Supplementary material

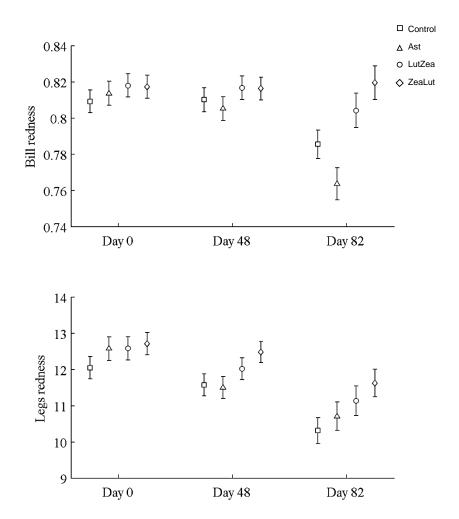
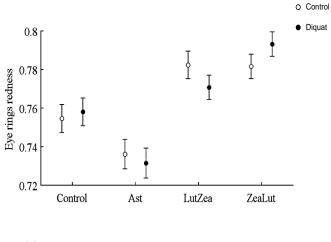
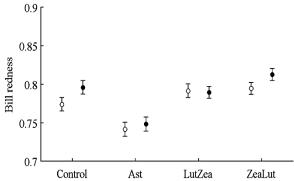


Figure 1SM: Changes in ornament coloration during the experiment depending on the carotenoid treatment. Least squared means \pm se were obtained from the models (see Methods and table 1).





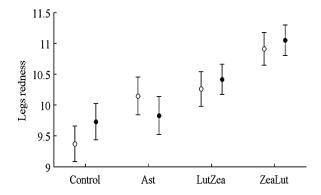


Figure 2SM: Changes in ornament coloration after diquat exposure depending on the carotenoid treatment. Least squared means \pm se from the models (see Methods and table 3).

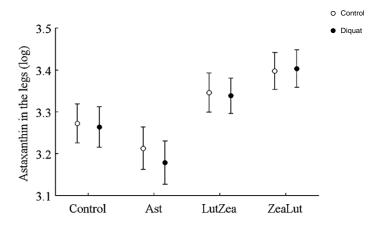
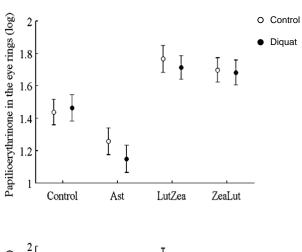
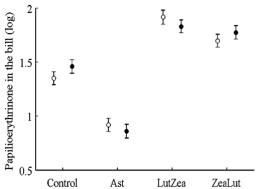


Figure 3SM: Levels of astaxanthin in the legs after diquat exposure depending on the carotenoid treatment. Least squared means \pm se from the models (see Methods and table 3).





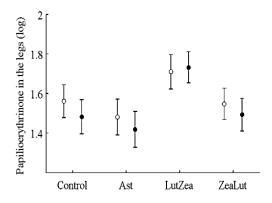
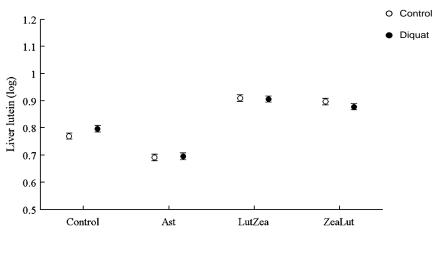


Figure 4SM: Levels of papilioerythrinone in the three ornaments after diquat exposure depending on the carotenoid treatment. Least squared means \pm se from the models (see Methods and table 3).



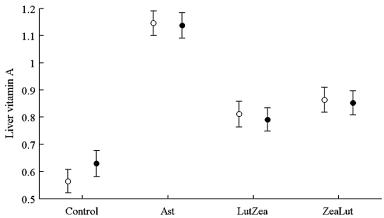


Figure 5SM: Levels of lutein and total vitamin A (free and esterified retinol) in liver after diquat exposure depending on the carotenoid treatment. Least squared means \pm se from the models (Methods and table 3).

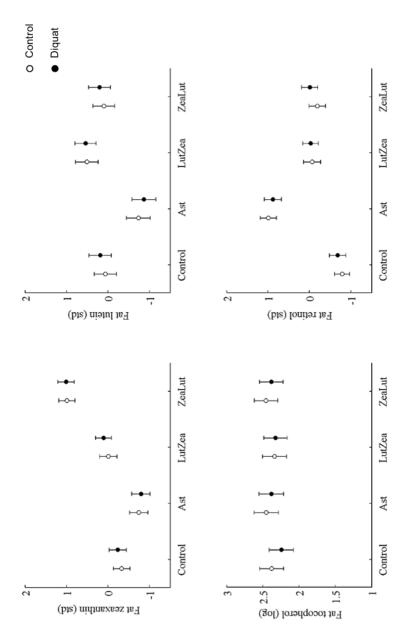


Figure 6SM: Levels of carotenoids and vitamins in subcutaneous fat after diquat exposure depending on the carotenoid treatment. Least squared means \pm se from the models (see Methods and table 3).

Table 15M: Raw data for carotenoids and vitamins (nmol/ml) in plasma throughout the study. The effects were provided by the models (see table 2). TXC: Time x carotenoid interaction; ns: No significant differences (p> 0.10). Sample size: time 0: N= 173; time 48: N= 173; and time 82: N= 86 (in time 82, diquat birds were discarded, see methods).

	Time	Control (mean ± sd)	Ast (mean ± sd)	LutZea (mean ± sd)	ZeaLut (mean ± sd)	Effect
	0	22.57 ± 5.45	21.52 ± 5.54	20.34 ± 6.42	20.16 ± 6.38	
Lutein	48	10.68 ± 2.87	6.56 ± 1.48	16.09 ± 6.10	12.65 ± 3.98	TxC
	82	9.48 ± 1.69	6.52 ± 0.75	16.86 ± 3.55	13.74 ± 2.45	
	0	10.96 ± 2.32	10.64 ± 1.74	10.33 ± 2.46	10.06 ± 2.30	
Zeaxanthin	48	7.64 ± 1.99	6.25 ± 1.58	13.37 ± 5.13	24.37 ± 9.20	TxC
	82	6.74 ± 1.07	6.59 ± 0.93	13.56 ± 3.28	25.88 ± 5.07	
	0	22.35 ± 9.67	22.73 ± 6.66	21.18 ± 8.15	21.37 ± 9.49	
Tocopherol	48	9.08 ± 3.29	9.30 ± 3.24	10.50 ± 4.65	11.83 ± 4.70	TxC
	82	11.02 ± 2.68	11.02 ± 2.56	12.60 ± 3.63	14.91 ± 3.99	
	0	23.89 ± 3.22	24.05 ± 4.21	24.08 ± 4.45	22.92 ± 3.57	
Retinol	48	22.11 ± 3.42	23.32 ± 3.62	23.78 ± 4.56	23.80 ± 4.49	ns
	82	25.74 ± 4.71	27.59 ± 4.44	27.01 ± 3.94	27.42 ± 4.38	

Table 2SM: Raw data for carotenoids and vitamins (nmol/g) in ornaments after the diquat exposure. The effects were provided by the models (see tables 3 and 4). C: Group of carotenoid supplement; DxC: Diquat x carotenoid interaction; D: Diquat treatment; S: Sex

			Control (mean ± sd)	Ast (mean ± sd)	LutZea (mean ± sd)	ZeaLut (mean ± sd)	Effect
	Actor	Control	66.68 ± 38.04	69.64 ± 28.80	113.57 ± 63.17	168.45 ± 74.50	2
	Astaxantinin	Diquat	61.52 ± 32.93	44.31 ± 20.24	103.46 ± 53.79	225.62 ± 141.05	חאר
200	Ozoniu dt. mooili moo	Control	7.63 ± 4.31	3.73 ± 2.42	16.59 ± 8.45	12.91 ± 5.26	
Eye rings	rapilloerytiiriilone	Diquat	6.30 ± 3.77	2.69 ± 2.01	16.65 ± 10.20	16.60 ± 10.55	د, ی
	LosodacocT	Control	63.91 ± 69.12	62.12 ± 23.49	45.10 ± 18.32	54.61 ± 20.44	2
	i ocopileroi	Diquat	39.21 ± 15.31	50.25 ± 16.65	45.48 ± 14.22	58.56 ± 19.50	חאר
	Actor	Control	156.80 ± 76.32	100.93 ± 36.08	373.51 ± 148.63	444.05 ± 287.12	2
	Astaxantinin	Diquat	148.61 ± 75.94	102.73 ± 50.98	224.45 ± 106.71	517.99 ± 276.06	מאר
n; o	4+ : !! 0	Control	15.10 ± 9.85	6.02 ± 3.87	52.31 ± 31.08	26.06 ± 14.90	,
III	Papilloerythrinone	Diquat	13.08 ± 6.36	4.72 ± 2.84	35.03 ± 24.01	32.67 ± 15.41	۲, ک
	LosodacocT	Control	84.42 ± 20.90	88.06 ± 23.40	91.98 ± 26.96	82.22 ± 26.64	,
	i ocopileroi	Diquat	65.46 ± 25.05	87.06 ± 28.84	71.20 ± 30.59	89.90 ± 28.68	מאר
	Actor	Control	49.07 ± 41.32	41.68 ± 25.82	71.45 ± 22.61	106.47 ± 70.17	,
	Astaxantinin	Diquat	36.64 ± 24.77	40.88 ± 49.75	60.27 ± 41.63	107.89 ± 70.37	د, ع
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Daniliand	Control	6.07 ± 3.75	4.41 ± 2.77	10.25 ± 2.55	8.29 ± 4.32	0
shar	rapilloeryullillolle	Diquat	5.12 ± 2.47	3.51 ± 4.48	9.71 ± 5.74	8.97 ± 7.54	د, ع
	Losodacoot	Control	53.78 ± 15.96	54.68 ± 11.53	46.26 ± 12.59	54.69 ± 16.50	ú
	i ocopileroi	Diquat	47.31 ± 12.84	48.53 ± 16.14	48.85 ± 16.19	55.73 ± 19.75	د, ی

Table 35M: Raw data for carotenoids and vitamins in plasma (nmol/mL), liver and fat (nmol/g) after the diquat exposure. The effects were provided by the models (see tables 3 and 4). C: Group of carotenoid supplement; DxC: Diquat x carotenoid interaction; S: Sex; ns: No significant differences.

			Control (mean ± sd)	Ast (mean ± sd)	LutZea (mean ± sd)	ZeaLut (mean ± sd)	Effect
	11.41.7	Control	9.48 ± 1.69	6.52 ± 0.75	16.86 ± 3.55	13.74 ± 2.45	,
	ratein	Diquat	9.45 ± 1.66	6.55 ± 0.77	15.03 ± 4.23	12.80 ± 2.67	ر
	-	Control	6.74 ± 1.07	6.59 ± 0.93	13.56 ± 3.28	25.88 ± 5.07	,
č	zeaxantnın	Diquat	6.79 ± 1.09	6.82 ± 1.31	12.66 ± 4.46	24.52 ± 6.12	ر
Plasma		Control	25.74 ± 4.71	27.59 ± 4.44	27.01 ± 3.94	27.42 ± 4.38	
	Ketinol	Diquat	24.71 ± 4.41	26.07 ± 3.94	26.86 ± 3.02	27.45 ± 4.19	ns
	H	Control	11.02 ± 2.68	11.02 ± 2.56	12.60 ± 3.63	14.91 ± 3.99	4
	locopnerol	Diquat	9.46 ± 3.65	11.14 ± 4.04	11.97 ± 3.95	13.71 ± 3.89	c, D
	1.04.1	Control	5.75 ± 0.49	4.86 ± 0.36	8.31 ± 1.54	8.82 ± 1.99	,
	ratein	Diquat	5.70 ± 0.63	4.83 ± 0.39	8.14 ± 1.80	8.20 ± 2.22	ر
		Control	4.16 ± 0.34	4.11 ± 0.48	6.52 ± 1.23	14.21 ± 3.80	2
	zeaxantnın Zeaxantnın	Diquat	4.11 ± 0.38	4.12 ± 0.53	6.29 ± 1.35	12.84 ± 4.45	חאר
TINEL	: :	Control	389.28 ± 245.49	1392.40 ± 490.99	679.07 ± 237.45	814.33 ± 325.32	
	l otal Vitamin A	Diquat	449.32 ± 297.65	1374.66 ± 682.11	618.66 ± 269.50	765.81 ± 399.72	۲, ۶
		Control	6.02 ± 1.69	6.67 ± 2.67	6.75 ± 2.66	9.03 ± 2.52	
	locopnerol	Diquat	4.71 ± 1.05	6.45 ± 2.68	6.65 ± 2.63	8.10 ± 3.76	DXC
	79-77-1	Control	17.74 ± 12.92	21.78 ± 13.77	25.31 ± 12.53	18.54 ± 13.63	,
	רמנפונו	Diquat	18.19 ± 11.16	19.95 ± 9.77	20.79 ± 16.24	21.46 ± 13.70	ر
	-: 47	Control	11.56 ± 8.25	15.37 ± 9.46	16.30 ± 7.63	16.07 ± 11.12	,
-	zeaxantnın	Diquat	11.98 ± 7.17	14.43 ± 6.98	13.89 ± 10.51	18.75 ± 11.71	ر
Ĕ	1001400	Control	87.09 ± 64.70	196.73 ± 108.90	149.17 ± 79.36	108.26 ± 86.98	,
	ופוווופע	Diquat	98.36 ± 65.76	179.52 ± 99.98	116.00 ± 99.21	131.30 ± 90.95	ر
	T	Control	381.21 ± 392.46	489.32 ± 599.44	328.65 ± 297.64	319.61 ± 260.11	;
	locopnerol	Diquat	267.97 ± 283.51	396.92 ± 341.49	318.61 ± 378.15	373.70 ± 384.49	ns

Table 4SM: Raw data for oxidative stress biomarkers in blood and other tissues at the end of the study after diquat treatment. The effects were provided by the models (see tables 3 and 4). C. Group of carotenoid supplement, D. Diquat treatment, DXCXS; Diquat x carotenoid x sex interaction; DXS: Diquat x Sex interaction.

Plasma TRG-MDA-corrected (μM) Male Diquat Control Diquat 10.138 ± 10.4 106.25 ± 11.89 10.867 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 11.79 ± 10.64 ± 10.04 ±		Sex		Control (mean ± sd)	(теа	n ± sd)	Ast (mean ± sd)	ean	‡ sd)	LutZea (mean ± sd)	(теа	(ps∓u	Zealu	t (me	ZeaLut (mean ± sd)	Effect
Male Control 3.387 ± 11.7 97.211 ± 10.04 100 Female Diquat 3.879 ± 0.687 2.954 ± 0.573 3.311 Female Diquat 3.879 ± 0.521 3.840 ± 0.576 4.057 Male Diquat 4.619 ± 1.894 4.330 ± 1.550 4.159 Female Diquat 0.008 ± 0.089 0.079 ± 0.114 0.003 Female Diquat 0.020 ± 0.070 ± 0.014 ± 0.047 Male Diquat 0.004 ± 0.006 0.006 ± 0.004 Female Diquat 0.023 ± 0.006 0.023 ± 0.006 Female Diquat 0.025 ± 0.006 0.023 ± 0.006 0.023 Female Diquat 0.025 ± 0.006	Resistance to oxidative stress		Control	101.38	+1	10.4	106.25	+1	11.89	103.67	+1	12.093	103.13	+1	11.64	
Male Control 3.387 ± 0.687 2.954 ± 0.573 3.311 Female Diquat 3.860 ± 0.521 3.840 ± 0.574 3.014 Male Diquat 4.619 ± 1.894 4.330 ± 1.550 4.159 Male Control 0.008 ± 0.089 0.079 ± 0.125 -0.038 Female Diquat 0.001 ± 0.160 0.008 ± 0.007 ± 0.047 Female Diquat 0.001 ± 0.007 0.023 ± 0.006 0.026 Female Diquat 0.025 ± 0.007 0.023 ± 0.007 0.025 Female Diquat 0.025 ± 0.007 0.033 ± 0.007 0.025 Female Diquat 0.025 ± 0.007 0.034 ± 0.010 0.035 Female Diq	in erythrocytes (min)		Diquat	100.2	+1	11.7	97.211	+1	10.04	100	+1	8.56	99.3	+1	9.739	٥
Wale Diquat 3.879 ± 0.521 3.840 ± 0.475 4.057 Female Control 3.660 ± 2.374 3.012 ± 0.514 3.114 Male Diquat 4.619 ± 1.894 4.330 ± 1.550 4.159 Male Diquat 0.008 ± 0.089 0.079 ± 0.125 -0.038 Female Diquat 0.001 ± 0.070 ± 0.047 ± 0.047 Male Diquat 0.004 ± 0.076 0.060 ± 0.047 Female Diquat 0.025 ± 0.007 0.023 ± 0.007 0.025 Female Diquat 0.025 ± 0.006 0.023 ± 0.007 0.033 Female Diquat 0.025 ± 0.006 0.033 ± 0.007 0.033 Female Diquat 0.025 ± <th></th> <td>:</td> <td>Control</td> <td>3.387</td> <td>+1</td> <td>0.687</td> <td>2.954</td> <td>+1</td> <td>0.573</td> <td>3.311</td> <td>+1</td> <td>0.490</td> <td>3.458</td> <td>+1</td> <td>0.965</td> <td></td>		:	Control	3.387	+1	0.687	2.954	+1	0.573	3.311	+1	0.490	3.458	+1	0.965	
Female Control 3.660 ± 2.374 3.012 ± 0.514 3.114 Male Diquat 4.619 ± 1.894 4.330 ± 1.550 4.159 Male Control 0.008 ± 0.089 0.079 ± 0.125 -0.038 Female Diquat 0.001 ± 0.072 0.104 ± 0.114 0.007 Male Diquat -0.004 ± 0.076 0.060 ± 0.047 Female Diquat 0.025 ± 0.007 0.023 ± 0.006 0.025 Female Diquat 0.025 ± 0.007 0.033 ± 0.007 0.033 Female Diquat 0.025 ± 0.006 0.033 ± 0.007 0.033 Female Diquat 0.025 ± 0.006 0.030 ± 0.010 0.033 Female Diquat 0.025 <		Male	Diquat	3.879	+1	0.521	3.840	+1	0.475	4.057	+1	0.503	4.102	+1	0.824	4
Pemale Diguat 4.619 ± 1.894 4.330 ± 1.550 4.159 Male Control 0.008 ± 0.089 0.079 ± 0.125 -0.038 Female Diguat 0.020 ± 0.076 0.104 ± 0.114 0.007 Male Diguat -0.004 ± 0.076 0.060 ± 0.047 Female Diguat 0.023 ± 0.006 0.023 ± 0.005 0.025 Female Diguat 0.025 ± 0.006 0.033 ± 0.007 0.033 Female Diguat 0.032 ± 0.006 0.033 ± 0.005 0.033 Female Diguat 0.032 ± 0.006 0.030 ± 0.010 0.033 Female Diguat 0.032 ± 0.006 0.030 ± 0.007 0.033 Female Diguat 0.032	Plasma IRG-MDA-corrected (µM)		Control	3.660	+1	2.374	3.012	+1	0.514	3.114	+1	0.543	3.408	+1	0.615	SXO I
Male Control 0.008 ± 0.089 0.079 ± 0.125 -0.038 Female Diquat 0.020 ± 0.072 0.104 ± 0.114 0.007 Male Diquat -0.004 ± 0.160 -0.008 ± 0.047 Female Diquat -0.004 ± 0.076 0.023 ± 0.004 Female Diquat 0.025 ± 0.006 0.023 ± 0.005 Female Diquat 0.032 ± 0.006 0.033 ± 0.001 Female Diquat 0.032 ± 0.006 0.033 ± 0.001 Diquat 0.025 ± 0.006 0.033 ± 0.007 0.024 Diquat 0.025 ± 0.006 0.033 ± 0.007 0.023		Female	Diquat	4.619	+1	1.894	4.330	+1	1.550	4.159	+1	1.337	4.517	+1	2.523	
Male Diguat 0.020 ± 0.072 0.104 ± 0.114 0.007 Female Control 0.001 ± 0.160 -0.008 ± 0.091 -0.047 Male Diguat -0.004 ± 0.007 0.023 ± 0.006 0.026 Female Diguat 0.025 ± 0.006 0.033 ± 0.007 0.025 Fomtrol 0.032 ± 0.006 0.034 ± 0.010 0.033 Control 0.032 ± 0.006 0.030 ± 0.012 0.024 Control 0.025 ± 0.006 0.030 ± 0.007 0.024 Diquat 0.025 ± 0.006 0.033 ± 0.007 0.027		0/0/4	Control	0.008	+1	0.089	0.079	+1	0.125	-0.038	+1	0.103	-0.026	+1	0.102	
Female Control 0.001 ± 0.160 -0.008 ± 0.047 -0.044 Male Diquat -0.004 ± 0.076 0.023 ± 0.006 0.026 Female Diquat 0.025 ± 0.006 0.023 ± 0.007 0.025 Fomtrol 0.025 ± 0.007 0.034 ± 0.007 0.033 Control 0.032 ± 0.006 0.034 ± 0.01 0.033 Control 0.025 ± 0.006 0.030 ± 0.01 0.034 Diquat 0.025 ± 0.006 0.030 ± 0.007 0.021 Diquat 0.024 ± 0.005 ± 0.005 ± 0.005 0.023		Male	Diquat	0.020	+1	0.072	0.104	+1	0.114	0.007	+1	0.080	-0.036	+1	0.097	, ,
Male	UA-ALB-corrected PLAUX (mmol/L)	-	Control	0.001	+1	0.160	-0.008	+1	0.091	-0.047	+1	0.078	-0.011	+1	0.176	DXCXS
Male Control 0.026 ± 0.007 0.023 ± 0.006 0.023 ± 0.006 0.023 ± 0.007 0.033 ± 0.007 0.033 Female Diquat 0.032 ± 0.007 0.034 ± 0.010 0.033 Control 0.032 ± 0.006 0.030 ± 0.010 0.033 Control 0.025 ± 0.005 0.023 ± 0.007 0.027 Diquat 0.024 ± 0.005 ± 0.005 ± 0.005 0.027 ± 0.005 0.023		remale	Diquat	-0.004	+1	0.076	0.060	+1	0.224	-0.043	+1	0.042	-0.043	+1	0.067	
Female Diquat 0.023 ± 0.006 0.023 ± 0.007 0.025 Fomula 0.035 ± 0.007 0.034 ± 0.010 0.033 Control 0.032 ± 0.006 0.030 ± 0.012 0.024 Control 0.025 ± 0.005 0.023 ± 0.007 0.027 Diquat 0.024 ± 0.005 0.027 ± 0.005 0.023		ole M	Control	0.026	+1	0.007	0.023	+1	90000	0.026	+1	0.005	0.024	+1	0.005	
Female Control 0.025 ± 0.007 0.034 ± 0.010 0.033 Control 0.032 ± 0.006 0.030 ± 0.012 0.024 Control 0.025 ± 0.005 0.023 ± 0.007 0.027 Diquat 0.024 ± 0.005 0.027 ± 0.005 0.023	(m) former) ACM acres	ואומוב	Diquat	0.023	+1	900.0	0.023	+1	0.007	0.025	+1	0.007	0.026	+1	0.007	2
Control 0.032 ± 0.006 0.030 ± 0.012 0.024 Control 0.025 ± 0.005 0.023 ± 0.007 0.027 Diquat 0.024 ± 0.005 0.027 ± 0.005 0.023	LIVET INDA (pmol/g)	0000	Control	0.025	+1	0.007	0.034	+1	0.010	0.033	+1	0.014	0.028	+1	0.004	DXCXS
Control 0.025 ± 0.005 0.023 ± 0.007 0.027 Diquat 0.024 ± 0.005 0.027 ± 0.005 0.023		בפוופוב	Diquat	0.032	+1	900.0	0.030	+1	0.012	0.024	+1	0.007	0.028	+1	0.010	
Diquat 0.024 ± 0.005 0.027 ± 0.005 0.023	(a) lower A A A A A Second		Control	0.025	+1	0.005	0.023	+1	0.007	0.027	+1	0.01	0.026	+1	0.011	(
	near MDA (pinor) g)		Diquat	0.024	+1	0.005	0.027	+1	0.005	0.023	+1	90000	0.024	+1	0.005	ر