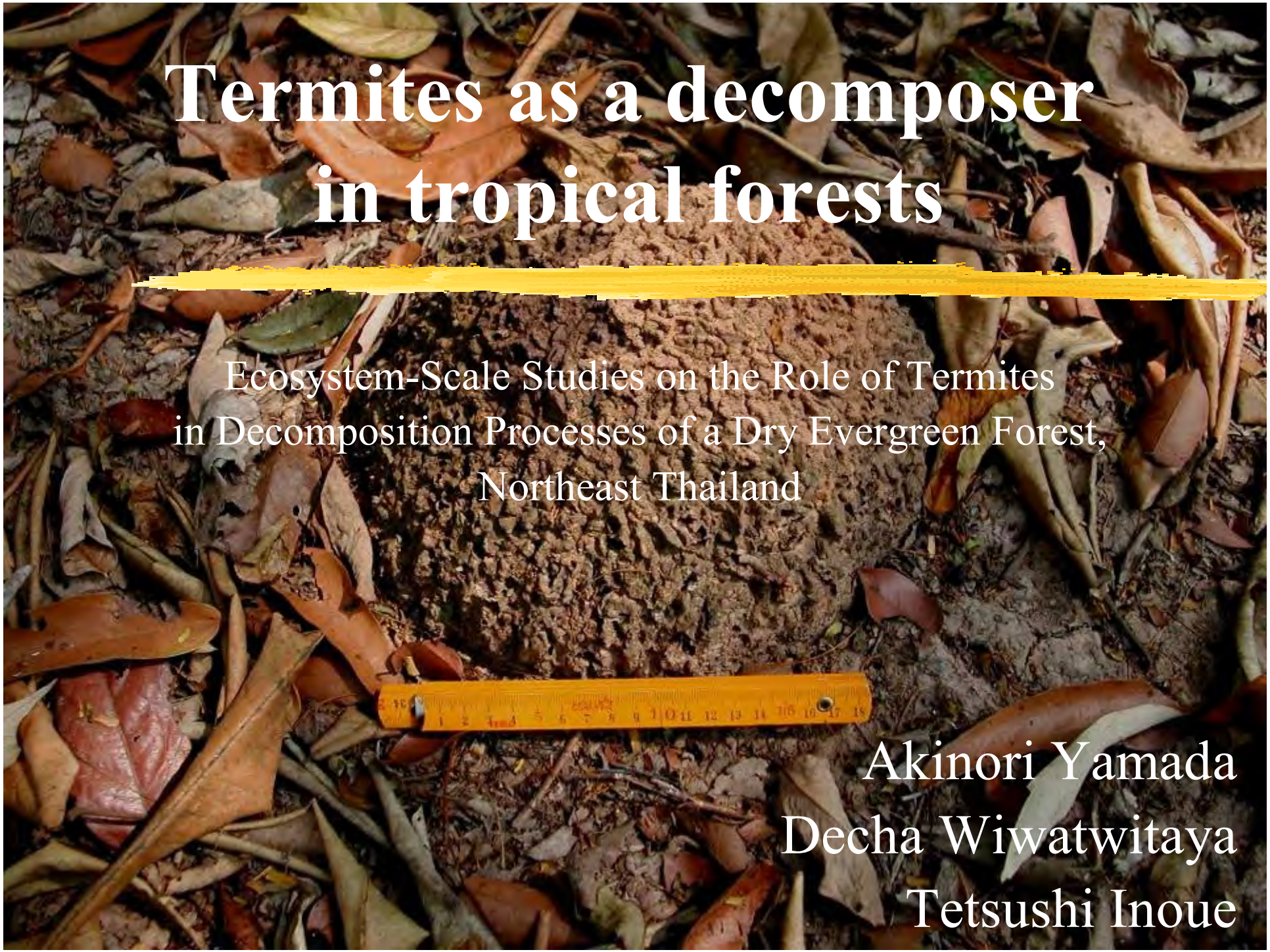

Termites as a decomposer in tropical forests

Ecosystem-Scale Studies on the Role of Termites
in Decomposition Processes of a Dry Evergreen Forest,
Northeast Thailand

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Carbon mineralization and nitrogen fixation by termites

- Recently, we have demonstrated that termites play ecologically significant roles in decomposition processes in terms of carbon mineralization as well as nitrogen fixation in a dry evergreen forest in Northeast Thailand.

- This presentation is focused on their role in C mineralization and shows the importance not only in the dry evergreen forest, but also in tropical regions (tropical forests and savannas).

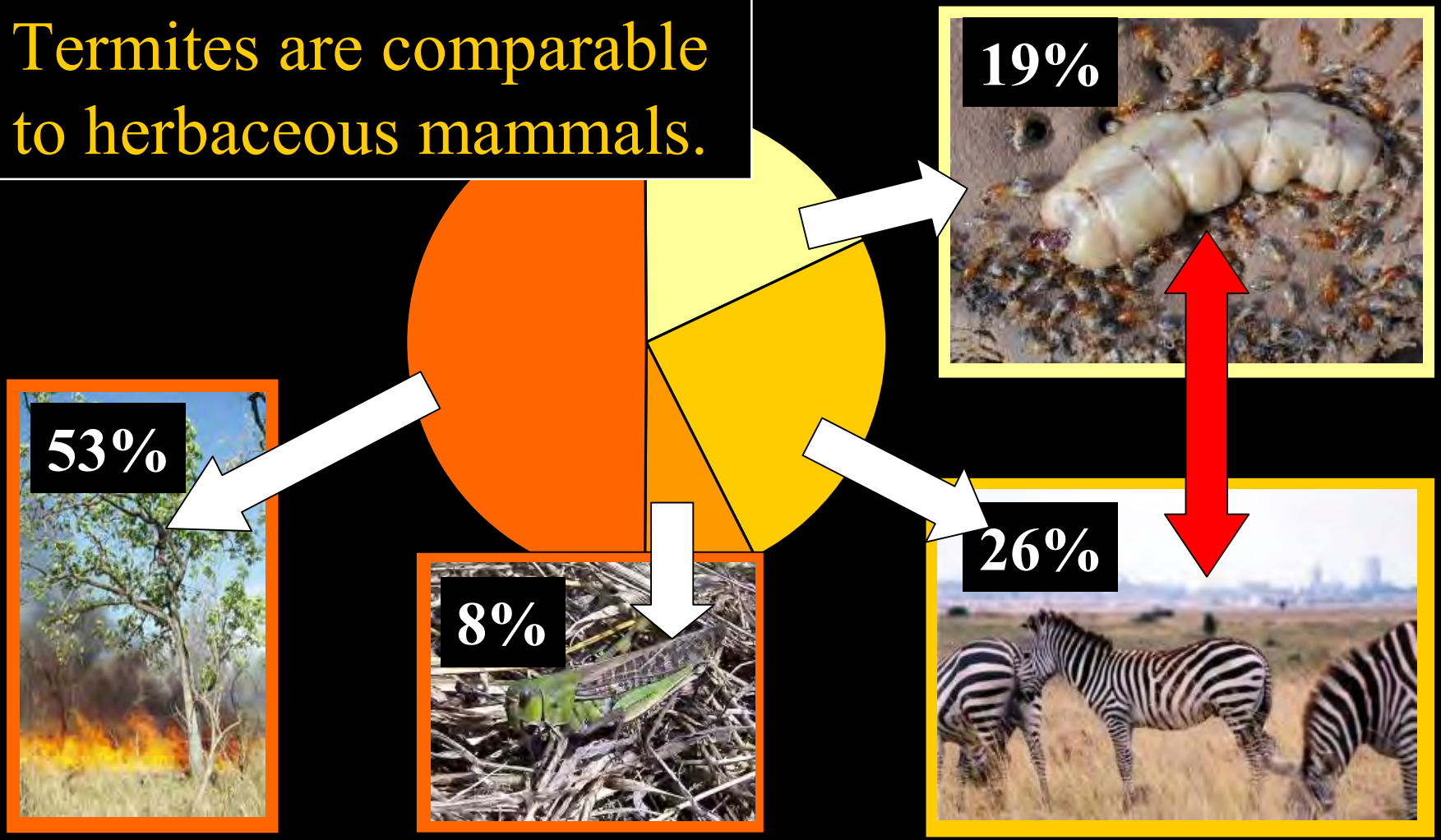
Ecological role of termites in tropical regions

- Termites are widely recognized as a major decomposer in terrestrial ecosystems, especially in tropical regions.
- Ecological role of termites in decomposition processes has been studied by conducting measurements of their consumption and respiration rates.
- Stronger cases come from observations in African savannas, showing that termites, especially fungus-growers, are a major litter-consumer.

Termites in savannas: litter-consumer

Serengeti grassland (Wood & Sands 1978)

Termites are comparable to herbaceous mammals.



Termites in tropical forests

- It had been sill unclear how important termites in tropical forests are in decomposition processes and whether the termites are comparable or not to those in savannas.
- There is an anomaly among the estimates in previous studies, even at the point of the biomass of termites.
- This is, in part, because tropical forests provide termites with more diverse habitats.

Comparison of typical foods of termites between savanna and tropical forest

Savanna

Tropical forest

grass-litter | **leaves, branches** | **trunks** | **rotten wood** | **humus** | **soil**

Macrotermes *Microcerotermes* *Globitermes*
Odontotermes *Nasutitermes* *Coptotermes*

Termes *Dicuspiditermes* *Pericapritermes*

Wood/litter-feeders

Soil-feeders

How are diverse termites in tropical forests evaluated?

- It is clearly difficult to measure food consumption rates of termites other than those consume litter, leaves, and/or branches.
- Thus, most of the previous studies in tropical forests have conducted measurements of respiration rate of termite population in order to evaluate the ecological role of termites.
- These studies have shown about only 1.0% of C in annual litter production to be mineralized by the respiration.
- However, a single study that demonstrated leaf-litter consumption by a fungus-grower indicates the potentially important role of termites in decomposition processes, which might be comparable to that in savannas.
- Why there is such an anomaly between studies using respiration rates and consumption rates?

Difference between consumption rate and respiration rate

Respiration (CO_2)

Consump

ion

Respiratory C is only a part of C in the consumed dead plant material.

Feces

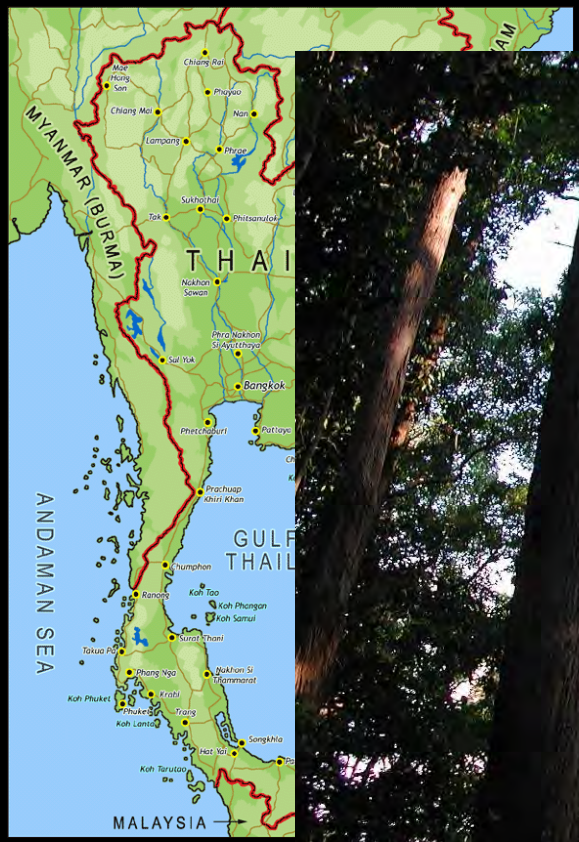
Feces (fungus-combs) as an external digestive channel for fungus-growers

- Feces of fungus-growers are material to make their fungus-combs.
- Fungus-combs function as an external digestive channel for fungus-growers and thus are assumed to be a part of their bodies.
- Therefore, despite the previous studies conducting measurements of respiration rates only for termite population (individuals), no consideration of respiration from fungus-combs will lead us to an underestimation of the importance of termites.

Objectives

- To clarify the ecological role of termites in decomposition processes, especially C mineralization process, in tropical forests by using respiration rates of fungus-combs as well as termite population.
- To compare the role of termites between tropical forests and savannas, where the importance of termites in decomposition processes have been emphasized as shown before.
- For the objectives, data for the biomasses and respiration rates of fungus-combs as well as termite population are needed.

Dry Evergreen Forest (DEF), Sakaerat Environmental Research Station



An epigeal nest of *Microcerotermes crassus*

Species diversity of termites in the DEF

Kalotermitidae
- *Glyptotermes brevicaudatus*
- *Incisitermes* sp.1
- *Neotermes* sp.1
- *Neotermes* sp.

Rhinotermitidae
- *Coptotermes curvignathus*
- *Schedorhinotermes medioobscurus*
- *Schedorhinotermes* spp.

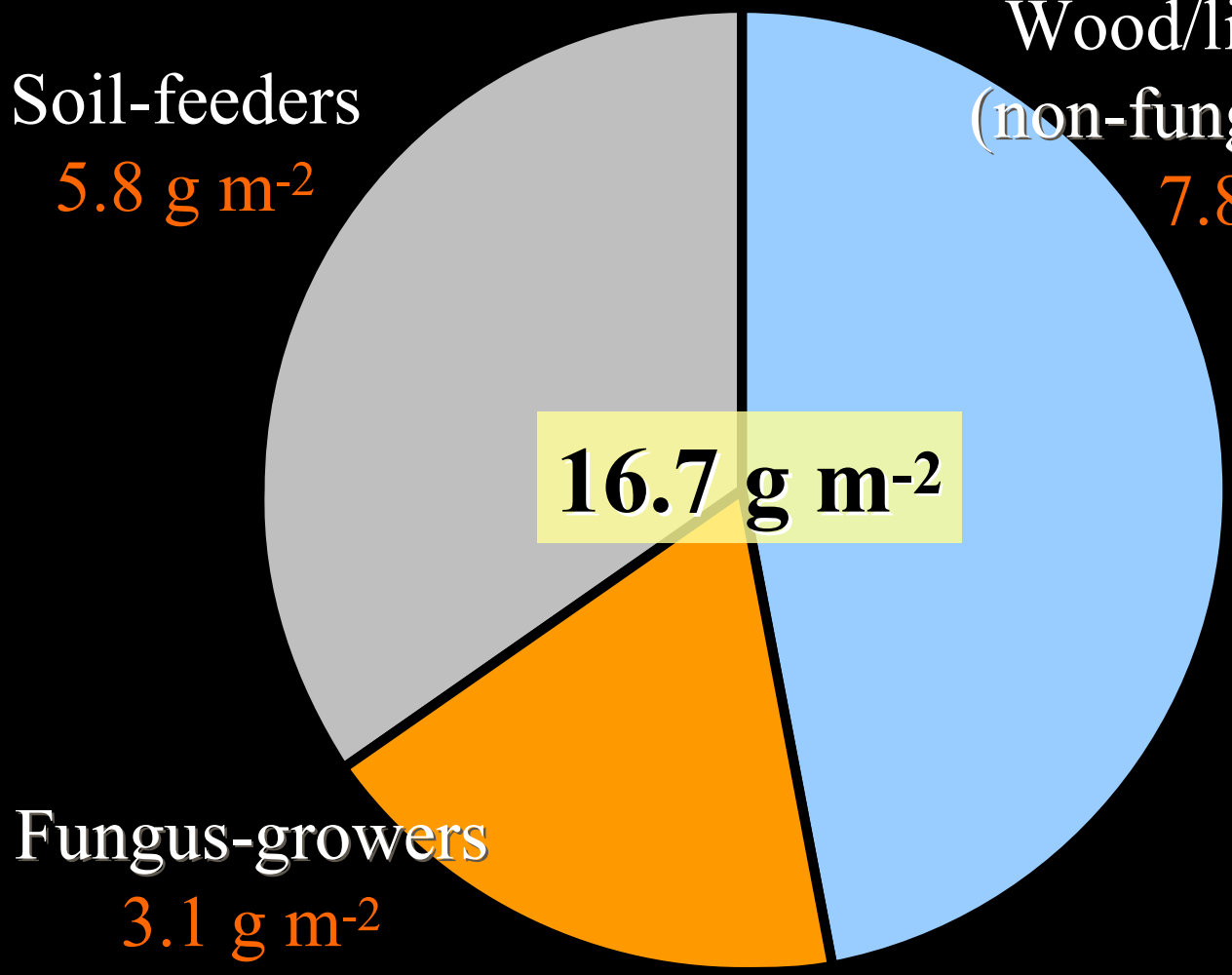
Termitidae
Macrotermitinae
- *Macrotermes annandalei*
- *Macrotermes carbonarius*
- *Macrotermes gilvus*
- *Odontotermes feae*
- *Odontotermes formosanus*
- *Odontotermes maesodensis*
- *Odontotermes proformosanus*- L
- *Hypotermes makhamensis*
- *Hypotermes* sp.1
- *Ancistrotermes pakistanicus*
- *Microtermes obesi*
- Macrotermitinae spp.

Apicotermitinae
- *Euhamitermes* sp.1
- *Speculitermes* sp.1
- Apicotermitinae spp.

Termitinae
- *Globitermes sulphureus*
- *Microcerotermes crassus*
- *Dicuspiditermes spinitibialis*
- *Dicuspiditermes makhamensis*
- *Mirocapritermes concaveus*
- *Mirocapritermes* sp.1
- *Pericapritermes semarangi*
- *Pericapritermes prosetiger*
- *Termes comis*
- *Termes propinquus*
- Termitinae spp.

Nasutitermitinae
- *Bulbitermes makhamensis*
- *Hospitalitermes bicolor*

Biomass of termites and the feeding group composition in the DEF



Biomass of fungus-combs in the DEF

	(g m^{-2})
Ma	6
Ma	4
	1
Hypotermes pakistanicus	4.6
Ancistrotermes pakistanicus	16.6
Microtermes obesi	0.5
not specified	3.2

40.0 g m^{-2}

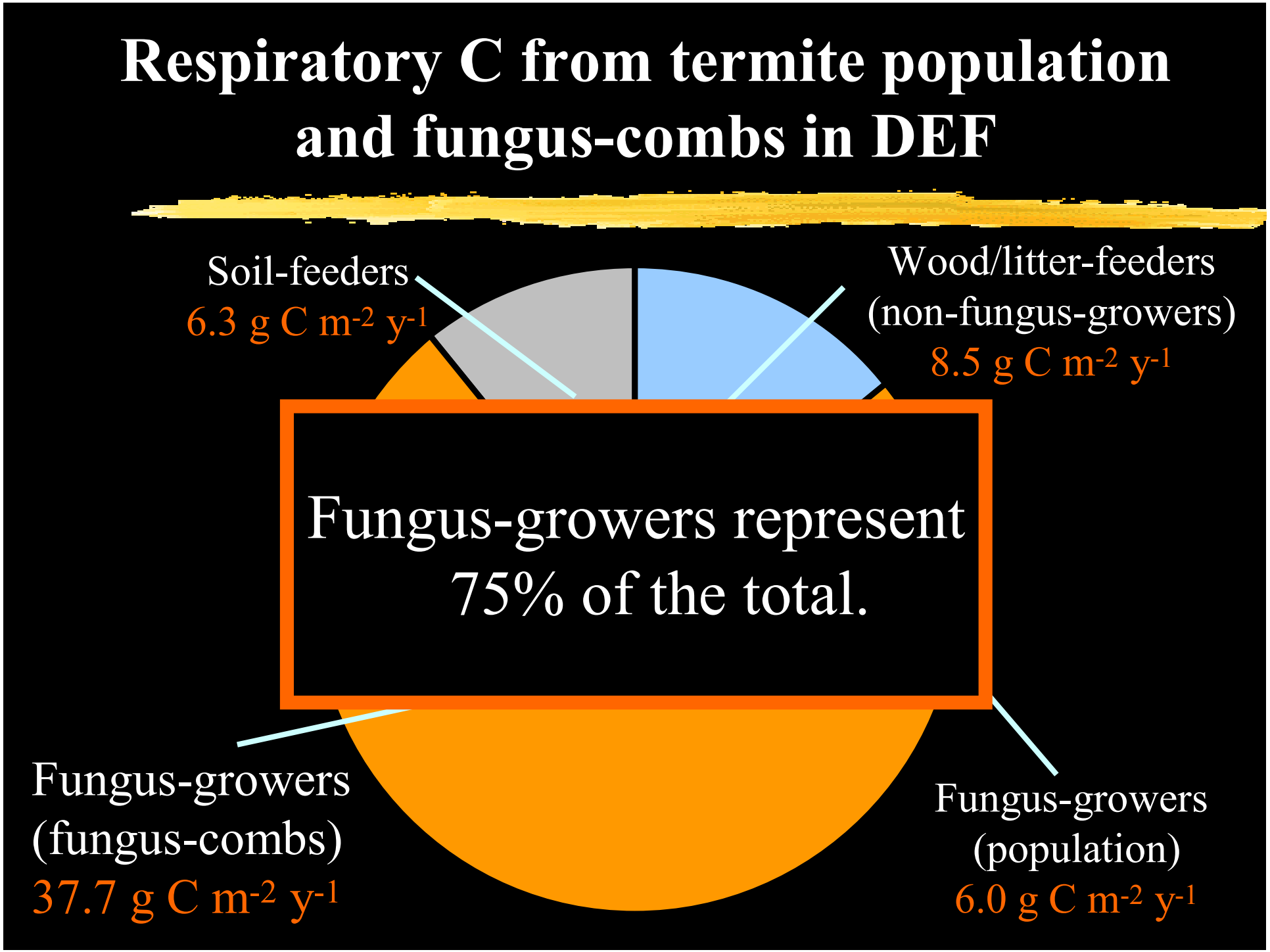
Respiration rates of termite individuals and fungus-combs in the DEF

species	FG	sample	Wt	CO_2
Kalotermitidae				
Neotermes sp.	wl	w	16.6	17.0
Dicuspiditermes makhamensis	s	w	2.8	14.2
		s	3.5	14.2
Mirocapritermes sp.	s	w	2.0	13.6
Procapritermes prosetiger	s	w(n=2)	2.6	7.0
Termes comis	s	w	2.8	7.2
Termes propinquus	s	w, s	1.1	19.2
Macrotermitinae				
Macrotermes annandalei	wl(f)	maw	16.0	25.0
Ancistrotermes pakistanicus	wl(f)	maw, mw	1.8	17.5
		fg		5.8
Nasutitermitinae				
Bulbitermes laticephalus	wl	w	2.9	14.0
		s	1.1	27.1
Bulbitermes sp.	wl	s	1.5	16.1

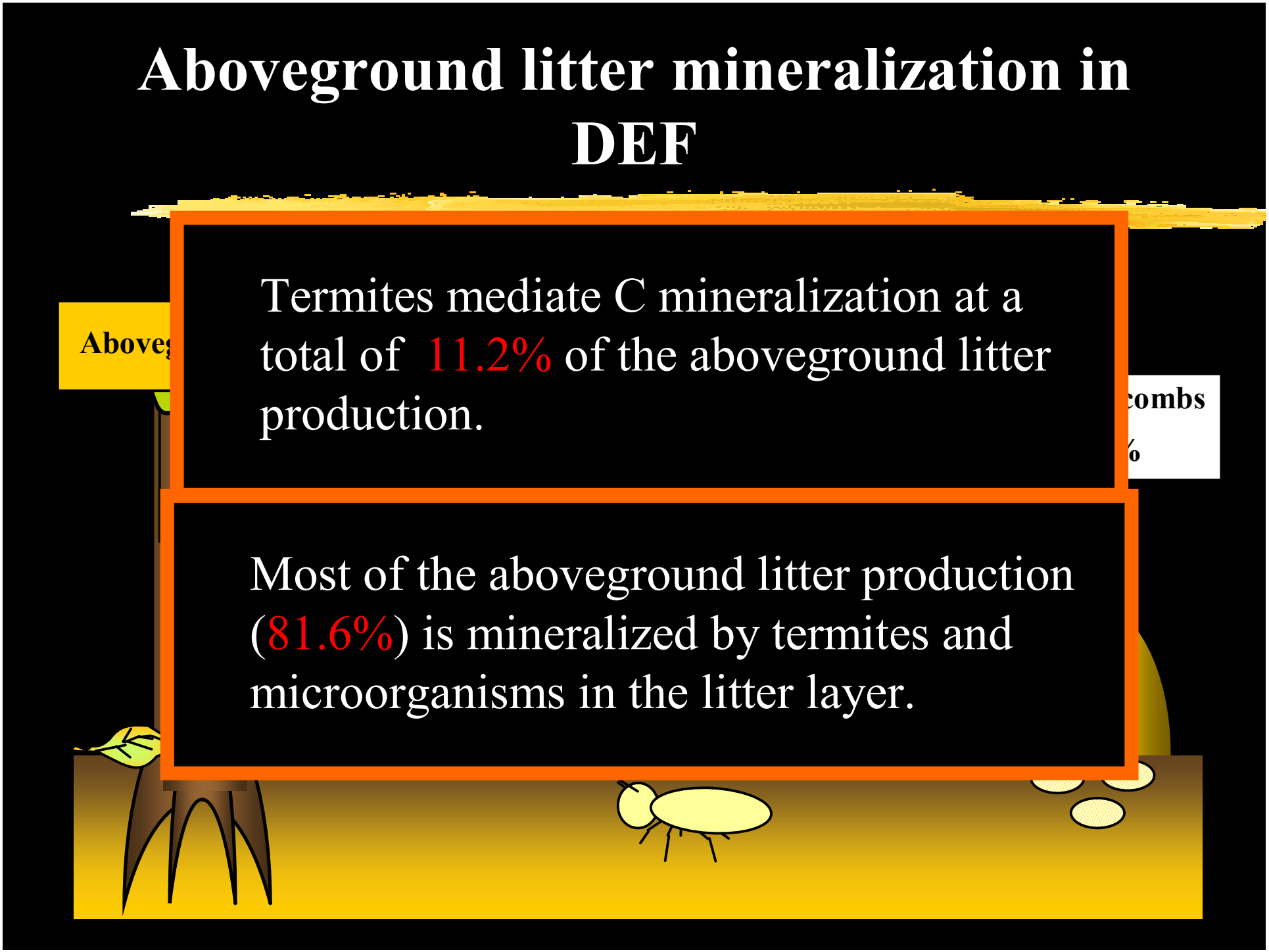
Termite individuals: 7.0-25.0 μ mol CO_2 g^{-1} h^{-1}

Fungus-combs: 5.8-14.7 μ mol CO_2 g^{-1} h^{-1}

Respiratory C from termite population and fungus-combs in DEF



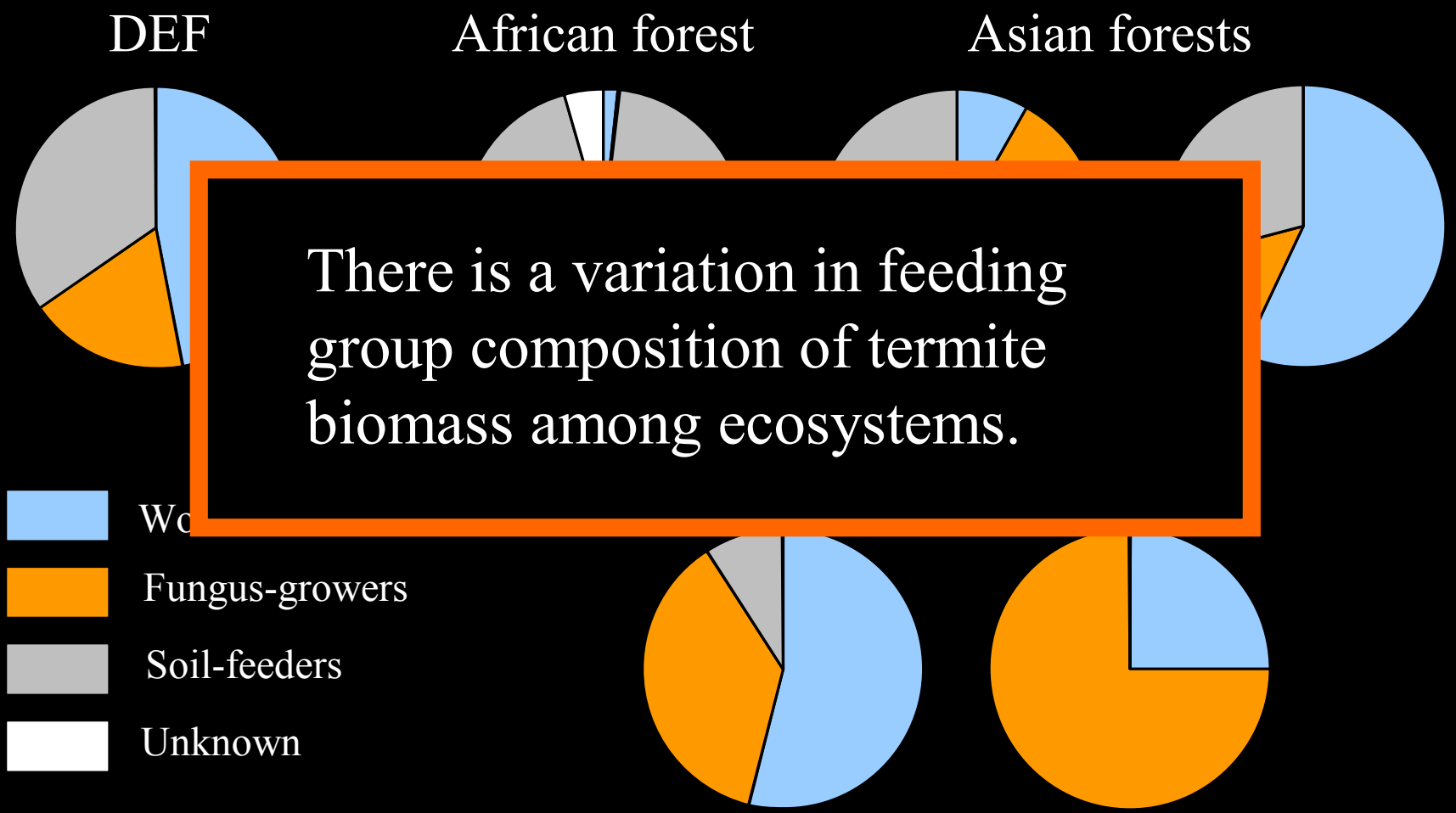
Aboveground litter mineralization in DEF



Termites mediate C mineralization at a total of 11.2% of the aboveground litter production.

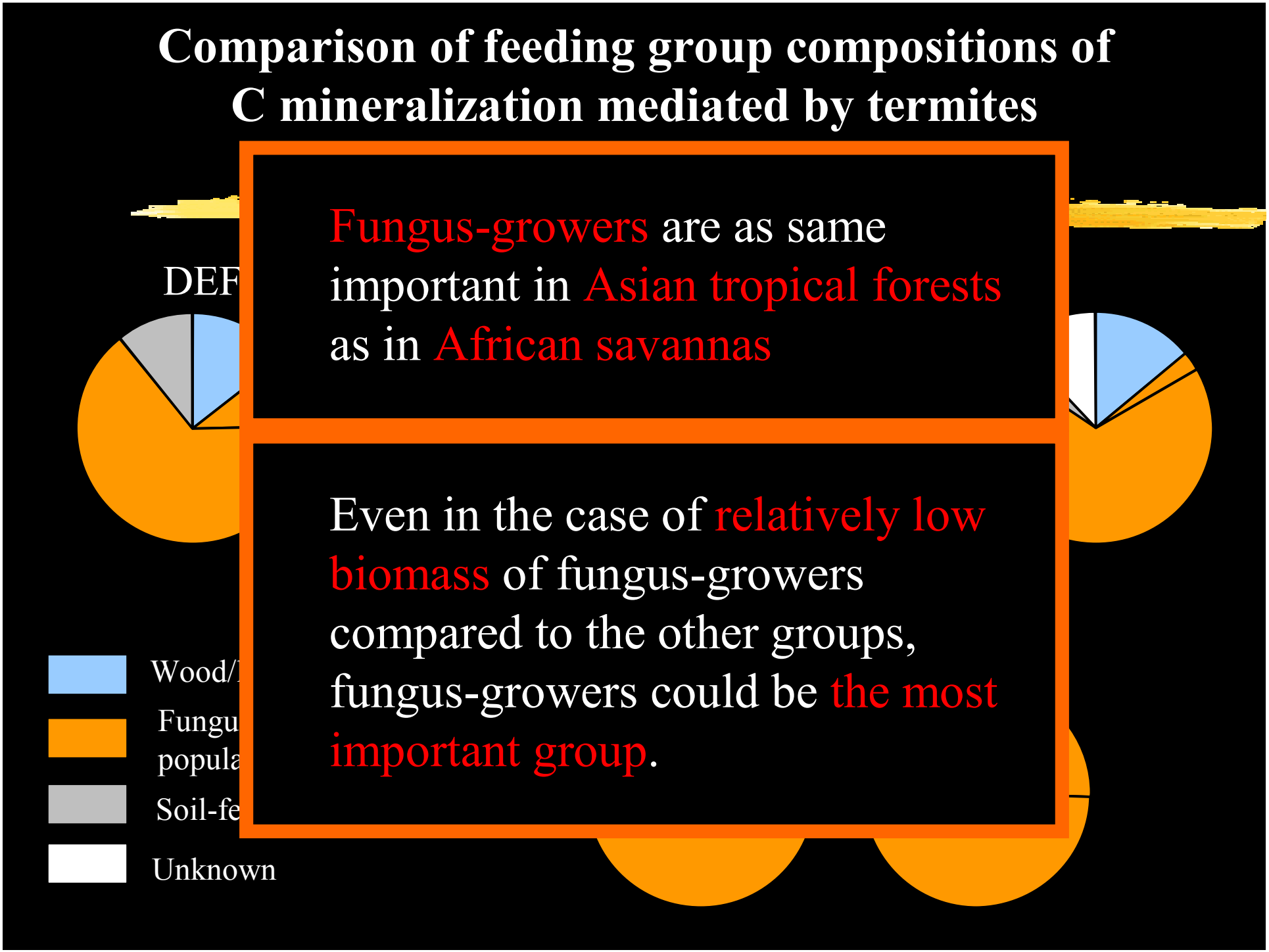
Most of the aboveground litter production (81.6%) is mineralized by termites and microorganisms in the litter layer.

Feeding group composition of termites in tropical forests and savannas



(Wood & Sands 1978; Bignell *et al*. 1997; Eggleton *et al*. 1999; Abe & Matsumoto 1979)

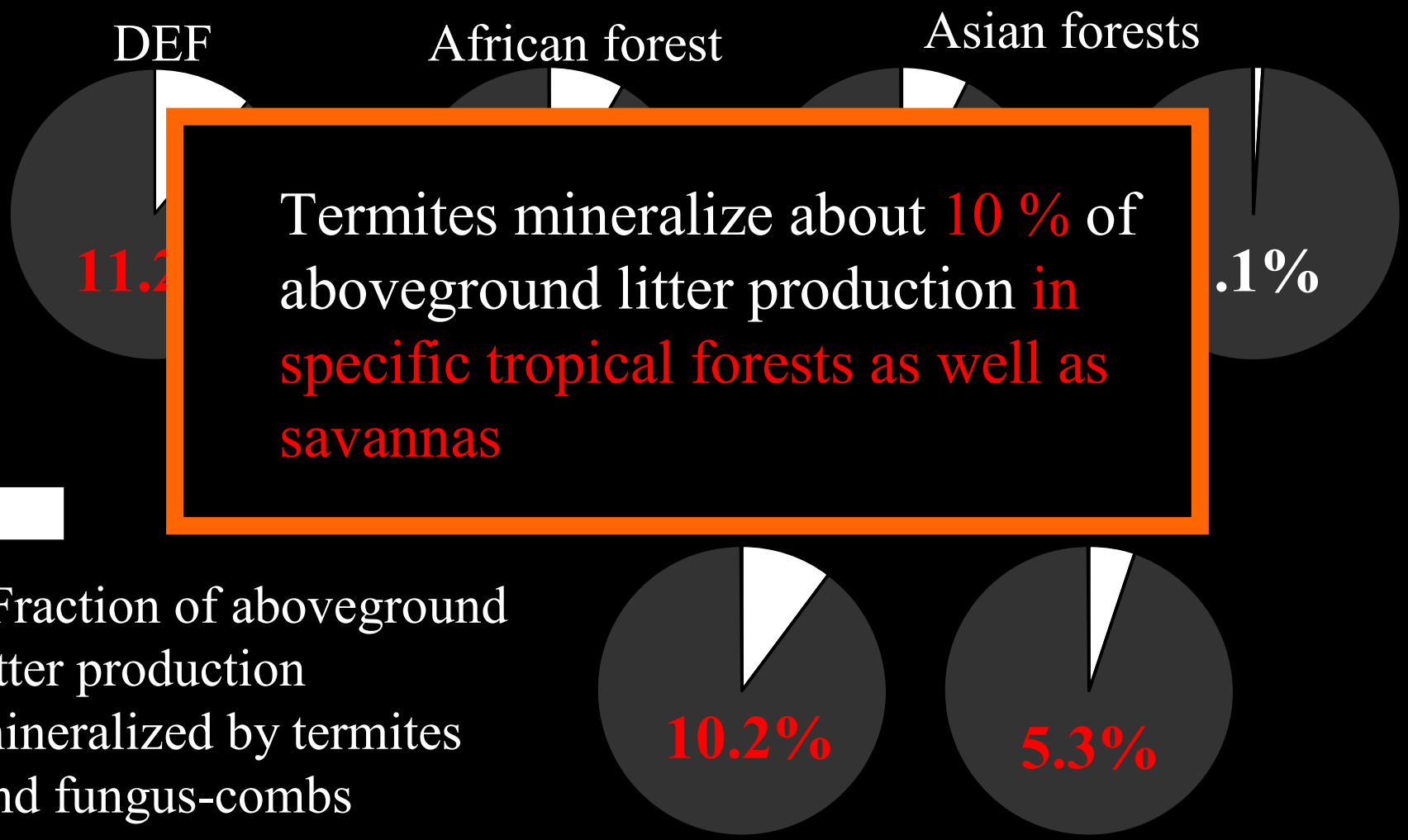
Comparison of feeding group compositions of C mineralization mediated by termites



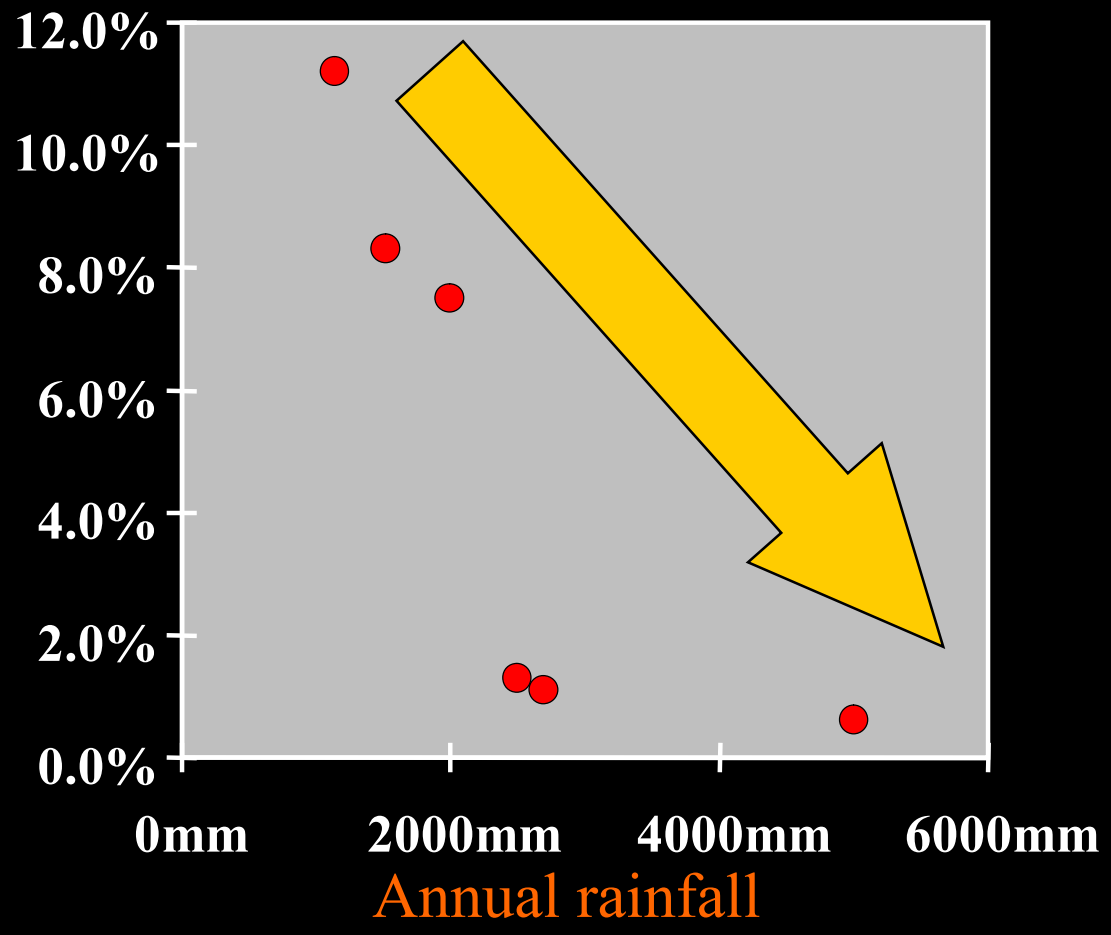
Fungus-growers are as same important in Asian tropical forests as in African savannas

Even in the case of relatively low biomass of fungus-growers compared to the other groups, fungus-growers could be the most important group.

Contribution of termites to C mineralization of aboveground litter production



Annual rainfall and C mineralization mediated by termites in tropical forests



Spearman's rank correlation coefficient: $p < 0.05$

Why is the contribution of termites larger in tropical forests with lower rainfalls?

- A possible explanation could be found in the positive correlation between respiration rate of litter and its moisture content (Chambers *et al*. 2001) .
- This is because higher respiration rates of litter (microorganisms in the litter layer) imply larger amount of C mineralized by the microorganisms, leaving smaller amount of C resources for termites.
- In fact, there appears to be a competitive relationship between termites and the microorganisms in the DEF, where 81.6% of the aboveground litter production is mineralized by termites and the microorganisms as shown before.
- This could be supported by a possible estimation in the DEF that termites consume 30-40% of the aboveground litter production, which means termites and the microorganisms consume or mineralize almost 100% of the aboveground litter production.

Ecological impact of termites in tropical forests and heterogeneity of tropical forests

- The uncertainty of the impact of termites in tropical forests could be attributed to heterogeneity of "tropical forests".
- Two different types of forests, tropical seasonal forests and tropical rainforests, are expressed as "tropical forests" and are approximately distinguished by annual rainfall.
- In other words, "tropical forests" consist of forests with high rainfall ("dry" forests) and those with low rainfall ("moist" forests).

Conclusions

- Fungus-growers are a much more influential group than previously expected in tropical forests, especially in Asia, as well as Africa savannas due to their fungus-combs.
- The ecological importance of termites in decomposition processes is greater in “dry” tropical forests than in “moist” tropical forests.
- Termites in “dry” tropical forests mineralize about 10% of the aboveground litter production, and are comparable to termites in savannas in this point.