PREFACE

Chapter 1 – The diversity of biological systems, at different levels of the organization of the material, forms one of the main characteristics of the organic universe – the phenomenon of polymorphism. Differences between species of one and the same genus, broken and unbroken diversity of the species, can be attributed to polymorphism in the broad sense of the word (Berg, 1957). The numerous investigations have shown that polymorphism appears beginning from the intracellular organization of the material up to the level of the biocenosis.

This work is based on the notion of polymorphism as the co-existence in the dynamic balance of two or more morphophysiologically distinctive forms within the population. The attribute of polymorphism was proposed in 1940 by E. Ford as: "The existence in the population simultaneously of two or more genotypically different forms, with the frequency of the most rare form being all the same rather large, so that its maintenance could be explained by the mutation pressure". There are also other versions of the definition of polymorphism. For instance: "Availability in the population of two or more alleles of one locus met with the perceptible frequency" (Cavalli-Sforza, Bodmer, 1971) or "Co-existence, in more or less dynamic equilibrium, of two or more morphophysiologically distinguished forms within the limits of the population or of a group of populations" (Timofeev-Resovskii et al., 1977).

Chapter 2 – The term pheromone was first introduced to describe the chemical compound released by silkworm females in *Bombyx mori* that triggers the attraction of males of the same species towards the females [86, 87]. Subsequently, this term has been used in many other insects and also in vertebrates to characterize a chemical signal secreted in minute amounts by an organism to induce a particular response from another organism of the same species. Wilson [235, 237] made a distinction between the releaser pheromones, which initiate immediate behavioral responses, and the primer pheromones, which cause physiological changes that will result in a behavioral response later. Although pheromones are widespread among vertebrates and insects, it is in the latter that they manifest their largest diversity of function. Released by exocrine glands, they are most likely used in all social activities, such as sexual behavior, foraging, defense, aggregation, recognition, caste determination, or building behavior. It is clear that the most widespread communication form in social insects is definitely based on pheromones, especially in termites which are blind and need these pheromones to maintain the integrity of their society. However, little is known about this pheromone communication and the pheromone systems involved in termites. In contrast to

Hymenoptera for which over sixty different exocrine glands are known [15], only a few exocrine glands and a few pheromones have been described in termites.

In this chapter, author am going to discuss the chemical nature of the two above-mentioned releaser pheromones in termites: the trail pheromone and the sex pheromone. Author will also review the structure and ultrastructure of the glands involved in the secretion of these pheromones, namely the sternal glands, tergal glands and posterior sternal glands. Author will only consider three different castes (workers, pseudergate, and alate imago), although larvae, soldiers, neotenics, kings and queens, may possess these glands and may secrete a pheromone. In the last section, particular attention will be given to the tentative use of pheromones in pest control management for the economically important species of termites.

Chapter 3 – In this chapter author intended to show that the potential use of the pheromones (scouting, monitoring, or optimal timing of insecticide application) depends on both: the pest and the pheromone. The case of the three most important corn pests for the region of South Eastern Europe: wireworms, western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte and European corn borer (ECB) *Ostrinia nubilalis* Hubn. will be discussed.Before any decision on control measures against wireworms possible damages should be predicted. By using pheromone traps for eight most important Europen species of the genus *Agriotes,* in west part of Croatia five species were found. The distribution and population level of these species was established on 2 fields in central Croatia from 2001-2005. Beside pheromones on the same fields, larvae were sampled by soil sampling and by bait traps. The use of pheromone traps for wireworm pest management is attractive because of the clarity of the data they yield. There are several possibilities to use pheromones in developing IPM against wireworms: (1) monitoring and investigation in wireworm biology and ecology; (2) use of pheromones as decision tool for predicting damages and necessity for the control; (3) distribution modeling; (4) trapping of males as an control option. There are numerous options but all of them require further work before consistent interpretation of results could be possible.WCR is an invasive species found for the first time in Europe in 1992. The first finding of sex pheromone of WCR dated in 1973. After the first finding the pheromone lure was produced by European scientists and pheromone trap for monitoring purposes were designed. This trap was used in Croatia for monitoring in the period between 1996-2006. Each year traps were set up in corn fields (between 30-140 fields/year). Together with pheromone the yellow sticky traps (Pherocon AM or Multigard) were installed. Pheromone traps showed to be more suitable for monitoring and prediction of population increase but, for the scouting purposes, yellow sticky traps showed to be more acceptable.

Chapter 4 – This review is devoted to the synthesis of pest pheromones. The basic attention is given to a paper proposing shorter convenient processes, environmentally benign results and synthesis based on commercially accessible raw material. The following aspects of pheromones synthesis are observed: in the synthesis of lengthfulchain pheromones, mainly considered were such reactions of increase of chain range as cross-coupling, cross-metathesis, different rearrangements, but minimum attention was given to it before the popular Wittig reaction because of a contradiction with requirements of "green chemistry". The majority of synthesis of enantiomeric pure pheromones is far from technologically appealing. But author hope that the interested reader can choose what is more commercially favourable: simple synthesis of racemic pheromone or complicated synthesis of enantiomeric pure pheromone.

Chapter 5 – Animals put effort into leaving their own genes to children. Males present themselves to females as superior mating partners for making descendants in order to have their own children. Accomplishments of the sexual behaviors are mediated by pheromones excreted from mating partners via the vomeronasal system in various animals. In rats and mice, author found that activities of urinary pheromones excreted from males with sexual experiences are stronger than those excreted from sexually inexperienced males. Maturation from prepuberty to puberty strengthens volatile pheromonal activities in male rat urine. To find a good mating partner, it is necessary that animals have superior vomeronasal systems. Pheromonal information received by vomeronasal sensory cells is transmitted to the accessory olfactory bulb (AOB). Sexually experienced male rats have been shown to prefer oestrous to dioestrous female urine, while sexually inexperienced males do not exhibit these preferences. In the localized region of the AOB, many more neurons were activated in the sexually experienced male rats than in the inexperienced rats after exposure to urinary pheromones excreted from oestrous females, suggesting that sexual experience in males enhances the transmission of reproductively salient information concerning potential oestrous status to a specific region of the AOB. In mice, maturation differentially affects abilities of the pheromonal reception of vomeronasal systems of males and females. Pheromonal responses of male mice to female urinary pheromones were augmented after maturation, while those of females to male urinary pheromones were depressed after maturation. These results suggest that sex differences are seen during maturation in vomeronasal systems of mice. In this chapter, author discuss changes in pheromonal reception and pheromonal activities during physiological changes such as sexual experiences and aging in relation with changes in gonadal hormones and neural circuits.

Chapter 6 – ACO (Ant Colony Optimization) represents a class of population based meta-heuristics which solves numerous optimization problems inspired by the real-world behavior of ant colonies in search of food. All of these algorithms are based on a software abstraction of the pheromone concept: in fact, as with real ants, all the decisions taken within the ACO-based algorithms are driven by the evaluation of pheromone traces. Particularly, the greater the quantity of pheromone the greater the probability a path will be followed. The evaluation process of the pheromone represents a fundamental aspect of these algorithms: different evaluation strategies, in fact, lead to different behaviors of the simulated ant colony characterizing functions and performance. The flexibility and the adaptability of these solutions is evident because of the number of applicative scenarios in which the ACO-based algorithms have been used (scheduling policies, routing solutions, flow management, traffic management, transport optimization, etc). Even though they are different from each other, all of these solutions are characterized by a common aspect: they present a decision system based on the chemical attraction of the pheromone. In this chapter, instead, the authors introduce a new method of considering the pheromone, studying thoroughly how the properties of the ACO-based algorithms are modified when the pheromone assumes a repulsive role.

Chapter 7 – This chapter describes the isolation, structure determination and behavioural testing of splendipherin [GLVSSIGKALGGLLADVVKSKGQPA(OH)], the peptide male sex pheromone of the Magnificent Tree Frog *Litoria splendida*. Behavioural tests show that female *L. splendida* is attracted to the pheromone in water at nM concentrations, and indicate that the pheromone moves across the surface of water towards the frog. Surface pressure and X-ray reflectometry experiments confirm that splendipherin is surface active. The 2D NMR spectrum of splendipherin in trifluoroethanol/water (1:1. v/v) indicates a mainly amphipathic

helical structure with a bend through G11 and G12. This structure is consistent with the hydrophilic side chains interacting with the water surface, and the hydrophobic side chains protruding into the air at the water/air interface. A mating between a male *Litoria caerulea* (the Green Tree Frog of Australia) and a female *L. splendida* produced five female interspecific hybrids. The females were not attracted to splendipherin. Six naturally occurring peptides related to splendipherin were tested for activity with female *L. caerulea*. No sex pheromone activity was noted.

Chapter 8 – The study of pheromones in non-human animals has a long pedigree. In contrast, the existence of human pheromones is controversial, although at its base this controversy may be largely semantic. Here author summarise the converging evidence from phylogeny, physiology, and behaviour that suggests that the human axilla may have some kind of communicative function, and that axillary secretions can influence social interactions. The author recommend that future work should be channelled by the growing scientific understanding that chemical influences on human behaviour may be dependent upon context and environment.

Chapter 9 – There is now a general consensus that humans use pheromones, as all mammals do. The armpits are prime sources, as their odor emanation develops along with other changes at puberty. However, both human behavior and chemical emissions are so complex that at present the research is still challenging. Up to now, no pheromones have been conclusively identified, but a strong contender for the first identified human pheromone is some elusive compound in the armpit of women that, apparently, causes menstrual synchrony in females living in close quarters. It has been speculated that its identification could potentially open the door to "sniffable" contraceptives. Furthermore, generally several possible challenges appear in the applied research on human pheromones. At this purpose, recent results show the effectiveness of the new methodology used. Through the collection and analysis of the secretion released at the level of different regions of body, the exhaled compounds can be investigated in a proper way. The study of human pheromones is important for acquisition of new knowledge concerning the emission of signal molecules essential for different kinds of biological phenomena, and for its practical consequences for several research topics as well as for health. Furthermore, understanding the mechanism of the olfactory communication in general, and the role of pheromones in particular, is very important because they are stepping stones in revealing the role of pheromones in human evolution, a subject long underestimated for its impact on human behaviour and evolution.

Chapter 10 - Pheromones are substances, secreted by insects for intraspecific communication: searching for mate, swarm, scattering, etc. As a rule, insect pheromones are volatile enough organic substances secreted into the environment as sprays affecting other insects in far distances from the source of smell. Knowing pheromone composition, which can include several individual chemical substances (major and minor components), it is possible to deliberately confuse insects, thereby affecting their normal development, mating, food searching, etc. However, wide application of these low toxic agents for protecting plants, materials, raw materials, environmental safe for the warm-blooded organisms, is limited by complexities in their extraction from natural sources. Today the only source of their extraction in quantities enough for practical application is chemical synthesis.