

Fifth Annual Meeting

International Society of Chemical Ecology

24 - 27 June, 1988

University of Georgia

Center for Continuing Education

Athens, Georgia

Fifth Annual Meeting
International Society of Chemical Ecology
Center for Continuing Education
University of Georgia
Athens, GA 30602
24-27 June 1988

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DAILY SCHEDULE

Fifth Annual Meeting
International Society of Chemical Ecology
Center for Continuing Education
University of Georgia*
Athens, GA 30602
24-27 June 1988

<u>Day and Date</u>	<u>Time</u>	<u>Event</u>	<u>Location</u>
Fri 24 June	1:00- 6:00	Registration	2nd Floor Registr. Desk
	6:30- 8:30	Reception	Banquet Area
Sat 25 June	7:00- 8:25	Breakfast	Banquet Area
	8:25-10:00	Symposium--Chemotaxis	Room L
	8:25- 9:50	Symposium--Reptiles	Lower Level Aud.
	10:00-10:15	Break	Lobby Lounge
	10:15-12:15	Symposium--Chemotaxis	Room L
	10:15-11:55	Symposium--Reptiles	Lower Level Aud.
	12:15- 1:15	Lunch	Banquet Area
	1:15- 2:45	Symposium--Chemotaxis	Room L
	1:15- 3:00	Invited Papers	Lower Level Aud.
	3:15- 3:30	Break	Lobby Lounge
	3:30- 5:30	Contributed Papers	Main Auditorium
	3:30- 5:30	Contributed Papers	Lower Level Aud.
	6:15- 7:30	Dinner	Banquet Area
7:30- 9:30	Poster Session	Lobby	
Sun 26 June	7:00- 8:15	Breakfast	Banquet Area
	8:15- 9:30	Society Business	Main Auditorium
	9:30- 9:45	Break	Lobby Lounge
	9:45-12:20	Symposium--Sequestration	Main Auditorium
	12:20- 1:30	Lunch	Banquet Area
	1:30- 3:00	Symposium--Sequestration	Main Auditorium
	3:00- 3:15	Break	Lobby Lounge
	3:15- 4:45	Symposium--Sequestration	Main Auditorium
	4:45- 6:05	Contributed Papers	Main Auditorium
	4:15- 5:25	Contributed Papers	Lower Level Aud.
	6:15- 7:30	Free	
	7:30- 9:00	Banquet	Banquet Area
	9:00- 9:15	Presentations	Banquet Area
9:15-10:00	Lecture--Dr. E.P. Odum	Main Auditorium	
Mon 27 June	7:00- 8:00	Breakfast	Banquet Area
	8:00-10:20	Symposium--Marine	Main Auditorium
	10:20-10:35	Break	Lobby Lounge
	10:35-11:20	Symposium--Marine	Main Auditorium
	11:20-12:20	Contributed Papers	Main Auditorium
	12:20	Meeting Adjourns	

Saturday 25 June SYMPOSIA - Room L

SENSORY BEHAVIOR OF MICROORGANISMS

Moderator: M. D. MANSON, Texas A & M University

			<u>Page No.</u>
8:25- 8:30	Introduction		
8:30- 9:00	M. D. MANSON Texas A & M University	BACTERIAL CHEMOTAXIS: HOW GENETICS AND MOLECULAR BIOLOGY CAN BE USED TO STUDY A SENSORY SYSTEM	38
9:00- 9:30	H. C. BERG Harvard University	PHYSICAL CONSTRAINTS ON MICROBIAL BEHAVIOR: HOW YOU ACT IF YOU ARE VERY SMALL	15
9:30-10:00	G. L. HAZELBAUER Washington State University	METHYL-ACCEPTING CHEMOTAXIS PROTEINS: TRANSMEMBRANE RECEPTORS PRESENT THROUGHOUT THE DIVERSITY OF BACTERIA	31
10:00-10:15	Break		
10:15-10:45	E. P. GREENBERG Cornell University	THE MOTILE BEHAVIOR OF <u>SPIROCHAETA</u> <u>AURANTIA</u> : A TWIST TO CHEMOSENSORY TRANSDUCTION IN BACTERIA	30
10:45-11:15	K. BERGMAN Northeastern University	THE ROLE OF BACTERIAL CHEMOTAXIS IN THE INITIATION OF THE RHIZOBIUM/ LEGUME SYMBIOSIS FOR NITROGEN FIXATION	15
11:15-11:45	K. NEALSON University of Wisconsin-Milwaukee	AUTOINDUCTION OF BACTERIAL LUMINESCENCE: A MECHANISM FOR ENVIRONMENTAL SENSING	
11:45-12:15	D. KAISER Stanford University	CELL-CELL INTERACTIONS IN <u>MYXOCOCCUS</u>	36
12:15- 1:15	Lunch		
1:15- 1:45	J. C. POMMERVILLE Texas A & M University	PHEROMONE INTERACTIONS AND IONIC COMMUNICATION IN GAMETES OF AQUATIC FUNGUS <u>ALLOMYCES</u>	
1:45 - 2:15	C. KUNG University of Wisconsin	ION CHANNELS OF <u>PARAMECIUM</u> , YEAST, AND <u>ESCHERICHIA COLI</u>	37
2:15- 2:45	D. R. SOLL University of Iowa	APPLICATION OF THE COMPUTER- ASSISTED DYNAMIC MORPHOLOGY SYSTEM IN ASSESSING THE ROLE OF TEMPORAL MECHANISMS IN <u>DICTYOSTELIUM CHEMOTAXIS</u>	53

Saturday 25 June SYMPOSIA - Lower Level

CHEMICAL ECOLOGY OF REPTILES

Moderator: PAUL J. WELDON, Texas A & M University

			<u>Page No.</u>
8:25- 8:30	Introduction		
8:30- 8:50	ALLISON ALBERTS University of California at San Diego	CHEMICAL PROPERTIES AND BIOLOGICAL FUNCTIONS OF FEMORAL GLAND PHEROMONES IN DESERT IGUANAS	13
8:50- 9:10	FRED M. SCHELL University of Tennessee	ANALYSIS OF CHEMICALS ELICITING PREY ATTACK IN NAIVE GARTER SNAKES	49
9:10- 9:30	DAVID CHISZAR University of Colorado	RECENT EXPERIMENTS ON RATTLESNAKE PREDATION: CHEMICAL CUES USED DURING POST-STRIKE TRAIL FOLLOWING	21
9:30- 9:50	WILLIAM COOPER JR. Auburn University at Montgomery	MEASUREMENT OF SQUAMATE RESPONSES TO PREY ODORS	22
9:50-10:15	Break		
10:15-10:35	BENJAMIN DIAL Chapman College	DETECTION AND IDENTIFICATION OF SKIN CHEMICALS FROM SAUROPHAGOUS SNAKES BY GEKKONID LIZARDS <u>COLEONYX</u> <u>VARIEGATUS</u>	24
10:35-10:55	DAVID DUVALL AND BRENT GRAVES University of Wyoming and Downstate Medical Center	SOURCES AND ORIGINS OF SKIN LIPID PHEROMONES IN RATTLESNAKE <u>CROTALUS</u> <u>VIRIDUS</u>	25
10:55-11:15	ROBERT MASON NIH, Bethesda, MD	ISOLATION AND IDENTIFICATION OF SEX ATTRACTANT PHEROMONES IN THE RED- SIDED GARTER SNAKE	39
11:15-11:35	PAUL J. WELDON AND JAMES W. WHEELER Texas A & M Univ. and Howard Univ.	CROCODILIAN SKIN GLANDS: HISTOLOGY, NATURAL PRODUCTS, AND MICROBIOLOGY	56
11:35-11:55	NEIL FORD University of Texas at Tyler	PEROMONES IN COMPETITIVE INTERACTIONS BETWEEN SNAKES	28

Saturday 25 June INVITED PAPERS - Lower Level AuditoriumPage No.

Moderator:	J. R. ALDRICH, USDA, Beltsville, MD		
1:15- 1:45	H. G. CUTLER USDA, Athens, GA	NATURAL PRODUCTS FROM MICROORGANISMS AND THEIR POTENTIAL FOR AGRICULTURAL USE	23
1:45- 2:15	WITTKO FRANCKE Universitat Hamburg, FRG	CHEMICAL PRINCIPLES IN ODOUR COMMUNICATION	29
2:15- 2:45	MANFRED KAIB Universitat Bayreuth	HOW <u>SCHEDORHINOTERMES</u> TERMITES BLUNT ANT PREDATION	35
2:45- 3:00	IZURU YAMAMOTO Tokyo Univ. of Agric., Tokyo, Japan	CHEMICAL COMMUNICATION: BASIC, APPLIED, AND SOCIETAL IMPLICATIONS	

Saturday 25 June CONTRIBUTED PAPERS - Main Auditorium

Moderator:	W. D. SEABROOK, University of New Brunswick		
3:30- 3:40	J. M. JALLON Gif-sur-Yvette, France	BIOSYNTHETIC AND GENETIC STUDIES OF PHEROMONE PRODUCTION IN <u>DROSOPHILA</u>	27
3:40- 3:50	STEFAN SCHULZ Cornell University	VOLATILE COMPOUNDS FROM ANDROCONIA OF DANAINA BUTTERFLIES	50
3:50- 4:00	J. H. TUMLINSON USDA, Gainesville, FL	IDENTIFICATION OF A SEX PHEROMONE BLEND FOR <u>MANDUCA</u> <u>SEXTA</u>	54
4:00- 4:10	ASHOK K. RAINA USDA, Beltsville, MD	SIGNIFICANCE OF HOST-PLANT FACTOR(S) IN THE PRODUCTION AND RELEASE OF SEX PHEROMONE BY FEMALES OF <u>HELIOTHIS</u> SPECIES	47
4:10- 4:20	JEREMY MCNEIL Universite Laval, Canada	PHEROMONE BIOLOGY OF TWO GEOGRAPHIC POPULATIONS OF BERTHA ARMYWORM <u>MAMESTRA</u> <u>CONFIGURATA</u>	40
4:20- 4:30	T. W. PHILLIPS Univ. of Florida	SEMIOCHEMICALS PRODUCED BY INDIVIDUAL BLACK TURPENTINE BEETLES DURING HOST COLONIZATION	46
4:30- 4:40	G. BIRGERSSON Univ. of Goteborg, Sweden	ATTACK SUCCESS INFLUENCING PRODUCTION AND RELEASE OF BARK BEETLE SEMIOCHEMICALS	16

Saturday 25 June CONTRIBUTED PAPERS - Main Auditorium (Cont'd) Page No.

4:40- 4:50	J.-P. FARINE Universite de Bourgogne, France	CHEMICAL COMMUNICATION IN <u>DYSDERCUS CINGULATUS</u> (HETEROPTERA: PYRRHOCORIDAE): CHEMISTRY AND FUNCTION OF THE EXOCRINE SECRETIONS	27
4:50- 5:00	REMY BROSSUT Universite de Bourgogne, France	SEXUAL COMMUNICATION WITH PHEROMONES IN COCKROACHES	19
5:00- 5:10	J. O. SCHMIDT USDA, Tucson, AZ	SWARM TRAPPING: PRACTICAL CHEMICAL ECOLOGY OF HONEY BEES	50
5:10- 5:20	W. JOE LEWIS USDA, Tifton, GA	CHEMICALLY MEDIATED ASSOCIATIVE LEARNING: MECHANISMS IN PARASITIDS	37
5:20- 5:30	W. JOE LEWIS USDA, Tifton, GA	CHEMICALLY MEDIATED ASSOCIATIVE LEARNING: ROLE IN FORAGING BEHAVIOR OF PARASITIDS	37

Saturday 25 June CONTRIBUTED PAPERS - Lower Level Auditorium

Moderator: G. BERGSTROM, Univ. of Goteborg, Sweden

3:30- 3:40	ELIZABETH D. JORDAN Louisiana State University	INVESTIGATION OF THE SOIL UNDER THE FLORIDA WILD ROSEMARY (<u>CERATIOLA</u> <u>ERICOIDES</u>): QUANTITATION OF THE ALLELOCHEMICAL HYDROCINNAMIC ACID	34
3:40- 3:50	JEFFREY WEIDENHAMER Louisiana State University	ALLELOPATHIC EFFECTS OF HYDROCINNAMIC ACID	56
3:50- 4:00	ROBERT JOHNSON University of South Carolina	GROWTH AND ALLEOCHEMICAL RESPONSES OF BASIN SAGEBRUSH TO CHRONIC DEFOLIATION IN ENRICHED CARBON DIOXIDE ATMOSPHERES	33
4:00- 4:10	UDO BLUM North Carolina State University	A PROCEDURE TO DETERMINE THE ACTION OF MIXTURES OF PHENOLIC ACIDS ON PLANT GROWTH	17
4:10- 4:20	JUDITH BRADOW USDA, New Orleans, LA	RELATIONSHIPS BETWEEN STRUCTURE AND INHIBITORY ACTIVITY OF VOLATILE ALLELOCHEMICALS FROM PLANT RESIDUES	18
4:20- 4:30	MARIOS MENELAOU Louisiana State University	CHARACTERIZATION OF ALLELOCHEMICALS OF <u>SOLIDAGO</u> <u>PAUCIFLOSCULOSA</u>	41

Saturday 25 June CONTRIBUTED PAPERS - Lower Level Auditorium (Cont'd) Page No.

4:30- 4:40	ROBERT BUCHSBAUM Mass. Audubon Soc. Gloucester, MA	VARIATION IN PHENOLIC AND NITROGEN CONTENTS IN EELGRASS, <u>ZOSTERA MARINA</u> AND ITS POSSIBLE EFFECT ON WASTING DISEASE	20
4:40- 4:50	D. RAGHUNATHA RAO Osmania University Hyderabad, India	NATURAL INSECTICIDAL CHEMICALS FROM CERTAIN PLANTS AS FEEDING DETERRENTS	47
4:50- 5:00	JOHN GLENDINNING Univ. of Florida Gainesville, FL	THE EFFECTIVENESS OF CARDENOLIDES AND PYRROLIZIDINE ALKALOIDS IN MONARCH BUTTERFLIES AS DETERRENTS TO MOUSE PREDATION	30
5:00- 5:10	C. A. MCDANIEL Gulfport, MS	MAJOR ANTITERMITIC COMPONENTS OF CATALPA HEARTWOOD	40
5:10- 5:20	CLIVE JONES Institute of Ecosystem Studies, Millbrook, NY	DOES PLANT CHEMICAL DIVERSITY AFFECT INSECT SPECIES RICHNESS?	34
5:20- 5:30	SUSAN SENNETT Univ. of Delaware Lewes, DE	PHYTOALEXINS: POST-INFECTIONAL DEFENSE IN HALOPHYTES?	51

Saturday 25 June POSTERS - Lobby

7:30- 9:30 PM	A. G. BAGNERES Universite P.M. Curie	CHEMOTAXONOMY AND POLYMORPHISM OF THE SPECIES <u>RETICULITERMES FLAVIPES</u> AND <u>R. SANTONENSIS</u>	14
	LEON W. BONE USDA-ARS, Auburn,	LETHALITY OF INSECTICIDAL BACILLI FOR NEMATODE EGGS AND LARVAE	17
	JOHN M. BRAND Univ. of Fort Hare South Africa	THE CHEMICAL COMPOSITION OF THE DUFOURS GLAND OF A SOUTH AFRICAN <u>POLYRHACHIS</u> SPECIES	19
	DAVID A. CARLSON USDA-ARS Gainesville, FL	DIMETHYLDISULFIDE DERIVATIVES OF LONG CHAIN ALKENES, ALKADIENES AND ALKATRIENES FOR GC AND GC-MS	21
	KARL E. ESPELIE Univ. of Georgia	<u>PARACHARTERGUS AZTECUS</u> , A SOCIAL WASP THAT NESTS IN ANT-ACACIAS	26
	HANS E. HUMMEL Justus-Liebig- University Giessen	SEMIOCHEMICALS OF <u>CUCURBITA</u> SP. SUPPRESS SEX ATTRACTION IN MALE <u>DIABROTICA UNDECIMPUNCTATA</u> <u>HOWARDI</u> BARBER (CHRYSOMELIDAE)	32

7:30- 9:30 PM	DAUREEN NESDILL Auburn University	DO TANNINS PLAY A ROLE IN THE FORAGING BEHAVIOR OF GRAY SQUIRRELS?	43
	RITSUO NISHIDA Kyoto University Kyoto, Japan	ECOLOGICAL ADAPTATION OF AN ARISTOLOCHIACEAE-FEEDING SWALLOWTAIL BUTTERFLY, <u>ATROPHANEURA ALCINOUS</u> , TO ARISTOLOCHIC ACIDS	43
	MARK STELLJES Univ. of California	PYRROLIZIDINE ALKALOIDS IN AN OVERWINTERING POPULATION OF MONARCH BUTTERFLIES (<u>DANAUS PLEXIPPUS</u>) IN CALIFORNIA	53
	M. YATAGAI Forestry and Forest Products Research Institute	CHEMICAL COMPONENTS OF JAPANESE CEDAR (SUGI), <u>CRYPTOMERIA JAPONICA</u> , CULTIVARS ASSOCIATED WITH THE RESISTANCE TO <u>CRYPTOMERIA</u> BARK BORER, <u>SEMANSTUS JAPONICUS</u>	57

Sunday 26 June SYMPOSIA - Main Auditorium

ARTHROPOD SEQUESTRATION OF NATURAL PRODUCTS

Moderator: MURRAY S. BLUM, University of Georgia

9:45- 9:50 Introduction

9:50-10:20 JERROLD MEINWALD
Cornell University SEQUESTRATION, SIGNAL SECRETION, AND SEXUAL SELECTION: POSSIBLE FACTORS IN THE EVOLUTION OF A CHEMICAL COMMUNICATION SYSTEM?

10:20-10:50 SAKUZO NISHIO
Takenami-cho
Ena-shi, Gifu-ken
509-71, Japan CARDENOLIDE PROCESSING DURING METAMORPHOSIS OF LEPIDOPTERA *hp* 45

10:50-11:20 MANUEL AREGULLIN
University of Arizona SESQUITERPENE LACTONE SEQUESTRATION BY THE TORTOISE BEETLE PHYSONATA ARIZONAE (CASSINIDAE) *Col Col* 14

✓ 11:20-11:50 JACQUES M. PASTEELS
Universite Libre Bruxelles SEQUESTRATION IN CHRYSOMELIDS: FACTS AND FALLACIES *Col Col* 45

11:50-12:20 L. P. BROWER,
STEVEN MALCOLM,
AND BARBARA
COCKRELL
Univ. of Florida COMPARATIVE CARDENOLIDE SEQUESTRATION IN DANAINAE BUTTERFLIES AND IMPLICATIONS FOR DEFENSE AND MIGRATION *Leg* 20

Sunday 26 June

SYMPOSIA - Main Auditorium (Cont'd)

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*A Generalist Herbivore
Specialist Mode Metabolic
Sequestrative, and Defensive*

12:20- 1:30

Lunch

✓ 1:30- 2:00

MURRAY S. BLUM
Univ. of Georgia

SEQUESTRATION OF NATURAL PRODUCTS
BY A GENERALIST HERBIVORE

Consequence

✓ 2:00- 2:30

MICHAEL BOPPRE
Fortzoologisches
Institut der
Universitat
Freiburg

LEPIDOPTERA AND PYRROLIZIDINE
ALKALOIDS - EXEMPLIFICATION OF
COMPLEXITY IN CHEMICAL ECOLOGY

lep 18

✓ 2:30- 3:00

RITSUO NISHIDA
Kyoto University

SEQUESTRATION OF "BITTER"
PRINCIPLES BY PHARMACOPHAGOUS
INSECTS

44

3:00- 3:15

Break

✓ 3:15- 3:45

FRANK STERMITZ
Colorado State
University

UTILIZATION OF IRIDOID GLYCOSIDES
BY LEPIDOPTERA

lep 54

3:45- 4:15

STEVEN LYNCH AND
RONALD MARTIN
Louisiana State
University

IMPLICATIONS OF CARDENOLIDE
SEQUESTRATION BY FIRST GENERATION
MONARCHS ON MILKWEEDS IN THE
SOUTHERN UNITED STATES

*Lep
Hemiptera*

✓ 4:15- 4:45

JEFFREY ALDRICH
USDA-ARS,
Beltsville, MD

SAPONDACEAE, CYANOLIPIDS, AND
BUGS

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Sunday 26 June

CONTRIBUTED PAPERS - Main Auditorium

Moderator:

J. L. CLEMENT, Universite P. & M. Curie, Paris

4:45- 4:55

SERGEI SHARYGIN
Nikitsky Botanical
Garden, Yalta,
Crimea, USSR

GEOCHEMICAL ECOLOGY OF AMPHIBIANS
AND REPTILES

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4:55- 5:05

YOKO NAYA
Suntory Institute
for Bioorganic
Research, Osaka
Japan

REGULATION OF MOLT CYCLE IN
CRUSTACEAN

42

5:05- 5:15

D. E. WOOD
Georgia State Univ.
Atlanta, GA

MODULATION OF A PHEROMONE-MEDIATED
BEHAVIOR: COURTSHIP DISPLAY IN
THE BLUE CRAB

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Sunday 26 June	<u>CONTRIBUTED PAPERS</u> - Main Auditorium (Cont'd)	<u>Page No.</u>
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5:25- 5:35	PETER DANIEL Georgia State Univ. Atlanta, GA	LEARNING TO EAT WELL: MODULATION OF CHEMORESPONSIVENESS OF MARINE CRUSTACEANS 23
5:35- 5:45	L. A. MARTINEZ Univ. of California Santa Barbara	OLFACTORY-MEDIATED RISK SENSITIVE FORAGING IN AQUATIC INVERTEBRATES 39
5:45- 5:55	DONALD GERHART Duke Univ. Marine Lab., Beaufort, NC	CHEMICAL AND PHYSICAL DEFENSES OF A GORGONIAN OCTOCORAL AGAINST CRUSTACEAN PREDATORS 29
5:55- 6:05	NICHOLAS VROLIJK Univ. of Delaware Lewes, DE	A SYNERGISTIC MODEL OF A NATURAL ANTIFOULING DEFENSE IN GORGONIAN CORALS 55

Sunday 26 June CONTRIBUTED PAPERS - Lower Level Auditorium

Moderator:	J. M. PASTEELS, Universite libre de Bruxelles, Belgium	
4:15- 4:25	TIMOTHY JOHNS Macdonald College of McGill Univ., Canada	A CHEMICAL ECOLOGICAL MODEL OF THE EVOLUTION OF MEDICINE 33
4:25- 4:35	MARGOT GRISWOLD Univ. of California Irvine	RESOURCE AVAILABILITY HYPOTHESIS AND DESERT SHRUBS 31
4:35- 4:45	CHARLES MIHALIAK Washington State University	REGULATION OF MONOTERPENE BIOSYNTHESIS WITH REFERENCE TO THE PALATABILITY OF <u>SATUREJA</u> <u>DOUGLASII</u> 41
4:45- 4:55	J. L. CLEMENT Universite P. et M. Curie	THE ROLE OF CUTICULAR HYDROCARBONS IN THE ANT <u>CAMPONOTUS VAGUS</u> : NESTMATE AND LARVAL RECOGNITION 22
4:55- 5:05	KLAUS PESCHKE Universitat Wurzburg, West Germany	DESCRIPTION AND FUNCTION OF CUTICULAR HYDROCARBON PATTERNS IN CLOSELY RELATED SPECIES OF THE ROVE BEETLE GENUS <u>ALEOCHARA</u> (COLEOPTERA: STAPHYLINIDAE) 46

Sunday 26 June CONTRIBUTED PAPERS - Lower Level Auditorium (Cont'd) Page No.

5:05- 5:15	RENEE JULLIEN Universite Paris Sud, Orsay, France	CHEMICAL TAXONOMIC STUDIES OF CUTICULAR HYDROCARBONS IN LOCUSTS OF THE <u>SHISTOCERCA AMERICANA</u> COMPLEX (ACRIDIDAE:CYRTACANTHACRIDINAE)	35
5:15- 5:25	ROY-KEITH SMITH Georgia Dept. Agri. Atlanta, GA	IDENTIFICATION OF AFRICANIZATION IN HONEY BEE QUEENS	52

Monday 27 June SYMPOSIA - Main Auditorium

CHEMICAL ECOLOGY IN THE AQUATIC ENVIRONMENT

Moderator: DON GERHART, Duke University Marine Laboratory

8:00- 8:05	Introduction		
8:05- 8:50	DAN RITTSCHOF Duke University Marine Laboratory	PEPTIDES AND SPECIFIC BEHAVIORS IN MARINE ORGANISMS: EVIDENCE FOR A COMMON THEME	48
8:50- 9:35	CHARLES KERFOOT Univ. of Michigan	ARE LILY PADS THE "TREES" OF THE LITTORAL ZONE?	36
9:35-10:20	PAUL SAMMARCO Australian Institute of Marine Science	THE MULTIPLE FUNCTIONS OF SECONDARY METABOLITES IN SOFT CORALS AND THEIR INTEGRATION WITH FUNCTIONALLY RELATED ADAPTATIONS	49
10:20-10:35	Break		
10:35-11:20	DANIEL E. MORSE University of California at Santa Barbara	CHEMICAL SIGNALS CONTROL SITE- SPECIFIC SETTLEMENT AND METAMORPHOSIS OF PLANKTONIC LARVAE: CHARACTERIZATION OF THE SIGNALS, RECEPTORS, TRANSDUCTION, AND REGULATORY MECHANISMS	42

Monday 27 June CONTRIBUTED PAPERS - Main Auditorium

Moderator: R. BROSSUT, Universite de Bourgogne, Dijon, France

11:20-11:30	BRIAN JACKSON Univ. of Keele England	THE CHEMICAL SECRETIONS OF SOME PRIMITIVE <u>MYRMECIA</u> ANTS OF AUSTRALIA	32
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Monday 27 June

CONTRIBUTED PAPERS - Main Auditorium (Cont'd)

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11:30-11:40	HUBERT DITTEBRAND University at Bayreuth, Fed. Rep. Germany	POISON GLAND SECRETION AND RECRUITMENT COMMUNICATION IN <u>MYRMICARIA EUMENOIDES</u>	25
11:40-11:50	G. A. ROSENTHAL Univ. of Kentucky	L-CANAVANINE DETOXIFICATION IN THE TOBACCO BUDWORM, <u>HELIOTHIS</u> <u>VIRESCENS</u> (NOCTUIDAE)	48
11:50-12:00	ROBERT VANDER MEER USDA Gainesville, FL	CHEMICAL DIFFERENTIATION OF CRYPTIC FIRE ANT SPECIES?: <u>SOLENOPSIS RICHTERI</u> (U.S.) VS <u>S. RICHTERI</u> (ARGENTINA)	55
12:00-12:10	C. EVERAERTS Univ. de Bourgogne Dijon, France	MODE OF ACTION OF THE DEFENSE SECRETION IN <u>NASUTITERMES</u> <u>PRINCEPS</u> : PART PLAYED BY MONO- AND DITERPENIC FRACTIONS	26
12:10-12:20	RITSUO NISHIDA Kyoto University Kyoto, Japan	OVIPOSITION STIMULANTS OF A CITRUS-FEEDING SWALLOWTAIL BUTTERFLY, <u>PAPILIO XUTHUS</u>	44

Alberts, Allison. Chemical Properties and Biological Functions of Femoral Gland Pheromones in Desert Iguanas. Department of Biology, University of California at San Diego, La Jolla, CA 92093.

Physical constraints on signal transmission can limit the use of pheromones for long range communication in certain environments. At high temperatures, volatile pheromones diffuse rapidly and rarely last long enough for a receiving animal to locate their source. One solution is use of low volatility chemical signals which act at short range, but remain detectable from a distance via longer range visual cues. This study investigates femoral gland secretions in desert iguanas, which inhabit deserts exclusively and may be especially subject to temperature constraints on pheromone use. Behavioral tests show that secretions elicit elevated levels of chemosensory investigation compared to controls, but must be contacted to be detected olfactorily. Electrophoretic and NMR studies indicate secretions are composed of 80% protein and 20% lipid material, mostly in the form of triglycerides and sterols. Individual and between-species differences in secretion chemistry suggest they could function in recognition. Reflectance spectroscopy reveals these secretions strongly absorb longwave UV light, and behavioral tests demonstrate the importance of an ultraviolet light source for their successful detection. Further tests suggest desert iguanas are visually sensitive to ultraviolet light, indicating that UV absorption could act as a long range visual cue allowing initial localization of pheromone deposits, which are then approached and investigated through chemosensory channels.

Aldrich, Jeffrey R., Scott P. Carroll, William R. Lusby, Malcolm J. Thompson, Jan P. Kochansky, and Rolland M. Waters. Sapindaceae, cyanolipids, and bugs. USDA, ARS, Insect and Nematode Hormone Laboratory, Bldg. 467, BARC-East, Beltsville, MD 20705 USA.

Scentless plant bugs (Heteroptera: Rhopalidae) are so named because adults of the subfamily Serinethinae have vestigial metathoracic scent glands. The Serinethinae are seed predators of Sapindales, especially the Sapindaceae producing toxic cyanolipids. In the two serinethine species whose ranges extend into the southern U.S., *Jadera haematoloma* and *J. sanguinolenta*, sequestration of host cyanolipids as glycosides renders these gregarious, aposematic insects unpalatable to a variety of predators. The blood glycoside profile and cyanogenesis of *Jadera* varies depending on the cyanolipid chemistry of host Sapindaceae. In addition, *Jadera* adults and larvae fed golden rain tree seeds (*Koelreuteria* spp.) excrete a volatile lactone (4-methyl-2(5H)-furanone) to which they are attracted. *Jadera* fed balloon vine seeds (*Cardiospermum* spp.) do not excrete the attractive lactone. Loss of the usual heteropteran defensive glands in serinethines may have coevolved with host specificity on toxic plants, and the orientation of *Jadera* individuals to a volatile excretory product could be an adaptive response to save time.

Aregullin Manuel and Robert L. Smith. Sesquiterpene lactone sequestration by the tortoise beetle *Physonota arizonae* (Cassinidae). Dept. of Entomology. University of Arizona. Tucson, AZ 85721.

The phenomenon of plant secondary metabolites sequestration by herbivorous arthropods and its importance as an arthropod defense strategy is widely appreciated. However, we have just begun to inventory the range of chemicals classes sequestered by arthropods. The sequestration of cardenolides, alkaloids and certain terpenoids has been extensively investigated, but our knowledge of other classes of plant natural products useful to arthropods in protection remains very limited. This deficiency impairs our ability to understand developmental and evolutionary aspects of sequestration. We wish to report the first account of sequestration of plant sesquiterpene lactones by an herbivorous insect. The pseudoguaianolides Damsin and Damsinic acid are sequestered by the tortoise beetle *Physonota arizonae* (Cassinidae) from the compositae *Ambrosia ambrosioides* (canyon ragweed). We discuss the chemistry, biology and mechanism of sequestration.

CHEMOTAXONOMY AND POLYMORPHISM IN THE TWO SPECIES : RETICULITERMES FLAVIPES AND R. SANTONENSIS

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Colonies of R. flavipes and R. santonensis were collected respectively in Georgia (U.S.A. during Autumn 1987 and in Charente Maritime (S.W./France). Epicuticular and allomonal extracts were analyzed.

WORKERS : hydrocarbons from R. flavipes and R. santonensis are similar. Only few quantitative variations were observed between societies.

SOLDIERS : different chemotypes were defined for the defensive compound (5 for R.f., 1 for R.s.) nevertheless cuticular substances are identical for the workers.

Lipides	R.s	R.f				
		A	B	C	D	E
Chemotypes		A	B	C	D	E
Monoterpenes	+	+	0	+	0	+
Camphène	0	++	+	++	+	0
Aldehyde C.	0	++	++	++	++	++
Geranyl Linol.	+	0	0	++	++	++
Unknown	+	0	0	0	0	0

The only difference between R. flavipes and R. santonensis is the composition of the defensive compound. According to the great polymorphism of the secretions in the species R.f. we can suppose that R. flavipes and R. santonensis belong to the same species flavipes which is very complex. In addition, they have the same behavior : societies are open (non aggression). Thus, the species R. santonensis would be imported from the U.S.A. both species R. santonensis and R. flavipes evaluated from non unknown population.

Berg, Howard C. Physical constraints on microbial behavior: How you act if you are very small. Department of Cellular & Developmental Biology, Harvard University, 16 Divinity Avenue, Cambridge MA 02138 and the Rowland Institute for Science, 100 Cambridge Parkway, Cambridge MA 02142

Physical constraints limit the way in which an organism as small as *Escherichia coli* can interact with its surroundings. Cells are propelled by the movement of thin helical flagella, because motion is dominated by viscous rather than inertial forces. Cells are unable to swim in straight lines because of perturbations due to rotational Brownian movement. Cells are unable to improve their lot locally by swimming or stirring, because transport of small molecules is effected by diffusion rather than bulk flow. Cells must sense gradients temporally rather than spatially, because comparison between concentrations in front and behind are overwhelmed by diffusive currents due to the cells' motion. Finally, the precision with which cells can make temporal comparisons are limited by statistical fluctuations. A survey of these constraints will be given, followed by a description of how *E. coli* has optimized its chemotaxis machinery to meet them.

Bergman, Kostia. The Role of Bacterial Chemotaxis in the Initiation of the *Rhizobium*/Legume Symbiosis for Nitrogen Fixation. Department of Biology, Northeastern University, Boston MA 02115

Many types of bacteria are equipped for chemotaxis, the movement toward or away from specific chemicals. Investigators of this behavior in enteric bacteria have often emphasized its importance as a model for the sensory physiology or even the central nervous system physiology of higher organisms. Our long-term aim is to extend the powerful methods developed in such work toward an understanding of the role that bacterial chemotaxis has in microbial ecology.

It is now clear that initiation of the *Rhizobium*/legume symbiosis for nitrogen fixation involves the exchange of multiple signals between the host plant and the microsymbiont. We have demonstrated that motile rhizobia accumulate at localized sites of attractant release on the surface of the plant root. The localized sites are found in the area of the root shown by others to be susceptible to the infection process which initiates symbiotic nitrogen fixation.

Studies with behavioral mutants of the rhizobia demonstrate that this response requires a functional system for the sensory and motor processes of chemotaxis. Furthermore, competition experiments between strains which are isogenic except for known mutations in their chemotaxis system suggest that this behavior has a role in the physiology of the interaction between the two organisms, presumably guiding the bacteria to potential infection sites.

We have used a soft agar swarm plate assay to test the attractant activity of purified chemicals and plant root extracts. This assay is made specific by the use of two mutants of *Rhizobium meliloti*, strain SU47, that no longer respond normally to any pure substance tested (primarily sugars and amino acids) but still detect the localized site attractant. Partial purification of active substances has shown that they are related to amino acids and are distinct from the known *nod* gene activators found by other investigators. However, recently others have shown, using capillary assays, that at low concentrations luteolin and other *nod* gene activators, are also attractants. The possible advantages of such a two attractant system for fine-tuning the response will be discussed.

Göran Birgersson,

Attack success influencing production and release of bark beetle semiochemicals.

Department of Chemical Ecology, University of Göteborg, P.O.Box 33031, S-400 33 GÖTEBORG, Sweden.

When spruce bark beetle males attack their host trees, they produce and release attractants. Their aggregation pheromone consists of two essential components, 2-methyl-3-buten-2-ol (MB) and *cis*-verbenol (cV), which are produced in different pathways. The release of MB starts very early in the attack, at the same time as the males initiate their excavation into the bark and phloem. The production of cV, from the host tree compound (-) α -pinene, increase during the first day of attack, and reaches its maximum one day after the first attack. In addition to bark beetle produced volatiles, compounds produced by the host tree and in the gallery walls are released from bark beetle attacks. Aereations outside individual entrance holes, show very large quantitative variations in released compounds between different attacks. The ratio between the amounts of released oxygenated monoterpenes from the gallery walls, such as the anti-aggregative verbenone, and the attractant cV increase as the attack proceeds. Male beetles are found to regulate their production of semiochemicals according to events, such as microorganismal activity, in their surrounding phloem.

¹Blum, M.S., ²D.W. Whitman, ³R.F. Severson, ³R.F. Arrendale. Sequestration of Natural Products by a Generalist Herbivore.

¹Laboratory of Chemical Ecology, Dept. of Entomology, University of Georgia, Athens, GA 30602, ²Dept. of Biology, Illinois State University, Normal, IL 61761, and ³USDA-ARS, Russell Research Center, Athens, GA 30613 USA.

The acridid Romalea guttata is a generalist herbivore which feeds on a wide range of plant species containing a multitude of allelochemicals. Under laboratory conditions this grasshopper can develop on a single host plant species and some effects (e.g., fitness, survivorship, longevity) of monophagy vs. polyphagy can be quantitatively analyzed. In addition, the propensity of R. guttata to sequester plant natural products in a defensive gland can be compared when this insect is in a monophagous vs. polyphagous feeding mode. Monophagy can result in grasshoppers sequestering high concentrations of plant compounds as is characteristic of many specialist herbivores. This acridid processes allelochemicals eclectically resulting in these compounds being subject to a menu of options prior to being sequestered. Thus, each phytochemical mixture ingested by R. guttata must be analyzed as a unique case in terms of the sequestrative potential of each plant compound.

Blum, Udo and Thomas M. Gerig. A procedure to determine the action of mixtures of phenolic acids on plant growth. Departments of Botany and Statistics, respectively, North Carolina State University, Raleigh NC 27695.

Cucumber seedlings growing in A-horizon Portsmouth soil (fine loamy, mixed thermic Typic Umbraqualts) were treated with 0, 0.25 or 0.5 mM/g soil ferulic acid, vanillic acid or an equal mixture (0.5 mM/g total) of the two acids every other day. A total of 5 treatments were given starting with day 7 from seeding. Absolute rates of leaf expansion were determined for seedlings prior to phenolic acid treatments. The experiment was terminated when seedlings were 17 days old. Both phenolic acids inhibited leaf expansion. Based on a Simple Joint Action analysis: a) the equivalent dose of vanillic acid expressed in terms of ferulic acid ranged from 1 (equivalent) initially to 0.5 (50% of ferulic acid) at the end of the experiment, and b) the effect of the mixture of the phenolic acids on leaf expansion was characterized initially as simple joint action and at the end as antagonistic.

Bone, Leon W. Lethality of Insecticidal Bacilli for Nematode Eggs and Larvae. USDA, ARS, Animal Parasite Research Laboratory, P.O. Box 952, Auburn, AL 36831-0952.

Thirty strains of the insecticidal bacterium Bacillus thuringiensis were lethal to eggs and larvae of the ruminant nematode Trichostrongylus colubriformis at nanogram to microgram levels of total protein/ml, depending on the microbial strain. Trypsinized products from B. sphaericus (strain 1593) also killed nematode eggs. The toxin from B. thuringiensis israelensis was active against six species of animal-parasitic nematode and two species of free-living nematode.

The microbial toxin from B. thuringiensis israelensis apparently altered the permeability of nematode eggs, based on increased uptake of a radiolabel and iodine stain. Ultrastructural changes in the lipoidal layer of the eggshell may be the source of the permeability change. Microbial toxins may allow biological control of the infective stages of nematodes in the environment.

Boppré, Michael. Lepidoptera and pyrrolizidine alkaloids - exemplification of complexity in chemical ecology.

Forstzoologisches Institut der Universität Freiburg, Föhrenbühl 27, D-7801 Stegen-Wittental, West Germany.

Pyrrolizidine alkaloids are defensive chemicals of numerous plant groups, but a variety of insects of different orders is specialized on these compounds and sequesters them as pheromone precursors and/or for their own defence; thus the insects' fitness depends on PAs. PAs can even serve as morphogens of androconial organs. Since insect-PA relationships seem to have evolved several times independently, they appear particularly suited to learn about the multiplicity of aspects which are encountered in the study of insect-plant relationships and they exemplify basic aspects of chemical ecology.

The paper briefly summarizes two examples of PA-sequestration by Lepidoptera (*Cretonotos*, Arctiidae; *Danaus*, Danaidae) as a framework for discussing behavioural, chemical, physiological, and phylogenetic aspects involved, stressing the entanglement of the variety of adaptations. From a comparative point of view, a lot of phenomenological similarity can be recognized in insect-PA relationships, however, not many generalizations can be drawn.

Bradow, Judith M., Connick, William J., Jr. Relationships Between Structure and Inhibitory Activity of Volatile Allelochemicals from Plant Residues. USDA, ARS, Southern Reg. Res. Center, P.O. Box 19687, New Orleans, LA, 70179.

Volatile emissions from residues of winter cover legumes (*Trifolium alexandrinum*, *T. incarnatum*, *Vicia hirsuta*), nutsedge (*Cyperus rotundus*), and amaranths (*Amaranthus palmeri* and other species) inhibited germination and seedling development of onion, carrot, and tomato and radicle elongation of cotton (*Gossypium hirsutum*). Using GC-MS, more than 65 simple C₂-C₁₁ organic compounds were identified in plant residue emissions, and structure-activity relationships were determined on the basis of onion, carrot, and tomato vapor-phase seed germination and cotton radicle elongation bioassays. The most inhibitory classes of compounds were unbranched C₆-C₉ alkenals, 2-alkanones, alkanals, and 2-alkanols. Monocarboxylic acids and alkanes of the same chain lengths caused minimal inhibition. Unbranched C₅ compounds were less bioactive than the analogous C₆ compounds, but two branched-chain compounds, 3-methylbutanal and 3-methyl-1-butanol, were highly inhibitory. The inhibitory activities of volatiles emitted from plant residues depended upon molecular weight, degree of unsaturation of the carbon chain, volatility, water solubility, and the type and position of the hydroxyl or carbonyl functional group.

BRAND, JOHN M

THE CHEMICAL COMPOSITION OF THE DUFOURS GLAND OF A SOUTH AFRICAN Polyrhachis SPECIES

Department of Biochemistry, University of Fort Hare,
Alice 5700 Ciskei, South Africa.

Colonies of the ant, Polyrhachis schistacea, are common on the Natal coast of South Africa. Workers of this soil-dwelling ant are easily aroused from their nests and vigorously defend their nest entrance by biting and spraying the contents of both the poison gland and the Dufours gland on any intruder. Gas-chromatographic-mass spectrometric analyses of the Dufours gland contents confirm the presence of n-alkanes from C-11 to C-17, numerous alkenes, and certain 3- and 5-methyl branched alkanes. Selected ion monitoring and extracted ion chromatograms indicate the presence of trace quantities of a 2-ketone and two long chain alcohols.

BROSSUT, R. CHEVIET, P. ABED, D. FARINE, J.P. SEXUAL COMMUNICATION WITH PHEROMONES IN COCKROACHES.

Laboratoire de Zoologie, UA, CNRS-674, Université de Bourgogne, 6, Bd Gabriel 21000 DIJON FRANCE.

The Blattaria are divided in two large superfamilies : The Blattoidea and the Blaberoidea. The sexual behavior was studied in several species of Blattidae (Blattoidea), Blattellidae, Blaberidae, oxyhaloinae (Blaberoidea). All the species present similar behavioral sequences and use chemical signals : males or females volatile sex pheromones, females contact sex pheromones, males a phrodisiacs. A more detailed survey of the mating behavior revealed many differences between and within each superfamily. The emission, the nature and the function of the chemical signals vary according to the species. Moreover the same behavioral sequences (e.g. antennal fencing, wing raising) can bear different meanings according to the position of the species in the phylogeny of the Blattaria.

Brower, Lincoln. P, Stephen B. Malcolm, Barbara J. Cockrell (University of Florida), Carolyn J. Nelson (University of Sydney), and John Edgar (CSIRO, Parkville, Australia). Comparative cardenolide sequestration in Danaine butterflies and implications for defense and migration.

Evidence suggests 4 classes of defensive compounds in butterflies of the subfamily Dainainae: cardenolides sequestered by larvae from foodplants, pyrrolizidine alkaloids sequestered by adults from various plant sources, and pyrazines and unknown cardioactive compounds which may be sequestered or produced by de novo synthesis. Evidence for protection against vertebrate predation by the 3 latter chemicals is largely anecdotal and the documented cardenolide paradigm of the monarch butterfly has been criticized as a special case, not typical of the majority of the other 156 known danaine species. Our new data on Australian danaines reinforce the monarch's efficiency as a cardenolide sequesterer. Rather than seeing this as an eccentricity of Danaus plexippus, we interpret it as a recently evolved adaptation to the North American Asclepias flora, the 108 species of which vary both in kinds and total content of cardenolides. Indeed, we argue that the unique migration and vast overwintering aggregations are integrated behaviors made possible in the monarch because it has access to temperate milkweeds from which it can sequester cardenolides more efficiently and therefore derive greater protection than other danaines from the floras available to them.

Buchsbaum, Robert¹, Fred T. Short², and Donald P. Cheney³. Variation in phenolic and nitrogen contents in eelgrass, Zostera marina and its possible effect on wasting disease. ¹Mass. Audubon Soc. Gloucester, MA, ²Univ. New Hamp. Jackson Estuarine Lab, Durham, NH, ³Northeastern Univ. Boston, MA.

Wasting disease, a parasitic-born infection is responsible for recent declines in some eelgrass (Zostera marina) populations along the north-east coast of the United States and may possibly have caused dramatic population declines in the past. We grew eelgrass in mesocosm tanks that differed in the amount of nitrogen available to the plants. Plants from the high nitrogen tank grew faster but were more susceptible to the disease-causing organism than those from the low nitrogen tank and eventually suffered complete mortality. Plants from the low nitrogen tank initially developed the characteristic black lesions of Labyrinthula infection but eventually recovered. The low nitrogen plants had significantly higher levels of soluble phenolics and these may inhibit the parasite. Analysis of field collected plants indicated wide variation in the levels of soluble phenolics. Paper chromatography and paper electrophoresis revealed qualitative differences in the types of compounds present in plants collected from different parts of North America; sulfated flavones for example, are absent in eelgrass from Baja California.

Carlson, David A. DIMETHYLDISULFIDE DERIVATIVES OF LONG CHAIN ALKENES, ALKADIENES AND ALKATRIENES FOR GC AND GC-MS
USDA-ARS, Insects Affecting Man and Animals Research Laboratory, PO Box 14565, Gainesville, Florida, USA 32604

Alkenes, alkadienes and alkatrienes were readily derivatized to stable adducts with dimethyldisulfide (DMDS). This technique was extended to long chain synthetic and natural alkenes (C₂₃ to C₃₇) and to mixtures of unseparated alkanes, alkenes and alkadienes. Capillary column EI-GC-MS of DMDS adducts located double bonds in alkenes with both internal and terminal unsaturated sites. For rapid analysis with minimal handling, derivatization of the total hydrocarbon fraction gave excellent results by GC-MS after only 4 hr reaction time. Alkanes eluted first and were underivatized, followed by the alkene adducts, then the diadducts of dienes, with each group well separated from the others. Molecular ions of diadducts showed low, but adequate ion intensity; cleavage between carbons bearing SCH₃ substituents then loss of 48 (HSCH₃) and 94 (CH₃SSCH₃) located positions of both double bonds. The C₃₅ (Tr=64 min) and C₃₇ diadducts (Tr=82 min) were well separated during GC-MS or GC, with no thermal cleavage observed in these or alkatriene triadducts.

Chiszar, D., Melcer, T., Lee, R., Radcliffe, C. and Duvall, D. Recent experiments on rattlesnake predation: Chemical cues used during post-strike trail following. Dept. of Psychology, Univ. Colorado, Boulder 80309 (DC, TM, RL), Dept. of Herpetology, San Diego Zoo, San Diego 92077 (CR), and Dept. of Zoology, Univ. Wyoming, Laramie 82071 (DD)

Rattlesnakes typically release adult rodents after envenomating them, presumably to reduce risk of being injured by the struggling prey's teeth, claws and/or guard hairs. The snake then follows the chemical trail deposited by the wounded prey. Experiment 1 showed that urine deposited by prey was not followed by rattlesnakes; instead, the predators followed materials of integumentary origin. Experiment 2 revealed that rattlesnakes acquired chemical information from the prey's integument during the predatory strike, and this information was later used in locating the rodent's carcass. Experiment 3 found that trails deposited by envenomated mice were preferred by rattlesnakes over trails deposited by nonenvenomated prey, but the snakes' ability to discriminate these trails interacted strongly with the angular separation between them. Rattlesnakes clearly possess several mechanisms that enhance their likelihood of recovering carcasses after predatory strikes have been delivered.

CLEMENT J.L.* , BONAVITA-COUGOURDAN A.** , LANGE C.*** , JOULIE C.*
THE ROLE OF CUTICULAR HYDROCARBONS IN THE ANT CAMPONOTUS VAGUS:
NESTMATE AND LARVAL RECOGNITION.

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In the ant Camponotus vagus workers are able to discriminate between adult nestmates and alien individuals of the same species. Introduction of alien workers dead or alive or lures with cuticular hydrocarbons from alien workers' head or thorax elicited a very strong behavioral response from resident workers. The results demonstrated that we can transfer the colony chemical label or signature on a worker. The chemical signature is composed of saturated hydrocarbons and the relative proportions of some of them, especially dimethylalkanes are responsible of the nestmate recognition. On the other hand, workers are able to recognize larvae, they discriminate between larvae originating from their own or alien society. The cuticle of larvae and workers is covered with the same hydrocarbons (24 to 35 carbons) but the relative proportions of the main hydrocarbons are statistically different. Larvae of each society exhibited a unique pattern and society diagnostic hydrocarbons are similar in both larvae and workers.

Cooper, William E., Burghardt, Gordon M. Measurement of Squamate Responses to Prey Odors. Auburn University at Montgomery, Montgomery, AL 36193 and the University of Tennessee, Knoxville, TN 37996.

In the most widely used experimental paradigm for study of squamate responses to prey odors, chemical stimuli from various sources are presented to reptiles on moistened cotton swabs. Potentially important response measures include orientation and duration of orientation to the swab, number of tongue-flicks directed to the swab, strikes or bites (attacks), and latency to bite. Different investigators have emphasized different responses, but nearly all have used response measures that include tongue-flicking. The most frequently used measure of responsiveness to prey odor is the tongue-flick attack score (TFAS), which incorporates the influence of attacks, latency to attacks, and tongue-flicking. In this talk, TFAS is compared to several other possible measures and characteristics of an ideal measure of response to prey odors are discussed. Sample data from lizards and snakes will be analyzed in different ways. TFAS is an excellent measure, its assignment of relative weights to number of tongue-flicks and latency to biting is arbitrary but apparently unavoidable. Because the relative weights for TFAS differ among studies and even individual snakes, various suggested conventions are proposed. Appropriate statistical analyses are also considered.

Cutler, Horace G.. Natural Products from Microorganisms and Their Potential for Agricultural Use. USDA-ARS, Richard B. Russell Center, Athens, GA 30613.

Biologically active natural products are characteristically diverse in structure, may have high specific activity and can be very target specific. They offer unique templates for synthetic derivatization and, for the most part, are short lived making them excellent candidates as environmentally safe agrochemicals. Natural products exhibit activity in a wide range of useful areas and included are antimicrobials, plant growth regulators, phytotoxins, insecticides, and pharmaceuticals. The isolation and activity of select compounds and their congeners will be traced from the primary to the tertiary bioassays and their structure-activity relationships discussed. These include moniliformin, which has been patented as a herbicide, cyclophenin, cyclophenol, the pergillins, some cyclic peptides, and others.

Daniel, Peter C., Charles D. Derby, and Jacqueline B. Fine-Levy.
Learning to Eat Well: Modulation of Chemoresponsiveness of Marine Crustaceans. Georgia State University, Atlanta, GA 30303.

Marine crustaceans glean information about their environment predominantly through their chemical senses. The meaning of these cues varies as a function of changes in internal and external conditions. Thus, it is advantageous for the animal to modulate its responses to chemical signals accordingly. American lobsters may increase responsiveness to prey they have previously ingested thus decreasing search time and consequently increasing the food value of that prey. The degree of this response may be affected further by the nutritional quality of the prey. We have also found that responsiveness by spiny lobsters to a food odor may decrease after 1) association of an aversive stimulus with that odor and 2) repetitive presentation of a food odor not followed by a food reward. Both of these learned responses should be important in optimizing the animal's behavior in its natural environment.
(Supported by the Whitehall Foundation and NINCDS)

Derby, C., P. Daniel, J. Fine-Levy, and M.-N. Girardot.
Behavioral and Neural Discrimination of Foods Based on
Their Odors by the Spiny Lobster. Dept. of Biology,
Georgia State University, Atlanta, GA 30303.

Lobsters feed on a vast diversity of prey species, but they also show selectivity in their food preferences over time. Since the chemical senses of lobsters are critical to their feeding behavior, it is likely that such food selectivity is possible because lobsters can discriminate among the odorant mixtures released by potential prey. Using associative and non-associative conditioning paradigms, we have demonstrated that lobsters can discriminate among four 41-component food mixtures. The

discrimination may be predicted from multivariate analyses and may number less than ten.

(Supported by the Whitehall Foundation and NINCDS)

Dial, Benjamin E. Detection and identification of skin chemicals from saurophagous snakes by gekkonid lizards (Coleonyx variegatus). Department of Biology, Chapman College, Orange, California 92666.

I examined the ability of Coleonyx variegatus to detect and identify integumentary-derived chemicals of a saurophagous snake (Phyllorhynchus decurtatus) and a nonsaurophagous snake (Chionactis occipitalis) by using tail display, a predator-specific behavioral bioassay of predator identification in this lizard species. Chemicals from P. decurtatus elicited defensive attack in 13% and tail display in 79% of the trials; tail display occurred only in response to these chemicals. Of the tail display trials, 29% included flight behavior after display. None of the trials with C. occipitalis resulted in tail display, however, 30% resulted in flight. I conclude that C. variegatus is capable of detecting snake skin chemicals and identifying the source as "predator". I suggest that geckos might detect chemical trails left on substrate by passing snakes and avoid such areas. This might place time/energy constraints on gecko foraging, but survival benefits would outweigh these costs.

DITTEBRAND, HUBERT AND MANFRED KAIB, Department of Animal Physiology, University of Bayreuth, Postfach 101251, D-8580 Bayreuth, Fed. Rep. Germany
POISON GLAND SECRETION AND RECRUITMENT COMMUNICATION IN *Myrmicaria eumenoides*

Myrmicaria eumenoides is a common ground dwelling ant species in Africa and an important termite predator. This ant reaches high population densities and is able to quickly utilize newly discovered protein sources. Food recruitment strategies are modulated by both, chemical signals from the poison gland secretion and by mechanical signals.

The poison gland reservoir develops age dependent. Its volume reaches in foraging ants (> 6 weeks old) up to 10% (= 0,6µl) of the gaster volume. The secretion is composed by a high-volatile and a low-volatile fraction. There is no evidence for a signal function of the low-volatiles during orientation or recruitment behaviour. Being a fixative for the low-volatiles it extends the evaporation of the olfactory signal. Limonene is the main component (97%) of the secretion's volatiles.

Limonene on its own elicits dose-dependent short-range-recruitment equally to poison gland secretion. It aggregates ants over a distance of 1 cm (95%) at the prey. The aggregation diminishes within < 10 min.

Long-range-recruitment is elicited by scout ants individually returning from food to the nest. Within the nest poison gland secretion alerts nestmates but does not trigger long-range-recruitment. However, in combination with mechanical stimuli (antennating behaviour) poison gland secretion or Limonene only recruits nestmates from the nest to a newly discovered food source.

Duvall, David and David Chiszar. Behavioral and Chemical Ecology of Prairie Rattlesnake Foraging Migrations and Movements: Field and Lab Experiments. Dept. of Zoology, University of Wyoming, Laramie 82071 and Dept. of Psychology, University of Colorado, Boulder 80309.

Prairie rattlesnakes (*Crotalus v. viridis*) studied in the field in the Rocky Mountain region, have been observed both to actively search for prey and to sit-and-wait in ambush. In Wyoming, vernal foraging migrations can be lengthy. We conducted coordinated lab and field experiments in Wyoming wherein vernal migrating, radiotagged snakes (field studies only) were presented with three experimental conditions as they moved: (1) live, caged deer mice (a natural prey item), (2) cages containing odors of deer mice alone, or (3) empty (control) cages. Rattlesnakes studied both in the lab and field ceased movement and spent significantly more time with cages containing live deer mice, but not with control cages or those containing deer mouse odors. However, in lab studies in Colorado, we found that prairie rattlesnakes were attracted by, and ceased locomotion in the vicinity of, cages containing the odors of lab strains of house mice. At a minimum, these results indicate (1) that the search for prey in Wyoming is one of, if not, the major functions of extensive vernal movements, (2) that the presence of live deer mice induced migration cessation in Wyoming (lab and field), and (3) that house mouse-derived, but not deer mouse-derived, odors were sufficient to stop moving or migrating individuals.

ESPELIE, Karl E. and HERMANN, Henry R. PARACHARTERGUS
AZTECUS, A SOCIAL WASP THAT NESTS IN ANT-ACACIAS.
Department of Entomology, University of Georgia, Athens,
GA., 30605

The social wasp, Parachartergus aztecus, was found to nest exclusively in ant-acacia trees in the Yucatan peninsula. The wasp was shown to possess the same cuticular hydrocarbon composition as the ant, Pseudomyrmex ferrugineus. This identicalness of surface lipids is probably responsible for the fact that the ants allow the wasps to nest in ant-acacia trees which are normally kept free of intruders by the ants. Furthermore, the surface of the wasp nest and the surface of the thorns of the acacia were shown to have wax layers with hydrocarbon compositions similar in chain length distribution to that found in the wasp and ant cuticular waxes. These facts strongly support a biochemical coevolution of acacia, wasp and ant.

EVERAERTS, C. ¹, ROISIN, Y. ², BONNARD, O. ¹ and PASTEELS, J.M. ² MODE OF ACTION OF THE DEFENSIVE SECRETION IN NASUTITERMES PRINCEPS: PART PLAYED BY MONO- AND DITERPENIC FRACTIONS.

¹: Lab.Zoologie. UA.CNRS-674. Université de Bourgogne. 6, bd. Gabriel. F-21000 DIJON.

²: Lab.Zoologie. DBA-CP.160. Université libre de Bruxelles. 51, av F.D.Roosevelt B-1150 BRUXELLES.

Termites of the genus Nasutitermes are known to possess special defensive cues. The soldiers present a pear-shaped head containing an important frontal gland which elaborates a mono- and diterpenic mixture. This gluey secretion is squirted onto all potential foes which are quickly incapacitated. Nowadays, the chemical composition of this secretion is well known in many species, but its mode of action and the role of both fractions are poorly documented. We present here some results about the secretion of a Neo-Guinean Termite: Nasutitermes princeps. The monoterpenic fraction of its secretion mainly consists of (+)-alpha-pinene. The role of this compound as toxic or as alarm pheromone is discussed. About the diterpenes, we consider their entangling properties, their toxicity, and their influence on monoterpenes action.

FARINE, J.P. CHEMICAL COMMUNICATION IN DYSDERCUS CINGULATUS
(HETEROPTERA, PYRRHOCORIDAE) : CHEMISTRY AND FUNCTION OF THE
EXOCRINE SECRETIONS.

Laboratoire de Zoologie, C.N.R.S, U.A. 674, Université de
Bourgogne, 6 Bd Gabriel, 21000, DIJON, FRANCE.

In D. cingulatus, semiochemicals control gregariousness, sexual behavior, alarm and defensive behavior. The chemistry (GC, GC-MS) of the exocrine secretions was studied in the three dorso-abdominal glands of the nymphs, in the two dorso-abdominal and metathoracic glands of the adults of both sexes, and in the sternal glands of the males. About fifty different compounds were identified (alkanes, alkenes, alkynes, aldehydes, ketones, alcohols, acetates, terpenes, acids) ; until now some of these had never been found in Heteroptera. Their function is discussed in alarm, defense, aggregation and sexual behavior.

BIOSYNTHETIC AND GENETIC STUDIES OF PHEROMONE PRODUCTION IN
DROSOPHILA.

J.M. Jallon and J.F. Ferveur. Biologie et Génétique Evolutives du
C.N.R.S. F-91198 Gif-sur-Yvette cedex

The main pheromonal compounds of D. simulans and D. melanogaster share part of their biosynthetic pathway which was studied with injected radioactive precursors. Palmitate and vaccenate but not stearate are common precursors for aphrodisiac monoene and diene biosynthesis. It is suggested that the first desaturation leading to 7 unsaturated hydrocarbons after the elongation and decarboxylation steps, is introduced on palmitate using an enzyme with the same specificity as stearyl desaturase, an enzyme used by both sexes and species. Such an enzyme activity has indeed been characterized in Drosophila. A crucial question is how the second double bond specific to mature D. melanogaster females is introduced.

We have looked for variants among strains from various regions of the world. Among females we have found two chemical races of D. melanogaster based on female dienes. All possess the characteristic 7,11 heptacosadiene, but in one race it is extremely abundant while in the other is produced, instead, a large amount of its position isomer, 5,9 heptacosadiene. Among males, 7-tricosene, the major cuticular component of Canton S males may be replaced by its homologous 7-pentacosene. This equilibrium between 7-tricosene and 7-pentacosene is also observed in D. simulans.

Complementary studies using intraspecific interracial hybridizations, in both D. melanogaster and D. simulans, interspecific hybridizations and chromosomal exchanges suggest the influence of several loci. A critical one which might produce allelic variants of a desaturase is on chromosome III.

Fischer, Daniel C., and Marcos Kogan. CHEMORECEPTORS OF ADULT MEXICAN BEAN BEETLES: STRUCTURE AND ROLE IN FOOD PREFERENCE. Illinois Natural History Survey, 607 E. Peabody Peabody Dr., Champaign, IL. USA 61820.

The Mexican bean beetle, *Epilachna varivestis*, is an oligophagous insect that accepts leaves of soybean, *Glycine max* as food but exhibits distinct preferences among varieties. It is believed that the basis for discrimination between the resistant PI 229358 and the susceptible cv. 'Williams' is chemical. By the ablation of chemosensilla on antennae, maxillary palpi, labial palpi, and foretarsi, followed with leaf disc preference tests, we found antennal and maxillary palp chemosensilla to be almost entirely responsible for Mexican bean beetles discrimination between foliage of resistant and susceptible genotypes. All appendages were examined by scanning electron microscopy and, except for foretarsi, were found to bear several types of olfactory and gustatory sensilla, which are figured and described. Since behavioral observations show that olfaction is usually sufficient to cause rejection of PI 229358, we conclude that olfactory sensilla on antennae and maxillary palpi are critical in food discrimination.

Ford, Neil B. and Perry-Richardson, Janice J., Snake avoidance of substrate odors from ophiophagous snakes. Department of Biology, University of Texas at Tyler, Texas 75701.

Recognition and avoidance of predators is important to the survival of any species and one significant predator of snakes is other ophiophagous snakes. Since chemoreception is an important sensory modality for snakes, it seems likely that predator odors should play a role in predator avoidance. We tested the ability of corn snakes, *Elaphe guttata* to avoid substrate from the cages of an ophidian predator, the eastern king snake, *Lampropeltis getulus*; and a species known to occasionally eat snakes, the cottonmouth, *Agkistrodon piscivorus*. Corn snakes were individually placed in a 270 cm circular tank containing 8 evenly spaced tile refuges. Two refuges opposite each other were randomly chosen for placement of substrate from cages of test snakes. Each corn snake was tested separately with substrate from king snakes, cottonmouths and a non-snake eating water snake, *Nerodia erythrogaster*. For each of these three tests snakes were left in the tank for two days and refuges were checked 3 times. The tank was cleaned and fresh brown wrapping paper taped to the floor before each test. Corn snakes showed a significant avoidance of substrates from king snake cages, no response to water snake substrate, but tended to be attracted to cottonmouth substrate. The ability to avoid a site where a king snake has been is of obvious selective advantage but the significance of being attracted to the site of a cottonmouth is unknown.

FRANCKE, Wittko

Chemical principles in odour communication

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Striking similarities are found among structures of chemical messengers both from animals and plants which point to general concepts in the evolution of "chemical languages". The variability of structures appears, however, not to be unlimited, and basic principles seem to exist in the chemistry of signalling. Most of the compounds used for chemical communication are produced from acetate units (acetogenins), from propionate units ("polyketids" with distinct branchings- chirality at the branching centers often is the same in different compounds) or from isoprene units (mevalogenins). Differences in physical and chemical properties of components of a mixture may open informations on the age of the signal and/or on the distance of the emitter. "Byproducts" of the biosynthesis of active compounds cause a "fine tuning" of the bouquet and thus may facilitate evolution.

Gerhart, Donald J.; Dan Rittschof; Theresa Hamilton; Jeffrey S. Handen; Kelly G. Eisenman; Nathan Simmons. CHEMICAL AND PHYSICAL DEFENSES OF A GORGONIAN OCTOCORAL AGAINST CRUSTACEAN PREDATORS. Duke University Marine Laboratory, Beaufort, NC 28516.

Crustacean predators are abundant in many marine systems. Past studies of the anti-predator defenses of gorgonian octocorals, however, have focussed almost exclusively on fish as gorgonian predators. We examined the interactions of the subtropical gorgonian Leptogorgia virgulata and the crabs Callinectes sapidus and Uca pugilator. Gorgonian spicules and chemical extract, when delivered singly, significantly inhibited feeding responses by crabs of both species. The simultaneous addition of spicules and extract caused strongest inhibition of feeding. Previous findings demonstrated a similar pattern for inhibition of fish feeding. Death occurred in one-third of the Uca exposed to mixtures of extract and spicules; crabs in other treatments showed negligible mortality. The chemical and physical defenses of L. virgulata can interact synergistically to inhibit predation by both crustaceans and fish.

Glendinning, John. The effectiveness of cardenolides and pyrrolizidine alkaloids in monarch butterflies as deterrents to mouse predation. Department of Zoology, University of Florida, Gainesville, FL 32611

The cardiac glycosides (CG's) and pyrrolizidine alkaloids (PA's) present in adult monarch butterflies are purported to deter vertebrate predators by virtue of their bitter taste and toxicity. I compared the taste sensitivity of the mice, Peromyscus melanotis, P. aztecus hyloces and Reithrodontomys sumichrasti, to a CG (digitoxin) and a PA (monocrotaline). Of these 3 predators, only P. melanotis feeds extensively on monarchs that overwinter in Mexico. I exposed all 3 species to multiple concentrations of digitoxin or monocrotaline in two-diet preference tests. Each species' respective taste rejection-thresholds were ranked R. sumichrasti < P. a. hyloces < P. melanotis, whereas those for monocrotaline were ranked P. a. hyloces < P. melanotis < R. sumichrasti. All 3 species rejected digitoxin at concentrations found in overwintering monarchs, but rejected monocrotaline only at concentrations above those normally found in overwintering monarchs. These results suggest that each species has different taste sensitivities to CG's and PA's, and that they perceive these substances as having different tastes. I conclude that the taste of CG's, and not PA's, plays a major role in determining whether a mouse species feeds upon monarchs.

Greenberg, E.P. The Motile Behavior of *Spirochaeta aurantia*: A Twist to Chemosensory Transduction in Bacteria. Cornell University, Department of Microbiology, Ithaca, NY 14853.

Like all spirochetes, *S. aurantia* is a relatively long, slender, helical, gram-negative bacterium with a distinctive morphology and motility. Spirochetes possess a protoplasmic cylinder which comprises the nuclear and cytoplasmic regions, as well as the membrane-peptidoglycan layer. Wrapped around the protoplasmic cylinder are periplasmic flagella. One end of each flagellum is inserted near one pole of the protoplasmic cylinder, whereas the other end is not inserted. In *S. aurantia* there are two flagella, one inserted near each pole and both wrap around most of the protoplasmic cylinder. Both the flagella and the protoplasmic cylinder are enclosed by an outer membrane. Except for their location, the periplasmic flagella of *S. aurantia* appear to be analogous to bacterial flagella; they propel cells by a proton motive force driven rotation. Flagellar filaments consist of several polypeptides.

The behavior of *S. aurantia* can be described as follows: Cells generally swim in straight lines at a speed of about 20 $\mu\text{m/s}$ (runs). Often cells are observed to reverse, and sometimes cells stop translating and flex. The duration of flexing varies but this behavior can persist for several seconds. According to the model for motility of *S. aurantia*, a cell should run when the motor for one flagellum is rotating clockwise (CW) and the motor for the other flagellum is rotating counterclockwise (CCW). When the two motors switch in synchrony a cell will reverse and if only one motor switches (asynchronous switching) the cell will flex. This is in contrast to the well studied flagellated bacterium, *Escherichia coli* which exhibits a CCW bias of flagellar motors. By controlling the degree of CCW bias, *E. coli* can modify its behavior and respond to chemical stimuli. *S. aurantia* can also respond to chemical stimuli; attractants stimulate smooth swimming (CW-CCW motor orientation). It has been demonstrated that a voltage clamp inhibits chemotaxis in *S. aurantia*, thus implicating changes in membrane potential or ion fluxes in the mechanism of chemotaxis. In similar experiments with *E. coli*, application of a voltage clamp did not inhibit chemotaxis. This suggests basic differences in the chemosensory transduction systems of *S. aurantia* and *E. coli*. However, there are also basic similarities in the sensory systems of these organisms. For example, *S. aurantia* possess proteins that insofar as is known are quite similar to the methyl-accepting chemotaxis proteins of *E. coli*.

Griswold, Margot. Resource Availability Hypothesis and Desert Shrubs.
Department of Ecology & Evolutionary Biology, University of
California, Irvine

Nine species of desert shrubs, varying in levels of drought resistance and leaf life-times, were studied with respect to herbivory and chemical defenses. Comparisons of immobile compounds (sensu Coley et al.) and levels of herbivory between species do not fit the predictions of the resource availability hypothesis.

Hazelbauer, Gerald L. Methyl-Accepting Chemotaxis Proteins: Transmembrane Receptors Present Throughout the Diversity of Bacteria. Biochemistry/Biophysics Program, Washington State University, Pullman, WA 99164-4660.

Methyl-accepting chemotaxis proteins are central components of the extensively studied chemotactic system of the enteric bacteria *Escherichia coli* and *Salmonella typhimurium*. These four transmembrane receptor proteins, called transducers, exhibit extensive sequence identity, consistent with common functions in signal transduction and adaptation. Methyl-accepting chemotaxis proteins have been observed in other bacterial species and this laboratory became interested in their relationship to the transducer proteins in the enterics. Initial studies with antiserum that recognized transducers from *E. coli* indicated that methyl-accepting proteins from *Bacillus subtilis* and *Spirocheata aurantia* were antigenically related to the enteric proteins. Immunoblot studies have identified candidate transducers in several eubacterial species. These observations prompted a detailed investigation of methyl-accepting taxis proteins in the archaeobacterium, *Halobacterium halobium*. The results revealed that basic themes observed in the study of the enterics persist in this representative of the archaeobacteria, although some interesting variations occur. In collaboration with others, we are searching in a number of bacterial species for genes that code for methyl-accepting sensory proteins. A series of oligonucleotide probes, representing regions of conserved sequence among the transducer genes of *E. coli*, are being used to search for complementary sequences. Cloning and sequencing of the genes contained on these fragments should provide insight into the degree to which the structure of these sensory proteins has been conserved over the evolutionary distances that separate the diversity of bacteria.

HUMMEL, Hans E. Semiochemicals of Cucurbita sp. suppress sex attraction in male Diabrotica undecimpunctata howardi Barber (Chrysomelidae). Justus-Liebig-University Giessen, Institute of Phytopathology and Applied Zoology, Ludwigstrasse 21, D-6300 Giessen-Federal Republic of Germany-

Sticky traps baited with the synthetic female sex pheromone 10-methyl-tridecane-2-one readily attract and trap male D.undecimpunctata how. beetles in cornfields, Zea mays (Gramineae), and soybean fields, Glycine max (Leguminosae), while the same traps exposed at the same time (August and September) under the same conditions in adjacent fields of Cucurbita sp. (Cucurbitaceae) attract only very few males, and do so quite erratically.

Field observations replicated over a period of 5 years in Illinois are reinforced by flight tunnel studies in the laboratory. Their results suggest a statistically significant negative correlation between the cucurbitacin content of cucurbit plants and the ability of the male beetles to orient towards female pheromone sources.

Neither population density nor sex ratio of beetles in cucurbit fields are responsible for this lack of orientation ability.

Suppressive (rather than stimulatory) effects of plant semiochemicals on sex pheromone communication have been rarely documented.

Diabrotica undecimpunctata howardi offers a facile model system for investigating such plant-insect interactions and towards the unraveling of a fascinating example of chemical ecology, both at the chemical and at the ecological level.

Jackson, Brian D., Johan P.J. Billen⁺ and E. David Morgan. THE CHEMICAL SECRETIONS OF SOME PRIMITIVE MYRMECIA ANTS OF AUSTRALIA. Department of Chemistry, University of Keele, Staffordshire ST5 5BG, England.

⁺Zoological Institute, University of Leuven, Naamsestraat 59, B3000 Leuven, Belgium.

The composition of the Dufour gland secretion of ants can be a useful taxonomic indicator. Investigation of its contents by GC and GC-MS showed predominantly linear hydrocarbons in Myrmecia gulosa and M. nigriceps but only acetates, aldehydes and propionates in M. pilosula. The chemical profiles of M. gulosa and M. nigriceps are similar to Nothomyrmecia macrops the most primitive living ant, their major components being (Z)-8-heptadecene, pentadecane and heptadecane. The main components of M. pilosula are hexadecyl acetate, (Z)-9-octadecenyl acetate, (Z)-11-eicosenyl acetate and (Z)-11-eicosenal. Some geographical variation was observed in the relative proportions of the components. The chemotaxonomic significance of these compositions for the primitive Australian ant subfamilies Myrmeciinae and Nothomyrmeciinae is discussed. (Z)-11-Eicosenal or geranyl citronellol, minor components of the Dufour gland secretion of M. gulosa may be responsible for the aggressive behaviour released by the natural stinging secretions.

JOHNS, Timothy, A Chemical Ecological Model of the Evolution of Medicine. School of Dietetics and Human Nutrition, Macdonald College of McGill University, Ste. Anne de Bellevue, Quebec, H9X 1C0, Canada.

Human medicine has analogies in three trophic level interactions involving plants, herbivores and parasites. Allelochemicals, while potentially toxic to humans, may have inherent positive functions in human physiology and ecology. Cultural influences on human dietary evolution, while improving nutritional quality, have reduced levels of allelochemicals in the diet. In conjunction with greater exposure to infectious disease, these dietary changes may have necessitated the more deliberate consumption of biologically active chemicals. Herbal medicine and modern pharmacological uses of chemicals, then, may be cultural extensions of the pharmacophagous behaviors of animals. A model is presented which hypothesizes that allelochemicals as dietary constituents in traditional subsistence systems play a role in controlling infectious disease. Field studies of the use of potentially toxic leafy vegetables by Luo-speaking people in western Kenya and bioassays of the antiparasitic activities of these plants are being carried out to test this hypothesis.

JOHNSON, ROBERT H. and DAVID E. LINCOLN. Growth and Alleochemical Responses of Basin Sagebrush to Chronic Defoliation in Enriched Carbon Dioxide Atmospheres. Dept. of Biology, University of South Carolina, Columbia, SC 29208.

Artemisia tridentata plants (64) were grown under projected (650 ppm) and approximate ambient (350 ppm) levels of CO₂. One half of the plants in each carbon dioxide treatment were subjected to three episodes of 40% defoliation. CO₂ enrichment did not significantly affect leaf volatile terpene yield. Although variation in terpene content was high, defoliated plants from both carbon dioxide regimes exhibited lower mean yields ($P < 0.056$). Carbon dioxide enrichment increased final shoot weight ($P < 0.0001$) and defoliation decreased it ($P < 0.0001$); similiar trends were also observed in leaf specific weight. Defoliation decreased final shoot biomass by 33% at 350 ppm, whereas shoot biomass decreased only 16% from defoliation at 650 ppm CO₂. Although root biomass was not significantly affected by any treatment, root/shoot ratios decreased in higher CO₂ concentrations ($P < 0.0001$) and increased with defoliation ($P < 0.0006$). The projected rise in atmospheric carbon dioxide may facilitate greater plant tolerance of chronic herbivory compared to plants under ambient conditions.

Jones, Clive G. and Lawton, John H. Does Plant Chemical Diversity Affect Insect Species Richness? Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545 and Department of Biology, University of York, Heslington, York YO1 5DD, England.

We investigated postulated relationships between the chemical diversity of plants (number of different biosynthetic pathways of secondary metabolism) and the number of species of phytophagous insects that utilize these plants. We used data on insects and natural products chemistry of the British Umbelliferae. There was no significant correlation between chemical diversity and insect species richness, indicating that chemical diversity per se is not a determinant of the number of species that eventually evolved to exploit these plants. We offer an explanation of these results. We also examine the consequences of a surprisingly strong relationship between the chemical diversity of plants and the extent to which they have been studied by chemists.

Jordan, Elizabeth D., Nikolaus H. Fischer, G. Bruce Williamson*, and Jeffrey D. Weidenhamer. INVESTIGATION OF THE SOIL UNDER THE FLORIDA WILD ROSEMARY (CERATIOLA ERICOIDES): QUANTITATION OF THE ALLELOCHEMICAL HYDROCINNAMIC ACID. *Departments of Chemistry and *Botany, Louisiana State University, Baton Rouge, Louisiana.

Ceratiola ericoides is a shrub endemic to the Florida sand pine scrub community. There is a bare zone surrounding mature Ceratiola shrubs, and field and laboratory studies have provided strong evidence of the allelopathic activity of the shrub. Hydrocinnamic acid (HCA) is a breakdown product of ceratiolin, a dihydrochalcone which is present in abundance in water washes of fresh Ceratiola foliage. HCA is biologically active on seeds of grasses native to the neighboring Florida sandhill community. In the present study, analysis of water extracts of monthly samples of the soil under three individual Ceratiola shrubs was carried out by reverse-phase HPLC. The extracts contained HCA in varying concentrations, with the higher concentrations occurring during the summer rainy season. The implications of this data to the allelopathic interactions of the scrub and sandhill communities will be discussed.

J.P. Grunshaw (2), H. Guermouche (1), S. Guermouche (1), N.D. Jago (2),
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CHEMICAL TAXONOMIC STUDIES OF CUTICULAR HYDROCARBONS IN LOCUSTS OF THE
SHISTOCERCA AMERICANA COMPLEX (ACRIDIDAE:CYRTACANTHACRIDINAE): chemi-
cal relationships between New World and Old World species :

Genetics studies gave an insight into the evolutionary systematics of
the S.Americana complex. Chemical analysis and comparison of the cuti-
cular hydrocarbons of five species of this complex: S.gregaria , can-
cellata , americana , piceifrons and pallens , confirmed the species
status previously established by hybridisation and also revealed new
elements. We have shown the existence of two groups of species: S. gre-
garia and S. cancellata on one hand, S. americana and S. piceifrons
on the other. S. pallens does not fit into either of these groups. These
analyses have thus shed some light on the possible origins of S. grega-
ria vis-à-vis S. cancellata .

MANFRED KAIB, Dept. Animal Physiology, University of Bayreuth, Postfach 101251,
D-8580 Bayreuth, Fed. Rep. Germany
HOW *Schedorhinotermes* TERMITE BLUNT ANT PREDATION

Termites live in colonies with large numbers of individuals locally concentrated in their hives. Thus termites are an excellent protein source to predators - like ants - with well-developed recruitment systems. To counteract ant predation, termites have evolved a variety of defense strategies on both, a communal and an individual level. By cryptic behaviour and by covering foraging trails or established foraging sites, termites are mechanically separated from ants and thus less vulnerable. During individual combat with ants most termite species rely on mandibulated defense.

Schedorhinotermes lamanianus possesses, in addition to defense strategies common in other termite species, extremely efficient defense mechanisms based on caste-specific polyethims during foraging and on the soldiers' frontal gland secretion (FGS).

Foraging is soldier-initiated. Soldiers lay orientation-trails with concentrations below threshold of termite workers. Only trails being reinforced by frequent soldier commuting are followed by termite workers. Thus workers are always guarded by soldiers. The caste-specific polyethism during foraging is based on the different trail-pheromone sensitivity of workers and soldiers.

The FGS is composed by aliphatic, saturated and unsaturated Ketones. It is released during ant attack and rapidly evaporates. FGS is not toxic nor sticky, but volatile constituents repel ants, cause to ants the loss of termite prey, and inhibit ant recruitment mechanisms, thus minimizing ant predation. Mass attacks by ants do not occur. The chemical defense by *Schedorhinotermes* is a generally effective strategy counteracting ant predation without physical contact. FGS-vapour, in addition, inhibits trail-following by termite workers in mechanically unprotected areas.

Kaiser, Dale, Lee Kroos, Adam Kuspa, Yvonne Cheng and Seung Kim.
Cell-cell interactions in Myxococcus. Dept. of Biochemistry,
Stanford University.

The time sequence of morphological, biosynthetic, and gene expression events during fruiting body development is controlled by chemical signals passed between cells. A set of mutants has been isolated that behave as if defective in cellular interactions necessary for development. Sporulation in fruiting bodies is restored to the mutants if they are mixed with developing wild-type cells. "Complementation" experiments with whole cells divide the mutants into 4 groups (A, B, C and D). Particular sets of transcriptional lac fusions to developmentally regulated promoters depend on the normal function of complementation groups, A, B, C and D. For example, A⁻ strains containing 18 among 21 different lac fusions tested fail to make β -gal, while strains containing 3 (of 21) other lac fusions do make β -gal. The pattern of dependences of β -gal expression on A, B, C and D is consistent with a branched linear regulatory pathway. A-dependent and C-dependent lac fusions are being used to purify the molecules responsible for an early (A) and a late (C) developmental signal. In crude extracts of developing wild-type cells, both activities are heat labile and nondialyzable.

Kerfoot, W. Charles. ARE LILY PADS THE "TREES" OF THE LITTORAL ZONE? Great Lakes Research Division and Department of Biology, University of Michigan, Ann Arbor, MI 48109

Until recently, freshwater macrophytes were considered impoverished in secondary compounds. Curiously, circumstantial evidence has long argued to the contrary, indicating the presence of active compounds. A crucial relationship is the life form of macrophytes. Recent surveys show 1) that noxious or unpalatable compounds are widespread and diverse among shoreline emergents related to known protected families, 2) that lily pad genera (e.g. Nymphaea, Brasenia, Nuphar) could represent the "trees" of the macrophyte community in that they contain elevated concentrations of phenolics and alkaloids, and 3) that submerged macrophytes show reduced levels of phenolics. Elevated phenolic concentrations in lily pads coincide with the presence of hydrolysable tannins. Preliminary experiments with flea beetles (Pyrrhalta nymphaeae) indicate sensitivity to phenolic concentrations.

Kung, Ching. ION CHANNELS OF Paramecium, YEAST AND E. coli. Laboratory of Molecular Biology and Department of Genetics, University of Wisconsin-Madison, Wisconsin 53706

Behavioral mutants of P. tetraurelia are continued to be examined. "Pantophobiacs" are defective in their Ca^{2+} -gated currents. These defects have been traced to amino-acid changes in their calmodulins, revealing a profound connection between this Ca^{2+} sensor and Ca^{2+} -gated channels.

We used patch clamps to study Saccharomyces cerevisiae spheroplasts. Their plasma membrane has a depolarization-gated K^+ channel which has selectivity, conductance and pharmacology like the delayed-rectifier K^+ channel of nerve. This membrane also has a channel that can be opened by mechanical forces at physiological range.

We also used the patch-clamp method to study spheroplasts of Escherichia coli made giant with cephalixin. The outer membrane has a depolarization-gated channel and another channel which is gated also by mechanical forces on the membrane.

Mechanically-gated channels may be operated by osmotic forces in vivo, and may be used in osmoregulation, osmotaxis, or during growth, division, budding or mating when morphogenetically-related surface stress is expected.

Supported by NIH GM22714, GM36386, GM37925, DK39121 and a grant from Lucille P. Markey Trust.

Lewis, W. Joe, J. H. Tumlinson. Chemically Mediated Associative Learning: Mechanisms and Role in Foraging Behavior of Parasitoids. USDA-ARS, P. O. Box 748, Tifton, GA 31793 and P. O. Box 14565, Gainesville, FL 32604, respectively.

Parasitoids use chemical cues to locate their hosts and prior experience can modify these responses. Females of the parasitoid wasp Microplitis spp. experienced by contact with host feces, orient and fly upwind to odors of their hosts, Heliothis zea larvae. Flight tunnel studies show that associative learning initially occurs at eclosion when the parasitoid contacts host frass on the surface of the cocoon and continues with each subsequent encounter with host feces. When females antennate, the feces they learn to recognize and subsequently fly to various volatile odors, even novel and otherwise unattractive odors like vanilla, associated with the feces. They link these volatile odors with a water extractable non-volatile chemical in the feces, evidently a host specific recognition cue. Antennation of the feces is elicited by the antennating stimulant, 13-methylhentriacontane. The association of tracking cues with host by-products, without the need for direct contact with the host, is a valuable adaptation for locating cryptic and evasive hosts.

Lynch, Steven P., and Ronald A. Martin. Implications of Cardenolide Sequestration by First Generation Monarchs on Milkweeds in the Southern United States. Department of Biological Sciences and Department of Chemistry, Louisiana State University, Shreveport, Louisiana 71115

Monarch larval host-plant utilization is correlated with cardenolide concentrations and thin-layer chromatography profiles of adult monarchs reared on three abundant southern U.S. milkweeds. Each host-plant species was found to be cardenolide-rich with mean concentrations of 245 ug/0.1g in Asclepias viridis, 886 ug/0.1g in A. asperula subsp. capricornu, and 432 ug/0.1g in A. humistrata. Butterflies reared on the three species were also found to be cardenolide-rich with mean concentrations of 337 ug/0.1g, 363 ug/0.1g, and 409 ug/0.1g, respectively. Cardenolide uptake by the butterflies appeared to incur no physiological costs and generally conformed to an inverse logarithmic relationship with saturation occurring in the butterflies with increasing host-plant concentrations. TLC patterns for all three species were unique yet similar, with the butterflies predominantly storing cardenolide metabolites more polar than those obtained from their host-plants. The data support the use of fingerprints to make ecological predictions concerning larval host-plant utilization. The breeding cycle in the southern states is short lived and by early to mid May, immature stages are generally absent and adults are rarely seen. We propose most first generation monarchs are reared on these three species and that their high levels of toxicity (146-1221 ug) are instrumental in educating naive predators as the species continues northward to establish its summer breeding patterns.

Manson, Michael D. Bacterial Chemotaxis: How Genetics and Molecular Biology Can Be Used to Study a Sensory System. Department of Biology, Texas A&M University, College Station, Texas 77843

Behavioral mutants exist for many organisms, but nowhere has the analysis of the genetic alterations yielded more information than for bacterial chemotaxis. This progress is due to the simplicity of the behavior studied and to the variety of genetic methods available. More recently, the genetic analysis has been augmented by the techniques of molecular biology. A combination of experimental approaches has characterized the three major component systems of the chemotactic apparatus: the chemoreceptors, the flagella with their reversible rotary motor, and the signal transduction mechanism that connects the other two elements. These systems will first be described in outline form. Then a more detailed account will be given of how genetics and molecular biology have been used to investigate specific elements of the receptors, the flagellar motor, and the signal transduction pathway.

Martínez, L.A. and R.K. Zimmer-Faust. Olfactory-Mediated Risk Sensitive Foraging in Aquatic Invertebrates. Neurosciences Research Program, Institute of Environmental Stress, and Marine Sciences Institute, University of California, Santa Barbara, CA 93106.

Although the chemical mediation of animal behavior has been intensively studied, few investigations have considered the strategic nature of animal response. We report findings from field experiments that explored how freshwater insect larvae and marine lobsters react to complex chemical signals consisting of substances released from prey and predators. For lobsters we found attractants in odors of prey and live conspecifics, and repellents in odors of live predators and dead conspecifics. The attraction of lobsters to live conspecifics caused cohabitation in refuges and communal defense against predators. Similarly, stream-dwelling stonefly and mayfly nymphs were attracted to chemical cues associated with prey, and repelled by chemical cues associated with predators. Interestingly, the odor of predatory fish was not repellent in habitats where there was no risk of predation by fish. In nature, animals must constantly balance conflicting demands of energetic requirements and predator avoidance. Our results suggest that chemosensory responses of aquatic animals are fine-tuned, and reflect complex ecological choices, such as the tradeoff between foraging efficiency and successful defense against predators.

Mason, Robert T., Isolation and Identification of Sex Attractant Pheromones in the Red-sided Garter Snake. Laboratory of Chemistry, NIH, Bethesda, MD 20892.

Female Canadian red-sided garter snakes, *Thamnophis sirtalis parietalis*, produce a sex attractiveness pheromone that elicits species-typical courtship behavior from adult males. Male garter snakes detect females by tongue-flicking pheromone cues from the female's dorsal surface and delivering them to the male's vomeronasal organ. The female sex attractiveness pheromone is soluble in hexane and can be extracted from the female's dorsum. Hexane washes of attractive, unmated females were fractionated on alumina columns and presented to courting males. Only one of 27 fractions contained any activity in bioassay tests with courting males. The components of the active fraction were isolated and analyzed by gas chromatography/mass spectrometry. Field tests of the components of the active fraction indicated that all of the activity was elicited by a series of saturated and unsaturated methyl ketones. The mono-unsaturated $\Delta 8$ -methyl ketones are undescribed and possess most of the attractivity. However, two of the saturated methyl ketones, C₂₉ and C₃₁ were synthesized and elicited courtship behavior in field tests. This work represents the first isolation and identification of a sex pheromone in the Class Reptilia.

McDaniel, C. A. Major Antitermitic Components of Catalpa Heartwood.
Forest Service, USDA, Southern Forest Experiment Station, P. O. Box
2008, GMF, Gulfport, MS 39505.

Heartwood of Catalpa bignonioides Walt (southern catalpa) was exhaustively extracted. The major components were separated by reverse-phase HPLC, and bioassayed using worker termites of the subterranean termite Reticulitermes flavipes. Identifications of the components were based primarily on GC/MS and UV data.

McNEIL, Jeremy and WEBSTER, R. Pheromone biology of two geographic populations of Bertha armyworm Mamestra configurata. Dept. biologie, Univ. Laval, Ste-Foy, Qué. Canada, GlK 7P4.

The identification of the female sex pheromone provided a potentially effective monitoring tool for the Bertha armyworm, a serious but sporadic pest of canola. However, results from a provincial-wide monitoring program established in Alberta in the early 1980's raised serious questions about its efficacy. Maximum trap catches decreased as one moved northward (75 1 male/trap/night) yet subsequent larval densities were at epidemic levels at all locations. Isozyme studies suggest that northward migration of mated females is unlikely, with the northern Peace River population being different from those further south. Given that the scotophase is considerably shorter (≈ 3 h) in the north than the south, it was hypothesised that if females in the two regions called for the same number of hours per night then differences in the levels of competition between calling feral females and pheromone lures might explain the differential trap efficacy. While calling patterns differed between the two populations, under both field and laboratory conditions, the levels of competition would be similar at different sites and would therefore not account for trap differences. Furthermore, the responsiveness of different aged males was similar for both populations when different combinations of pheromone concentration and light intensity were tested using a wind tunnel. The direction of future research, based on data obtained to date, will be discussed.

Menelaou, Marios A., Nikolaus H. Fischer, G. Bruce Williamson*, and Jeffrey D. Weidenhamer. CHARACTERIZATION OF ALLELOCHEMICALS OF SOLIDAGO PAUCIFLOSCULOSA. Departments of Chemistry and Botany, Louisiana State University, Baton Rouge, Louisiana.

Solidago pauciflosculosa (syn Chrysoma pauciflosculosa) is a shrub which occurs in the Florida panhandle in open areas of sand pine scrub. Very few plants grow in the vicinity of the shrub so it is suspected of having allelopathic properties. Water and hexane extracts completely inhibited germination of lettuce (Lactuca sativa). Germination of grass seeds (little bluestem, Schizachyrium Scoparium) was unaffected by water extracts but radicle growth was inhibited. These results led to the investigation of the chemical constituents of S. pauciflosculosa. The organic extracts were very rich in sesquiterpenoids. Four sesquiterpenoids were isolated from the hexane and methylene chloride extracts and purified by column chromatography and preparative thin layer chromatography. The compounds have been characterized using different spectroscopic techniques mainly modern nuclear magnetic resonance experiments. The isolation and structure elucidation of these compounds will be presented.

Mihaliak, Charles, Frank Karp and Rodney Croteau. Regulation of monoterpene biosynthesis with reference to the palatability of Satureja douglasii. Institute of Biological Chemistry, Washington State University, Pullman, WA 99164-6340.

Satureja douglasii (Labiatae) chemotypes which accumulate primarily the bicyclic monoterpenes camphene and camphor are more palatable to a native molluscan herbivore (Ariolimax Dolichophallus) than are chemotypes which, in addition to the bicyclic monoterpenes, accumulate either C-2 or C-3 oxygenated monocyclic monoterpenes (i.e. carvone and menthone). The objective of the current study was to identify the key enzymes which may regulate accumulation of the herbivore-detering oxygenated monoterpenes. Data from cell free enzyme preparations derived from the epidermal oil glands suggest that the appropriate geranyl pyrophosphate cyclase must be present to produce limonene, and that one of two distinct cytochrome P-450-dependent hydroxylases is required to produce either carvone or menthone from limonene. Chemotypes which accumulate only camphene and camphor apparently lack the P-450-dependent hydroxylases and/or the appropriate cyclase enzyme. These enzymes may play a primary role in determining the monoterpene composition, as well as the palatability of S. douglasii chemotypes.

Morse, Daniel E. Chemical Signals Control Site-Specific Settlement and Metamorphosis of Planktonic Larvae: Characterization of the Signals, Receptors, Transduction and Regulatory Mechanisms. Marine Science Institute, Univ. of Calif., Santa Barbara, CA 93106 USA.

Two kinds of environmental chemical signals regulate settlement and metamorphosis of Haliotis (gastropod) larvae; contact with GABA-mimetic peptides on the surfaces of crustose red algae induces settlement and metamorphosis, and diamino acids dissolved in seawater amplify sensitivity of the larvae to the morphogenetic inducer. These molecules act at different chemosensory receptors; both receptors recently have been labeled and characterized directly at the biochemical level. Information about these receptors, and the mechanisms of signal transduction and amplification by which they regulate site-specific settlement and metamorphosis, is presented. Results with the gregarious tube-building polychaete, Phragmatopoma californica, and with Agaricia spp. corals, further demonstrate: (a) that similar mechanisms control settlement and metamorphosis in larvae of these species; and (b) that the natural biochemical inducers found to trigger settlement and metamorphosis in the laboratory also induce substratum-specific settlement, metamorphosis, and recruitment in the ocean. In each of these cases, the receptors and signal transducers appear closely related to those of evolutionarily antecedent endogenous chemical signaling systems.

NAYA Yoko, Wataru Miki, Mayumi Ohnishi, Midori Ikeda and Koji Nakanishi
REGULATION OF MOLT CYCLE IN CRUSTACEAN
Suntory Institute for Bioorganic Research: Wakayamadai, Mishima-gun, Osaka 618, Japan

Growth in crustaceans involves periodic shedding and re-formation of the exoskeleton. The metabolic events, both before and after ecdysis taken together, are defined as a molt. When crabs are reared in the same tank, the population is decreased to about half after each ecdysis, that resulted from their cannibalistic habitude towards freshly molted animals. If the duration of molting was synchronously controlled by chemicals, an increased number of the survivors is expected. Hence, we have studied their endocrinology in the molting process.

By means of *in vitro* assay, eyestalk-derived 3-hydroxy-L-kynurenine (3-OH-K) and its metabolite, xanthurenic acid (XA), were found to repress the ecdysterogenic Y-organ. Repression was demonstrated to be dose-dependent within the same species, and species-nonspecific with respect to the source of eyestalks and Y-organ donors. Injection with physiological doses of the 3-OH-K, in accord with the experiment using XA, delayed the onset of induced molts and prolonged the duration of molt cycles of eyestalk-ablated crayfish. Thus, *in vitro* function in suppressing ecdysteroidogenesis was verified *in vivo*. In the Y-organ with adhering tissues, XA titer peak in November/December was followed by increases in ecdysone titer in February/March, thus exhibiting a phase-contrasted correlation. The enzyme involved in ecdysteroidogenesis was activated upon incubation during the critical period in the maximum titer of XA. Further details will be discussed.

Nesdill, Daureen, A. Houston Williams. Do tannins play a role in the foraging behavior of gray squirrels? Dept. of Zoology and Wildlife Sciences, Auburn University, AL 36849-5508.

Results of other investigators' laboratory oriented studies of feeding preferences of gray squirrels, *Sciurus carolinensis*, based on tannin content (TC) are conflicting. The present field oriented study is an investigation of the percent utilization of nuts (i.e., proportion of nuts ingested or buried of the total foraging behaviors) by gray squirrels in relation to TC and nut availability (i.e., proportion of tree species mast production of the total mast production). Two study sites were used. Mast trees of Site-1 were predominantly *Carya tomentosa* and *Quercus* spp., while Site-2 consisted mainly of *Q. nigra* and *Pinus* spp.. Tannin content of nuts, percent wet weight, was determined and ranked so that *Q. nigra* > *Q. palustris* > *Q. stellata* > *C. tomentosa* > *Pinus* spp.. Nut availability did not influence nut utilization. At Site-1 72.3% of the nuts available were *Q. nigra* acorns, but utilization was only 26.7% (5.6% ingested, 9.98% buried). In contrast, the availability of nuts of *C. tomentosa* was 11.2%, but utilization was 64.3% (59.6% ingested, 4.7% buried). These data also indicate that a greater percentage of acorns were buried than ingested. During early fall, while squirrels at Site-1 were ingesting nuts from *C. tomentosa*, squirrels at Site-2 were feeding on *Pinus* spp. seeds. These results suggest that gray squirrels may choose to ingest or bury nuts on the basis of TC.

NISHIDA, Ritsuo, and Hiroshi FUKAMI. Ecological Adaptation of an Aristolochiaceae-Feeding Swallowtail Butterfly, *Atrophaneura alcinous* to Aristolochic Acids. Pesticide Research Institute, Kyoto University, Kyoto, 606 Japan.

A Japanese pipevine swallowtail, *Atrophaneura alcinous*, feeds exclusively on the plant family Aristolochiaceae. The host adaptation of this species is associated with host-originated toxic substances, aristolochic acids (AAs). Not only the adults but also eggs, larvae, and pupae of *A. alcinous* have been found to store AAs in very high concentrations. Distastefulness of AAs for birds has suggested an ecological advantage for this papilionid species. Adult females of *A. alcinous* were found to be stimulated to oviposit by AAs, in addition to other components (sequoyitol and 3-hydroxy-4-methoxycinnamoylmalic acid) in their host plant, *Aristolochia debilis*. In addition, AAs synergize the activity of larval feeding stimulants. Considering the rare distribution of AAs in the plant kingdom, these compounds could serve admirably as efficient cues for both host recognition and assessing food quality, since perception of these specific chemical cues could guarantee consequent protection from predators.

NISHIDA, Ritsuo, Takao OHSUGI and Hiroshi FUKAMI. Oviposition Stimulants of a *Citrus*-Feeding Swallowtail Butterfly, *Papilio xuthus*. Pesticide Research Institute, Kyoto University, Kyoto, 606 Japan.

A large number of swallowtail butterfly species feed exclusively on members of the plant family, Rutaceae, and the female butterflies lay eggs with great precision on their host plants, detecting specific chemicals through their tarsal chemoreceptors.

Papilio xuthus is a *Citrus*-feeding swallowtail, and the females are stimulated to oviposit by contact with a piece of filter paper treated with a methanolic extract of *Citrus unshiu* leaves. The oviposition stimulant of *P. xuthus* appears to be a mixture of highly polar non-volatile compounds, which were identified as vicenin-2, narirutin, hesperidin, rutin, adenosine, N-methylserotonin, bufotenine, synephrine, stachydrine and D-*chiro*-inositol. No individual component induced a significant oviposition response by itself, but acted synergistically with the others. Simultaneous occurrence of these components seems to account for the very narrow specificity of the oviposition stimuli.

NISHIDA, Ritsuo. Sequestration of "Bitter" Principles by Pharmacophagous Insects. Pesticide Research Institute, Kyoto University, Kyoto, 606 Japan.

A number of insects are strongly associated with specific chemicals produced by plants which are not their own hosts. Ecological adaptations in some of these pharmacophagous insects are discussed in this paper.

Turnip sawfly: *Athalia rosae* feeds exclusively on the plant family, Cruciferae. The adults, however, visit *Clerodendron trichotomum* (Verbenaceae), and feed on glandular organs on the leaf surface. Clerodendrins were identified as the potent feeding stimulants. Females sequester the bitter principles in body tissues, and become more attractive to the males.

Cucurbit leaf beetles: Some chrysomereid leaf beetles associated with cucurbitacins were found to store high concentrations of 23,24-dihydro-cucurbitacin D in the body tissues.

Oriental fruit fly: Two phenylpropanoids closely related to methyl eugenol accumulate in the rectal glands of *Dacus dorsalis* and are released in the air during courtship period.

All of these sequestered compounds strongly deterred feeding by some predatory animals, strongly suggesting that they possess an ecological significance as deterrent allomones.

Nishio, Sakuzo. Cardenolide processing during metamorphosis of Lepidoptera. 1786 Takeori, Takenami-cho, Ena-shi, Gifu-ken 509-71, JAPAN.

Many mildweed-feeding insects have the ability to sequester and store cardenolides within their bodies and these compounds generally render insects unpalatable and emetic to vertebrate predators. In the present paper, comparison is made between two lepidopterous species, Danaus plexippus and Cycnia inopinatus, in distributional patterns and metabolic alterations of cardenolides within their bodies during metamorphosis. Ecological implications of the observed differences are discussed.

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- (1) Pasteels, J.M., (2) S.S. Duffey, (3) M. Rowell-Rahier.
From de novo to plant-derived chemical defenses in Chrysomelid beetles.
(1) Univ. Brussels, Belgium; (2) UC Davis, U.S.A.; (3) Zoologisches Institut, Basel, Switzerland.

Several examples of plant-derived chemical defenses have been reported in Chrysomelid beetles but sequestration of hypericin by Hypericum-specialists was not confirmed. In some species, plant-derived toxins are stored in and released by preexisting defensive glands, and have replaced autogenous toxins. Examples of such evolution in adults and larvae are presented. It is stressed that these shifts in toxins' origin offer propitious opportunities to analyse host-plant influence on insect chemical defence both in terms of proximate and ultimate causes. In larvae, it is suggested that replacement of ~~de novo~~ toxins by plant-derived toxins could have been triggered by a simple change in one enzyme's specificity, with obvious metabolic economy for the insect.

PESCHKE, Klaus. DESCRIPTION AND FUNCTION OF CUTICULAR HYDRO-CARBON PATTERNS IN CLOSELY RELATED SPECIES OF THE ROVE BEETLE GENUS *Aleochara* (COLEOPTERA: STAPHYLINIDAE). Zoologisches Institut III, Universität Würzburg, Röntgenring 10, D-8700 Würzburg, West Germany.

The patterns of cuticular hydrocarbons of *Aleochara* species are investigated by gas-chromatography and mass-spectrometry. Traits for comparison are: (1) the relative abundance of alkenes, n-alkanes, and diverse methyl-branched alkanes; (2) the equivalent chain length distribution of hydrocarbon classes; (3) the evenness of abundance of components. Striking differences of patterns are even observed between species of the same subgenus. The adaptive significance of these patterns is discussed with respect to protection from water loss and communication. Alkenes of proper chain length and position of double bond serve as female sex pheromones; males modulate intrasexual aggression (chemical mimicry) and female choice by use of these alkenes. Aggression among males is released by the species specific pattern of saturated compounds. The divergence of information channels does not only allow species specific sexual recognition, it also prevents maladaptive sexual competition between sympatric species.

Phillips, Thomas W. and James L. Nation. Semiochemicals Produced by Individual Black Turpentine Beetles during Host Colonization. Entomology and Nematology Department, University of Florida, Gainesville, FL 32611.

Adults of the black turpentine beetle, *Dendroctonus terebrans* (Olivier) (Coleoptera: Scolytidae) produce sex-specific pheromones and an array of metabolites from host monoterpenes upon colonization of a pine tree. Amounts of the pheromones frontalin and *exo*-brevicomin, and the terpenoids *trans*-pinocarveol, *cis*-verbenol, *trans*-verbenol, myrtenal, verbenone, and myrtenol in the hindguts of individual attacking beetles were estimated with quantitative GC. A total of 52 beetle galleries, representing seven attack ages, were excavated from 15 mature slash pines, *Pinus elliottii* Engelm. All beetles sampled displayed similar profiles of terpene metabolites in their guts regardless of attack age, gallery length, or the presence of eggs. Only 15 out of 46 females contained the male attractant frontalin, while 12 out of 44 males were producing *exo*-brevicomin, an inhibitor of male response to frontalin. Interestingly, nine of the females producing frontalin were each paired with a male producing *exo*-brevicomin. This non-random association suggests that male *D. terebrans* may be able to produce a male-inhibiting signal as a consequence of being paired with a female that remains attractive.

Raina, Ashok K. Significance of host plant-factor(s) in the production and release of sex pheromone by females of Heliothis species. USDA, Agricultural Research Service, Insect Chemical Ecology Laboratory, Beltsville, MD 20705.

Females of Heliothis phloxiphaga and H. zea reared from field collected larvae did not produce the sex pheromone unless provided with their respective host plants. The females in each case did not require physical contact with the plant material, indicating the involvement of certain volatile factor(s). The mechanism through which the host-signal operates, and its importance in ensuring the survival of the progeny will be discussed.

D. Raghunatha Rao* and G. Srimannarayana**

NATURAL INSECTICIDAL CHEMICALS FROM CERTAIN PLANTS AS FEEDING DETERRENTS

Department of Zoology, Osmania University, Hyderabad 500 007 INDIA.

Natural chemicals isolated from Leguminous and other plants reputed for insecticidal activity and their related compounds were screened for their feeding deterrent activity by choice-method (Munakata, 1974) against IV instar larvae of Spodoptera litura F. None of the compounds exhibited insecticidal activity but showed feeding deterrent activity to a varying degree. Natural Proanthocyanidin 'Annonaphenolic' isolated from the unripened fruits of Annona squamosa, natural flavone 'Karanjin' an active principle of Pongamia glabra Vent, Natural isoflavone 'Maxima substance-c' an active principle of Tephrosia purpurea var maxima and natural 3-aryl-4-hydroxy coumarin 'Lonchocarpic acid' an extract from Derris scandens Benth exhibited a high feeding deterrent activity. The study indicates that the plants categorized under insecticidal plants may not possess true insecticidal principles but positively possess unpalatable chemicals which interfere with the feeding behaviour of the phytophagous insects.

** Department of Chemistry, Osmania University, Hyderabad - 7, INDIA.

Rittschof, Dan. Peptides and Specific Behaviors in Marine Organisms: Evidence for a Common Theme. Duke University Marine Laboratory, Beaufort, NC 28516, USA.

In marine organisms, nonspecific behaviors such as feeding are externally cued by small polar compounds such as amino acids and nucleotides. A few studies have examined the nature of cues that evoke highly specific behaviors. This talk will synthesize information concerning the role of four peptide cues in the location of prey by snail predators, the gregarious settlement behavior of barnacles, larval release in brachyuran crustaceans, and shell location behavior by hermit crabs. In each instance, the behavior is cued by peptides that contain a carboxy-terminal arginine or lysine. Studies with synthetic analogs of the native molecule demonstrate that the carboxy-terminal lysine or arginine residue is essential for activity. In the best studied system, submicromolar amounts of 4 families of macromolecular serine protease inhibitors can also substitute for the native peptide pheromone. This indicates a high degree of similarity between the receptor for the peptide and the catalytic site of serine proteases. A model will be presented in which a peptide receptor binding site could evolve from a proteolytic enzyme catalytic site through a change in a single amino acid.

Berge, M. and ROSENTHAL, G.A. L-Canavanine Detoxification in the tobacco budworm, Heliothis virescens [Noctuidae]. The Graduate Center for Toxicology, University of Kentucky, Lexington, Kentucky 40506.

The tobacco budworm, Heliothis virescens [Noctuidae] exhibits remarkable resistance to the potentially toxic higher plant allelochemical, L-canavanine. This destructive generalist herbivore can tolerate more than 55,000 ppm dietary canavanine with little ill effect. The biochemical basis for the natural ability of this herbivore to metabolically process L-canavanine will be examined.

SAMMARCO, Paul W.
THE MULTIPLE FUNCTIONS OF SECONDARY METABOLITES
IN SOFT CORALS AND THEIR INTEGRATION WITH
FUNCTIONALLY RELATED ADAPTATIONS

Australian Institute of Marine Science

P.M.B. No. 3

Townsville M.C., Qld. 4810

Australia

Secondary compounds, particularly terpenes, in alcyonacean soft corals (Coelenterata, Octocorallia) may play a role in predator defense, competitor defense, anti-fouling/anti-biosis, or possibly reproduction and recruitment. The mere presence of the compound, however, does not imply any particular role. It may play one or more different ecological roles within a single species, and the effectiveness of the compounds varies in a highly species-specific manner, both between alcyonaceans and between other organisms with which the soft coral interacts. In addition, at low levels of taxonomic resolution, the absence of a specific morphological or behavioural trait does not necessarily indicate the presence of a chemical adaptation or vice versa. This is due to confounding effects imposed by the presence of other functionally related adaptations (morphological, behavioural, reproductive, etc.). Within a single species, the role of a secondary compound is integrated with these various other adaptations, but such integration is complex, subtle, and highly species-specific. Thus, the manner in which functionally related adaptations are integrated becomes most apparent at high levels of taxonomic resolution.

Schell, Fred M., Burghardt, Gordon M., Johnston, Adam, and Coholich, Christopher. Analysis of Chemicals Eliciting Prey Attack in Naive Garter Snakes. The University of Tennessee-Knoxville, Knoxville, TN 37996

Earthworms (*Lumbricus terrestris*) and fathead minnows (*Pimephales promelas*) were reexamined for surface components eliciting prey-attack using methods developed in our and Halpern's laboratories. Purified high and low molecular weight components were tested using standard tongue flick and prey-attack measures. Previous results from adult snakes were replicated using naive unfed newborn *Thamnophis sirtalis*. We also attempted to relate the active extracts chemically and biologically to other surface components including the extraction of collagen fractions by literature methods. Using material obtained in two different ways we were able to show attack activity by the naive unfed *Thamnophis*, thus replicating Halpern's earlier results obtained in adult snakes. During the purification of the low molecular weight earthworm material we were able to obtain a partial fractionation. While this did not lead to significant enhancement or reduction of activity in any fraction, chromatography did establish at least a two component nature for the earthworm low molecular material.

Schmidt, Justin O. and Steven C. Thoenes. Swarm Trapping: Practical Chemical Ecology of Honey Bees. Carl Hayden Bee Research Center, USDA-ARS, 2000 E. Allen Road, Tucson, AZ 85719

Honey bees produce a cornucopia of pheromones that mediate virtually all social behaviors within and outside the nest. Although various honey bee pheromones possess potential for use in managing and regulating behaviors and populations, little such use has been reported. We developed pheromone lures containing components of the Nassenov gland pheromone and traps to attract and capture reproductive and absconding honey bee swarms. The chemistry, formulation, and loading of the lures and the trap design and placement will be presented. Data collected over three years in the U.S. and one year in Costa Rica illustrates the effectiveness of the pheromone traps and has provided information for optimal trap design. The economic potential of these pheromone traps will be discussed.

Schulz, Stefan¹, and Francke, Wittko²,

Volatile compounds from androconia of danaine butterflies.

¹Cornell University, Department of Chemistry, Ithaca, N.Y. 14853, USA,

²Universität Hamburg, Institut f. Organische Chemie, Martin-Luther-King-Platz 6, D-2000 Hamburg 13, FRG.

A large number (273) of compounds were identified from male hairpencils and wing androconia of 25 danaine butterfly (Lep.) species, in which they occur in specific blends. While the already known pyrrolizidine alkaloid derivatives such as danaidone are present in all but two species, other substances occur much more specifically. Epoxytetrahydroedulan, a new carotenoid, is the main component in some *Euploea* spp.. In *Danaus* and *Tirumala* spp. dioxygenated bis-norterpenes, terpenes and bishomoterpenes occur; some of these represent new natural products. Many different carboxylic acids are present in four *Amauris* spp.. New unsaturated ketocarboxylic acids represent the most interesting class of compounds within these. Typical moth pheromone components such as Z-(11)-octadecenal were identified in *Lycorea ilione*. Besides these substances, aromatic compounds, acetogenins, hydrocarbons and terpenoids are found in various species. Wing androconia, which are present in some of the species investigated, generally contain only small amounts if any of the compounds present in the hairpencils.

Loneragan, G.C., and W.D. Seabrook. A sensitive method for the detection and quantitation of spruce budworm pheromone. University of New Brunswick, P. O. Box 4400, Fredericton, N.B. Canada. E3B 5A3.

Abstract:

The detection and quantitation of pheromone (spruce budworm, 11-tetradecenal E:Z, 95:5) released from ICI micro-cap formulation into a forest environment has been accomplished by a procedure employing the GC-EAD technique. Concentrations of air-born pheromone as low as 0.1 pg/M³ can be realized with this method. The pheromone was quantitated from plots with application dosages of 10, 50 and 170 gai/ha.

Sennett, Susan, H. and Nancy M. Targett. Phytoalexins: Post-infectional defense in halophytes? College of Marine Studies, University of Delaware, Lewes, DE

Phytoalexins are plant secondary metabolites which are not stored in the plant but are produced de novo in response to biotic or abiotic induction. There is mounting evidence in support of the defensive role of phytoalexins in terrestrial plants. However, in marine angiosperms, little is known about the role of defensive chemicals, their mode of induction, mechanisms of release, and mode of action. Nonpathogenic fungi are being challenged with extracts from sterile, callus culture, and field collections of selected halophytes (all with phytoalexin producing terrestrial analogs) to determine if these plants respond to fungal attack by a mechanism similar to terrestrial plants. Callus culture and sterile plant cultures are being used in an effort to maximize the potential chemical differences between treated and untreated plants. Results of these bioassays will be discussed.

Sharygin, Sergei A. Geochemical Ecology of Amphibians and Reptiles. The Scientific Museum of the Nikitsky Botanical Garden. Yalta, Crimea, 334267 USSR.

Effects of geochemical conditions of environment on amphibians and reptiles has been studied. Phenotypes of colour and pattern of back and sides in *Podarcis taurica* depend upon manganese, copper and nickel content in soils of their habitats. Relationship between striped and spotted phenotypes in different area parts of *Rana arvalis* is connected with habitat's geochemistry. Variability of coloration and pholidosis, and also of indices of liver, heart and intestine of *Lacerta agilis* are determined by conditions of different biogeochemical provinces, especially in areas of geochemical anomalies where mutations become more frequent and natural selection sharpens. In populations of amphibians and reptiles the habitat's geochemical conditions influence the microevolutionary process.

Smith, Roy-Kelth. Identification of Africanization in Honey Bee Queens. Rm 610 Laboratories Division, Georgia Department of Agriculture, Capitol Square Atlanta, GA 30334.

The highly successful method for identification of Africanization in Honey Bee workers via assay of unsaturated hydrocarbons has been applied to the identification of hybridization in Queens, for which no methods currently exist. Queens exhibit a series of N-15 mono-olefins not present in the workers, which are found to localized on the exo-skeleton in the area of the tergal glands, while the worker olefins are uniformly distributed over the cuticle. Abundantly present in all pure European Queens, the queen olefins are found only in about half of the Africanized reproductives with no correlation to degree of hybridization. Unexpectedly, the development of an accurate identification model hinged upon ignoring the presence of the queen olefins, and treating the unsaturated hydrocarbon profile as if the queens were workers.

Soll, David R. Application of the Computer-assisted Dynamic Morphology System in Assessing the Role of Temporal Mechanisms in Dictyostelium Chemotaxis. Biology Department, University of Iowa, Iowa City, Iowa 52242.

A computer-assisted Dynamic Morphology System (DMS) has been developed which allows the rapid quantitation of more than 30 parameters of motility and dynamic morphology for up to 40 amoebae in parallel. This system is especially useful in quantitating the dynamics of pseudopod formation and has been applied to amoebic chemotaxis. The results demonstrate that amoebae are capable of assessing the direction of a temporal gradient in the absence of a spatial gradient and altering their behavior accordingly. Amoebae respond to an increasing temporal gradient of cAMP, which mimics the front of a natural cAMP wave in aggregation territory, with stimulated motility, and to a decreasing temporal gradient, which mimics the back of a natural wave, with depressed motility. The frequency of new pseudopod formation and turning are also regulated by the direction of a temporal gradient. By monitoring the behavior of cells in a relatively stable spatial gradient of cAMP, amoebae migrating towards the source move faster, extend fewer pseudopods and turn less frequently than amoebae moving away from the source. Amoebae facing the source at an angle formed just as many new pseudopodia towards the source as away from it, but more often turned into the pseudopod generated towards the source. These results suggest that amoebae may employ a temporal mechanism to read spatial gradients, as in the case of bacteria.

Stelljes, Mark; James N. Seiber. Pyrrolizidine alkaloids in an overwintering population of monarch butterflies (Danaus plexippus) in California. University of California-Davis, Department of Environmental Toxicology, 4422 FASB, Davis, CA 95616.

California overwintering monarch butterflies contain both pyrrolizidine alkaloids (PA's) and their N-oxides. Analysis of individual monarchs by TLC, GLC, HPLC, and GC/MS has shown the presence of at least two types of PAs, the saturated diester safranine and the unsaturated monoester 7-angelylretronecine. Monarchs arriving at the overwintering site in Santa Cruz, CA, showed a wide variation in both the type and amount of PA present. Those sampled later, after a PA-containing plant (Senecio mikanioides) had bloomed at the site, showed a different PA profile. Thus, monarchs apparently store PAs in route to their overwintering site and also take in additional PAs by feeding on PA-containing plants at the site. The potential chemical defense value of this strategy toward mammalian predators will be discussed.

Stermitz, Frank R.; Karen M. L'Empereur, Dale R. Gardner, Christie H. Boros and Noel McFarland. Utilization of Iridoid Glycosides by Lepidoptera. Department of Chemistry, Colorado State University, Fort Collins, Colorado 80523.

Three Colorado checkerspot butterflies, *Euphydryas anicia*, *Poladryas arachne*, and *Thessalia fulvia*, sequester iridoid glycosides which they obtain via larval consumption of hostplants in the Scrophulariaceae: *Castilleja integra*, *Besseya plantaginea*, and *Penstemon virgatus*. These butterflies are aposematic throughout their life stages and maintain the iridoids into the adult stage, although large amounts are also excreted in the meconium emitted after eclosion. Iridoid content of the hostplants and all life stages has been measured quantitatively. Results from both laboratory-raised and field-collected organisms will be presented.

Two noctuid and one geometrid moth species (*Oncocnemis* or *Lepipolys perscripta*, an unidentified taxon, and *Meris paradoxa*) have highly aposematic larvae, but cryptic imagos. These moths are all hosted by *Maurandya antirrhiniflora* (Scrophulariaceae) in southern Arizona. The larvae sequester high concentrations of the iridoid glycoside antirrhinoside, but relatively little is maintained in the imago. When handled excessively, *M. paradoxa* larvae emit a yellow liquid from near the intersegmental membrane and this liquid is high in antirrhinoside content.

Tumlinson, J. H., M. M. Brennan, R. E. Doolittle, E. R. Mitchell, A. Brabham, B. E. Mazomenos, A. H. Baumhover, and D. M. Jackson. Identification of a Sex Pheromone Blend for *Manduca sexta*. United States Department of Agriculture, Agricultural Research Service Insect Attractants, Behavior and Basic Biology Research Laboratory 1700 S.W. 23rd Drive, Gainesville, FL 32604

Analyses by capillary GC and GC-MS of extracts of pheromone glands from calling *M. sexta* females revealed the presence of a series of 16- and 18-carbon aldehydes with varying degrees of unsaturation. A blend of synthetic compounds that included all the components identified in the gland was equal to the gland extract in eliciting the complete sequence of behaviors by male *M. sexta* in a wind tunnel. Two of the components, (E,Z)-10,12-hexadecadienal and (E,E,Z)-10,12,14-hexadecatrienal, were critical for the elicitation of the complete response. The absence of either from the blend resulted in very few males completing taxis to the pheromone source. The role of the remaining components is more subtle and not yet completely elucidated.

Vander Meer, Robert K., Daniel P. Wojcik, and Donald P. Jouvenaz. USDA/ARS, 1600 S.W. 23rd Drive, Gainesville, FL 32608. Chemical Differentiation of Cryptic Fire Ant Species?: Solenopsis richteri (U.S.) vs S. richteri (Argentina). Venom alkaloid and species-specific hydrocarbon data on collections of fire ants in Argentina have pin-pointed the location of the chromatotype that was accidentally imported into the United States. Another chromatotype that is morphologically identical to S. richteri is found in other parts of Argentina, including the type location. Although the 2 chromatotypes do not overlap in distribution, they do come within 20 km of each other. However, no intermediate patterns have been found. This data has implications regarding our understanding of the current distribution of S. richteri and S. invicta in the United States.

Vrolijk, Nicholas H. and Nancy M. Targett. A synergistic model of a natural antifouling defense in gorgonian corals. University of Delaware College of Marine Studies, 700 Pilottown Road, Lewes, DE 19958.

In marine environments, biofouling is a continuous threat to sessile and sedentary organisms. In response, they have developed strategies to inhibit attachment and growth of biofouling organisms. Gorgonian corals (Octocorallia: Coelenterata) are large, sessile benthic organisms which maintain an essentially clean surface. In order to understand this phenomena, a novel approach was taken in which the physical-chemical surface properties of two species of gorgonian coral, Pseudopterogorgia americana and P. acerosa, were characterized and the role of these properties in preventing biofouling, i.e. bacterial biofilm formation, was assessed. The defensive role of toxic or inhibitory secondary metabolites produced by these organisms is also considered in order to postulate a synergistic model of a natural antifouling defense.

Weidenhamer, Jeffrey D., G. Bruce Williamson, Nikolaus H. Fischer and Nesrin Tanrisever. ALLELOPATHIC EFFECTS OF HYDROCINNAMIC ACID. Departments of Chemistry and Botany, Louisiana State University, Baton Rouge, Louisiana 70803.

Hydrocinnamic acid has been implicated as the allelopathic agent of the Florida wild rosemary (Ceratiola ericoides) in the Florida Scrub. Assays have been conducted to determine the inhibitory effects of hydrocinnamic acid on the germination and growth of twelve mono- and dicotyledon species. Hydrocinnamic acid strongly inhibits several native grasses and herbs thought to be allelopathically excluded from the scrub, including Schizachyrium scoparium, Leptochloa dubia and Rudbeckia hirta, as well as the roadside weed Heterotheca subaxillaris. Of the species tested, only big bluestem (Andropogon gerardii) was unaffected. Studies of the influence of pH on the phytotoxicity of hydrocinnamic acid and the comparative phytotoxicity of several hydrocinnamic and trans-cinnamic acid derivatives will be presented. Preliminary greenhouse experiments show that the toxicity of hydrocinnamic acid is increased under nutrient-limiting conditions.

WELDON, Paul J.*, Abdul SHAFAGATI, and James W. WHEELER. Crocodilian Skin Glands: Histology, Natural Products, and Microbiology. Texas A&M University, College Station, TX * and Howard University, Washington D.C.

All crocodilians possess paired gular glands, on the ventral aspect of the lower jaw, and paracloacal glands, embedded in the walls of the cloaca. Most authors suggest that these organs produce pheromones, but there are no rigorous tests of this function. Histological studies of the American alligator (Alligator mississippiensis) indicate that each gland is comprised of a single secretory sac divided by connective tissue septa containing blood vessels. A conglomerate of cells and secretions occur at the center of the glands. GC-MS analyses of paracloacal and gular gland exudates indicate acetate esters (C_{10} - C_{18}), C_{12} - C_{18} dodecanoates, 3-methyl butanoates, cholesterol, free fatty acids, and alpha-tocopherol. Thin-layer chromatograms suggest steryl esters, ceramides, and other lipid classes. d-Citronellol, often cited as a constituent of alligator glands, was not detected. Preliminary studies of aerobic bacteria in alligator glands indicate Escherichia coli, Edwardsiella tarda, Serratia marcescens, and other species.

Wood, D.E., R.A. Gleeson*, and C.D. Derby. Modulation of a Pheromone-mediated Behavior: Courtship Display in the Blue Crab. Dept. of Biology, Georgia State University, Atlanta, Ga. 30303. *Whitney Laboratory, St. Augustine, Fl. 32086.

The courtship display of the male blue crab is a stereotypical rhythmic behavior produced in response to a pheromone released by the female. Males appear to have a seasonal sensitivity to the female pheromone, and we have observed males spontaneously displaying without pheromone. As with courtship displays in other animals, the threshold of display response is probably modulated by hormones, the internal levels of which may be entrained by environmental factors. The production of the display behavior is modulated by an inhibiting factor released by the sinus gland in the eyestalk. When the eyestalks of the animal are ligated the behavior is produced in the absence of pheromone. Bioassays using neuromodulators have revealed that subsets of the behavior are produced by proctolin, dopamine, and serotonin in a dose-dependent manner.

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Yatagai, M.^{*}, M.D.Bentley^{**}, H.Makihara^{*}, K.Oba^{***}, Azizol b.A.Kadir^{****}
Chemical components of Japanese cedar(sugi), Cryptomeria japonica, cultivars associated with the resistance to cryptomeria bark borer, Semanstus japonicus. *Forestry and Forest Products Research Institute, P.O.Box 16, Tsukuba Norin Kenkyu Danchi-nai, Ibaraki, Japan, **Department of Chemistry, University of Maine, Orono, Maine, U.S.A., ***Inst. of Biological Sci., University of Tsukuba, Tsukuba, Ibaraki, Japan, ****Forestry Research Institute Malaysia, Kepong, Selangor, Malaysia.

The differences of chemical components of sugi between resistant cultivars and susceptible ones to cryptomeria bark borer have been studied. The resistant cultivars contained larger amounts of essential oils in the inner barks than the susceptible ones. The inner bark essential oils of the susceptible cultivars displayed attractant activity against cryptomeria bark borer, while those of the resistant ones showed low attractant and repellent activities. The latter contained large amounts of α -terpineol, nerolidol and δ -cadinene which were repellent in the assays. A series of terpenes other than the components of sugi were assayed against cryptomeria bark borer. The components of the essential oils from the inner bark, sapwood and leaves of three resistant cultivars and two susceptible ones to cryptomeria bark borer were studied quantitatively. The methanol extractives of sugi cultivars were also studied.

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