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Appendix 1. ESM-culture medium for marine phytoflagellates (Lirdwitayaprasit, 1990)

Sea water	1,000 ml
$NaNO_3$	120 mg
K_2HPO_4	5 mg
EDTA-Fe	0.26 mg
EDTA-Mn	0.33 mg
Vitamin B1-HCl	0.1 mg
Vitamin B12	10 μg
Biotin	1 μg
Tris-buffer	1 g
pH	8.0

Appendix 2. Modified Johnson's medium (J/1) for *Dunaliella* spp (Borowitzka, 1988)

to 980 ml of distilled water add:

NaCl	as needed to obtain required salinity
$MgCl_2.6H_2O$	1.5 g
$MgSO_4.7H_2O$	0.5 g
KCl	0.2 g
$CaCl_2.2H_2O$	0.2 g
KNO_3	1.0 g
$NaHCO_3$	0.043 g
KH_2HPO_4	0.035 g
Fe-solution	10 ml
Trace-element solution	10 ml

Fe-solution (for 1 liter)

Na_2EDTA	189 mg
$FeCl_3.6H_2O$	244 mg

autoclave to dissolve

Trace-element Solution (for 1 liter)

H_3BO_3	61.0 mg
$(NH_4)6Mo_7O_{24}.4H_2O$	38.0 mg
$CuSO_4.5H_2O$	6 mg
$CoCl_2.6H_2O$	5.1 mg
$ZnCl_2$	4.1 mg
$MnCl_2.4H_2O$	4.1 mg

adjust pH to 7.5 with HCl

Appendix 3. Total Carotenoid assay (Borowitzka, 1991) (suitable for Dunaliella salina)

1. Filter 10-20 ml of culture volume through a glass fibre filter
2. Cut the dry filter into small pieces and add 10 ml 90% (v/v) cold acetone containing a little $MgCO_3$
3. Store filter in 90% acetone in the dark and on ice until assayed
4. Grind filter and then transfer to graduated glass centrifuge tube and centrifuge at 3000-5000 rpm for 2-3 min
5. Measure volume of supernatant and measure absorbance at 452 nm
6. Calculate the total carotenoid content (in $\mu g.ml^{-1}$ culture volumn) by using the following equation:

$$\text{Total Carotenoids} = ABS_{452} * 3.86 * \frac{\text{Total Vol of extract(ml)}}{\text{Total Vol of Culture Sample(ml)}}$$

Appendix 4. Determination of Chlorophyll (Borowitzka, 1991)

1. Filter a known volume of algae onto a GF/C filter then place in a glass centrifuge tube.
2. Add several ml of ice-cold 90% acetone and mix with a glass rod.
3. Pore off supernatant into a graduate glass centrifuge tube and, if necessary, re-extract with fresh acetone. Pour off this supernatant and combine the supernatants.
4. Centrifuge and then measure the volume of the supernatant.
5. Measure absorbance at the appropriate wavelengths in a spectrophotometer.
6. Calculate the concentrations of chlorophyll as follows:

$$\text{Chlorophyll a} = 11.93\ E_{664} - 1.93\ E_{647}$$

$$\text{Chlorophyll b} = 20.36\ E_{647} - 5.50\ E_{664}$$

Appendix 5. Determination of β-carotene by HPLC (Borowitzka, 1991).

Extraction of Carotenoids

(1) Filter know volume of Culture onto Whatman GF/C filter.

(2) If storing filters, wrap in aluminium foil and freeze at -20°C (under a nitrogen atmosphere if at all possible).

(3) Extract filter in dim light in cold 90% acetone with gentle grinding.

(4) Centrifuge, and carefully remove supernatant and measure volume.

HPLC Conditions

Moblie phase: 79.9% Acetonitrile, 10.0% Dichloromethan, 10.0% Methanol, 0.1% Water (filter through 0.5 μ PTFE filter). The solvent can be used immediately, or stored at room temperature under about 5 psi Helium.

Chromatographic Conditions

Isocratic separation at 1.0 ml/min for a total run time of 15 min.

Column Temperature: 30°C

Detection: Absorbance at 452 nm

Calibration: Standardise with a standard β-carotene in acetone.

Appendix 6. Isomer separation of β-carotene by HPLC (Ben-Amotz, Lers and Avron, 1988).

Extraction

(1) Dry algae (about 0.05g) was extracted with 5 ml acetone and homogenate with glass homogenizer.

(2) Adding 5 ml of acetone then centrifuge at 3,000 rpm for 10 minute, keep supernatant and reextract the residue with 5 ml acetone and then centrifuge.

(3) Evaporate the supernatant until dry

(4) Saponification and evaporation (with benzene and Potassium Hydroxide) will need if there was low concentration of carotenoid but not necessary for D. salina.

(5) Adding dichloromethan, inject to HPLC

HPLC Condition

HPLC:	Shimadsu model SPD-M6A
	Photodiode Array UV-VIS Detecter
	wavelength 450 nm
Column:	Vydac TP201 54
	C-18
	particle size 5μ
Mobile phase:	Methanol:Acetonitrile (90:10)
	(reverse phase)
	wash the column with
	methanol:Acetonitrile:methylene chloride
	(8:1:1) after about 20 injection
Flow rate:	0.8 ml/min
Run time:	80 minute

Appendix 7. Ash free dry weight (AFDW) determination.

Pretreatment

(1) Precombust Whatman GF/C filters at 100°C for 1 h.

(2) Store filters in vacuum desiccator over $KMnO_4$ crystals until use.

Dry weight Dertermination

(1) Carefully weigh precombusted filters to 4 decimal places.

(2) Place filters in filter unit and filter culture until filter appears completely dry.

(3) Wash filter with 10 ml of isotonic ammunium formate solution (0.65 M for marine spp.)

(4) Remove filter from filter unit and dry at 100°C for 1 h and then place in vacuum desiccator over $KMnO_4$ over night.

(5) Weigh dried filter containing algae to 4 decimal places.

Dry weight = (weight of filter plus algae)-(weight of filter)

Ash-free dry weight (organic dry weight) determination

(1) Take filters from above dry weight determination and ash at 450°C for 5 h.

(2) Cool filters in a vacuum desiccator over $KMnO_4$

(3) Rapidly and carefully weight filter.

Ash-free dry weight = Dry weight - Weight after ashing.

Appendix 8. HPLC printout chromatogram of the experiment 3.1.

(1) Standard β-carotene

(2) D. salina cultivated in 5,000 lux light intensity.

Appendix 8. (continue) HPLC printout chromatogram of the experiment 3.1.

(3) D. salina cultivated in 10,000 lux light intensity.

(4) D. salina cultivated in 15,000 lux light intensity.

Appendix 9. Statistical analysis.

(Strain selection)

ANALYSIS OF VARIANCE OF CAROTENOID CONTENT IN 10%NaCl
One-Way Analysis of Variance

Data: CARO100.CAROTENE
Level codes: CARO100.STRAIN
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan
Analysis of variance

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	492.98361	5	98.596722	29.512	.0010
Within groups	16.70440	5	3.340881		
Total (corrected)	509.68801	10			

0 missing value(s) have been excluded.

Multiple range analysis for CAROTENE BY STRAIN

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups (95% C.F.)
DS91010	2	6.02900	*
DS91001	2	6.17950	*
DS91009	2	10.35600	**
DS91002	1	15.19700	**
DS91007	2	17.38800	*
DS91008	2	24.07800	*

ANALYSIS OF VARIANCE OF CAROTENOID CONTENT IN 20%NaCl
One-Way Analysis of Variance

Data: CARO200.CAROTENE
Level codes: CARO200.STRAIN
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan
Analysis of variance

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	932.95748	5	186.59150	21.848	.0009
Within groups	51.24225	6	8.54038		
Total (corrected)	984.19973	11			

0 missing value(s) have been excluded.

Multiple range analysis for CAROTENE BY STRAIN

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups (95% C.F.)
DS91010	2	10.70500	*
DS91001	2	11.04750	*
DS91009	2	12.84000	*
DS91007	2	25.01400	*
DS91002	2	27.72000	**
DS91008	2	32.80400	*

ANALYSIS OF VARIANCE OF CAROTENOID IN 30%NaCl
One-Way Analysis of Variance

Data: CARO300.CAROTENE
Level codes: CARO300.STRAIN
Labels:

Appendix 9. (Continue)

Means plot: Conf. Int. Confidence level: 95 Range test: Duncan
Analysis of variance

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	2328.7354	5	465.74708	31.661	.0000
Within groups	161.81545	11	14.71049		
Total (corrected)	2490.5508	16			

0 missing value(s) have been excluded.

Multiple range analysis for CAROTENE BY STRAIN

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups (95% C.F.)
DS91009	3	47.08700	*
DS91010	3	47.17700	*
DS91001	2	53.75300	*
DS91007	3	54.64000	*
DS91002	3	61.98066	*
DS91008	3	80.38933	*

Experiment 3.1 Discriminant analysis for D. salina cell dimensions in different light intensities.

Discriminant Function	Eigenvalue	Relative Percentage	Canonical Correlation
1	.4680149	87.34	.56463
2	.0678318	12.66	.25204

Functions Derived	Wilks Lambda	Chi-Square	DF	Sig.Level
0	.6379207	40.458715	6	.0000
1	.9364771	5.906720	2	.05216

Group Centroids

	1	2
1 (3,000 lux)	-1.31663	-0.06100
2 (5,000 lux)	0.21133	0.42614
3 (10,000 lux)	0.47757	-0.21674
4 (15,000 lux)	0.31999	-0.14583

(Effect of nitrate)

SPSS/PC+ Studentware 2/25/93

```
ANALYSIS OF COVARIANCE FOR GROWTH RATE
data list file'c:\ancova\gn.prn' free/trt[treatment] day no[log cell number].
anova no by trt(1,5) with day.
```

Page 3 SPSS/PC+ Studentware 2/25/93

* * * A N A L Y S I S O F V A R I A N C E * * *

NO
BY TRT (NITRATE)
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	15.443	1	15.443	353.169	.000
DAY	15.443	1	15.443	353.169	.000
Main Effects	.875	4	.219	5.000	.001
TRT	.875	4	.219	5.000	.001
Explained	16.317	5	3.263	74.634	.000
Residual	2.798	64	.044		
Total	19.116	69	.277		

```
anova no by trt(1,2) with day.
```

Appendix 9. (continue)

```
Page  6                SPSS/PC+ Studentware                    2/25/93
          *** A N A L Y S I S   O F   V A R I A N C E ***
            NO
         BY   TRT
         WITH DAY

                                  Sum of                 Mean            Signif
Source of Variation              Squares     DF         Square       F    of F
Covariates                         3.153      1          3.153  138.030    .000
  DAY                              3.153      1          3.153  138.030    .000
Main Effects                        .172      1           .172    7.540    .011
  TRT                               .172      1           .172    7.540    .011
Explained                          3.326      2          1.663   72.785    .000
Residual                            .571     25           .023
Total                              3.897     27           .144
------------------------------------------------------------------------------

     70 Cases were processed.
     42 Cases ( 60.0 PCT) were missing.

anova no by trt(2,3) with day.
------------------------------------------------------------------------------
Page  9                SPSS/PC+ Studentware                    2/25/93
          *** A N A L Y S I S   O F   V A R I A N C E ***
            NO
         BY   TRT
         WITH DAY

                                  Sum of                 Mean            Signif
Source of Variation              Squares     DF         Square       F    of F
Covariates                         4.817      1          4.817  213.864    .000
  DAY                              4.817      1          4.817  213.864    .000
Main Effects                        .082      1           .082    3.624    .069
  TRT                               .082      1           .082    3.624    .069

Explained                          4.899      2          2.449  108.744    .000
Residual                            .563     25           .023
Total                              5.462     27           .202
------------------------------------------------------------------------------

     70 Cases were processed.
     42 Cases ( 60.0 PCT) were missing.

anova no by trt(3,4) with day.
------------------------------------------------------------------------------
Page  12               SPSS/PC+ Studentware                    2/25/93
          *** A N A L Y S I S   O F   V A R I A N C E ***
            NO
         BY   TRT
         WITH DAY

                                  Sum of                 Mean            Signif
Source of Variation              Squares     DF         Square       F    of F
Covariates                         7.391      1          7.391  425.438    .000
  DAY                              7.391      1          7.391  425.438    .000
Main Effects                        .650      1           .650   37.391    .000
  TRT                               .650      1           .650   37.391    .000
Explained                          8.041      2          4.020  231.415    .000
Residual                            .434     25           .017
Total                              8.475     27           .314
------------------------------------------------------------------------------

     70 Cases were processed.
     42 Cases ( 60.0 PCT) were missing.

anova no by trt(4,5) with day.
------------------------------------------------------------------------------
Page  15               SPSS/PC+ Studentware                    2/25/93
          *** A N A L Y S I S   O F   V A R I A N C E ***
            NO
         BY   TRT
         WITH DAY

                                  Sum of                 Mean            Signif
Source of Variation              Squares     DF         Square       F    of F
Covariates                        10.256      1         10.256  246.216    .000
  DAY                             10.256      1         10.256  246.216    .000
Main Effects                        .259      1           .259    6.213    .020
  TRT                               .259      1           .259    6.213    .020
```

Appendix 9. (continue)

Explained	10.515	2	5.257	126.214	.000
Residual	1.041	25	.042		
Total	11.556	27	.428		

70 Cases were processed.
42 Cases (60.0 PCT) were missing.
This procedure was completed at 9:35:57
finish

ANALYSIS OF VARIANCE ON CAROTENOID, CHLOROPHYLL-A AND CAR/CHL RATIO

One-Way Analysis of Variance

Data: CAROTENOID (LOG PHASE)
Level codes: CNL.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	10916.194	4	2729.0485	3.303	.1369
Within groups	3304.592	4	826.1479		
Total (corrected)	14220.786	8			

Multiple range analysis for CNL.car by CNL.nitrate

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
3	2	43.02500	*
5	1	49.47000	**
4	2	59.81500	**
1	2	79.55500	**
2	2	137.20000	*

One-Way Analysis of Variance

Data: CAROTENOID (STATIONARY PHASE)
Level codes: CNS.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	368.14635	4	92.036588	2.113	.2826
Within groups	130.70100	3	43.567000		
Total (corrected)	498.84735	7			

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (LOG PHASE)
Level codes: CNL.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	569.24915	4	142.31229	11.475	.0182
Within groups	49.60945	4	12.40236		
Total (corrected)	618.85860	8			

Multiple range analysis for CNL.chla by CNL.nitrate

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
5	1	5.610000	*

Appendix 9. (continue)

3	2	5.965000	*
4	2	7.200000	*
1	2	14.050000	*
2	2	26.200000	*

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (STATIONARY PHASE)
Level codes: CNS.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	12.212250	4	3.0530625	3.106	.1894
Within groups	2.948550	3	.9828500		
Total (corrected)	15.160800	7			

One-Way Analysis of Variance

Data: CAROTENOID/CHLOROPHYLL-A RATIO (LOG PHASE)
Level codes: CNL.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	14.506624	4	3.6266559	1.069	.4749
Within groups	13.566500	4	3.3916250		
Total (corrected)	28.073124	8			

One-Way Analysis of Variance

Data: CAROTENOID/CHLOROPHYLL-A RATIO (STATIONARY PHASE)
Level codes: CNS.nitrate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	7.0870485	4	1.7717621	2.384	.2507
Within groups	2.2296170	3	.7432057		
Total (corrected)	9.3166655	7			

(EFFECT OF PHOSPHATE)

ANALYSIS OF COVARIANCE FOR GROWTH RATE
data list file'c:\kag\gp.prn' free/trt day no.
anova no by trt(1,5) with day.

Page 2 SPSS/PC+ Studentware 2/25/93

* * * A N A L Y S I S O F V A R I A N C E * * *

NO
BY TRT (phosphate)
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	17.025	1	17.025	243.846	.000
DAY	17.025	1	17.025	243.846	.000
Main Effects	6.229	4	1.557	22.303	.000
TRT	6.229	4	1.557	22.303	.000
Explained	23.254	5	4.651	66.612	.000
Residual	4.817	69	.070		

Appendix 9. (continue)

```
Total                                28.071     74         .379
------------------------------------------------------------------------------

     75 Cases were processed.
      0 Cases (    .0 PCT) were missing.

anova no by trt(1,2) with day.
------------------------------------------------------------------------------
Page   5                SPSS/PC+ Studentware                        2/25/93
          * * *  A N A L Y S I S   O F   V A R I A N C E  * * *
            NO
         BY   TRT
         WITH DAY

                                  Sum of                    Mean            Signif
Source of Variation              Squares      DF           Square       F    of F
Covariates                         2.567       1            2.567   46.063    .000
  DAY                              2.567       1            2.567   46.063    .000
Main Effects                        .132       1             .132    2.366    .136
  TRT                               .132       1             .132    2.366    .136
Explained                          2.699       2            1.349   24.214    .000
Residual                           1.505      27             .056
Total                              4.204      29             .145
------------------------------------------------------------------------------

     75 Cases were processed.
     45 Cases ( 60.0 PCT) were missing.

anova no by trt(2,3) with day.
------------------------------------------------------------------------------
Page   8                SPSS/PC+ Studentware                        2/25/93
          * * *  A N A L Y S I S   O F   V A R I A N C E  * * *
            NO
         BY   TRT
         WITH DAY

                                  Sum of                    Mean            Signif
Source of Variation              Squares      DF           Square       F    of F
Covariates                         5.385       1            5.385  264.761    .000
  DAY                              5.385       1            5.385  264.761    .000
Main Effects                        .408       1             .408   20.040    .000
  TRT                               .408       1             .408   20.040    .000
Explained                          5.793       2            2.896  142.400    .000
Residual                           .549       27             .020
Total                              6.342      29             .219
------------------------------------------------------------------------------

     75 Cases were processed.
     45 Cases ( 60.0 PCT) were missing.

anova no by trt(3,4) with day.
------------------------------------------------------------------------------
Page  11                SPSS/PC+ Studentware                        2/25/93
          * * *  A N A L Y S I S   O F   V A R I A N C E  * * *
            NO
         BY   TRT
         WITH DAY

                                  Sum of                    Mean            Signif
Source of Variation              Squares      DF           Square       F    of F
Covariates                         9.891       1            9.891  245.755    .000
  DAY                              9.891       1            9.891  245.755    .000
Main Effects                       3.482       1            3.482   86.501    .000
  TRT                              3.482       1            3.482   86.501    .000
Explained                         13.373       2            6.686  166.128    .000
Residual                           1.087      27             .040
Total                             14.460      29             .499
------------------------------------------------------------------------------

     75 Cases were processed.
     45 Cases ( 60.0 PCT) were missing.

anova no by trt(4,5) with day.
------------------------------------------------------------------------------
Page  14                SPSS/PC+ Studentware                        2/25/93
          * * *  A N A L Y S I S   O F   V A R I A N C E  * * *
            NO
         BY   TRT
         WITH DAY
```

Appendix 9. (continue)

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	13.172	1	13.172	302.968	.000
DAY	13.172	1	13.172	302.968	.000
Main Effects	.000	1	.000	.002	.968
TRT	.000	1	.000	.002	.968
Explained	13.172	2	6.586	151.485	.000
Residual	1.174	27	.043		
Total	14.346	29	.495		

75 Cases were processed.
45 Cases (60.0 PCT) were missing.
This procedure was completed at 9:39:02
finish

ANALYSIS OF VARIANCE FOR CAROTENOID, CHLOROPHYLL-A AND CAR/CHL RATIO

One-Way Analysis of Variance

Data: CAROTENOID (LOG PHASE)
Level codes: CPL.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	490.94532	4	122.73633	1.106	.4623
Within groups	443.88690	4	110.97173		
Total (corrected)	934.83222	8			

One-Way Analysis of Variance

Data: CAROTENOID (STATIONARY PHASE)
Level codes: CPS.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	128.10884	4	32.027210	.372	.8200
Within groups	429.91545	5	85.983090		
Total (corrected)	558.02429	9			

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (LOG PHASE)
Level codes: CPL.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	7.5611389	4	1.8902847	5.952	.0561
Within groups	1.2703500	4	.3175875		
Total (corrected)	8.8314889	8			

Multiple range analysis for CPL.chlal by CPL.phosphate

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
5	2	7.2350000	*
4	2	7.4100000	*
1	1	7.8600000	*
3	2	8.4950000	**
2	2	9.6450000	*

Appendix 9. (continue)

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (STATIONARY PHASE)
Level codes: CPS.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	2.7897796	4	.6974449	.380	.8154
Within groups	9.1863245	5	1.8372649		
Total (corrected)	11.976104	9			

One-Way Analysis of Variance

Data: CAROTENOID/CHLOROPHYLL-A RATIO (LOG PHASE)
Level codes: CPL.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	2.4221787	4	.6055447	.620	.6727
Within groups	3.9065395	4	.9766349		
Total (corrected)	6.3287182	8			

One-Way Analysis of Variance

Data: CAROTENOID/CHLOROPHYLL-A RATIO (STATIONARY PHASE)
Level codes: CPS.phosphate
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	3.810313	4	.9525781	.329	.8481
Within groups	14.480285	5	2.8960571		
Total (corrected)	18.290598	9			

(EFFECT OF pH)

ANALYSIS OF COVARIANCE FOR GROWTH RATE
data list file'd:\gph20.dat' free/trt day no.
anova no by trt(1,7) with day.

Page 2 SPSS/PC+ Studentware 2/25/93

* * * A N A L Y S I S O F V A R I A N C E * * *

NO
BY TRT (pH)
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	3.774	1	3.774	366.985	.000
DAY	3.774	1	3.774	366.985	.000
Main Effects	1.512	6	.252	24.512	.000
TRT	1.512	6	.252	24.512	.000
Explained	5.286	7	.755	73.437	.000
Residual	.710	69	.010		
Total	5.996	76	.079		

77 Cases were processed.
0 Cases (.0 PCT) were missing.

anova no by trt(1,2) with day.

Page 5 SPSS/PC+ Studentware 2/25/93

Appendix 9. (continue)

*** ANALYSIS OF VARIANCE ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	.422	1	.422	52.616	.000
DAY	.422	1	.422	52.616	.000
Main Effects	.008	1	.008	.965	.338
TRT	.008	1	.008	.965	.338
Explained	.430	2	.215	26.790	.000
Residual	.152	19	.008		
Total	.582	21	.028		

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

anova no by trt(2,3) with day.

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*** ANALYSIS OF VARIANCE ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	.961	1	.961	63.354	.000
DAY	.961	1	.961	63.354	.000
Main Effects	.680	1	.680	44.810	.000
TRT	.680	1	.680	44.810	.000
Explained	1.641	2	.820	54.082	.000
Residual	.288	19	.015		
Total	1.929	21	.092		

---

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

anova no by trt(3,4) with day.

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*** ANALYSIS OF VARIANCE ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	2.101	1	2.101	451.491	.000
DAY	2.101	1	2.101	451.491	.000
Main Effects	.022	1	.022	4.782	.041
TRT	.022	1	.022	4.782	.041
Explained	2.123	2	1.062	228.136	.000
Residual	.088	19	.005		
Total	2.212	21	.105		

---

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

anova no by trt(4,5) with day.

*** ANALYSIS OF VARIANCE ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	1.690	1	1.690	235.101	.000
DAY	1.690	1	1.690	235.101	.000
Main Effects	.002	1	.002	.210	.652
TRT	.002	1	.002	.210	.652
Explained	1.691	2	.846	117.655	.000
Residual	.137	19	.007		
Total	1.828	21	.087		

Appendix 9. (continue)

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

```
anova no by trt(5,6) with day.
```

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*** A N A L Y S I S O F V A R I A N C E ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	1.146	1	1.146	205.053	.000
DAY	1.146	1	1.146	205.053	.000
Main Effects	.043	1	.043	7.701	.012
TRT	.043	1	.043	7.701	.012
Explained	1.189	2	.594	106.377	.000
Residual	.106	19	.006		
Total	1.295	21	.062		

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

```
anova no by trt(6,7) with day.
```

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*** A N A L Y S I S O F V A R I A N C E ***

NO
BY TRT
WITH DAY

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	1.006	1	1.006	171.185	.000
DAY	1.006	1	1.006	171.185	.000
Main Effects	.001	1	.001	.180	.676
TRT	.001	1	.001	.180	.676
Explained	1.007	2	.504	85.682	.000
Residual	.112	19	.006		
Total	1.119	21	.053		

77 Cases were processed.
55 Cases (71.4 PCT) were missing.

```
finish
```

ANALYSIS OF VARIANCE FOR CAROTENOID, CHLOROPHYLL-A AND CAR/CHL RATIO

One-Way Analysis of Variance

Data: CAROTENOID (LOG PHASE)
Level codes: CPHL.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	162.61167	4	40.652918	.533	.7213
Within groups	304.99555	4	76.248888		
Total (corrected)	467.60722	8			

One-Way Analysis of Variance

Data: CAROTENOID (STATIONARY PHASE)
Level codes: CPHS.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	1089.1012	6	181.51686	5.504	.0285
Within groups	197.8784	6	32.97973		

Appendix 9. (continue)

Total (corrected) 1286.9796 12

Multiple range analysis for CPHS.cars by CPHS.pH

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
4	2	24.685000	*
3	1	24.940000	*
2	2	33.265000	**
5	2	35.515000	**
1	2	36.600000	**
7	2	42.450000	**
6	2	53.575000	*

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (LOG PHASE)
Level codes: CPHL.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	4.411139	4	1.1027847	.408	.7970
Within groups	10.822150	4	2.7055375		
Total (corrected)	15.233289	8			

One-Way Analysis of Variance

Data: CHLOROPHYLL-A (STATIONARY PHASE)
Level codes: CPHS.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	26.447642	6	4.4079404	3.861	.0624
Within groups	6.850450	6	1.1417417		
Total (corrected)	33.298092	12			

Multiple range analysis for CPHS.chlas by CPHS.pH

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
7	2	5.1150000	*
4	2	5.3050000	*
3	1	6.1400000	*
5	2	7.0450000	**
1	2	7.2050000	**
2	2	7.8450000	**
6	2	9.3900000	*

One-Way Analysis of Variance

Data: CAROTENOID/CHLOROPHYLL-A RATIO (LOG PHASE)
Level codes: CPHL.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	2.0608389	4	.5152097	.591	.6888
Within groups	3.4896700	4	.8724175		
Total (corrected)	5.5505089	8			

One-Way Analysis of Variance

Appendix 9. (continue)

Data: CAROTENOID/CHLOROPHYLL-A RATIO (STATIONARY PHASE)
Level codes: CPHS.pH
Labels:
Means plot: Conf. Int. Confidence level: 95 Range test: Duncan

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
Between groups	23.450270	6	3.9083783	5.708	.0262
Within groups	4.108009	6	.6846682		
Total (corrected)	27.558279	12			

Multiple range analysis for CPHS.phsratio by CPHS.pH

Method: 95 Percent Duncan

Level	Count	Average	Homogeneous Groups
3	1	4.0620000	*
2	2	4.2320000	*
4	2	4.6550000	*
5	2	5.0480000	*
1	2	5.0815000	*
6	2	5.7605000	*
7	2	8.3250000	*

* denotes a statistically significant difference.

BIOGRAPHICAL DATA OF AUTHOR

Mr. Sorawit Powtongsook was born on July 5, 1968 in Bangkok. He graduated with the a Bachelor degree in Aquatic Science from Department of Aquatic Science, Faculty of Science, Srinakharinwirot University, Bangsaen Campus (Burapha University presently), Chonburi Province. During undergraduate study, he used to join with the Coral Reef Ecology Study Team (CREST) of the Department of Aquatic Science as a research assistant in the ASEAN-Australia Coastal Living Resources subproject on marine science (coral reef study in the eastern part of Thailand). In May 1988, he attended to the Friendship Program for the 21st Century which support by Japan International Cooperation Agency (JICA) to visit Japan with a duration of one month in Agriculture observation tour.

During his study at the Department of Marine Science, Faculty of Science, Chulalongkorn University in Bangkok. He received research and teaching assistant in the Marine Plankton Laboratory of the Department for one year. Thereafter, he became working as research assistant of the Marine Biotechnology Research Unit on Dunaliella project.

In May 12th-June 22nd 1991, he attended the advanced training course on photosynthesis and algal biotechnology at Microalgal Biotechnology Laboratory, The Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev at Sede-Boker, Israel.

Research Publications:

Sirirattanachai, S., V. Manthachitra, V. Cheevaporn, S. Jaritkruan, P. Sonchaeng, K. Chanthawong, S. Powtongsook and S. Jedsadavisuit. 1989. Baseline Information of Coral Community in Chonburi Province. **Final report, ASEAN-Australia Cooperative Program on Marine Science Project II, Living Resource in Coastal Areas with Emphasis on Mangrove and Coral Reef Ecosystems, submit to National Environmental Board of Thailand**, 100 p.

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