(compensating larval water loss) or a wax exchange (reducing larval water loss). Consequently two possible mechanisms can be hypothesized: 1) the tritium could have been incorporated in some of the females' epicuticular lipids which in turn could have been transferred to the larvae merely by contact, or 2) the tritium could have simply left the female and been absorbed by the larvae just as liquid water or steam.

Long term direct observations failed to reveal any signs of water exchange straight from the mouth. The larvae never approached the buccal area of the mother, nor was the mother seen to actively move the larvae toward its mouth. The amount of water that scorpions can lose by evaporation is in any case quite high. At 10% RH, in laboratory, adult *Euscorpius* can lose 20% of their total weight in a week, without appearing to be damaged[11]. On the other hand, it has also been shown[12, 13] that hydrocarbon biosynthesis in adult scorpions is very slow, and that the cuticular lipid turnover depends more on dietary hydrocarbon than on autonomous synthesis. Furthermore, it has been pointed out[14] that the maximum waterproofing effectiveness is provided by long-chain, highly viscous molecules, which presumably cannot easily be transferred from the female to the larvae simply by contact. In conclusion, the hypothesis that water is exchanged directly through the cuticle seems the most plausible for the moment.

1 We thank Prof. L. Pardi and Prof. A. Ercolini for their critical reviews of the manuscript. This study was supported by the Ministero della Pubblica Istruzione (60% contributions).
2 Williams, S. C., Proc. Calif. Acad. Sci. *37* (1981) 1.
3 Maury, E. A., Physis *29* (1969) 131.
4 Alexander, A. J., XVth int. Ethol. Conf., Bielefeld 1977.
5 Vannini, M., Ugolini, A., and Marucelli, C., Monit. Zool. Ital. *12* (1978) 143.
6 Vannini, M., and Ugolini, A., XVIIth int. Ethol. Conf., Oxford 1981.
7 Pavan, M., Boll. Zool. *21* (1954) 283.
8 Kwartinikow, M. A., Acta zool. bulg. *17* (1981) 5.
9 Ugolini, A., Vannini, M., and Carmignani, I., J. Arachnol. (in press).
10 Vannini, M., and Ugolini, A., Behav. Ecol. Sociobiol. *7* (1980) 45.
11 Ugolini, A., and Vannini M., Boll. Zool. *45* (1978) 247.
12 Hadley, N. F., and Hall, R. L., J. exp. Zool. *212* (1980) 373.
13 Hall, R. L., and Hadley, N. F., J. exp. Zool. *240* (1982) 195.
14 Hadley, N. F., in: Biology of Integument, p. 841. Eds J. Bereiter-Hahn et al. Springer, Berlin–Heidelberg 1984.

0014-4754/85/121620-02$1.50 + 0.20/0
© Birkhäuser Verlag Basel, 1985

## An extremely cadmium-sensitive strain of *Chlorella*

E. Kessler[1]

*Institut für Botanik und Pharmazeutische Biologie der Universität, D-8520 Erlangen (Federal Republic of Germany), 15 April 1985*

*Summary.* Growth of 14 strains from five *Chlorella* species is rather insensitive towards cadmium. One strain (211–1a) of *C. saccharophila*, however, was found to have a sensitivity towards this toxic heavy metal about 100 times higher than that of the other strains of *C. saccharophila*.
*Key words. Chlorella;* cadmium; growth.

The species of the genus *Chlorella* exhibit a surprising diversity of biochemical and physiological properties[2]. Some of them are able to grow under rather extreme conditions of salinity and acidity[3]. Therefore, it seemed interesting to study also their ability to grow in the presence of environmentally important toxic heavy metals[4]. In the course of this work we found that the common and fast-growing species[3], i.e. *C. vulgaris, C. sorokiniana, C. saccharophila, C. fusca* var. *vacuolata*, and *C. kessleri* (three strains each), show rather uniform and fairly low sensitivities (as measured in growth) towards lead, copper, and cadmium (unpublished results).

There was one striking exception, however. Strain 211–1a of *C. saccharophila* has a sensitivity towards cadmium about 100 times higher than that of the other strains of *C. saccharophila*. It shows good growth only up to a concentration of 1 µmole cadmium, in contrast to a limit of 100 µmoles for the other strains (table). It is interesting to note that strain 211–1a had earlier been found to differ rather considerably in some biochemical properties from the other, typical strains of *C. saccharophila*[2], so that its taxonomic position within the '*C. vulgaris* group' (which includes *C. sorokiniana, C. vulgaris*, and *C. saccharophila*) remained somewhat problematic.

Our present results, therefore, are of interest both taxonomically and for a possible utilization of these microalgae for growth in heavy metal-contaminated water[5–7]. Whereas most *Chlorella* species, due to their low sensitivity, appear to be suitable for growth in and purification of heavy metal-polluted water, strain 211-1a might serve as a highly sensitive indicator organism for cadmium contamination. It should be stressed that its extreme sensitivity seems to be restricted to cadmium; only with the chemically related mercury does it exhibit a slightly increased sensitivity, whereas it appears perfectly normal in the presence of lead and copper.

Growth of *Chlorella saccharophila* (Krüger) Migula, strains 211-1d, 211-1b, and 211-1a from the culture collection at Göttingen, in the presence of various concentrations of cadmium. Production of dry mass ($g \cdot l^{-1}$) after 14 days at 25 °C and 6000 lux (continuous illumination; air + 2% $CO_2$) in culture medium[4]. Mean values from 4 experiments (n.d. = not determined)

| Strain | $Cd(NO_3)_2$ ($\mu mol \cdot l^{-1}$) 0 | 0.5 | 1 | 2 | 5 | 10 | 20 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| 211-1d | 0.77 | n.d. | n.d. | n.d. | 0.58 | 0.60 | 0.54 | 0.52 | 0.40 |
| 211-1b | 0.73 | n.d. | n.d. | n.d. | 0.55 | 0.66 | 0.53 | 0.56 | 0.47 |
| 211-1a | 0.54 | 0.50 | 0.44 | 0.23 | 0.06 | 0 | 0 | 0 | 0 |

1 Acknowledgment. For excellent technical assistance I am indebted to Mrs U. Knoch and Mrs E. Weitemeyer.
2 Kessler, E., Prog. phycol. Res. *1* (1982) 111.
3 Kessler, E., Algol. Stud. *26* (1980) 80.
4 The culture medium (pH 6.4) of Kessler, E., and Czygan, F.-C., Arch. Mikrobiol. *70* (1970) 211, contains (the NaCl was omitted): $KNO_3$ (0.81 g/l), $NaH_2PO_4 \cdot 2H_2O$ (0.47 g/l), $Na_2HPO_4 \cdot 12H_2O$ (0.36 g/l), $MgSO_4 \cdot 7H_2O$ (0.25 g/l), $CaCl_2 \cdot 2H_2O$ (0.014 g/l), $FeSO_4 \cdot 7H_2O$ (0.006 g/l), $MnCl_2 \cdot 4H_2O$ (0.5 mg/l), $H_3BO_3$ (0.5 mg/l), $ZnSO_4 \cdot 7H_2O$ (0.2 mg/l), $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ (0.02 mg/l), and EDTA ('Titriplex III') (8.0 mg/l).
5 Jennett, J. C., Hassett, J. M., and Smith, J. E., Miner. Envir. *2* (1980) 26.
6 Rai, L. C., Gaur, J. P., and Kumar, H. D., Biol. Rev. Cambr. Phil. Soc. *56* (1981) 99.
7 Aaronson, S., and Dubinsky, Z., Experientia *38* (1982) 36.

0014-4754/85/121621-01$1.50 + 0.20/0
© Birkhäuser Verlag Basel, 1985