Nervous Systems in Invertebrates

NATO ASI Series

Advanced Science Institutes Series

A series presenting the results of activities sponsored by the NATO Science Committee, which aims at the dissemination of advanced scientific and technological knowledge, with a view to strengthening links between scientific communities.

The series is published by an international board of publishers in conjunction with the NATO Scientific Affairs Division

A Life Sciences	Plenum Publishing Corporation
B Physics	New York and London
C Mathematical and Physical Sciences	D. Reidel Publishing Company Dordrecht, Boston, and Lancaster
D Behavioral and Social Sciences	Martinus Nijhoff Publishers
E Engineering and Materials Sciences	The Hague, Boston, Dordrecht, and Lancaster
F Computer and Systems Sciences	Springer-Verlag
G Ecological Sciences	Berlin, Heidelberg, New York, London, Paris, and Tokyo
H Cell Biology	

Recent Volumes in this Series

Volume 135—Signal Transduction and Protein Phosphorylation
edited by L. M. G. Heilmeyer

Volume 136—The Molecular Basis of Viral Replication
edited by R. Perez Bercoff

Volume 137—DNA—Ligand Interactions: From Drugs to Proteins
edited by Wilhelm Guschlbauer and Wolfram Saenger

Volume 138—Chaos in Biological Systems
edited by H. Degn, A. V. Holden, and L. F. Olsen

Volume 139—Lipid Mediators in the Immunology of Shock
edited by M. Paubert-Braquet

Volume 140—Plant Molecular Biology
edited by Diter von Wettstein and Nam-Hai Chua

Volume 141—Nervous Systems in Invertebrates
edited by M. A. Ali

Volume 142—A Multidisciplinary Approach to Myelin Diseases
edited by G. Serlupi Crescenzi

Series A: Life Sciences

Nervous Systems in Invertebrates

Edited by

M. A. Ali

University of Montreal
Montreal, Quebec, Canada

Plenum Press

New York and London

Published in cooperation with NATO Scientific Affairs Division

Proceedings of a NATO Advanced Study Institute on
Nervous Systems in Invertebrates,
held July 20–August 2, 1986,
at Bishop's University, Lennoxville, Quebec, Canada

Library of Congress Cataloging in Publication Data

NATO Advanced Study Institute on Nervous Systems in Invertebrates (1986:
Bishop's University)

Nervous systems in invertebrates / edited by M. A. Ali.

p. cm.—(NATO ASI series. Series A, Life sciences: v. 141)

“Proceedings of a NATO Advanced Study Institute on Nervous Systems
in Invertebrates, held July 20–August 2, 1986, at Bishop's University, Len-
noxville, Quebec, Canada”—T.p. verso.

Includes bibliographies and index.

ISBN-13: 978-1-4612-9084-1

e-ISBN-13: 978-1-4613-1955-9

DOI: 10.1007/ 978-1-4613-1955-9

1. Nervous system—Invertebrates—Congresses. I. Ali, M. A. (Mohamed
Ather), 1932–. II. Title. III. Series. [DNLM: 1. Invertebrates—congresses.

2. Nervous System—congresses. QL 935 N279n]

QL364.N38 1986

592/.0188—dc19

87-25898

CIP

© 1987 Plenum Press, New York

Softcover reprint of the hardcover 1st edition 1987

A Division of Plenum Publishing Corporation

233 Spring Street, New York, N.Y. 10013

All rights reserved

No part of this book may be reproduced, stored in a retrieval system, or transmitted
in any form or by any means, electronic, mechanical, photocopying, microfilming,
recording, or otherwise, without written permission from the Publisher

PREFACE

The idea of holding an Advanced Study Institute (ASI) and getting a volume out, on the Nervous Systems in Invertebrates first cropped up in the summer of 1977 at the ASI on Sensory Ecology. I had prepared a review of the nervous systems in coelomates and noticed how much we depended on Bullock and Horridge's treatise on the one hand and how much new material and requirements has cropped up since 1965, when this classical work was published. Interest in the concerted study of pollution and environmental toxicology was growing in geometrical proportions and the use of invertebrates as indices was growing. As a teacher of a course on the biology of invertebrates since the beginning of my career I had also noticed how the interest of the students and the content of my course was shifting gradually and steadily from the traditional morphology-taxonomy type to the physiology-ecology-embryology orientation. Students were demanding to know the relevancy of what they had to learn. Thus, after the ASI on Photoreception and Vision in Invertebrates held in 1982 the question of one on nervous systems was raised by a number of colleagues. It appeared then that the consensus was that the time was ripe to hold one and that it will be worthwhile. Therefore, as usual arrangements had to begin at least two years in advance. Most of the persons I contacted to lecture and write chapters on selected topics agreed enthusiastically. As is usual in the case of most ASIs, the programme had to be structured with the tutorial nature of the gathering and the ensuing volume in mind. This called for the selection of topics which were often imposed on the lecturers-authors. Also, as a NATO-ASI the choice of lecturers had to be made with as wide a national distribution as possible in mind. Of course, the reputation of the lecturer-author, his or her ability to present an interesting lecture and chapter and, his or her ability to get along with a heterogeneous group over a two-week period had also to be taken into consideration. As the organiser, I was extremely lucky to gather a group of people who satisfied all these conditions as evidenced by the smooth way the ASI functioned. As I usually do, I asked the authors-lecturers to be as provocative and speculative as possible, especially in their oral presentations at the ASI. Most were so as evidenced by the lively discussions that ensued. At a meeting of the authors we ironed out the details and established general standards. Apart from the criticism the presentations received at the ASI, the finished products were also reviewed critically by the editor and at least one other competent person. As the organiser I attended every session and as editor read every chapter and learned a great deal about the matter and I hope that the users of this volume would find it of some use. The authors and I have tried to present the situation, as much as possible, as it reflects the actual state of affairs in this field. The concluding chapter, based on the rapporteur presentations and ensuing discussions which took place on the last day of the ASI tries to bring out as many perspectives as possible. We wanted to put in a glossary of terms but the constraints of time made this most impossible and I regret that it had to be so.

I am very grateful to my colleague Mary Ann Klyne for the help she

gave in the organisation of the meeting and the editing of the volume. I thank Catherine Joron of Jacmar Informatique Inc. for the preparation of the typescript. Françoise Simard and Miss Margaret Pertwee helped with the various aspects of the organisation. I am also very appreciative of the help that Nick Strausfeld and Michel Anctil gave in the choice of lecturers-authors. Michel Anctil also kindly helped with the preparation of the introductory chapter.

Financial assistance was provided to a large extent by the Scientific Affairs Division of NATO and I thank the director of the ASI programme, Craig Sinclair, for his encouragement throughout. Other financial help came from the Natural Sciences and Engineering Research Council of Canada, FCAR du Québec and the Université de Montréal. I thank Jean-Luc Grégoire, vice-principal and Marcia Boisvert, coordinator of events at Bishop's University for their help. The director of my department, Roch Carboneau, extended the numerous facilities of the department to facilitate the organisation of the ASI. My editor at Plenum Press, Patricia Vann has been patient, understanding and helpful and I am thankful to her for that.

Montréal, May 1987

M.A. ALI

CONTENTS

Introduction.....	1
M.A. Ali	
Ultrastructure of invertebrate synapses.....	3
Jane A. Westfall	
Synapse formation between identified invertebrate neurones in vitro.....	29
Jonathan P. Bacon	
Identified neurons and cellular homologues.....	41
Roger P. Croll	
Functions of invertebrate glia.....	61
V.W. Pentreath	
Neuropeptides in invertebrates.....	105
C.J.P. Grimmelikhuijzen, D. Graff, A. Groeger and I.D. McFarlane	
Purification, characterisation and cellular distribution of insect neuropeptides with special emphasis on their rela- tionship to biologically active peptides of vertebrates.....	133
Alan Thorpe and Hanne Duve	
Neuroactive substances in the insect CNS.....	171
Dick R. Nässel	
Organization of conducting systems in "simple" invertebrates: Porifera, Cnidaria and Stenophora.....	213
Richard A. Satterlie and Andrew N. Spencer	
Organisation and development of the peripheral nervous system in annelids.....	265
Susanna E. Blackshaw	
Ontogenèse du système nerveux central des Chélicérates et sa signification éco-éthologique.....	303
Arturo Muñoz-Cuevas et Yves Coineau	
The nervous system of the Crustacea with special reference to the organisation of the sensory system.....	323
M.S. Laverack	
Aspects of the functional and chemical anatomy of the insect brain.....	353
Dick R. Nässel	

Insect neurons: synaptic interactions, circuits and the control of behavior.....	393
R.M. Robertson	
Ontogenesis of the nervous system in Cephalopods.....	443
H.-J. Marthy	
Nervous system in Chaetognatha.....	461
T. Goto and M. Yoshida	
Neurobiology of the Echinodermata.....	483
J.L.S. Cobb	
Tunicates.....	527
Q. Bone	
Nervous mechanisms of spawning in regular echinoids.....	559
M. Yoshida, H. Nogi and Y. Tani	
Neural control mechanisms in bioluminescence.....	573
M. Anctil	
Acoustic communication in crickets: Behavioral and neuronal mechanisms of song recognition and localization.....	603
Klaus Schildberger	
A model for decision making in the insect nervous system	621
J.S. Altman and J. Kien	
General conclusions.....	645
M.A. Ali	
Species Index.....	651
Subject Index.....	655