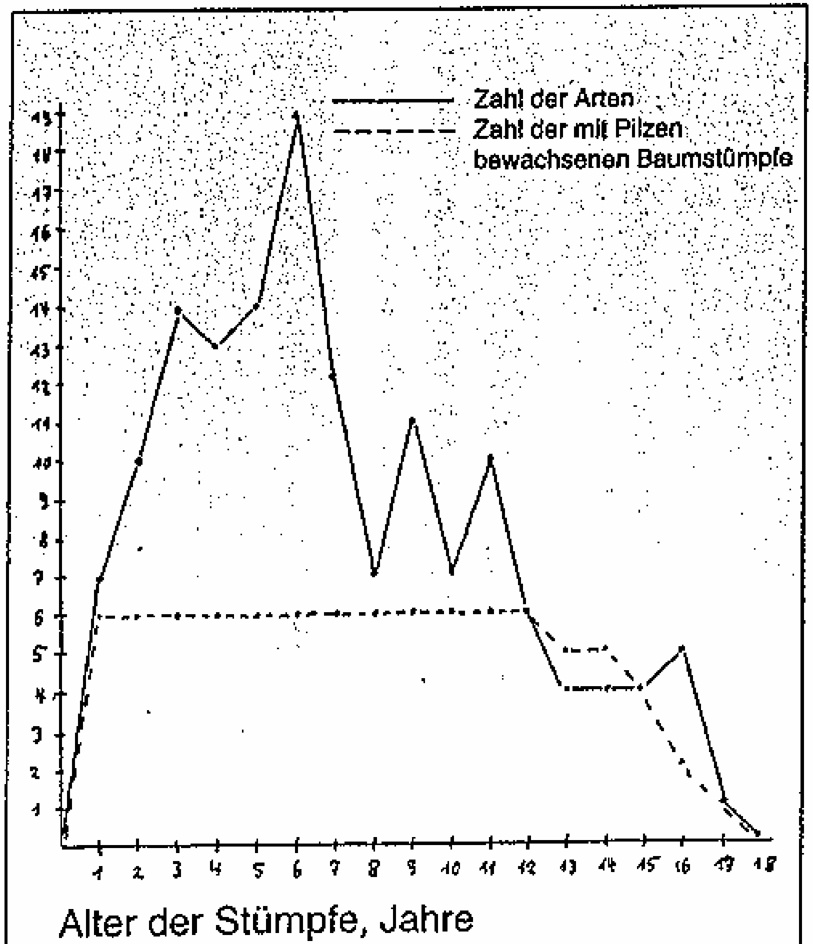



*Abb. 2: Pilzbewuchs an 6 Laubholzstümpfen aus der Ordnung der Fagales*

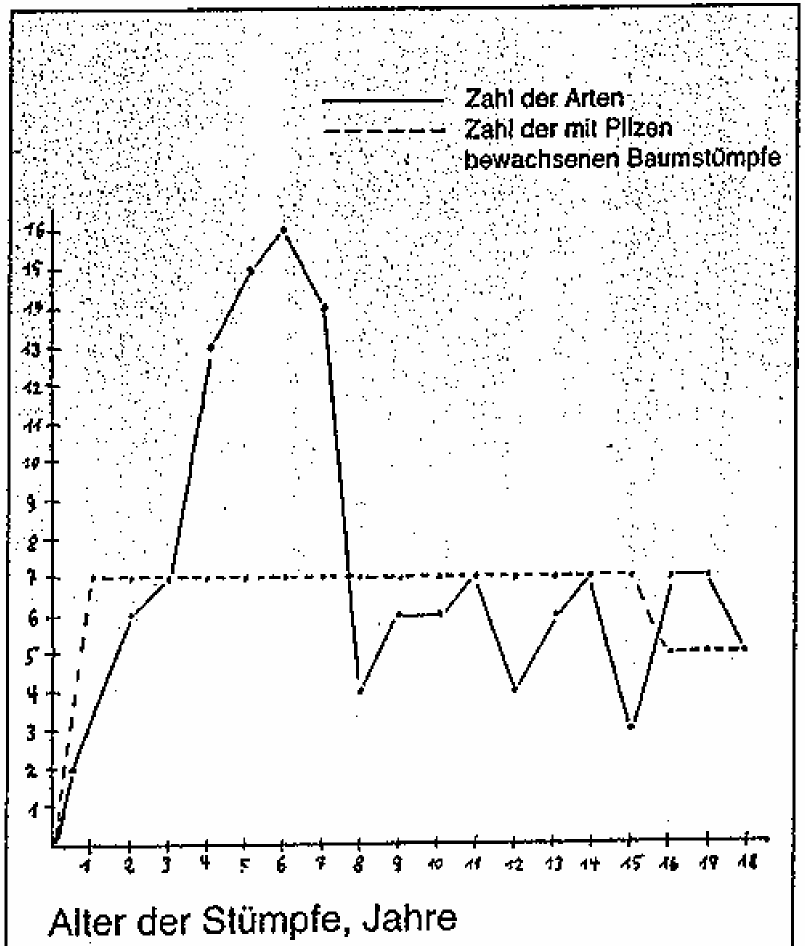



*Abb. 4: Pilzbewuchs an 7 Kiefernstümpfen*

Growth of fungi on tree stumps (on the left - 6 stumps of deciduous trees of the order Fagales, on the right – 7 pine stumps; solid line – number of species, dashed line – number of stumps with fungi; x-axis: age of stumps in years)

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

*Abb. 1: Pilzsukzession an Laubholzstümpfen auf Kahlschlägen*

Initialphase: Beginn: 7–10 Monate nach dem Schlag
Dauer: 8–18 Monate

| Buche | Eiche | Birke, Erle u.a. |
|---|---|---|
| „Tintenstrichpilz" | Zottiger Schichtpilz | Violetter Schichtpilz |
| *Bispora monilioides* | *Stereum hirsutum* | *Chondrostereum purpureum* |

↓

Ablösender Rindenpilz *(Cylindrobasidium evolvens)*
Fleischroter Gallertbecher *(Ascocoryne sarcoides)*

↓

Optimalphase: Beginn: 1½–2¾ Jahre nach dem Schlag
Dauer: (1–) 2–3½ (–5) Jahre

Schmetterlingsporling *(Trametes versicolor)*
Birkenblättling *(Lenzites betulina)*
Angebrannter Rauchporling *(Bjerkandera adusta)*
und mehrere andere Arten

↓

Finalphase: Beginn: (3½–) 4½–5½ Jahre nach dem Schlag
Dauer: 8–12 Jahre und länger

Geweihförmige Holzkeule *(Xylaria hypoxylon)*
Vielgestaltige Holzkeule *(Xylaria polymorpha)*
Brandkrustenpilz *(Ustulina deusta)*
holzbewohnende Blätterpilze
bodenbewohnende Blätterpilze

*Abb. 3: Pilzsukzession an Kiefernstümpfen auf Kahlschlägen*

Initialphase: Beginn: 1–1½ Jahre nach dem Schlag
Dauer: (1½–) 2–3 (–4) Jahre

Riesenkammpilz *(Phlebiopsis gigantea)*
Fleischroter Gallertbecher *(Ascocoryne sarcoides)*
Blutender Schichtpilz *(Stereum sanguinolentum)*
Violetter Lederporling *(Trichaptum abietinum)*

↓

Optimalphase: Beginn: 3–5 Jahre nach dem Schlag
Dauer: 2–4 Jahre

Blauender Saftporling *(Leptoporus caesius)*
Bitterer Saftporling *(Leptoporus stipticus)*
Rötlicher Holzritterling *(Tricholomopsis rutilans)*
Graublättriger Schwefelkopf *(Hypholoma capnoides)*
Grünblättriger Schwefelkopf *(Hypholoma sublatericium)*
und einige andere Arten

↓

Finalphase: Beginn: 7–8 Jahre nach dem Schlag
Dauer: 5–12 Jahre und länger

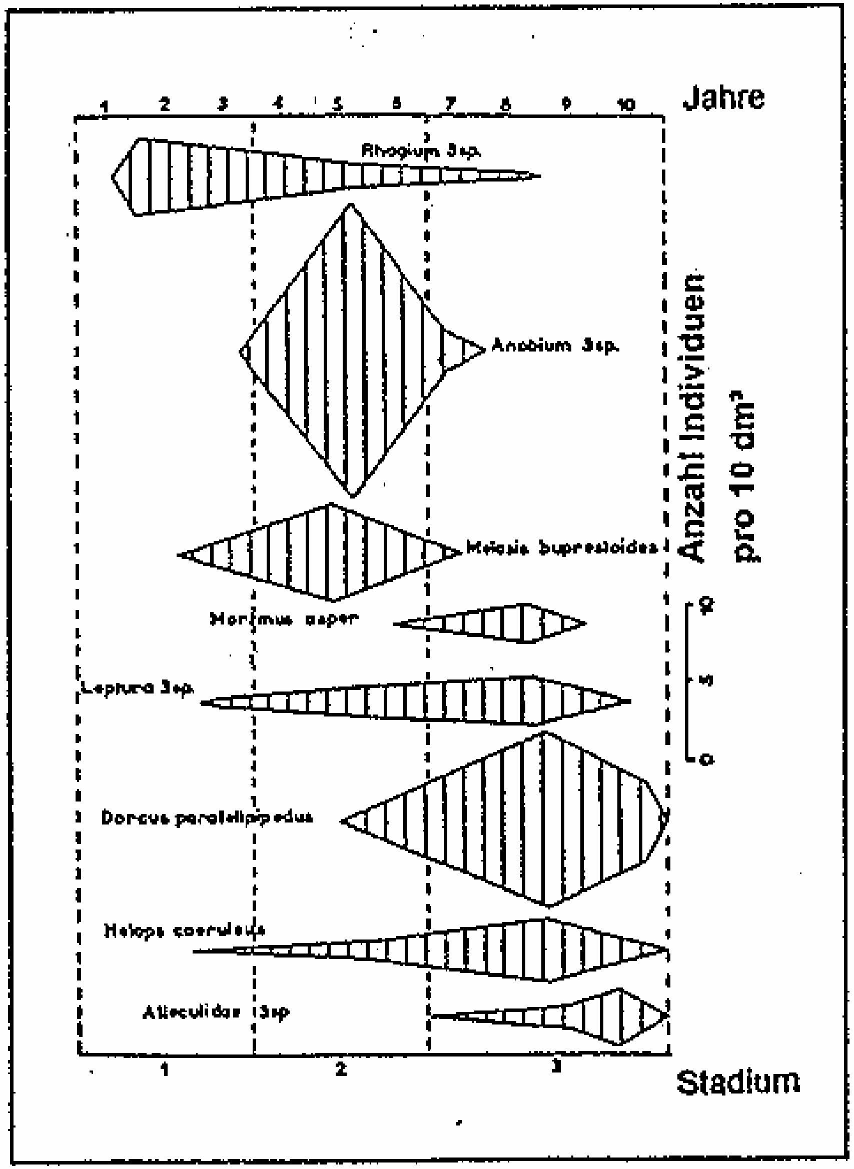
Zitterzahn, Eispilz *(Tremellodon gelatinosum)*
Graublättriger Schwefelkopf *(Hypholoma capnoides)*
Grünblättriger Schwefelkopf *(Hypholoma sublatericium)*
Wurzelporling *(Heterobasidion annosum)*
Schleimpilze *(Myxomycetes)*
bodenbewohnende Blätterpilze

Succession of fungi on clear-cuts: deciduous trees on the left, pine stumps on the right)

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

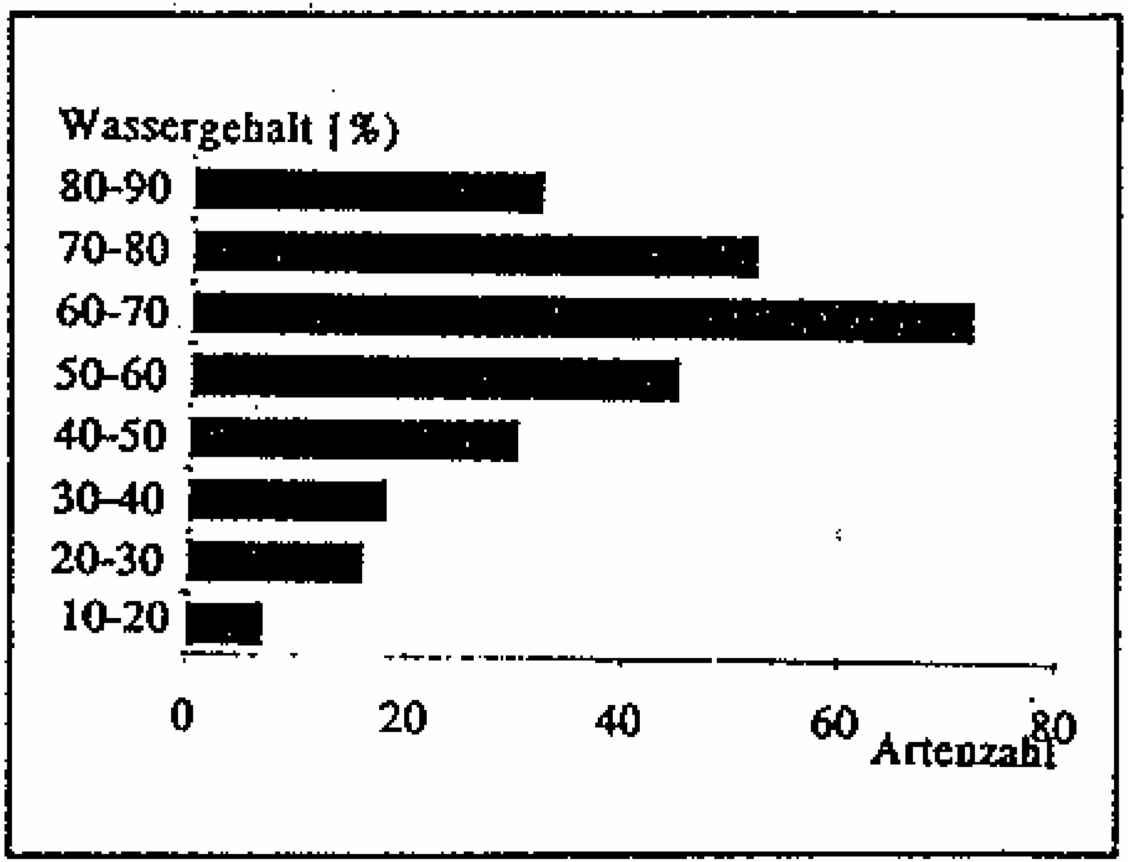
| Decomposition Stage | DERKSEN 1941 | | BRAUNS 1970 | |
|---|---|---|---|---|
| I | Scolytidae<br>Colydiidae | Borkenkäfer<br>Rindenkäfer | Scolytidae<br>Platypodidae<br>Lymexylonidae | Borkenkäfer<br>Kernkäfer<br>Werftkäfer |
| II | Cerambycidae<br>Lymexylonidae<br>Elateridae | Bockkäfer<br>Werftkäfer<br>Schnellkäfer | Cerambycidae<br>Buprestidae<br>Curculionidae | Bockkäfer<br>Prachtkäfer<br>Rüsselkäfer |
| III | Mordellidae<br>Lucanidae<br>Pyrochroidae | Stachelkäfer<br>Hirschkäfer<br>Feuerkäfer | Lamellicornier<br>Tenebrionidae<br>Elateridae | Blatthornkäfer<br>Schwarzkäfer<br>Schnellkäfer |
| IV | Mycetophagidae | | Moder-, Humus-, Pilzfresser | |

Succession of beetle assemblages
In the course of wood decomposition
according to Derksen (beech) and
Brauns (various tree species)




Quantitative development of the
dominant beetle species in dead
beech wood in the course of wood
decomposition (after Dajoz, 1966)

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition




Relation of water content (%) and insect species number in rotten wood (after Dajoz, 1966)

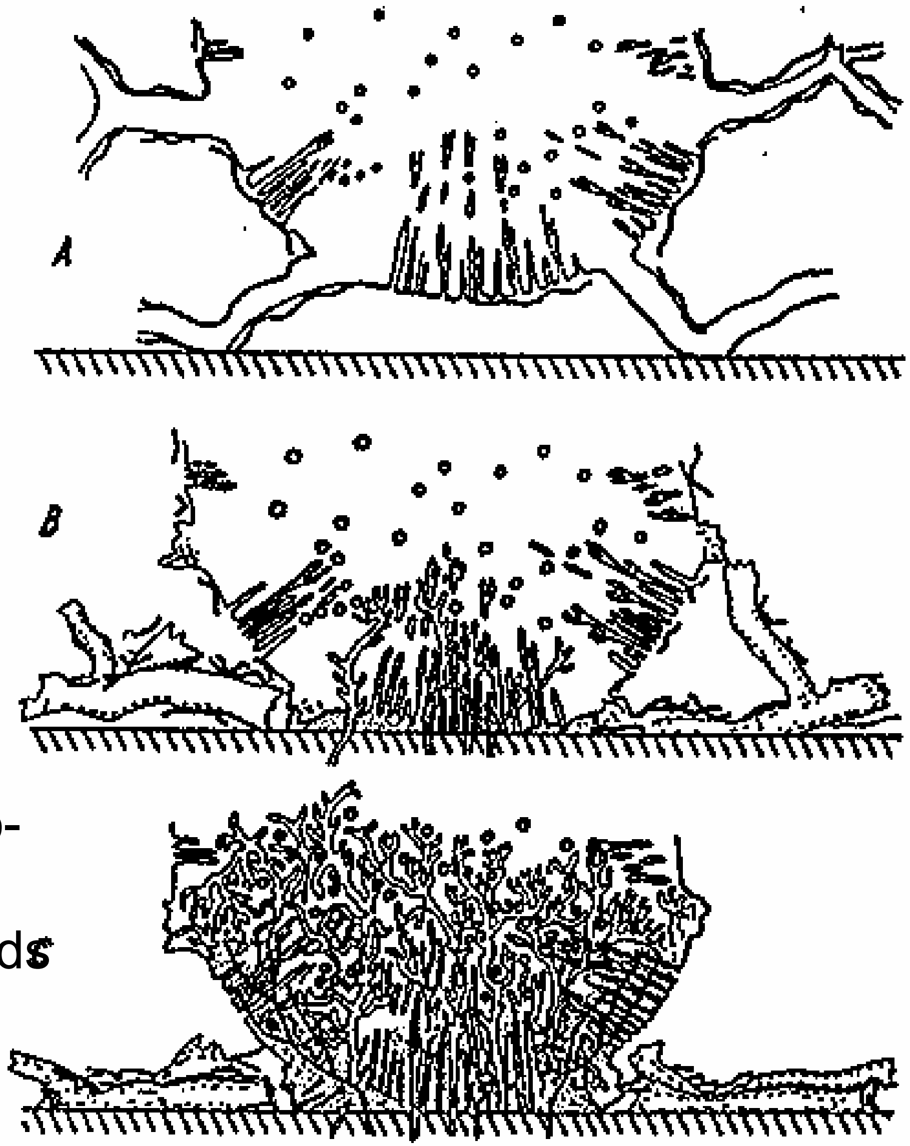
<u>The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition</u>

**Decomposition stages of a fallen tree trunk in the African tropics:**

A – cerambycid galleries in the central part, galleries of Platypodidae leading from the periphery towards the centre

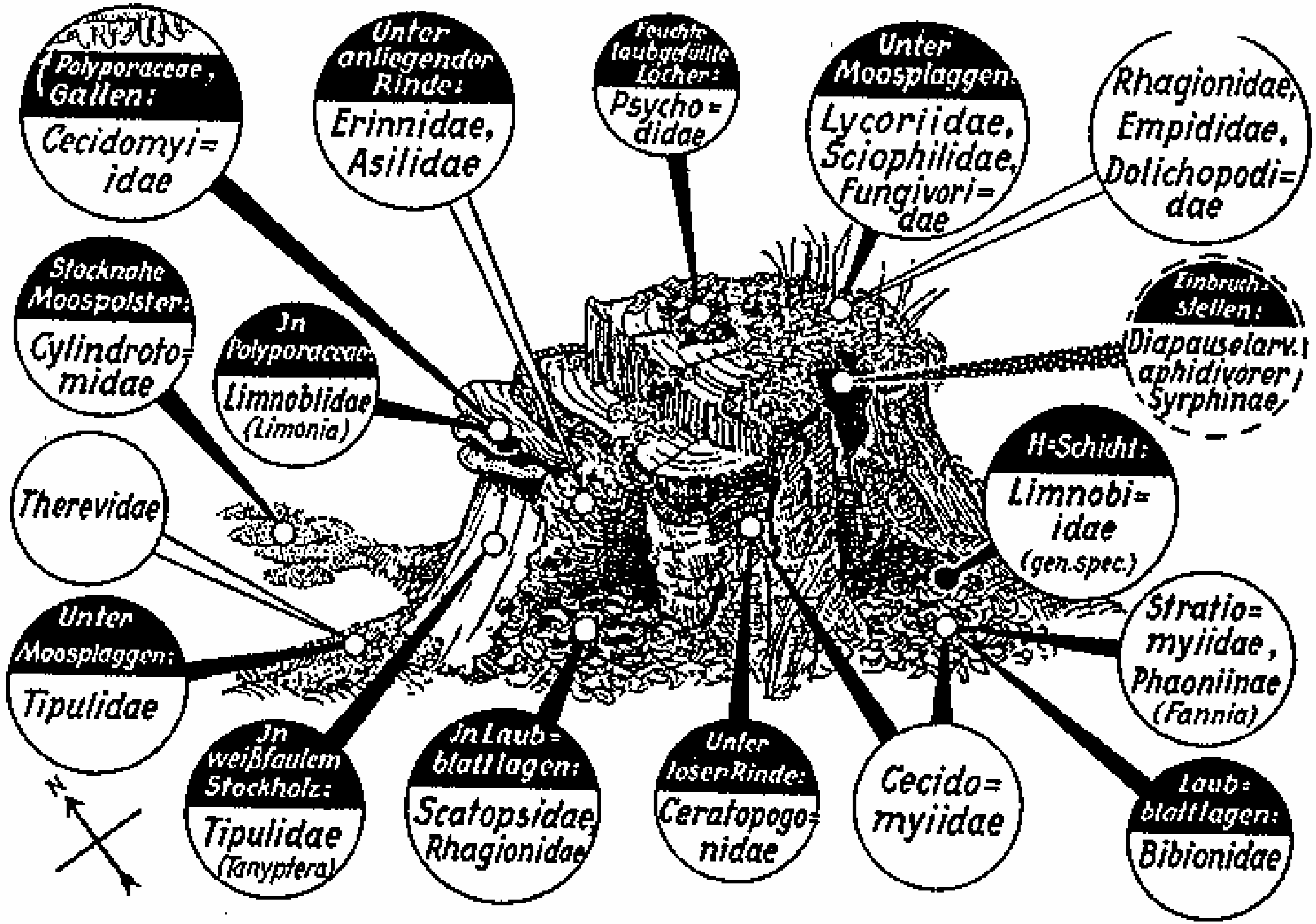
B – limbs fallen off, bark detached, walls of insect galleries covered by bacteria and fungi; termite galleries from the ground surface into the trunk

C – wood further decomposed by micro-organisms; numerous termite galleries; gradual collonization by clitellate annelids (earthworms) and further soil fauna.




(after Delamare-Deboutville, 1951 / Tischler, 1955)

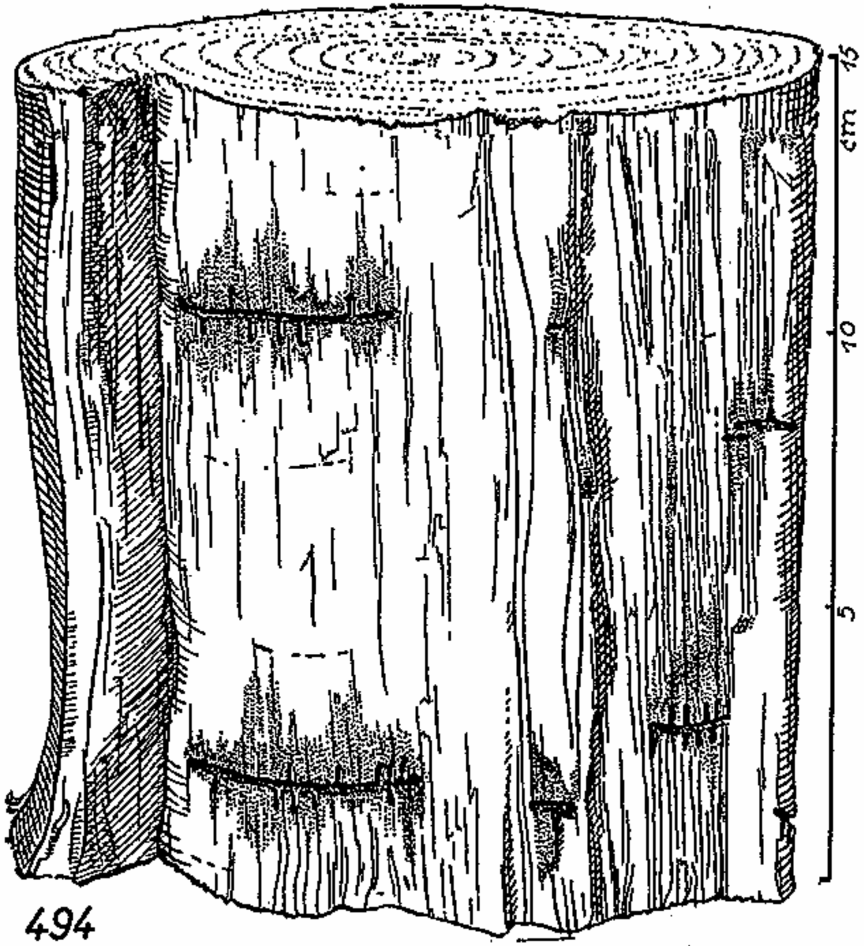
## The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition



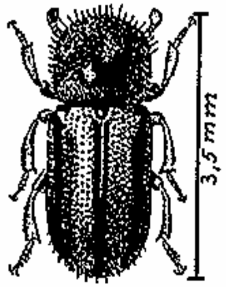

Occurence of the most frequent terricolous dipteran larvae in a 6-8 year old beech stump

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

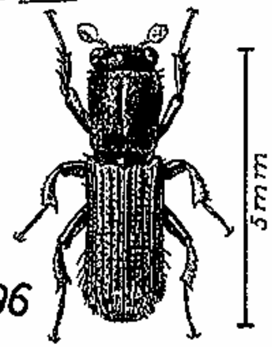
*Xyloterus lineatus* (Scolitidae = Ipidae, now Scolitinae within Curculionidae), on the left, and *Platypus cylindrus* (Platypodidae) on the right: Segment of a spruce trunk with mother and larval Galleries.




494

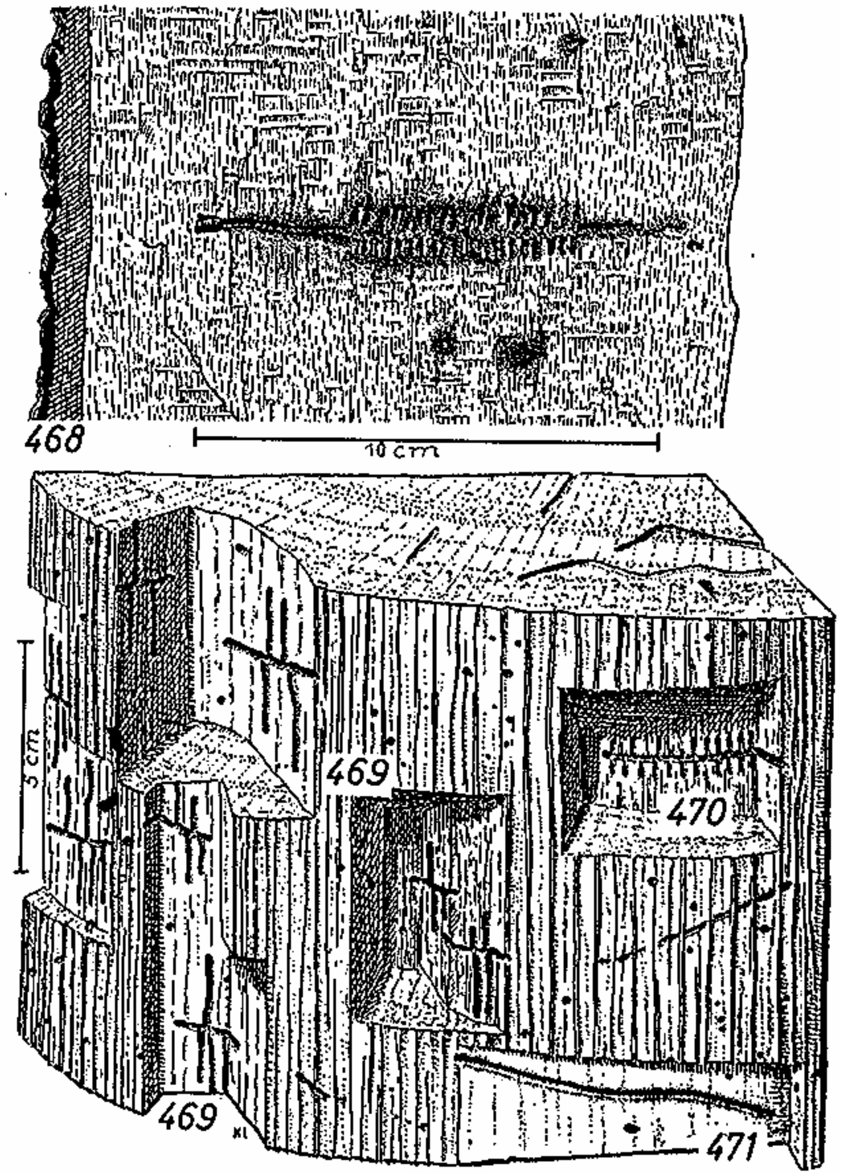



495




496

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

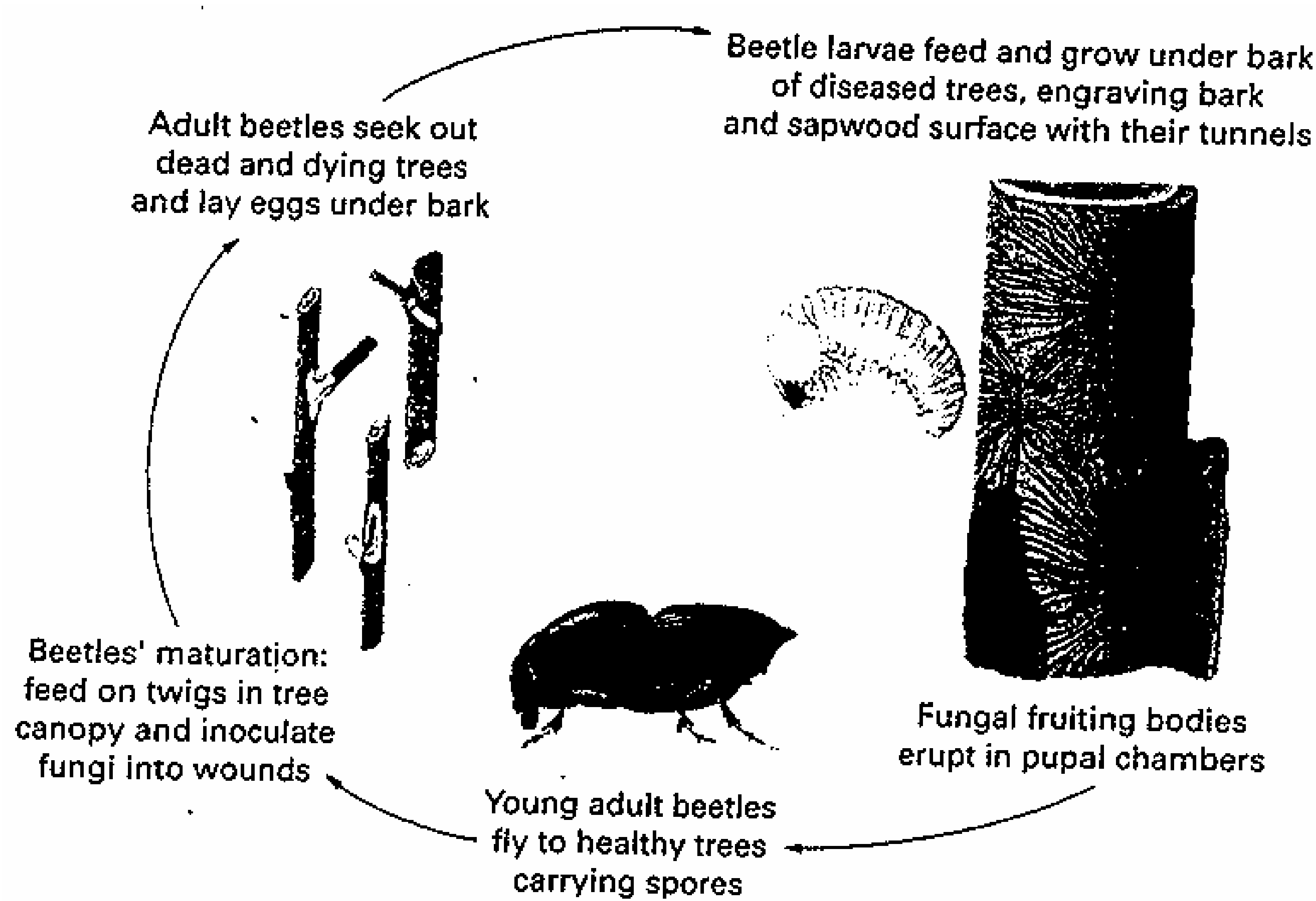



Galleries of ambrosia beetles in deciduous wood:

Above (468) – mother and larval galleries of *Xyloterus domesticus*

Below (471) – galleries (on various levels) of Xyleborus (= Anisandrus) dispar.

The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition




Life cylce of *Scolytus* bark beetles (e.g. *S. intricatus*) in association with the fungus *Ophiostoma (=Ceratocystis) ulmi*, causing the Dutch elm disease

# The saprotrofic food chain in terrestrial ecosystems: Wood Decomposition

**Fig. 9.9** Proposed pattern of spread of (a) the non-aggressive, and (b) the EAN and NAN aggressive subgroups of *O. ulmi* during the first and second epidemics of Dutch elm disease. Small arrows, overland spread; large arrows, major introductory events as follows. (1) Introduction of the non-aggressive subgroup from NW Europe to North America, *c.* 1920s. (2) Introduction of the non-aggressive subgroup from Krasnodor to Tashkent, *c.* late 1930s. (3) Introduction of a form close to the EAN aggressive subgroup into North America (Illinois area), *c.* 1940s, and its subsequent evolution into the NAN subgroup. (4) Introduction of the NAN subgroup from the Toronto area into the UK, *c.* 1960. (5) Introduction of the EAN subgroup into the Tashkent area, *c.* mid-1970s. (From Brasier 1990.)