Fingerprinting of genetic diversity and patterns of spatial genetic variation in the endemic tree *Cedrus brevifolia* (Hook f.) Henry from Cyprus: implications for its conservation

DISSERTATION

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Ph.D.)

at the Department of Forest Genetics and Forest Tree Breeding,
Faculty of Forest Sciences and Forest Ecology,
Georg-August University of Göttingen

By
Nicolas-George H. Eliades
born in Carson City, Nevada, U.S.A

Göttingen 2008

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de. ISBN 978-3-941274-06-8

Bibliographic information published by the KYΠΡΙΑΚΗ BΙΒΛΙΟΘΗΚΗ (Cyprus Library)

The KYΠΡΙΑΚΗ ΒΙΒΛΙΟΘΗΚΗ lists this publication in the KYΠΡΙΑΚΗ ΒΙΒΛΙΟΘΗΚΗ; detailed bibliographic data are available in the Internet at http://www.cypruslibrary.gov.cy. ISBN 978-9963-9412-0-9

Referees: Prof. Dr. Reiner Finkeldey

Dr. habil. Bruno Fady

Date of oral examination: 11th September 2008

Printed with the grant of:



Eliades, Nicolas-George:

Fingerprinting of genetic diversity and patterns of spatial genetic variation in the endemic tree *Cedrus brevifolia* (Hook f.) Henry from Cyprus: implications for its conservation ISBN 978-3-941274-06-8 ISBN 978-9963-9412-0-9

All Rights Reserved

Edition 2008, Göttingen
 Optimus Mostafa Verlag
 URL: www.optimus-verlag.de

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, scanning, or otherwise without the prior written permission of the Publisher. Request to the Publisher for permission should be addressed to service@optimus-verlag.de.

Acknowledgments

Though the following dissertation is a personal work, it would not have been possible without the support, guidance and efforts of numerous people. First and foremost, I am honestly grateful to Prof. Dr. R. Finkeldey for accepting me as a Ph.D. candidate, and for his continuous support and advice throughout my study at this Institute.

My honest thanks to Dr. habil. B. Fady for his kind hospitality at the French National Institute for Agricultural Research (*INRA*), as well as for his positive and continued support regarding issues of my thesis, and finally, for acting as a co-referee of my work and a member of my examination committee. Additionally, I am thankful to Prof. Dr. C. Kleinn for participating in the committee of my examination.

I am deeply grateful to my mentor, Dr. A.C. Papageorgiou, Assistant Prof. at the Demokritos University of Thrace, for introducing me to forest genetics, as well as for his guidance and continuous encouragement.

My warm gratitude is extended to Dr. O. Gailing and Dr. L. Leinemann for their guidance in laboratory work, their helpful comments and their constructive discussions. I am also grateful to Prof. Dr. H.H. Hattemer, Prof. Dr. M. Ziehe, Prof. Dr. H.R. Gregorius, Dr. B. Vornam and Dr. E. Gillet for their productive discussions and suggestions.

Special acknowledgements are given to the technical assistants in laboratory work, namely Mrs O. Artes, Mrs O. Dolynska, Mrs C. Radler, Mr. G. Dinkel and Mr. Th. Seliger. My thanks to the Institute's secretary Mrs M. Schwahn, for her invaluable help in office work, as well as to my colleagues and friends: Dr. C.P. Cao, Dr. A. Akinnagbe, Dr. A.L. Curtu, Dr. A. Derero, Dr. A. Höltken, Dr. H.T. Luu, Dr. M. Mottura, Dr. M. Pandey, Dr. V.M. Stefenon, Dr. L. Nyari, Mrs O. Kuchma, Mrs D. Lorentzen, Mrs S. Nascimento, Mrs H. Nuroniah, Mrs Y. Rachmayanti, Mrs A. Vidalis, Mr. T.B. Ayele, Mr. M. Ekue and Mr. N.P. Nguyen for their friendship and their interesting academic and non-academic discussions. I also would like to thank the coordinators of the Ph.D. Program "Wood Biology and Technology", Dr. E. Kürsten and Dr. G. Büttner, for helping me with the office work of my Ph.D.

I would also like to express my thanks to the Cyprus Forestry Department and especially to Dr. A. Christou, Mr. K. Nikolaou and Mr. G. Stelikos for their help in sampling and for providing me with supplementary material.

Many thanks also to the *A.G. Leventis Foundation* for granting me the scholarship that has made this study possible. Special acknowledgments also go to the *Pitsilia Co-Operative Savings Bank* (Nicosia) Ltd., for funding the publication of this dissertation.

Last but assuredly not least my deepest and genuine gratitude is extended to my parents, Homer and Panagiota Eliades for their unconditional support and love.

TABLE OF CONTENTS

Chapt	er 1: Introduction	1
1.1	Genetic diversity and differentiation	1
1.2	Spatial genetic structure	3
1.3	Genetic conservation.	4
1.4	The genus <i>Cedrus</i>	5
1.5	Cedrus brevifolia	7
	1.5.1 Taxonomy and botanic characteristics	
	1.5.2 Reproduction biology	
	1.5.3 Natural distribution and habitat	11
	1.5.4 Conservation status	12
1.6	Study objectives	13
Chapt	er 2: Materials and Methods	14
2.1	Material	14
	2.1.1 Description of the study area	14
	2.1.2 Sampling procedures	15
2.2	Methods of genetic analysis	15
	2.2.1 Molecular markers	15
	2.2.2 DNA sequencing	18
2.3	Data analysis and statistical methods	
Chapt	eer 3: Summary of results	22
3.1	Genetic variation and genetic structure of molecular markers	22
3.2	Genetic diversity of natural population	25
3.3	Patterns of spatial genetic structure	26
3.4	Comparison between the natural population and the plantations	27
Chapt	er 4: General discussion	29
Chapt	er 5: Conclusions and outlook	37
Chapt	ter 6: Specific results	
Γ	Gene diversity of the endemic <i>Cedrus brevifolia</i> Henry at nuclear and DNA: I. Genetic variation and structure of the natural population and increase of the natural population and increase of the natural population.	ssessed by