CHRONOBIOLOGY OF PEPTIDE HORMONES - POSSIBLE APPLICATION TO STUDIES IN INSECTS

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MINI REVIEW

Chronobiology is the study of rhythmic manifestations of life, in which quantification and mechanisms of biologic time structure are investigated. This summary will deal with the possible application of chronobiology to the discovery and determination of the roles of peptides in insect development and diapause.

Arthropods, especially insects, have long been used in studies from which conclusions have been drawn concerning the role of synchronizers and the effects of rhythm alteration. Scientists who conduct entomological research are aware of the importance of rhythms; they usually rear insects under carefully specified photoperiodic and temperature schedules.

The rhythms of some bioregulatory peptides have been quantified in experimental animals, primarily in man. Rhythms in synthesis and release of peptides from the central nervous system of insects have not been examined, probably because the quantities available are limited. Determination that insect peptide hormones exhibit circadian rhythms may only be possible now after development of new analytical techniques based on high performance liquid chromatography.

When scientists obtain samples from living organisms they believe that they eliminate errors in experimentation and interpretation by always sampling at the same time of day. This does not provide an acceptable alternative since rhythms of sensitivity to a treatment may be quite different at one time than at another. Rsponses to treatment may cause a phase shift in the rhythm as well or the mesor (rhythm adjusted mean) may not change but the amplitude may be decreased. This has been discussed in numerous publications of Halberg and his group (for example see Halberg et al. 1982). Without preliminary studies, we cannot be sure of the timing of greatest susceptibility to a hormone. In addition, some insect development occurs so rapidly that the underlying circadian or ultradian rhythms may be difficult to pinpoint.

The chronobiology of the peptide hormone, insulin, has been extensively studied in mammals (Meis and Rose 1981; Melani et al. 1975; Sensi et al. 1975). Peptides such as prolactin (De Remigis et al. 1981) exhibited a rhythm in euthyroid and hypothyroid subjects, but not in hyperthyroid individuals.

In human males, blood insulin, gastrin, prolactin, and TSH exhibited a statistically significant 24 h. rhythm (Graham et al. 1981).

In embryos of Rhode Island Red hens, thyroxin and prolactin exhibited a 12 h. rhythmicity which developed to a 24 h. rhythmicity after 8 days. Incubation at lower temperature resulted in some different expressions of these rhythms (Kuhn et al. 1981a & b).

The prolactin response to insulin-induced hypoglycemia in men is greater at 1900 h. than at 0900 h. and this response is inhibited to greater degrees by atropine in the evening (Nathan et al. 1981).

Insulin and prolactin in women were found to have several statistically significant rhythms by Kuzel (1981).

Hansen (1975) observed monthly gonadotropic cycles even in premenarchal girls.

Levels of receptors for peptides such as insulin (Consoli et al. 1981) and triiodothyronine (Berg et al. 1981) have also been shown to differ according to the time of day at which the hormone is given. The adrenal cortex is more responsive to a microdose of corticotrophins (Ferrari et al. 1981) at 0800 and at 2000 h. (at 0800 the plasma cortisol was high; at 2000, low).

Opiate antagonists, which may affect receptors for endorphins, had differing effects at different times of day, having a strong suppressive effect on hyperphagia at night and little or no effect during the daylight hours (Mendonoff and Apfelbaum 1981); this is consistent with a finding of a circadian rhythm in circulating opiates.

Rietvelt and Boon (1981) attributed the differing acrophases* in the responses of periodic acid Schiff (PAS) staining material and nuclear size to differences in the expression of the rhythms in response to activity of the endocrine system.

Growth hormone has also been investigated - both for ultradian (Salvadorini et al. 1977; Brambilla et al. 1977) and circadian rhythms (response to L-DOPA stimulation (D'Alessandro et al. 1977). In humans a high frequency rhythm in gonodotropin secretion has been observed (Isidori et al. 1977; Brambillia et al. 1977).

Scheving has investigated rhythms in the epidermal growth factor (EGF) which is believed to be a small peptide (Scheving et al. 1979). He found by means of bioassay a circadian stage dependence in the stimulatory effects of this peptide on DNA synthesis in the intestinal tract of the adult male mouse.

The examples presented in this mini review of circadian rhythms in production, release, circadian stage dependency and assayable receptors are by no means exhaustive. Rather they serve to illustrate the necessity for taking into account the various rhythms, circadian, ultradian and infradian, of systems involved in the isolation, bioassay and application of neurohormones. The process is further complicated by developmental chronobiology since the cells of some tissues may not be at a developmental stage at which they can respond. For example, the variations in hemolymph ecdysone levels during development are probably evidence of increasing sensitivity of target tissue to the trophic hormone. Alternatively or perhaps concurrently they may also reflect circadian or other rhythms in the levels of enzymes metabolyzing ecdysone or trophic hormone or in the available receptors.

Insects and other arthropods can be entrained; their survival often depends upon such entrainment (i.e., diapause induction, eclosion at an appropriate time of day etc.), and we would expect the peptide hormones involved in the regulation of development to exhibit endogenous rhythms, circadian and otherwise.

It behooves us to consider and exploit in research an insect rhythms peptides those which have been well documented in mammals, birds and other multicellular animals.

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*acrophase - Measure of timing; the lag from a defined reference time of the crest time in a function appropriately approximating a rhythm (Halberg et al. 1977).

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