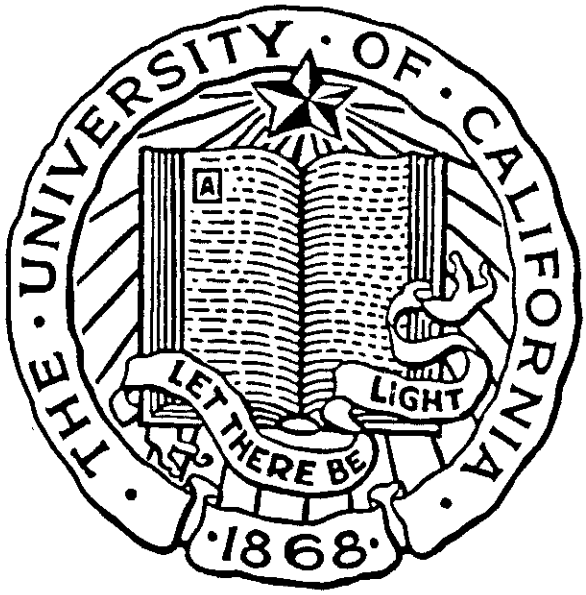
Third Annual Meeting

International Society of Chemical Ecology



University of California, Berkeley
Cheney Hall
June 21 – 24, 1986

Third Annual Meeting

International Society of Chemical Ecology

Cheney Hall - Unit 1, Residence Hall

2650 Durant Avenue

University of California, Berkeley

June 21-24, 1986

Daily Schedule
Third Annual Meeting
International Society of Chemical Ecology
Cheney Hall - Unit 1, Residence Hall
2650 Durant Avenue
University of California, Berkeley
June 21-24, 1986

Day & Date	Time	Event	Location
Sat. June 21	1:00-6:00	Registration	Cheney Hall
	5:30-8:30	Mixer	Cheney Hall
Sun. June 22	7:15-8:30	Breakfast	Cheney Hall
	8:30-9:45	Society Business	Univ. Art Museum Theater (UAMT)
	9:45-10:10	Break	UAMT
	10:10-11:45	Invited Papers	UAMT
	11:45-1:00	Lunch	Cheney Hall
	1:00-2:30	Invited Papers	UAMT
	2:30-3:00	Break	Cheney Hall
	3:00-5:00	Contributed Papers	Cheney Hall
	7:30-9:30	Poster Session	Cheney Hall
Mon. June 23	7:15-8:30	Breakfast	Cheney Hall
	8:30-10:05	Invited Papers	UAMT
	10:05-10:30	Break	UAMT
	10:30-12:00	Invited Papers	UAMT
	12:00-1:25	Lunch	Cheney Hall
	1:25-3:30	Invited Papers	UAMT
	3:30-3:45	Break	Cheney Hall
	3:45-4:45	Contributed Papers	Cheney Hall
	4:45-6:00	Free	
	6:00-7:30	Host's Reception	Plaza Dining Commons
	7:30-9:00	Banquet	Plaza Dining Commons
	9:00-9:15	Presentations	Plaza Dining Commons
	9:15-10:00	Lecture	Plaza Dining Commons
Tues. June 24	7:15-8:30	Breakfast	Cheney Hall
	8:30-10:05	Invited Papers	UAMT
	10:05-10:30	Break	UAMT
	10:30-11:30	Invited Papers	UAMT
	11:30-1:00	Lunch	Cheney Hall
	1:00-2:00	Contributed Papers	Cheney Hall
	2:00	Meeting Adjourns	

Sunday, June 22 — INVITED PAPERS - University Art Museum Theater

ECOLOGICAL CHEMISTRY: FROM SPONGES TO MAMMALS

Moderator: MURRAY S. BLUM, University of Georgia

5 min.	10:10-10:15	Introduction		Page No.
30 min.	10:15-10:45	DAVID JONES University of Hull England	GENETICS OF HERBIVORY	23
30 min.	10:45-11:15	FRANKLIN H. BRONSON University of Texas	CHEMICAL ECOLOGY OF RODENTS	
30 min.	11:15-11:45	SHOZO TAKAHASHI Kyoto University Japan	CHEMICAL ECOLOGY OF HOST LOCATION BY PARASITOIDS	36
	11:45-1:00	Lunch		
30 min.	1:00-1:30	HENRY M. FALES Lab. of Chemistry National Institutes of Health	CHEMICAL ECOLOGY OF SOCIAL INSECTS	
30 min.	1:30-2:00	REMY BROSSUT Universite of Dijon France	CHEMICAL ECOLOGY OF COCKROACHES	
30 min.	2:00-2:30	DALOZE DESIRE Universite Libre de Bruxelles, Belgium	CHEMICAL ECOLOGY OF SPONGES	
30 min.	2:30-3:00	Break		

CONTRIBUTED PAPERS - Cheney Hall

Session Leader A: MARGOT J. GRISWOLD
Session Leader B: MICHAEL RYAN

12 min.	3:00-3:12	A*	JAMES B. ANDERSON Univ. of Florida	THE CHEMICAL BASIS FOR A CIRCADIAN CYCLE OF FREEZE-RESISTANCE IN MONARCH BUTTERFLIES OVERWINTERING IN MEXICO	12
		B*	SARAH Y. H. LIN Univ. of California Riverside	ACTIVITY OF VOLATILE COMPOUNDS IN GLANDULAR TRICHOMES OF LYCOPERSICON SPECIES AGAINST TWO INSECT HERBIVORES	24

*Rooms in Cheney Hall: A = Main Lounge; B = Freeborn

12 min. 3:12-3:24	A	JOHN I. GLENDINNING Univ. of Florida	MICE AVOID THE CARDENOLIDE DEFENSE OF OVERWINTERING MONARCH BUTTERFLIES IN MEXICO	19
	B	KAORU NIKI Univ. of California Berkeley	LOCATION OF 22-ACYLESTER TRANSFERASE of 20-HYDROXYECDYSONE IN *HELIOTHIS VIRESCENS*	31
12 min. 3:24-3:36	A	JOHN H. BORDEN Simon Fraser Univ. Canada	RESPONSE OF THE MOUNTAIN PINE BEETLE TO FIVE SEMIOCHEMICALS	13
	B	J. J. NEAL Univ. of Illinois	IDENTIFICATION OF PLANT PRODUCED SYNERGISTS OF INSECTICIDAL COMPOUNDS USING ENZYME INHIBITION ASSAYS	30
12 min. 3:36-3:48	A	GERALD N. LANIER State University of New York	GENETIC CONTROL OF SEMIO-CHEMICAL SYSTEMS IN *IPS* BARK BEETLES (COLEOPTERA: SCOLYTIDAE)	24
	B	DAVID E. LINCOLN University of South Carolina	THE EFFECT OF CARBON RESOURCE LEVEL ON ALLOCATION TO SECONDARY CHEMICALS	25
12 min. 3:48-4:00	A	PETER R. WHITE Oxford University England	HOW DO BORING MALES FIND THE RIGHT MATE?: SEX PHEROMONES OF ANOBIID BEETLES	39
	B	MICHAEL F. RYAN University College Dublin, Ireland	A NEW THEORY OF PHEROMONE EVOLUTION	33
12 min. 4:00-4:12	A	J. KENNETH GRACE Univ. of California Berkeley	CONCENTRATION-DEPENDENT RESPONSES OF *RETICULITERMES HESPERUS* TO TERMITE TRAIL PHEROMONE	20
	B	SHERRI L. SANDBERG Univ. of Illinois	*HYPERICUM PERFORATUM* (HYPERICACEAE OR GUTTIFERAE) AND ITS LEAF TIER *PLATYNOTA FLAVEDANA* (LEPIDOPTERA: TORTRICIDAE)	34

Sunday, June 22 CONTRIBUTED PAPERS (Cont'd) Page No.

12 min. 4:12-4:24	A	JEAN-LUC CLEMENT Université Pierre et Marie Curie, France	ANTS' PYRROLIDINES IN THE GENUS MONOMORIUM: INSECTICID ACTION AND MOLECULAR TARGUET	16
	B	CHARLES T. ROBBINS Washington State University	THE INTERACTION OF RUMINANTS WITH PLANT TANNINS	33
12 min. 4:24-4:36	A	DOUGLAS R. CRUMP DSIR Petone New Zealand	TRAIL FOLLOWING CHEMICALS FOR THE EASTERN TENT CATERPILLAR	17
	B	CHARLES MIHALIAK University of South Carolina	ACCUMULATION OF VOLATILE LEAF TERPENES UNDER NITRATE-LIMITING CONDITIONS PROVIDES GREATER DEFENSE AGAINST A GENERALIST HERBIVORE	28
12 min. 4:36-4:48	A	ROBERT T. MASON Univ. of Texas	PHEROMONAL PROPERTIES OF SKIN LIPIDS IN GARTER SNAKES	26
	B	CHARLES S. WISDOM Univ. of California Los Angeles	ECOLOGICAL TANNIN ASSAYS: EVALUATION OF PROANTHOCYANIDINS, PROTEIN BINDING ASSAYS AND PROTEIN PRECIPITATING POTENTIAL	40
12 min. 4:48-5:00	A	JOCELYN G. MILLAR Plant Biotechnology Institute, Canada	SEX PHEROMONES OF THE GEOMETRIDAE: AN OVERVIEW	29

POSTERS - Cheney Hall

7:30-9:30	JEFFREY R. ALDRICH USDA-ARS, Agric. Res. Ctr.-East	SEMIOCHEMISTRY OF PREDACEOUS STINK BUGS (HEMIPTERA: ASOPINAE)	11
	YUKIHIRO ASAKA Univ. of California Berkeley	INSECT GROWTH INHIBITORS FROM CROTON CAJUCARA	12
	JUDITH M. BRADOW USDA-ARS, Southern Reg. Res. Ctr.	SEED GERMINATION INHIBITION BY VOLATILES FROM AMARANTHUS RESIDUES	14
	JANICE C. CAVIN Univ. of California Irvine	EFFECTS OF SIMPLE BETA CARBOLINE ALKALOIDS ON THE GROWTH OF SPODOPTERA EXIGUA (HUBNER)	16

Monday, June 23 — INVITED PAPERS - University Art Museum

CHEMICAL ECOLOGY - FRONTIERS AND THE FUTURE

Moderator: David L. Wood, University of California, Berkeley

5 min. 8:30-8:35	Introduction		
30 min. 8:35-9:05	JAMES H. CANE Auburn University	EVOLUTION OF HOST AND CONSPECIFIC DISCRIMINATION IN BARK BEETLES	15
30 min. 9:05-9:35	KENNETH E. GLANDER Duke University	THE IMPACT OF PLANT PRODUCED CHEMICALS ON HOWLING MONKEY FEEDING BEHAVIOR	19
30 min. 9:35-10:05	ANA LOUISA ANAYA Universidad Nacional Autonoma de Mexico	FUTURE PERSPECTIVES OF STUDIES ON ALLELOPATHY IN MEXICAN TRADITIONAL AGROECOSYSTEMS	11
25 min. 10:05-10:30	Break		
30 min. 10:30-11:00	WILHELM BOLAND Institute fur Biochemie, Koln Federal Republic of Germany	CHEMICAL COMMUNICATION IN MARINE BROWN ALGAE: PHEROMONES AND THEIR BIOGENETIC INTERRELATIONS	13
30 min. 11:00-11:30	PATRICIA BERGER University of Utah	AVIAN REPRODUCTIVE RESPONSES TO ENVIRONMENTAL CUES	
30 min. 11:30-12:00	SVATA LOUDA Univ. of Nebraska	CONTRIBUTION AND LIMITATION OF CHEMICAL VARIATION AS A MEDIATING MECHANISM FOR IMPACT ON NATIVE PLANT POPULATIONS	
12:00-1:25	Lunch		

CURRENT TOPICS IN SEMIOCHEMISTRY

University Art Museum

Moderator: Isao Kubo, University of California, Berkeley

5 min. 1:25-1:30	Introduction		
30 min. 1:30-2:00	GERRIT DE BOER Univ. of California Berkeley	ROLE OF PHYTOECDYSTEROIDS IN INSECT-PLANT INTERACTIONS	17

Monday, June 23 INVITED PAPERS (Cont'd)

				Page No.
30 min.	2:00-2:30		YOKO NAYA Suntory Institute Osaka, Japan	CHEMICAL IDENTITY OF SYNOMONES OR SYMBIOSIS-INDUCING COMPOUNDS BETWEEN SEA ANEMONE AND ANEMONEFISH	29
30 min.	2:30-3:00		D. P. RICHARDSON Cornell University	DEFENSIVE AGENTS FROM ASIAN TREE RESINS	32
30 min.	3:00-3:30		DAVID LYNN Univ. of Chicago	PLANT-PLANT INTERACTIONS	25
15 min.	3:30-3:45		Break		

CONTRIBUTED PAPERS - Cheney Hall

Session Leader A: ADAM MESSER
Session Leader B: JEFFREY R. ALDRICH

12 min.	3:45-3:57	A	LINCOLN P. BROWER Univ. of Florida	BIOGEOGRAPHICAL INVESTIGATION OF THE MIGRATION OF THE MONARCH BUTTERFLY THROUGH CARDENOLIDE CHROMATOGRAPHY	14
		B	TETSUO IWAGAWA Univ. of California Berkeley	ANALYTICAL AND PREPARATIVE SEPARATION OF BARK BEETLE PHEROMONES BY HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY	22
12 min.	3:57-4:09	A	DAVID SCOTT Indiana University	SEXUAL MIMICRY REGULATES THE POST-MATING ATTRACTIVENESS OF DROSOPHILA MELANOGASTER FEMALES	35
		B	ARNON SHANI Ben-Gurion Univ. of the Negev Israel	CHEMICAL PROTECTION OF PHEROMONES, CONTAINING CONJUGATED DIENE SYSTEM, FROM CHEMODEGRADATION (ISOMERIZATION AND OXIDATION)	36
12 min.	4:09-4:21	A	KENNETH S. HAGEN Univ. of California Berkeley	SYNOMONE WANING WITH PLANT AGE PRECLUDES LACEWINGS' ATTRACTION TO PREY KAIROMONE	21
		B	DONALD J. GERHART Univ. of Hawaii	CHEMICAL ECOLOGY ON CORAL REEFS: PROSTAGLANDINS IN THE OCTOCORAL PLEXAURA HOMOMALLA	18

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12 min. 4:21-4:33	A	FREDERICK J. HANKE Univ. of California Berkeley	CALIZONAMINE, A NEW NITROGEN CONTAINING TERPENOID FROM THE MILLIPEDE CALIZONIA SP.	21
	B	NANCY M. TARGETT Univ. of Delaware	SECONDARY METABOLITES AS NATURAL ANTIFOULING AGENTS IN GORGONIAN CORALS	37
12 min. 4:33-4:45	A	PHILLIP G. McDOWELL Internatl. Centre of Insect, Kenya	HALOGENATED PHENOLS IN ADULT AND NYMPHAL STAGES OF THE TICK RHIPICEPHALUS APPENDICULATUS	27
	B	E. EVAN WARD Univ. of Delaware	EXTERNAL METABOLITES FROM A BLOOM CAUSING MARINE DIATOM: DELETERIOUS EFFECTS ON MUSSEL FILTRATION RATES	38

Tuesday, June 24 INVITED PAPERS - University Art Museum Theater

DEFENSIVE STRATEGIES AGAINST TANNINS

Moderator: Larry Butler, Purdue University

5 min. 8:30-8:35	Introduction		
30 min. 8:35-9:05	MICHAEL M. MARTIN Univ. of Michigan	ARE TANNINS DIGESTIBILITY-REDUCING-SUBSTANCES, TOXINS, OR FEEDING DETERRENTS FOR INSECTS	26
30 min. 9:05-9:35	RICHARD LINDROTH Univ. of Wisconsin	THE ROLES OF PLANT TANNINS IN NUTRITIONAL ECOLOGY OF SMALL MAMMALS	25
30 min. 9:35-10:05	DON M. CARLSON Univ. of California Davis	SALIVARY PROLINE-RICH TANNIN-BINDING PROTEINS	15
25 min. 10:05-10:30	Break		
30 min. 10:30-11:00	CHARLES T. ROBBINS Washington State University	THE INTERACTION OF RUMINANTS WITH PLANT TANNINS	33
30 min. 11:00-11:30	RALPH L. NICHOLSON Purdue University	PROTECTION OF FUNGI FROM TOXIC PHENOLS IN THE ENVIRONMENT: A ROLE FOR GLYCOPROTEIN MUCILAGES	30
11:30-1:00	Lunch		

Tuesday, June 24 — CONTRIBUTED PAPERS - Cheney Hall

Session Leader A: STEPHEN A. TEALE
Session Leader B: JUDITH M. BRADOW

12 min. 1:00-1:12	A	DAN RITTSCHOF Duke University	DETECTION OF VOLATILE CHEMICALS BY SUPRALITTORAL CRABS	32
	B	JEFF D. WEIDENHAMER Univ. S. Florida	SOLUTION VOLUME AND SEED NUMBER: OVERLOOKED FACTORS IN ALLELOPATHIC BIOASSAYS	39
12 min. 1:12-1:24	A	KATHE R. JENSEN Zoological Museum Copenhagen, Denmark	CHEMORECEPTION OF FOOD ATTRACTANTS IN ASCOGLOSSAN OPISTHOBRANCHS	23
	B	KELSEY R. DOWNUM Florida Internatl. University	ENDOGENOUS ANTIMICROBIAL AGENTS OF CITRUS AND RELATED RUTACEAE	18
12 min. 1:24-1:36	A	JUSTIN O. SCHMIDT Carl Hayden Bee Res. Ctr., Tucson, AZ	MANDIBULAR GLAND CHEMISTRY OF THE BEEWOLF, PHILANTHUS TRIANGULUM	35
	B	RALPH L. NICHOLSON Purdue University	PROTECTION OF FUNGI FROM TOXIC PHENOLS IN THE ENVIRONMENT: A ROLE FOR GLYCOLPROTEIN MUCILAGES	30
12 min. 1:36-1:48	A	MARTIN S. OBIN Univ. of Florida	DIETARY EFFECTS ON NESTMATE RECOGNITION CUES IN THE FIRE ANT SOLENOPSIS INVICTA BUREN (FORMICIDAE:MYRMICINAE)	31
12 min. 1:48-2:00	A	ABRAHAM HEFETZ Tel Aviv University Israel	IS NESTMATE RECOGNITION IN EVYLAEUS MALACHURUM BASED ON INDIVIDUALITY OR NEST ACQUIRED ODOURS?	22
2:00		Meeting Adjourns		

SEMIOCHEMISTRY OF PREDACEOUS STINK BUGS (HEMIPTERA: ASOPINAE).

J. R. Aldrich, USDA-ARS, Agricultural Research Center-East, B-467, Beltsville, MD. 20705

Males in the pentatomid genus Podisus possess hypertrophied dorsal abdominal glands (DAG) which produce blends of previously known volatile compounds. Flying males and females of 2 sympatric species are highly attracted to (E)-2-hexenal with either (+)-α-terpineol (P. maculiventris) or (+)-linalool (P. fretus) (1:1, v:v). A complex of parasitoids and certain yellowjacket species are also attracted to these blends. In the nearctic asopines, Perillus bioculatus, Stiretrus anchorago and Mineus strigipes, and the neotropical asopines, Oplomus severus and O. dichrous, the DAG are not sexually dimorphic but males possess conspicuous sternal glands (SG) that are absent in females. Except for O. dichrous, males of each of these species produce predominantly a single compound; 6,10,13-trimethyltetradecyl isovalerate in the allopatric species P. bioculatus, O. severus and M. strigipes, and 6,10,13-trimethyltetradecanol in S. anchorago, a species sympatric with P. bioculatus. O. dichrous appears to be parapatric with P. bioculatus to the north and O. severus to the south, and males of this species release both the alcohol and the ester from their SG. In addition to the male-specific DAG or SG secretions, adults of all these stink bug species possess monomorphic metathoracic glands responsible for the noxious odors characteristic of true bugs.

FUTURE PERSPECTIVES OF STUDIES ON ALLELOPATHY IN MEXICAN TRADITIONAL AGROECOSYSTEMS.

Anaya, A. L., L. Ramos, R. Cruz, J. Hernańdez and V. Nava. Instituto de Fisiología Celular, UNAM. Apdo. Postal 70-600, 04510 Mexico, D. F.

Agroecosystems in Tlaxcala, Mexico, are surrounded by water channels and have a great variety of cultivated and noncultivated plants. The main results of a study carried out on a traditional agroecosystem in Santa Inex, Tlaxcala, are presented. Some ecological aspects of polycultures, plant covers (dry leaves of Alnus firmifolia, Berula erecta and Juncus sp.), and the allelopathic potential of crops and noncultivated plants (fresh and dry material) were analyzed. The main plants (trees, shrubs and herbs) present in the agroecosystem were identified. The total number of weeds in plots where plant covers were added, was reduced. The number of nodules of Rhizobium phaseoli increased with Alnus cover. Corn, beans, and squash showed a clear allelopathic effect, as well as Chenopodium murale, Tradescantia crassifolia, Melilotus indicus, and Amaranthus hybridus, among other weeds. The contribution of allelopathy in the studies of traditional agroecosystems, is of great importance for the management of species in space and time. Allelopathy can be the basis of biological control of pests and weeds, and of the discovery of new useful substances.

CHEMICAL COMMUNICATION IN MARINE BROWN ALGAE: PHEROMONES AND THEIR BIOGENETIC INTERRELATIONS

Wilhelm Boland, Institut fur Biochemie, D-5000 Cologne, FRG

Female gametes of many marine brown algae secrete highly volatine C_8H_{12} or $C_{11}H_n$ (n=14,16,18) hydrocarbons into the outer environment to lure their conspecific male gametes. Most of these pheromones are unbranched linear or alicyclic hydrocarbons lacking additional functional groups. Besides marine brown algae, the same componds are also found in terrestrial plants. Senecio isatideus (Compositae) is particularly noteworthy because of its high production of several different $C_{11}H_{16}$ hydro- carbons. This enabled us to clarify the pheromone biosynthesis in a continuously available model system.

According to chain length and double bond positions these molecules derive from α-linolenic or linoleic acid after three ß-oxidation cycles. A single hydrogen from C(5) or C(8) of the resulting dodeca-3,6,(9)-polyenoic acids is enzymatically split off and induces a simultaneous fragmentation into the hydrocarbons and carbon dioxide.

The same mechanism is working in the biosynthesis of a number of long chain 1-alkenes from fatty acid precursors. The steriochemical aspects of this new metabolic pathway and its possible significance for the biosynthesis of other classes of natural products will be discussed.

RESPONSE OF THE MOUNTAIN PINE BEETLE TO FIVE SEMIOCHEMICALS

J. H. Borden, Simon Fraser U., Burnaby, B.C., Canada V5A 1S6

In British Columbia lodgepole pine forests, Dendroctonus ponderosae responded positively to (-)-trans-verbenol in multiple funnel traps. (±)-exo-Brevicomin and (±)-frontalin were multifunctional, being attractive at low release rates and antiattractive at high release rates, exo-brevicomin to males and frontalin to females. Verbenone had an antiaggregative effect. Increasing the release rate of the synergist, myrcene, 8-fold doubled the response. A conceptual model outlines 5 phases of mass attack mediated by these semiochemicals and describes the roles of autoxidation and microorganisms in their production.

EVOLUTION OF HOST AND CONSPECIFIC DISCRIMINATION IN BARK BEETLES

J. H. Cane, Auburn University, Auburn, AL. 36849

Sibling species within Hopping's Group IX of Ips bark beetles today share narrow zones of sympatry along altitudinal ecotones where their host pines have been intermixed for at least the last 18,000 years. Species identities in these regions are taxonomically discernable by minor morphometric and electrophoretic differences, and are biologically enforced by post-mating developmental incompatibilities. Chemical and perhaps acoustical premating host and species discrimination mechanisms among these sympatric pairs of sibling Ips are incompletely evolved. Further, these characters are unevenly possessed by the interacting populations. In other words, the various combinations of pheromone, host volatiles, and/or phloem flavors are sufficient to permit some individuals/sexes/species of these Ips to adequately discern conspecifics and hosts, but not others. These pre-/post-mating barriers are being organized onto a phylogenetic framework to yield hypotheses regarding the order of evolution of divergences in pheromonal attributes, host specialization, and the behavioral capacities for pheromone and host chemical recognition.

SALIVARY PROLINE-RICH TANNIN-BINDING PROTEINS.

D. M. Carlson, D. K. Ann, H. Mehansho, T. Asquith and L. Butler, University of California, Davis, Davis, CA. 95616 and Purdue University, West Lafayette, IN. 47907

Salivary glands of various animals synthesize or can be induced to synthesize a unique group of proteins which are unusually high in proline, the so-called proline-rich proteins (PRPs). These proteins contain 25 to 45 mol % proline and collectively constitute the largest group of proteins inhuman salivary secretions making up more than 70% of the secreted proteins. PRPs fall into acidic and basic groups, and may be phosphorylated or glycosylated, or both. These unusual proteins are presumably constitutive in human saliva, but families of similar proteins are dramatically increased or induced in salivary glands of rats, mice and hamsters by isoproterenol treatment. Recently we presented evidence that a primary role of PRPs in saliva is to bind polyphenolic compounds such as tannins, and that feeding tannins mimics the effect of isoproterenol. The synthesis of PRPs in response to feeding tannins has a pronounced beneficial effect with rats and mice. Hamsters do not respond similarly, however, and tannins fed to these animals cause an unusual growth inhibition and can be highly toxic.

TRAIL FOLLOWING CHEMICALS FOR THE EASTERN TENT CATERPILLAR MALACOSOMA AMERICANUM

D. R. Crump, DSIR Petone, New Zealand, T. D. Fitzgerald, SUNY, Cortland, NY. 13045, and R. M. Silverstein, SUNY, Syracuse, NY. 13210

5ß-Cholestane-3,2 4-dione has been identified as an active component of the trail of the eastern tent caterpillar. Several related compounds are also active.

PLANT PHENOLIC ACIDS IN SOILS: A COMPARISON OF EXTRACTION PROCEDURES

B. R. Dalton, Savannah River Ecology Laboratory, Aiken, SC. 29801

Various extraction procedures were employed in the recovery of ferulic acid (4-hydroxy-3-methoxycinnamic acid), a common allelopathic compound, from soil materials sampled from the A_1 and B_1 horizons of a Cecil soil (clayey, kaolinitic, thermic Typic Hapludults) and a Portsmouth soil (fine loamy, mixed, thermic Typic Umbraquualts). Ferulic acid was added (1000ug/g) to different sterilized soil materials, varying in mineralogy and organic matter content, and allowed to equilibrate for 90 days. The ferulic acid was then extracted from the soil materials using procedures that have been previously employed in the recovery of water soluble simple phenolic acids from soil. Concentrations of extracted ferulic acid were determined by HPLC. The amount of ferulic acid recovered from the A_1 horizons were significantly different from the amounts recovered from the B_1 horizons for both Cecil and Portsmouth soil materials. Water and CH_3OH recovered the least amounts of ferulic acid while NaOH and high concentrations (0.5M) of DTPA recovered the most, depending on the extracting time. In the B_1 horizons a major portion of the ferulic acid anions appear to be adsorbed by polyvalent cations (either exchangeable or non-exchangeable). The behavior and extraction of phenolic acids in soil environments are discussed.

ROLE OF PHYTOECDYSTEROIDS IN INSECT-PLANT INTERACTIONS

Gerrit de Boer, Yiukihiro Asaka, Sakae Komatsu and Isao Kubo, University of California, Berkeley, CA. 94720

Ingestion of phytoecdysteroids resulted in inhibition of the moulting process of several insects. The activity varied with the ecdysteroids and the insect species tested. Ponasterone A was more active than the natural moulting hormone, 20 hydroxyedcysterone (20-HE), and much more active than ajugalactone against pink bollworm, Pectinophora gossypiella. The pink bollworm and the fall armyworm, Spodoptera frugiperda, are susceptible to phytoecdysteroids concentrations well below those found in many plant species. However, larvae of the tobacco budworm, Heliothis virecens, were not affected even by high concentrations of 20-HE in their diet. These insects converted the ingested phytoecdysteroid to presumably inactive 22-acyl esters. Thus, the present data show that phytoecdysteroids may serve a protective function in plants to some herbivorous insect species.

THE IMPACT OF PLANT PRODUCED CHEMICALS ON HOWLING MONKEY FEEDING BEHAVIOR

Kenneth E. Glander, Duke University, Durham, NC. 27706

Howling monkeys (Alouatta palliata) feed very selectively both within and between tree species. They avoid mature leaves from the commonest tree species. In fact, feeding time is negatively correlated with tree abundance (r_s=-2.87, n=62, $p<.05$). The howlers obtained 79% of their food from only 5.2% of the available trees. The influence of plant produced chemicals on howler food choice was investigated by chemically analyzing plant material. Samples of both food and nonfood items were tested for alkaloids, phenolics, tannins, amino acids, fiber, and ash. Chemically the leaves the howlers ate were very different from those they did not eat, yet those leaves were from the same tree species and in some cases from adjacent trees of the same species. The howlers did not eat leaves with condensed tannin, low total protein, and unbalanced amino acids. The leaves they ate were significantly (1) lower in fiber, (2) higher in all amino acids except isoleucine, and (3) higher in total protein.

MICE AVOID THE CARDENOLIDE DEFENSE OF OVERWINTERING MONARCH BUTTERFLIES IN MEXICO

John I. Glendinning, Zoology Dept., U. of Florida, Gainesville, FL.

Enormous aggregations of overwintering monarch butterflies (Danaus plexippus) are rich potential food resources for mammalian predators. Utilization of monarch aggregations as food, however, was hypothesized to be limited by cardenolides and pyrrolizidine alkaloids (PAs) stored in the bodies of many adult monarchs. Trapping studies revealed that 3 rodent species (Peromyscus aztecus, Reithrodontomys sumichrasti, and Microtus mexicanus) were extremely rare underneath one monarch colony (colony A), but abundant in nearby areas. In contrast, P. melanotis was substantially more abundant and reproductively active in areas underneath colony A than in nearby areas. Stomach content analyses and feeding experiments showed that P. melanotis preys heavily on overwintering monarchs and that they feed preferentially on low cardenolide monarchs and monarch body parts. The same degree of feeding selectivity was not observed for P. aztecus and M. mexicanus. The ability of P. melanotis to avoid the monarch's cardenolide defense, and possibly the monarch's PA defense as well, may be a crucial factor enabling it to capitalize on this superabundant food resource.

HERBIVORY IN THREE DESERT SHRUBS

M. J. Griswold, H. Stuppner, E. Rodriguez, U.C. Irvine, Irvine, CA. 92717

Organic extracts from Viscainoa geniculata (Zygophyllaceae), a dominant shrub in central Baja California, were tested for antifeedant and insecticidal activity against a generalist insect herbivore. Feeding tests demonstrated significantly increased mortality, reduced growth and extended developmental time of the insect as compared to controls. Comparisons of herbivory and chemical defenses in three desert shrubs, V. geniculata, Larrea tridentata and Simmondsia chinesis, as well as future research plans are presented.

SYNOMONE WANING WITH PLANT AGE PRECLUDES LACEWINGS' ATTRACTION TO PREY KAIROMONE

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Chrysoperla carnea (Stephens) adults have to receive a volatile signal (synomone), i.e., caryophyllene in order to respond to the kairomone (tryptophan breakdown product) which in turn signals presence of prey (honeydew). The requirement of simultaneous reception of two volatiles may explain why the attraction of the lacewings to artificial honeydews applied in the field varies with the phenology of crop plants.

CALIZONAMINE, A NEW NITROGEN CONTAINING TERPENOID FROM THE MILLIPEDE CALIZONIA SP.

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Species of arthropods are known to produce a great diversity of chemical secretions. These secretions are believed to serve a number of purposes, such as in defense. We recently examined the secretion, that is emitted upon physical disturbance, of a presently unnamed species of millipede of the genus Calizonia (order Polyzoniida). This secretion was found to consist of 2 common monoterpenes and a third compound containing nitrogen and consisting of a previously unknown carbon skeleton. We suspect this secretion is used defensively by the millipede. The chemistry of this secretion is unlike that from any previously examined species of millipede.

CHEMORECEPTION OF FOOD ATTRACTANTS IN ASCOGLOSSAN OPISTHOBRANCHS.
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Behavioral responses to homogenates of food and non-food plants were tested in 6 species of Florida Ascoglossa (Mollusca: Opisthobranchia), Oxynoe azuropunctata, Elysia evelinae, E. papillosa, E. subornata (= E. cauze), E. tuca, and Ercolania fuscata. All species showed positive responses towards homogenates of their food plants. The species having the widest food spectra also showed positive responses towards the widest array of homogenates. The position of Caulerpa spp. (Chlorophyta: Caulerpales) as the "ancestral" ascoglossan food was reflected by the fact that all ascoglossans tested showed a positive response towards at least one species of Caulerpa, whether Caulerpa spp. are included in their diets or not. For species with relatively wide food spectra the responses towards preferred food were significantly more positive than the responses towards less-preferred food and non-food. No correlation was found between positive responses and protein content of plant homogenates. The plant homogenates were separated by gel-filtration into a fraction containing molecules heavier than approx. 3,500 daltons and a fraction containing molecules lighter than this. The responses of the ascoglossans towards these fractions were not statistically significant, partly because of the high dilution during gel-filtration, and partly because the ascoglossans showed a more positive response towards the eluant (0.1M NaCl) than towards full strength seawater.

GENETICS OF HERBIVORY.
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The use of genetical techniques for proving chemical defence by particular compounds will be demonstrated. Conversely, a spectacular example of chemical variation in plants will be shown to be almost independent of insect activity.

CLITOCINE, A NEW INSECTICIDAL NUCLEOSIDE FROM THE MUSHROOM CLITOCYBE INVERSA.
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Chemical investigation of pest insect control agents produced by mushrooms has led to the isolation of clitocine, a new nucleoside. This compound showed strong insect growth inhibitory activity against the pink bollworm Pectinophora gossypiella. The elucidation of structure of clitocine was greatly simplified by comparison of its spectral properties to adenosine which was isolated from the same source.

THE EFFECT OF CARBON RESOURCE LEVEL ON ALLOCATION TO SECONDARY CHEMICALS.
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The carbon supply of peppermint plants was manipulated by growing clonal propagules under three carbon dioxide regimes (350, 500 and 650 ppm), while providing equal amounts of light, nutrients and water. Leaf weight increased significantly with the increased carbon supply, but the amount of nitrogen per leaf did not change. The amount of volatile leaf mono- and sesquiterpenes which characterize peppermint increased proportionately with total leaf dry weight.

The coordination of increased secondary chemical production with a carbon-based increase in leaf weight suggests that, in peppermint, secondary chemical production is coupled to carbon resource level, but not independently of the synthesis of other leaf constituents.

Leaves were fed to fourth instar larvae of a laboratory strain of the noctuid moth, Spodoptera eridania. The feeding rate of larvae was increased by the high carbon/nitrogen ratio which results from carbon dioxide fertilization and was also increased by a high proportion of leaf volatile terpenoids.

ROLES OF PLANT TANNINS IN THE NUTRITIONAL ECOLOGY OF SMALL MAMMALS.
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Laboratory studies with artificial diets and fresh plants have shown that tannins can strongly reduce growth and survival of voles. Tannins exhibit feeding deterrent, toxic, and digestibility reducing effects, and the severity of the effects is influenced by the type and amount of tannins, other dietary constituents, and animal species. Condensed tannins in particular appear capable of disrupting digestion; Lespedeza tannins, for example, reduced protein digestibility by 50%. Field studies showed that plant tannins influence diet selection by voles and that changes in phenolic levels of preferred food plants alter vole growth rates, which in turn influence demographic parameters. Preliminary evidence suggests that small mammals utilize a combination of biochemical, physiological, and behavioral adaptations to reduce the negative consequences of ingesting plant tannins.

HOST-RECOGNITION IN PARASITIC ANGIOSPERMS: CHEMICAL REGULATION OF DISTANCE BETWEEN PLANTS
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Striga asiatica is one of the most devastating parasites of grain crops in the world. Host recognition in these parasitic plants, at the stage of germination, is triggered by chemical factors released by the host plant roots. We report here the identification of 2-hydroxy-5-methoxy-3-[8'Z,11'Z)-8',11',14'-pentadecatriene] hydroquinone as the first germination stimulant for Striga from a natural host. The germination stimulus was isolated in the quinone form, and its structure was established by 2D-NMR and selective decoupling experiments. An explanation for the role of the hydroquinone in the regulation of distance between host and parasite is provided.

ANALYSIS OF HOST ODOUR ATTRACTANTS FOR TSETSE FLIES

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Urine from the buffalo, Syncerus caffer, a natural host of the tsetse fly, is known to be potent olfactory attractant for tsetse flies in the field. Using Challier-Laveissiere biconical traps, catches of Glossina pallidipes can be increased by the order of ten-fold. The attractant compounds, which are extractable into dichloromethane, were separated into four fractions, one of which gave approximately a seven-fold increase in trap catches. Seven simple phenols were identified in this fraction by gas chromatography and gas chromatography-mass spectrometry, one of which, 3-n-propylphenol, appears to be important for field activity when tested against G. palldipes. The phenols have been shown to be breakdown products of polar precursors which act as a reservoir of the attractant compounds. This may serve as a promising model for a controlled release attractant system in the field.

HALOGENATED PHENOLS IN ADULTS AND NYMPHAL STAGES OF THE TICK RHIPICEPHALUS APPENDICULATUS

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Rhipicephalus appendiculatus is an important vector of Theileria parva in East Africa. Chemical studies revealed the presence of not only 2,6-dichlorophenol, but also other halogenated phenols including brominated phenols. 2-Bromo-6-chlorophenol has been detected in virgin females in quantities in the range 0.4-1.2 ng per female. Trace quantities of 2,6-dibromophenol have also been observed. This appears to be the first report of the presence of these compounds in ticks. The nymphal stage of the tick has also been analysed and found to contain both 2,6-dichlorophenol (1.5-2.1 ng/nymph) and 2-bromo-6-chlorophenol (.09-.13 ng/nymph). Single cell electrophysiological recordings from males indicated that 2-bromo-6-chlorophenol stimulates certain olfactory cells in a similar manner to 2,6-dichlorophenol. However, behavioural studies are in progress to elucidate the responses of males to these compounds. Preliminary behavioural data will be presented.

SEX PHEROMONES OF THE GEOMETRIDAE; AN OVERVIEW

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There have been sporadic reports of the identification of sex pheromones for geometrid moth species. We have been field screening a number of compounds as geometrid sex attractants for several years, with remarkable success. An interesting picture is developing of the diversity of compounds used as sex pheromones by this insect family. These compounds include dienes, trienes, and tetraenes, and oxygenated analogs thereof, such as racemic and chiral unsaturated epoxides, alcohols, and ketones. Examples of blends of these compounds as sex attractants will be given.

CHEMICAL IDENTITY OF SYNOMONES OR SYMBIOSIS-INDUCING COMPOUNDS BETWEEN SEA ANEMONE AND ANEMONEFISH

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The species-specific partnership in symbiosis between the sea anemone and anemonefish is a well-known phenomenon in many parts of the Indo-Pacific region. The chemicals secreted by the sea anemone to elicit symbiotic behavior of the fish have been studied for two host-guest pairs: Radianthus kuekenthali(sea anemone)/Anphiprion perideraion(anemonefish) and Stoichactis kenti/A. ocellaris. This has led to the isolation and characterization from R. kuekenthali of a new pyridinium compound amphikuemine which induces characteristic attracted swimming in A. perideraion. Several other chemicals which elicit characteristic symbiotic movements have also been characterized. These are the first chemicals to be identified as compounds involved in symbiosis between marine organismms. In addition, the synthetic specimens were demonstrated to exhibit the same biological activity.

LOCATION OF 22-ACYLESTER TRANSFERASE OF 20-HYDROXYECDYSONE IN HELIOTHIS VIRESCENS

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The tobacco budworm, Heliothis virescens, has resistance for many toxic chemicals which kill most other insects. We have investigated the detoxification mechanism of phytoecdysteroids in this insect. The insect molting hormone, 20-hydroxyecdysone, which is now identified in many plant species, plays one of the key roles in insect development. However, excess exogenous 20-hydroxyecdysone and other phytoecdysteroids ingested inhibit ecdysis of many insects. This indicates that plants may biosynthesize these phytoecdysteroids as defense substances against insect attack.

We have demonstrated that 22-acylesters of 20-hydroxyecdysone seem to be the major metabolites in frass of H. virescens. However, organs responsible for this esterification remain unclear. Recent experiments suggest that the gut is the organ which contains the 22-acylester transferase.

DIETARY EFFECTS ON NESTMATE RECOGNITION CUES IN THE FIRE ANT SOLENOPSIS INVICTA BUREN (FORMICIDAE:MYRMICINAE)

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Field and laboratory colonies were used to (1) induce aggression (recognition) between nestmates by maintaining them on different diets, and reduce aggression between non-nestmates by maintaining them on similar diets, (2) demonstrate no "queen effect" on worker-worker recognition, (3) document that foragers contacting novel food are attacked by nestmates during the early stages of recruitment and trail formation, (4) tentatively propose that colony conditioning to novel food occurs within 24 h of feeding, rendering previously-foraged items "novel", (5) demonstrate that species-specific hydrocarbons found in insect prey of fire ants are found in the cuticle and post-pharyngeal glands of workers after feeding. When the prey is the roach P. americana, post-pharyngeal glands of workers contain increased amounts of the major roach hydrocarbons, n-pentacosane and 3-methyl pentacosane, but none of the predominant roach hydrocarbon, 6,9-heptacosadiene. Interestingly, S. invicta worker post-pharyngeal glands contain some endogenous amounts of the two, former compounds, but none of the latter. These data are discussed with respect to bioassays of individual compounds, the ant's environmentally-labile recognition profile and the possible role of the post-pharyngeal gland in nestmate recognition.

THE INTERACTION OF RUMINANTS WITH PLANT TANNINS

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The understanding of diet selection and individual productivity by deer is dependent on knowledge of the defensive role of plant tannins. The effect of tannins in reducing plant proteins and cell wall digestibility and intake are being investigated. Digestible protein is significantly reduced in higher-tannins feeds, such as flowers and tree, shrub and forb leaves. The reduction in digestible protein is proportional to the protein-precipitating capacity of plant tannins. Diciduous browse stems have very low levels of protein-precipitating tannins and only a slight reduction in protein availability. Cell wall digestion in deer is not affected by soluble tannins. This observation is contrary to earlier reports for domestic sheep. We hypothesize that browsing deer produce proline-rich salivary proteins that bind plant tannins and prevent a reduction in cell wall digestion. Intake of high-tannin forages by deer is reduced 50 to 60% in comparison to low tannin feeds. We hypothesize that protein-precipitating tannins and absorbed, toxic phenolics act synergistically to defend some plants against ruminants.

A NEW THEORY OF PHEROMONE EVOLUTION

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The evolutionary origin of insect pheromones is unclear. Structural considerations specifically chain length and the presence and relative positions of carbonyl and adjacent hydrophobic groups in many pheromones suggest similarities, apparently hitherto unrecognized, with acetylcholine. Functional effects are consistent with this as fourteen of the fifteen pheromones investigated here inhibit acetylcholinesterase. This may provide a new perspective on pheromone evolution.

MANDIBULAR GLAND CHEMISTRY OF THE BEEWOLF, PHILANTHUS TRIANGULUM

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Male of Philanthus, beewolves, apply a marking pheromone to leaves and stems of plants within their territories. The marking pheromones are produced only in the mandibular glands of males. In North American Philanthus, the marking pheromones consist of blends of C_{13}-C_{19} ketones, fatty acids, aldehydes, and ethyl esters of fatty acids (Schmidt et al. [1985] J. Chem. Ecol. 11: 895-901; McDaniel et al. J. Chem. Ecol. [in press]). We now report that the cephalic secretions of males of Philanthus triangulum, the (honey)bee wolf, an Old World species, are different in nature from the investigated North American species. The main component of the secretion of P. triangulum (~90% of total secretion) is Z-11-eicosen-1-ol, a component also present in Apis mellifera, the prey of P. triangulum. In honey bees the compound has been shown to be attractive to foragers. The most important minor component of the secretion is Δ^x-eicosenal. In our samples, levels of pyrazines were below detection limits by GC and MS. Overall, the European P. triangulum differs from the North American species in possessing a much simpler cephalic secretion that is based on a component not present in the North American species.

SEXUAL MIMICRY REGULATES THE POST-MATING ATTRACTIVENESS OF DROSOPHILA MELANOGASTER FEMALES

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Using capillary GC, I have analyzed changes in the volatile compounds of D. melanogaster females that are associated with courtship and mating. During mating, male D. melanogaster transfer to the female's cuticle an antiaphrodisiac compound (7-tricosene) which is almost absent from virgin females, but is the major hydrocarbon of the male's cuticle. For the first few hours after mating, the amount of 7-tricosene on females decreases sharply, but stays significantly above virgin levels. By 6 h after mating, however, female synthesis of 7-tricosene has increased, and females release 7-tricosene when they are exposed to courting males. No release of cis-vaccenyl acetate, another potential antiaphrodisiac for this species, can be detected. Topical application of synthetic 7-tricosene to virgin females significantly decreases their attractiveness to males. Thus, mated D. melanogaster females appear to mimic males by releasing an antiaphrodisiac compound that is only present at low levels on virgin females, but is the most abundant hydrocarbon of the male's cuticle.

ALLELOPATHIC CONSTITUENTS FROM TWO MEMBERS OF THE FLORIDA SCRUB COMMUNITY
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Ceratiola ericoides (Empetraceae) and Calamintha ashei (Lamiaceae) were investigated chemically for allelopathic constituents. From C. ericoides, flavanones, a chalcone, catechins and dihydrochalcones were isolated along with a novel dihydrochalcone, ceratiolin. Ceratiolin, which did not show appreciable activity in bioassays, decomposed slowly to yield the highly active hydrocinnamic acid.

From C. ashei, a mixture containing caryophyllene oxide, evodone and a new menthofuran, calaminthone, completely inhibited test seed germination. However, the individual compounds did not show appreciable activity. Ursolic acid, which is present in both plants but shows no significant allelopathic activity, increased the levels of activity of several test compounds.

SECONDARY METABOLITES AS NATURAL ANTIFOULING AGENTS IN GORGONIAN CORALS
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Sessile and sedentary marine organisms are continuously subject to biofouling in their natural habitats. As a result, these organisms have often developed mechanisms or strategies to control or prevent the early attachment of biofoulers. Chemical mediation of fouling organisms appears to be one strategy that is important. Gorgonian corals were chosen as a model system in which to study chemical antifouling mechanisms. Secondary metabolites produced by the gorgonian corals Pseudopterogorgia americana and Pseudopterogorgia acerosa were tested for evidence of antifouling activity with benthic pennate diatoms (e.g. Navicula salinicola and Nitzchia spp.) in laboratory and field experiments using natural template and agar plate assays. Active metabolites were localized in specific fractions and identified. Comparisons of water soluble and non-water soluble active metabolites from the morphologically similar gorgonian coral species showed distinct differences. Threshold concentration values approach the estimated naturally occurring concentrations. The degradation rates of active compounds and their possible modes of action are discussed.

SOLUTION VOLUME AND SEED NUMBER: OVERLOOKED FACTORS IN ALLELOPATHIC BIOASSAYS

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Cucumber seeds were germinated under various combinations of solution volume and seed number, with a range of ferulic acid concentrations. At each concentration, greater inhibition was observed as the relative amount of ferulic acid available per seed increased from x (25 seeds/5 ml) to 18x (25 seeds/90 ml). With 2.0 mM ferulic acid, radicle lengths after 48 hours ranged from 51 to 21% of control. Similar results were obtained in 72 hour treatments. Ferulic acid remaining in 2.0 mM solution after 48 hours ranged from 4 to 77% depending upon the amount initially available. Solution volume and seed number also significantly affected inhibition by vanillic acid, caffeic acid and juglone. With 0.5 mM vanillic acid, radicle lengths after 48 hours were 94% of control with 25 seeds/5 ml, 73% with 5 seeds/5 ml and 54% with 25 seeds/90 ml. These results show that solution volume and seed number, because of their effect on the amount of phytotoxin available per seed, are important factors in allelopathic bioassays. Greater inhibition occurs at a given concentration if there are fewer seeds per dish or a larger solution volume. Lower phytotoxin concentrations may produce greater inhibitory effects than higher concentrations if the amount available for uptake is greater. Evidence from available literature on herbicides shows that similar effects occur in greenhouse and field studies.

HOW DO BORING MALES FIND THE RIGHT MATE?: SEX PHEROMONES OF ANOBIID BEETLES

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The common furniture beetle or woodworm (Anobium punctatum) is a common and destructive pest of structural timbers and hardwood furniture in northern Europe, yet little is known of its reproductive behaviour. Observations and reports suggested that, on emergence, females use a sex pheromone to attract males. Ovipositor extracts showed the presence of a single major compound, which was shown to be active by EAG and GC-EAG, and to attract males in both arena and wind tunnel behavioural assays. The compound was identified by GC-MS as 2,3-dihydro-2,3,5-trimethyl-6-(1-methyl-2-oxo butyl)-4H-pyran-4-one and appears to be identical to the known sex pheromone of another anobiid beetle - Stegobium paniceum (the drug store beetle) with which it partially overlaps geographically and ecologically. Male A. punctatum respond equally to female extracts of either species, at both the sensory (EAG) and behavioural level. This poses the question of how reproductive isolation is achieved?

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