Table 1. *P. pityographus*: Comparison of field response to modified flight barrier traps (Röchling, Haren, FRG) baited with racemic grandisol and the enantiomers of trans-pityol (St. Peter/Black Forest, FRG, September 9–30, 1986)

Bait[a]	Beetles responding		
	$\bar{x}$[b]	Range	Reps.[c]
rac. grandisol + (+)-trans-pityol	66.50	0–322	12
rac. grandisol + (−)-trans-pityol	2.58	0– 18	12

[a] All substances released from capillaries (1 mm i.d.)
[b] Differences between means significant for $P<0.05$ (Mann-Whitney U-Test)
[c] Replicate = catch per trap and per control interval

predator which was previously thought to respond to the *P. chalcographus* pheromone, chalcogran, only [11].

Though nothing is known about the biosynthesis of pityol, some interesting structural relations to other pheromones may be discussed (see Fig. 4). Simple biotransformations of the widespread terpenoid, 6-methyl-5-hepten-2-one (*3*), present in the beetles, and also known as a component of pine resin [12], would lead to 6-methyl-5-hepten-2-ol (*7*) ("sulcatol", a pheromone of ambrosia beetles, *Gnathotrichus* spp. [13]) or to 1,5-dimethyl-6,8-dioxabicyclo[3.2.1]octane (*8*) ("frontalin", a pheromone of American bark beetles, *Dendroctonus* spp. [14]) or to pityol. An isomer of pityol, 3-hydroxy-2,2,6-trimethyltetrahydropyran (*9*) which may also be derived from *3* could recently be identified from the elm bark beetle *Pteleobius vitatus* [15]. While *3* is the main compound among the volatile constituents of the pygidial/anal gland of the Australian meat ant, *Iridomyrmex purpureus*, the relatively unstable 4,6,6-trimethyl-5,7-dioxabicyclo-[2.2.1]heptane (*10*), the bicyclic acetal-complement of pityol, represents a minor constituent [16].

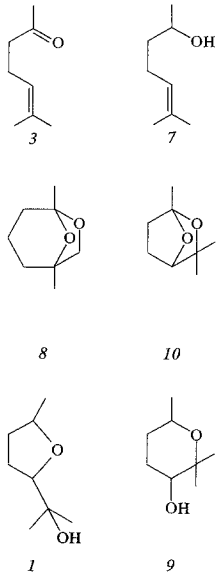

Fig. 4. Structural relations between methylheptenone (*3*) and insect pheromones like pityol (*1*), sulcatol (*7*), and frontalin (*8*)

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Thrombosis Induction by Different Carrageenans in Rats and Mice

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Carrageenans are used as food additives (chocolate, jam, cheese, icecream a.o.), in drug formulation (binding and blasting agent, emulgator, stabilisator, ointment base), as a laxative and slimming remedy, in the treatment of gastric ulcers, and they were even injected because of their binding capacity for drugs in order to produce sustained release of the active agent [1]. In these respects, κ-carrageenan is preferably used.

However, after i.p. injection of carrageenans at doses of 5–100 mg kg^{-1} thrombosis and infarction of the tail and of digits was seen in mice, rats, and guinea pigs, respectively [2]. We were able to confirm these findings and to show that κ-carrageenan causes tail infarction at doses below 1 mg kg^{-1} i.v. in rats, whereas ι-carrageenan exhibits only weak and transient activity at doses considered lethal (Table 1). λ-Carrageenan has no effect in this respect (Table 1, [3]). With κ-carrageenan, thrombosis and infarction of the tail can be produced by i.v., i.p.,

Table 1. Thrombosis frequency (animals with tail thrombosis to number of animals per group) 0.5–24 h after carrageenan (Sigma, München) administration in rats (100–150 g, female)

Carrageenan [mg kg^{-1}]	Thrombosis frequency [h]				
	0.5	1	3	5	24
λ-c, 2.0 i.v.	0/10	0/10	0/10	0/10	0/10
λ-c 10.0 i.v.	0/10	0/10	0/10	0/10	0/10
κ-c 0.44 i.v.	2/10	2/10	2/10	2/10	2/10
κ-c, 0.88 i.v.	4/10	4/10	4/10	4/10	4/10
κ-c, 1.76 i.v.	8/10	8/01	8/10	8/10	8/10
ι-c, 4.0 i.v.	0/10	1/10	1/10	1/10	1/10
ι-c, 6.0 i.v.	0/10	0/10	0/10	0/10	0/10
ι-c, 8.0 i.v.	10/14	10/14	6/14	6/14	2/ 9[e]
ι-c, 12.0 i.v.	5/10	5/10	4/10	3/10	0/10
during 3 days 100 mg kg^{-1} daily p.o.:					
κ-c, in water	0/5	0/5	0/5	0/5	0/5
κ-c, in ethanol[a]	0/5	0/5	0/5	0/5	0/5
κ-c, in glycerol[b]	0/5	0/5	0/5	0/5	0/5
κ-c, in Fit®[c]	0/5	0/5	0/5	0/5	0/5
κ-c, in water + indometh.[d]	0/5	0/5	0/5	0/5	0/5

[a] 1 ml 70% per animal
[b] 1 ml undiluted per animal
[c] 0,5 ml Fit® (mixture of alkylaryl- and alkylsulfonates, undiluted, VEB Leuna-Werke W. Ulbricht) per animal
[d] 2 mg kg^{-1} daily
[e] 5 of 14 rats died several h after injection

Table 2. Thrombosis frequency (animals with tail thrombosis to number of animals per group) in κ-carrageenan-pretreated (50 mg kg^{-1} κ-carrageenan p.o. daily during 3 days) rats (95–115 g, female) and mice (23–29 g, female) after i.v. injection of 0.1 (rats) and 1.0 (mice) mg kg^{-1} κ-carrageenan

Species	Thrombosis frequency [h]				
	0.5	1	3	5	24
Rats					
control	1/10[a]	2/10[a]	2/10[a]	0/10	0/10
κ-c-pretreated	1/ 6[a]	2/ 6[a]	2/ 6[a]	2/ 6[a]	0/ 6
Mice					
control	1/5[a]	0/5	0/5	0/5	1/5[a]
κ-c-pretreated	1/5[a]	1/5	1/5	1/5	1/5[a]

[a] tip of the tail, only

i.m. and s.c. administration [3]. With regard to its high thrombogenic efficacy and its use as a food additive, in drug formulation etc., we investigated whether κ-carrageenan can induce thrombosis and infarction of the tail in rats by oral administration, too.

According to Table 1, no tail infarction occurred after p.o. κ-carrageenan despite doses as high as 100 mg kg^{-1}. No tail infarction was found even if κ-carrageenan was orally administered together with tissue irritating or mucosa damaging and gastric ulcer producing substances like ethanol, glycerol, Fit® (tenside) or indomethacin (Table 1).

In order to disclose subthrombogenic effects of oral κ-carrageenan it was first given orally in rats and mice at a dose of 50 mg kg^{-1} daily for 3 days, and then κ-carrageenan was injected i.v. A relatively low i.v. dose was administered in order to detect a possibly subthrombogenic effect of the oral pretreatment. According to Table 2, no difference between unpretreated and pretreated animal groups could be found, obviously indicating that there is no subthrombogenic effect induced by oral κ-carrageenan.

Our results confirm that carrageenans are practically not absorbed by the intestine. After supplementation by 2–20% carrageenan of the diet in young rats, 90–100% and 68–88% were found in the faeces of κ- and ι-carrageenan, respectively. The recovery rate of partly degraded ι-carrageenan was 82–95% [5]. No metachromasia was found in the urine of adult baboons after p.o. 240 mg kg^{-1} of partly degraded ι-carrageenan, apparently indicating no or poor absorption of this carrageenan [4, 5]. In any case, absorption rate of carrageenan is obviously too low to induce tail infarction or subthrombogenic effects in our investigations.

In conclusion, our experiments give no support to the theory that carrageenans should not be used as food additives, as laxatives, in the treatment of gastric ulcers and in oral drug formulations. Nevertheless, it seems worth testing the influence of oral carrageenans on the coagulation system, blood vessel alterations etc., in long-term feeding experiments. However, the use of κ- and ι-carrageenans in sustained-release drug injections and the like must be admonished against, unless proof can be afforded that carrageenans are not thrombogenic in man.

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