Phase Shifting Effect of Caffeine in the Circadian Rhythm of *Phaseolus coccineus* L.

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4-hour caffeine pulses (10 mM) offered *via* the transpiration stream advances or delays the phase of the circadian leaf movement rhythm of *Phaseolus coccineus* as a function of the phase of application. It is hypothesized that the caffeine effect upon sleep and wakefulness in man is partly due to this phase-shifting effect.

Light and temperature are the best known Zeitgebers for circadian rhythms in plants and animals [1, 2]. Administered as pulses they shift the phase of the circadian oscillation as a function of the phase of application.

Many chemicals where tested, but only a few act on the circadian clock. A clear phase-shifting effect has been shown only for D_2O [2, 3], ethanol [2, 4, 5], Valinomycin [2, 5], K^+ [2, 4] and CN^- [6].

Recently, a phase-shifting effect of theophylline and pentobarbital has been described for the deep body temperature rhythm in the rat [7]. Furthermore, a phase-shifting *and* period-lengthening effect of theophylline could be shown in the case of the circadian leaf movement rhythm in Phaseolus coccineus [8]. In addition to theophylline (1,3-dimethylxanthine) we tested the phase-shifting effect of caffeine (1,3,7-trimethylxanthine) on the leaf movement rhythm of Phaseolus coccineus.

Fig. 1 shows typical examples of movements of two isolated primary leaves of the same plant under continuous light (LL) of 5600 lx and 23 °C. One leaf served as a control. To the other leaf 10 mM caffeine was offered *via* the transpiration stream for 4 h. A pulse starting 4.4 h after "0" time (corresponding to the second maximum of the night position in LL) delayed the rhythm by 2 h (Fig. 1, above), a pulse starting 21.2 h after "0" delayed by about 4.5 h (Fig. 1, center) and a pulse starting 24.2 h after "0" advanced the rhythm by 2.5 h (Fig. 1, below).

These results show that not only theophylline, but also caffeine has in addition to its well known pharmacological effects a further one: it rephases a circadian rhythm.

Since circadian rhythms in unicellular organisms, plants, animals, and man have similar properties [2], we hypothesize, that not only the theophylline effect [7], but also the caffeine effect upon sleep and wakefulness in man is partly due to the phase-shifting effect of these substances. This could be of

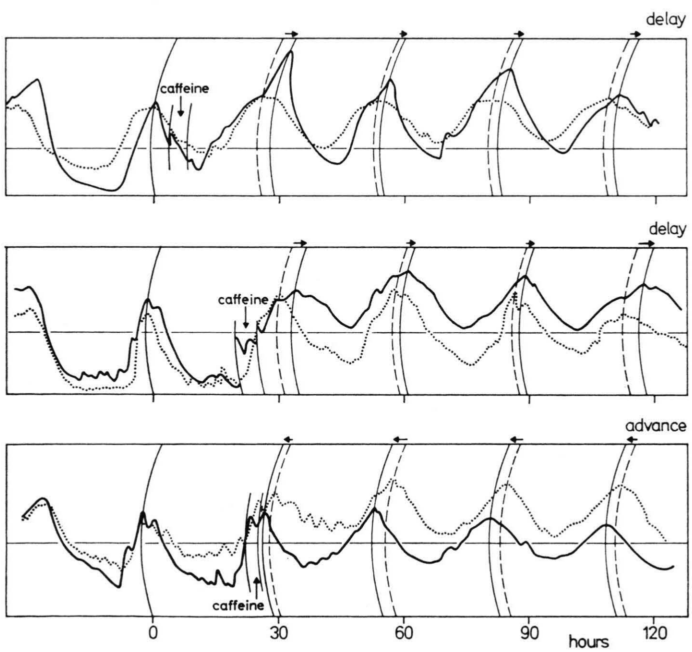

Fig. 1. Typical examples for circadian leaf movements of two isolated primary leaves of one individual plant of *Phaseolus coccineus* under LL 5600 lx and 23 ± 1 °C showing the phase-shifting effect of 4 h pulses of caffeine (10 mM) (····) control leaves; (——) leaves are treated in the noted phase (above 4.4 h, center 21.2 h, below 24.2 h after "o" corresponding to the second maximum of the night position in LL).

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pharmacological interest, since it opens the possibility to use caffeine and theophylline as drugs for the phase control of circadian rhythms *e. g.* of transmeridional travellers and shift-workers.

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