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Carotenoid composition of *Caloplaca regalis* (Vain.) Zahlbr. (*Lichenes*) and of penguin faeces at King George Island (Antarctica)*

ABSTRACT: Carotenoid composition of both penguin faeces and the lichen *Caloplaca regalis* has been analyzed by thin layer chromatography. Carotenoids in both samples are almost identical to those found in the krill, the main food of the penguins, including β-carotene, which is not found in other *Theloschistaceae* species.

Key words: Antarctic, lichens, penguin faeces, carotenoids.

1. Introduction

Penguins are the most common sea birds in the South Shetland Islands. There are three different species: chinstrap — *Pygoscelis antarctica* (Forster), Adelie — *P. adeliae* (Hombron and Jacquinot) and gentoo —

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P. papua (Forster). During the summer season, these pygoscelids live near the rocks in which many lichens and mosses are found. Penguins primarily consume one euphausiid species, *Euphausia superba* Dana (Volkman et al., 1980). Besides many nutritive substances, krill is rich in carotenoid pigments in a range from 6.0 to 36.0 (Fisher et al., 1955), 7.88 to 16.12 (Czeczuga and Kłyszejko, 1978) or 31 to 41 μg per g dry weight (Protasowicka, unpubl.). The main carotenoid in *E. superba* is astaxanthin (Watanabe et al., 1976; Bykov et al., 1981), although it contains also valuable amounts of cryptoxanthin, flavoxanthin, zeaxanthin, aurochrome and β-carotene (Czeczuga and Kłyszejko, 1978; Jackowska et al., 1980).

"At the present, the possibility of monitoring krill resources through the control of avifauna abundance, mainly the penguins, is being discussed" (Rakusa-Suszczewski, 1980). Now, this possibility enlarges to Antarctic Ecosystem through the analysis of penguin faeces containing carotenoids.

The object of the present paper is to compare the composition in carotenoids of the lichen *Caloplaca regalis* (Vain.) Zahlbr. and penguin dregs on which lichens develop.

2. Material and methods

Both penguin faeces and *C. regalis* were collected in King George Island, near Arctowski Station, during February 1984.

Samples of 20 g faeces or 50 g lichens were ground in a mortar and extracted three times with 250 cm^3 acetone. The samples of 200 cm^3 of each extract were used for saponification and then they were analyzed according to Jackowska et al. (1980) except etheral fractions that were dried in vacuum at 303°K. Dry residues were re-dissolved in petroleum ether in proportions of 0.4% faeces and 1% lichen (w/v). Absorption spectra were measured by using a Pye Unicam V-spectrophotometer. TCL of carotenoids was carried out on silica gel 60 F-254 (plastic roll Merck) using benzene: petroleum ether: acetone (10:2.5:2 v/v) as solvent. β-Carotene (BDH, England) was used as a standard. The amount of the different carotenoids was spectrophotometrically calculated according to Protasowicka (unpubl. materials).

3. Results

Fig. 1 shows that the composition in carotenoids of both penguin faeces and the lichen *C. regalis* is almost identical and very similar to that described as the main fraction in the krill. Astaxanthin and its ester, as well as β-carotene, are the most abundant chemical compounds.

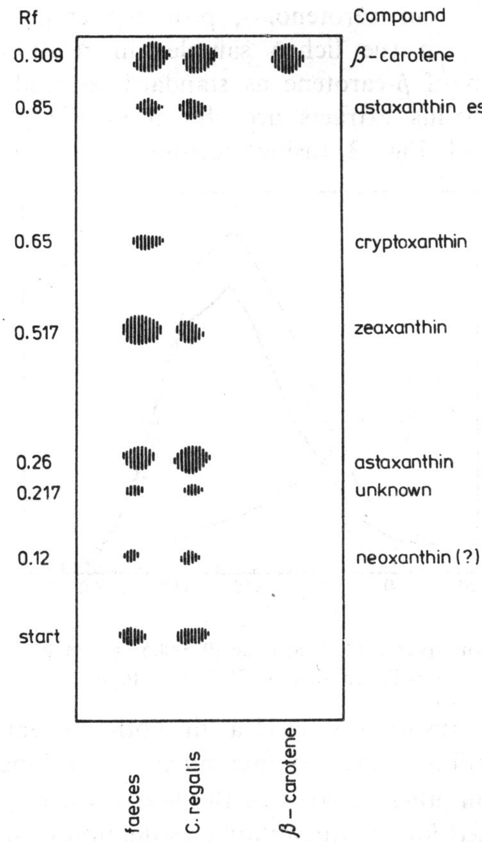

Fig. 1. TLC of β-carotene as standard and extracts of both penguin faeces and lichen thallus

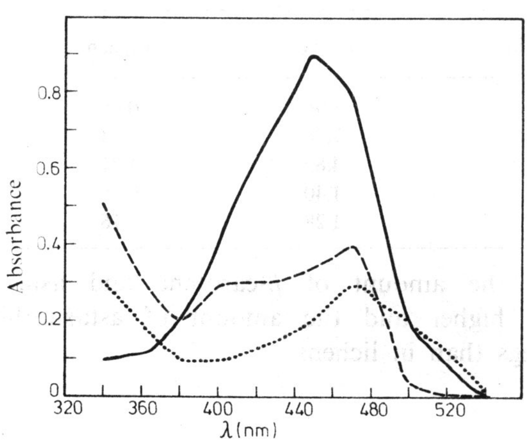

Fig. 2. Absorption spectra of β-carotene (0.00005% w/v), penguin faeces (0.04%) and lichen thallus (0.1%) in petroleum ether

Only one of the different carotenoids, probably cryptoxanthin, found by TLC, is not present in the lichen samples in relation to those found in faeces. Absorption of β-carotene as standard, as well as those of both faeces and lichen thallus extracts are shown in Fig. 2 (using petroleum ether as solvent) and Fig. 3 (using acetone as solvent). By comparing

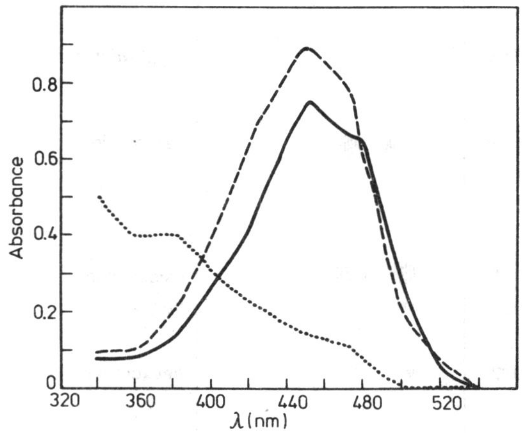

Fig. 3. Absorption spectra of β-carotene (0.00005%), penguin faeces (2%) and lichen thallus (5%) in acetone

the maxima in the absorption spectra in both solvents, it is observed that, after saponification, these maxima moved into longer wave lengths. In addition, petroleum ether behaves as the best extracting solvent and thus these spectra were used for the quantitative estimation of the main pigments.

Table I

Amount of carotenoids (μg/g) in penguin faeces and *Caloplaca regalis* thallus

Carotenoid	Faeces	Lichen
Astaxanthin	3.96	0.65
Astaxanthin ester	7.56	2.24
β-carotene	4.89	1.71
Zexanthin	1.40	0.74
Neoxanthin (?)	1.28	0.76

Table I shows that the amount of β-carotene and astaxanthin ester is about three times higher and the amount of astaxanthin six times higher in penguin dregs than in lichens.

4. Discussion

Our results concerning the carotenoid composition of penguin faeces show that it is very similar to that reported for krill (Czeczuga and

Kłyszejko, 1978; Jackowska et al., 1980). This is in agreement with the analysis of penguin diet (Volkman et al., 1980) and, then, both diet and faeces compositions can be correlated. This is supported by similar results obtained about fish nutrition (Isler, 1979). However, similarities in carotenoids composition between dregs and lichen *C. regalis* must be taken with more caution, since astaxanthin is normally produced by other lichen species from the family of *Teloschistaceae* (Czeczuga, 1979a) as *Xanthoria candelaria*, although this species, as well as *X. lobulata* and *X. parietina*, did not contain significant amount of both β-carotene and astaxanthin ester. The most abundant pigment in these species is revealed as mutatochrome. Nevertheless, these *Teloschistaceae*, otherwise known also as nitrophilous, are growing also on tree bark or hoardings and thus nutritional sources are different from those of *C. regalis*.

Another interesting point concerns the quantitative analysis of carotenoids in both *Xantoria* and *Caloplaca* genera. Whereas *X. parietina* contains 16.23 mg of total carotenoids per g dry weight (Czeczuga, 1979a), the amount of total pigments in *C. regalis* does not surpass 5.0 μg/g dry weight. This fact can be explained on the basis of mineral and organic nutrients availability, and irradiance and temperature differences.

The lack of cryptoxanthin in this lichen is very surprissing, since its occurrence in lichens is normally reported in *Teloschistaceae* (Czeczuga, 1979a), *Usneaceae* (Czeczuga, 1979b), *Peltigeraceae* (Czeczuga, 1980a) and *Parmeliaceae* (Czeczuga, 1980b).

5. Резюме

Сравнивался состав каротеноидов в экскрементах пингвинов и лишайниках *Caloplaca regalis* (Vain.) Zahlbr., растущих вблизи колонии пингвинов в районе станции им. Г. Арцтовского. Применяя измерение абсорбанции и тонкослойную хроматографию, выявлено, что состав каротеноидов *Caloplaca regalis* и экскрементов является похожим и типичным для каротеноидов криля. Особенностью является отсутствие в лишайниках одного из каротеноидов, вероятно криптоксантины. Полученные результаты свидетельствуют о возможности использования каротеноидов для наблюдения перемещения материи в типично континентальных организмах.

6. Streszczenie

Porównano skład karotenoidów w ekskrementach pingwinów i porostach *Caloplaca regalis* (Vain.). Zahlbr. rosnących w pobliżu pingwiniska, w rejonie stacji im. Arctowskiego. Stosując pomiar absorbancji i chromatografię cienkowarstwową, wykazano, że skład karotenoidów porostów i ekskrementów jest podobny i typowy dla karotenoidów kryla. Wyjątek stanowi brak w porostach jednego z karotenoidów, prawdopodobnie kryptoksantyny. Uzyskane wyniki świadczą o możliwości wykorzystania karotenoidów do śledzenia przepływu materii w ekosystemie antarktycznym oraz, że łańcuch ten może być przedłużony na organizmy typowo lądowe.

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