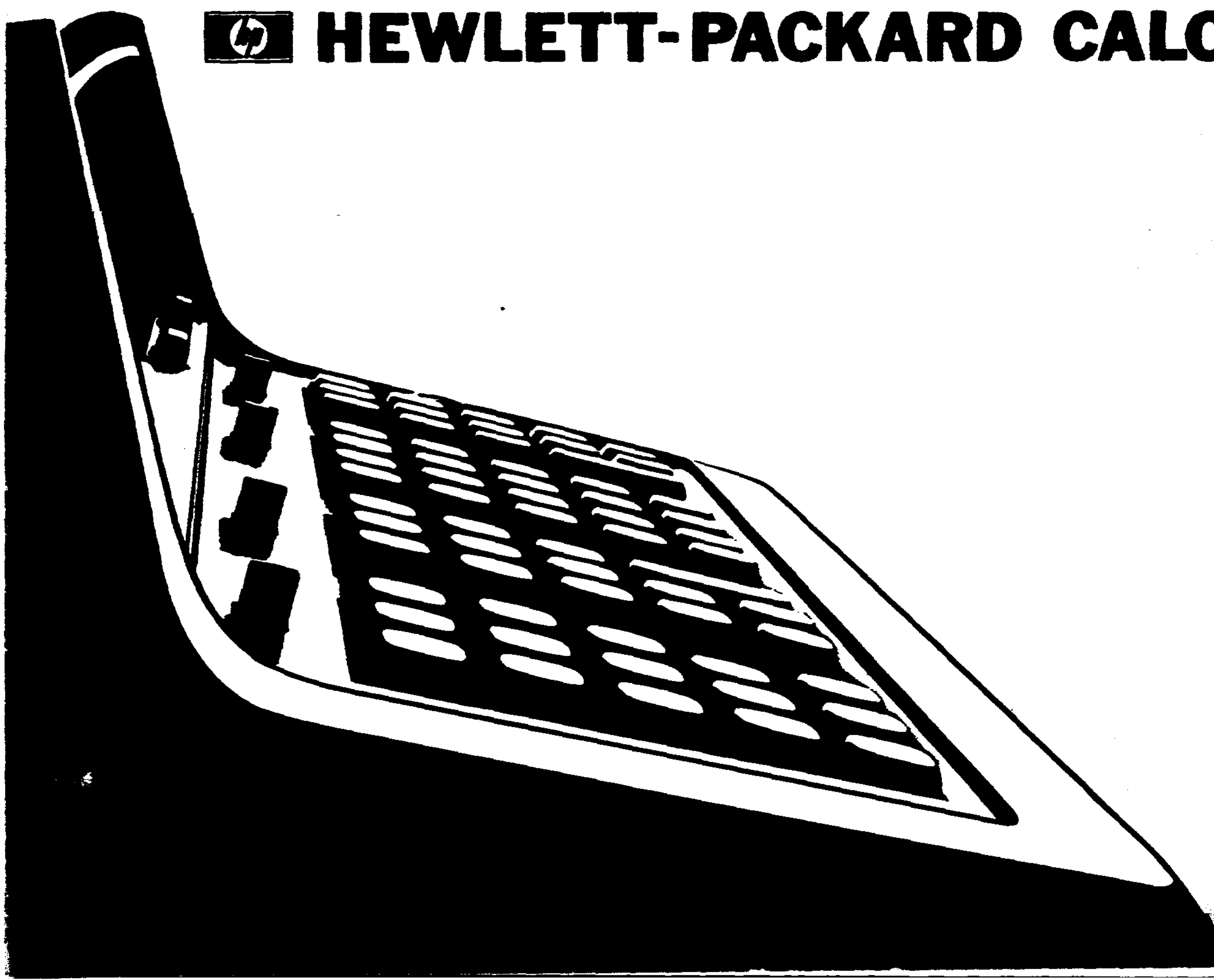
ANIMAL
ECOLOGY

HEWLETT-PACKARD CALCULATOR



HEWLETT PACKARD

INTER-OFFICE CORRESPONDENCE

FROM: Pat Welch

DATE:

TO: CALCULATOR SALESMEN

SUBJECT: Animal Ecology

The enclosed programs are some examples of how Dr. J. D. Weintraub at California State College in Fullerton, California has employed the 9100 in teaching and research in the field of Animal Ecology.

In addition to these examples, Animal Ecologists use general statistics, so, the STAT-PAC should be useful to them.

If you have any inputs regarding other general purpose programs or specific examples of how the 9100 is being used in this field, let us know.

Go get 'em!!!!

Regards,

Pat

PW/bd

ANIMAL ECOLOGY PROGRAM LISTING

1 -- "K" Value of the Negative Binomial-Trial and Error

2 -- Expected Values for Negative Binomial Distribution

3 -- Logistic Versus Exponential Curves for Population Growth

4 -- Species Diversity Index Based on Information Theory

5 -- Expected Number from a Poisson Series

6 -- Mann-Whitney Ranking Statistic

7 -- Population Estimate and Confidence Limits of a Simple Capture - Recapture Index

8 -- Population Estimate and Confidence Limits of Removal Trapping

"K" VALUE OF THE NEGATIVE BINOMIAL-TRIAL AND ERROR

If the distribution of animals or plants in space or time does not fit a Poisson series, then the negative binomial may be compared with the observed data. This program calculates an index of aggregation, k, by a trial and error method.

The equation used in this calculation is:

$$\text{Log}_{10}\left(\frac{N}{N_0}\right) = K\,\text{Log}_{10}\left(\frac{1 + M}{K}\right)$$

N = Total number of sample quadrants
N_0 = Number having 0 items
M = Mean

This is good for means below 10.

EXAMPLE

With 100 quadrants sampled, of which 15 had no animals, and a mean for the entire sample of 4.25 animals per quadrant? What is the K value?

ANSWER: 1.58

Reference: Ecological Methods,
by T. R. E. Southwood, 1961,
Methuen and Company, Ltd.

				X	X	X
	X	X			5	
1.	PRESS: END					
2.	ENTER PROGRAM					
3.	PRESS: CONTINUE			1	0	0
4.	ENTER DATA			M	N_o	N
5.	PRESS: CONTINUE			2	0	0
6,	ENTER estimated K Value			K	0	0
7.	PRESS: CONTINUE			0	$\text{Log}\left(\frac{N}{N_o}\right)$	K
8.	If Z = Y, K is correct					
	If $Z \neq Y$					
9.	PRESS: CONTINUE					
	Reestimate K					
	Return to Step 6					

EXAMPLE

N	100.
N_O	15.
M	4.25
	0.
	0.
Estimated K	1.4
Log $\left(\frac{N}{N_O}\right)$	.80364
K Log $10\left(\frac{1+M}{K}\right)$	.82391
	0.
	0.
	0.
	1.5
	.81610
	.82391
	0.
	0.
	0.
A	1.58
	.82397
	.82391
	0.

ANIMAL ECOLOGY -- 1

00	CLR	20
01	1	01
02	STP	41
03	PNT	45
04	PNT	45
05	XTO	23
06	a	13
07	RDN	31
08	DIV	35
09	DN	25
0a	LOG	75
0b	XTO	23
0c	b	14
0d	CLR	20
10	2	02
11	STP	41
12	PNT	45
13	RDN	31
14	a	13
15	XEY	30
16	1	01
17	+	33
18	DN	25
19	XEY	30
1a	DIV	35
1b	XEY	30
1c	LOG	75
1d	RUP	22
20	X	36
21	b	14
22	RUP	22
23	CLX	37
24	STP	41
25	PNT	45
26	PNT	45
27	CLX	37
28	GTO	44
29	0	00
2a	d	17
2b	END	46

EXPECTED VALUES FOR NEGATIVE BINOMIAL DISTRIBUTION

Knowing the value of 'k' from Program 1, this program calculates expected values of the negative binomial. One application is to find the number of quadrants containing 0, 1, 2 ... n animals in a sampling area.

The equation used in this calculation is:

$$N \cdot f(x_i) = N \left[\frac{\gamma (K + x_i)}{x_i ! \gamma (K)}\right] \cdot \left[\frac{M}{M+K}\right]^{x_i} \cdot \left[\frac{K}{K+M}\right]^{K}$$

N = Number of quadrants
K = Aggregation index
x_i = Number of items per quadrant
γ and T = Constants
M = Mean

EXAMPLE

Given a 'k' value of 1.58, a mean of 4.25, and 100 quadrants sampled, calculate the expected number of quadrants containing 0, 1, 2 ... n number of animals using the negative binomial distribution.

$\gamma K = .891$

$T(K + x_i)$	$x_i!$	x_i
$T(K+0) = .891$	$x_0! = 1$	0
$T(K+1) = 1.408$	$x_1! = 1$	1
$T(K+2) = 3.634$	$x_2! = 2$	2
$T(K+3) = 13.009$	$x_3! = 6$	3
$T(K+4) = 59.581$	$x_4! = 24$	4
$T(K+5) = 332.462$	$x_5! = 120$	5

Answers:

x	values of the negative binomial
0	12.71
1	14.64
2	13.77
3	11.98
4	10.00
5	8.14

X	X	X	X	X	
			5		

1. PRESS: END
2. ENTER PROGRAM
3. PRESS: CONTINUE
4. ENTER DATA
5. PRESS: CONTINUE
6. ENTER DATA
7. PRESS: CONTINUE
8. ENTER DATA
9. PRESS: CONTINUE
10. PRESS: CONTINUE (Recycle to Step 8)

    For new data

    PRESS: END

    PRESS: CONTINUE

1	0	0
M	K	
2	0	0
γ (K)	N	
3	0	0
x_i	$x_i!$	$T(K+x_i)$
x_i	0	$N \cdot f(x_i)$

EXAMPLE

	0.
K	1.58
Mean	4.25
	0.
Quadrants	100.
γK	.891
T(K + 0)	.891
$x_0!$	1.
x_0	0.
Negative Binomial	12.70931
	0.
	0.
T(K +1)	1.408
$x_1!$	1.
x_1	1.
Negative Binomial	14.64088
	0.
	1.
	3.634
	2.
	2.
	13.77336
	0.
	2.
	13.009
	6.
	3.
	11.98114
	0.
	3.

```
00  CLR  20
01   1   01
02  STP  41
03  PNT  45
04  PNT  45
05  AC+  60
06   +   33
07  XEY  30
08  DIV  35
09  XEY  30
0a  LN   65
0b  XTO  23
0c   a   13
0d  RCL  61

10  XEY  30
11   +   33
12  UP   27
13  RUP  22
14  DIV  35
15  RDN  31
16  LN   65
17   X   36
18  XEY  30
19  EXP  74
1a  XTO  23
1b   b   14
1c  CLR  20
1d   2   02

20  STP  41
21  PNT  45
22  PNT  45
23  XTO  23
24   c   16
25  YTO  40
26   d   17
27  CLR  20
28   3   03
29  STP  41
2a  PNT  45
2b  PNT  45
2c  AC+  60
2d   c   16

30   X   36
31  RDN  31
32  DIV  35
33   d   17
34   X   36
35   b   14
36   X   36
37  RUP  22
38   f   15
39  XEY  30
3a   a   13
3b   X   36
3c  XEY  30
3d  EXP  74

40  RUP  22
41   X   36
42  CLX  37
43  RUP  22
44   f   15
45  PNT  45
46  PNT  45
47  GTO  44
48   2   02
49   7   07
4a  END  46
```

LOGISTIC VERSUS EXPONENTIAL CURVES FOR POPULATION GROWTH

Population increase of yeast, protozoa, etc., will not continue indefinitely, but will reach a plateau. The first part of the growth curve may resemble the exponential curve, while the overall growth pattern will be more closely related to the logistic curve. This program calculates both curves, mainly for teaching comparison.

The equations used in these calculations are:

(1) Exponential $N_t = N_0 e^{rt}$

N_t = Population at time t

N_0 = Population at time 0

(2) Logistic $N_t = \dfrac{K}{1 + e^{a-rt}}$

K = Upper limit of population

r = Innate rate of increase

a = Constant of integration defining position of the curve related to the origin

Reference: Laboratory Manual of General Ecology
by George W. Cox

EXAMPLE

Given an innate rate of increase (r) of 1.022 individuals per day, a population ceiling (K) of 450 individuals per .5 ml. and an 'a' value of 5.041, compare the logistics and exponentials curve of population growth that starts with 2 individuals per .5 ml.

ANSWER:

Time (t)	Exponential ($N_0 e^{rt}$)	Logistics $\frac{K}{1 + e^{a-rt}}$
0	2	2.9
1	5.6	7.9
2	15.4	21.4
3	42.9	.54.8
4	119.2	125.2
5	331.3	232.8
6	920.7	336.9
7	2558.4	401.5
8	7109.2	431.2
9	19754.7	443.1
10	54893.3	447.5

X	X	X	X	X	5

1.	PRESS: END			
2.	ENTER PROGRAM			
3.	PRESS: CONTINUE	0	1	0
4.	ENTER DATA	r	N_0	1
5.	PRESS: CONTINUE	0	2	0
6.	ENTER DATA	a	K	2
7.	PRESS: CONTINUE	3	0	0
8.	ENTER: t	t	0	0
9.	PRESS: CONTINUE DISPLAY	t	N_0e^{rt}	$\frac{K}{1+e^{a-rt}}$
10.	PRESS: CONTINUE (return to step 7)			
11.	PRESS: END, CONTINUE for new data set (return to step 3)			

ANIMAL
ECOLOGY
Program 3

EXAMPLE

Data Entry	1.
N_0	2.
R	1.022
Data Entry	2.
K	450.
a	5.041
$\frac{K}{1+e^{a-rt}}$	2.89157
$N_0 e^{rt}$	2.00000
t	0.
	7.94415
	5.55749
	1.
	21.40271
	15.44287
	2.
	54.83378
	42.91181
	3.
	125.22685
	119.24106
	4.
	232.75942
	331.34071
	5.
	336.85649
	920.71190
	6.

00	CLR	20
01	1	01
02	XEY	30
03	STP	41
04	PNT	45
05	PNT	45
06	XTO	23
07	a	13
08	YTO	40
09	b	14
0a	CLR	20
0b	2	02
0c	XEY	30
0d	STP	41
10	PNT	45
11	PNT	45
12	XTO	23
13	c	16
14	YTO	40
15	d	17
16	CLR	20
17	3	03
18	STP	41
19	UP	27
1a	a	13
1b	XEY	30
1c	X	36
1d	XTO	23
20	9	11
21	AC+	60
22	b	14
23	LN	65
24	+	33
25	XEY	30
26	EXP	74
27	XTO	23
28	f	15
29	c	16
2a	XEY	30
2b	e	12
2c	-	34
2d	XEY	30
30	EXP	74
31	UP	27
32	1	01
33	+	33
34	d	17
35	XEY	30
36	DIV	35
37	f	15
38	UP	27
39	YE	24
3a	9	11
3b	XEY	30
3c	PNT	45
3d	PNT	45
40	GTO	44
41	1	01
42	6	06
43	END	46

SPECIES DIVERSITY INDEX
BASED ON INFORMATION THEORY

This program calculates the expected species diversity in a given area. The equation used in this calculation is:

$$H \sim 3.3219 \left[\text{Log}_{10} N - \frac{1}{N} (\Sigma N_i \text{ Log}_{10} N_i) \right]$$

N = Total number of species
N_i = Number of individuals of i^{th} species
H = Species diversity index

EXAMPLE

A collection of invertebrates yielded the following number of individuals:

Species A = 300
Species B = 150
Species C = 10
Species D = 5
Species E = 2
Species F = 1

What is the species diversity?

Answer:

Diversity = 1.1785

Number of individuals = 468

Number of species = 6

Reference: Ecological Methods
by T. R. F. Southwood,
1966, Methuen & Company, Ltd.

				X	X	
	X	X				5
1.	PRESS: END					
2.	ENTER PROGRAM					
3.	PRESS: CONTINUE				0	1
4.	ENTER DATA				N_i	
5.	PRESS: CONTINUE					
6.	PRESS: SET FLAG (after last data point)					
7.	PRESS: CONTINUE				N	i
8.	PRESS: CONTINUE (ready for new data)					
					H	0

i	1.
N_i	300.
	2.
	150.
	3.
	10.
	4.
	5.
	5.
	2.
	6.
	1.
N	468.
i	6.
	0.
H	1.17848

```
00   CLR   20
01   XTO   23
02    d    17
03    1    01
04   XEY   30
05   STP   41
06   IFG   43
07    2    02
08    3    03
09   PNT   45
0a   PNT   45
0b   YTO   40
0c    d    17
0d   UP    27

10   UP    27
11   LOG   75
12    X    36
13   RDN   31
14   AC+   60
15   CLX   37
16   RDN   31
17    d    17
18   UP    27
19    1    01
1a    +    33
1b    0    00
1c   UP    27
1d   RDN   31

20   GTO   44
21    0    00
22    5    05
23    e    12
24   UP    27
25   LOG   75
26   RDN   31
27   XEY   30
28    1    01
29   XEY   30
2a   DIV   35
2b    f    15
2c    X    36
2d   RDN   31

30    -    34
31    3    03
32    .    21
33    3    03
34    2    02
35    1    01
36    9    11
37    X    36
38    e    12
39   RUP   22
3a    d    17
3b   PNT   45
3c   PNT   45
3d   CLX   37

40   RUP   22
41   PNT   45
42   PNT   45
43   END   46
```

EXPECTED NUMBER FROM A POISSON SERIES

This program checks randomness of distribution of individual animals of a class in a sampling area. For ecological work, the Poisson series is used to check this assumption. Calculated values can be compared to measured values using a χ^2 goodness of fit test.

The equation used in this calculation is:

$$f(N; \lambda) = \frac{\lambda^N e^{-\lambda}}{N!}$$

EXAMPLE

If the mean number of beetles in (N) 100 sampling areas is (λ) 5.43, what is the expected areas that have 0, 1, 2 ... x beetles?

(0)	N_i	$f(N_i; \lambda)$	$N(N_i)$
	1	.0238	2.38
	2	.0646	6.46
	3	.1170	11.70
	4	.1588	15.88
	5	.1724	17.24
	6	.1560	15.60
	7	.1210	12.10
	8	.0821	8.22

(0) Example Entry

X X X

X X 5

1.	PRESS: END			
2.	ENTER PROGRAM			
3.	PRESS: CONTINUE	0	0	0
4.	ENTER DATA:	λ(mean)	N_i	N
5.	PRESS: CONTINUE			
	DISPLAY	N_i	$f(N_i;\lambda)$	$N(N_i)$
6.	PRESS: CONTINUE			
	DISPLAY	N_{i+1}	$f(N_{i+1}\lambda)$	$N(N_{i+1})$
	etc.			
7.	To reset, PRESS: END			
	PRESS: CONTINUE (return to step 4)			

EXAMPLE

N	100.
N_i	1.
λ	5.43
$N(N_i)$	2.38002
$f(N_i; \lambda)$	.02380
N_i	1.
	6.46176
	.06462
	2.
	11.69578
	.11696
	3.
	15.87702
	.15877
	4.
	17.24245
	.17242
	5.
	15.60441
	.15604
	6.
	12.10457
	.12105
	7.
	8.21597
	.08216
	8.

```
00  CLR  20
01  STP  41
02  PNT  45
03  PNT  45
04  XTO  23
05   c   16
06  YTO  40
07   b   14
08  RUP  22
09  XTO  23
0a   d   17
0b  XEY  30
0c  CHS  32
0d  EXP  74

10  UP   27
11   c   16
12  LN   65
13  UP   27
14   b   14
15   X   36
16  XEY  30
17  EXP  74
18  RUP  22
19   X   36
1a  YTO  40
1b   a   13
1c   b   14
1d  UP   27

20  UP   27
21   1   01
22   -   34
23  X>Y  53
24   2   02
25   c   16
26  RDN  31
27   X   36
28  RUP  22
29  GTO  44
2a   2   02
2b   2   02
2c   a   13
2d  RUP  22

30  UP   27
31   0   00
32  XEY  30
33  X=Y  50
34  CNT  47
35   1   01
36  XEY  30
37  DN   25
38  DIV  35
39   d   17
3a  XEY  30
3b   X   36
3c  RUP  22
3d   b   14

40  STP  41
41  PNT  45
42  PNT  45
43  CLR  20
44   b   14
45  UP   27
46   1   01
47   +   33
48  YTO  40
49   b   14
4a   c   16
4b  GTO  44
4c   0   00
4d   c   16

50  END  46
```

MANN-WHITNEY RANKING STATISTIC

This program is a significance test for differences in the medians of two samples, x and y. The distribution need not be normal. A rank is given to each x and y item, and the statistics U_1 and U_2 calculated. The values can be compared with the lowest U value in a suitable table to determine significance of the differences between medians.

The equations used in these calculations are:

$$U_1 = N_1N_2 + 1/2\, N_2 (N_2 + 1) - R_2$$

$$U_2 = N_1N_2 + 1/2\, N_1 (N_1 + 1) - R_1$$

$$U_2 = N_1N_2 - U$$

$$R_1 = \text{Sum of ranks of } x$$

$$R_2 = \text{Sum of ranks of } y$$

EXAMPLE

Two species of insects were caught at a blacklight. Species x appeared at 1, 5, 8, 11, 20, 30, 35, and 40 minutes after 6:00 p.m. (each time represents one individual), and species y appeared at 3, 7, 9, 12, 13, 15, 18, and 22 minutes after 6:00 p.m. What is the U statistic?

	x values	1	5	8	11	20	30	35	40
	y values	3	7	9	12	13	15	18	22
Rank	x rank	1	3	5	7	12	14	15	16
	y rank	2	4	6	8	9	10	11	13

Answers:

Ux = 37 Uy = 27 Nx = 8 Ny = 8

Reference: Statistics for Biologists
by R. C. Campbell
1967, Cambridge University Press

	X	X	X X	5	
1.	PRESS: END				
2.	ENTER PROGRAM				
3.	PRESS: CONTINUE		0	1	0
4.	ENTER DATA (Rank of x)		x_i	i	0
5.	PRESS: CONTINUE (Repeat for each x value)				
6.	PRESS: SET FLAG after last data point				
7.	PRESS: CONTINUE		0	1	0
8.	ENTER DATA (Rank of y)		y_i	i	0
9.	PRESS: CONTINUE (Repeat for each y value)				
10.	PRESS: SET FLAG after last entry				
11.	PRESS: CONTINUE		Ux	Uy	0
12.	PRESS: CONTINUE (Return to Step 4)		Nx	Ny	

EXAMPLE

X_i	1.
i	1.
.	2.
.	3.
.	3.
.	5.
.	4.
.	7.
.	5.
.	12.
.	6.
.	14.
.	7.
.	15.
.	8.
.	16.
Y_i	1.
i	2.
.	2.
.	4.
.	3.
.	6.
.	4.
.	8.
.	5.
.	9.
.	6.
.	10.
.	7.
.	11.
.	8.
.	13.
U_x	37.0
U_y	27.0
N_x	8.
N_y	8.

00	CLR	20
01	XTO	23
02	d	17
03	1	01
04	XEY	30
05	STP	41
06	IFG	43
07	1	01
08	b	14
09	PNT	45
0a	PNT	45
0b	YTO	40
0c	d	17
0d	XEY	30
10	CLX	37
11	XEY	30
12	AC+	60
13	d	17
14	UP	27
15	1	01
16	+	33
17	CLX	37
18	GTO	44
19	0	00
1a	5	05
1b	f	15
1c	XTO	23
1d	c	16
20	CLR	20
21	1	01
22	XEY	30
23	STP	41
24	IFG	43
25	3	03
26	9	11
27	PNT	45
28	PNT	45
29	YTO	40
2a	b	14
2b	XEY	30
2c	CLX	37
2d	XEY	30
30	AC+	60
31	b	14
32	UP	27
33	1	01
34	+	33
35	CLX	37
36	GTO	44
37	2	02
38	3	03
39	b	14
3a	UP	27
3b	d	17
3c	X	36
3d	CLX	37
40	AC+	60
41	f	15
42	-	34
43	RUP	22
44	b	14
45	XEY	30
46	1	01
47	+	33
48	b	14
49	X	36
4a	.	21
4b	5	05
4c	X	36
4d	RDN	31
50	+	33
51	XEY	30
52	YE	24
53	e	12
54	-	34
55	XEY	30
56	UP	27
57	CLX	37
58	RDN	31
59	PNT	45
5a	PNT	45
5b	d	17
5c	XEY	30
5d	b	14
60	PNT	45
61	PNT	45
62	END	46

POPULATION ESTIMATE AND CONFIDENCE LIMITS OF A SIMPLE CAPTURE - RECAPTURE INDEX

This program calculates the simple Lincoln Index estimate of population, with input data supplied by capture-recapture procedures. It also calculates limits of the estimate for a 95% confidence level.

The equations used in these calculations are:

$$\text{Population estimate} = \frac{a\,n}{r}$$

$$\text{Standard error} = \frac{\left[\frac{a^2\, n(n-r)}{r^3}\right]^{1/2}}{r^3}$$

a = number marked initially

n = number captured on 2nd occasion

r = number of marked animals recaptured

EXAMPLE

335 animals are marked and released on day 1. 150 are recaptured on day 2, of which 30 are marked. What is the estimated population on day 1 ?

Answer:

Population Estimate = 1675

95% Confident Limits = 1139 - 2211

Reference: Ecological Methods
by T. R. E. Southwood, 1966,
Methuen and Company, Ltd.

ANIMAL
ECOLOGY
Program 7

X X X

X X 5

1. PRESS: END
2. ENTER PROGRAM
3. PRESS: CONTINUE
4. ENTER DATA
5. PRESS: CONTINUE
6. PRESS: CONTINUE for new set of data, return to Step 4.

1 0 0

r n a

$\frac{an}{r}$ $\frac{an}{r}-1.96\sqrt{\frac{an}{r}}$ $+1.96\sqrt{\ }$

EXAMPLE

	Data	
	a	335.
	n	150.
	r	30.
Answer:	Upper Limit	2211.11166
	Lower Limit	1138.88834
	Probable Error	1675.00000

00	CLR	20
01	1	01
02	STP	41
03	PNT	45
04	AC+	60
05	RDN	31
06	YTO	40
07	a	13
08	X	36
09	f	15
0a	DIV	35
0b	YTO	40
0c	b	14
0d	a	13
10	UP	27
11	X	36
12	e	12
13	X	36
14	RUP	22
15	f	15
16	-	34
17	RDN	31
18	X	36
19	DN	25
1a	RDN	31
1b	X	36
1c	X	36
1d	RDN	31
20	DIV	35
21	RDN	31
22	$\sqrt{}$	76
23	UP	27
24	1	01
25	.	21
26	9	11
27	6	06
28	X	36
29	RDN	31
2a	UP	27
2b	RUP	22
2c	b	14
2d	+	33
30	RUP	22
31	-	34
32	b	14
33	PNT	45
34	PNT	45
35	END	46

POPULATION ESTIMATE AND CONFIDENCE LIMITS OF REMOVAL TRAPPING

Animals are trapped and removed on a series of occasions, and it is expected that the number caught on subsequent occasions, (and it is expected that the number caught on subsequent occasions) will diminish in a predictable manner. This program uses data from this procedure to predict initial total population and limits for a 95% confidence level.

The equations used in these calculations are:

(1)

$$T = n_1 + n_2 + \ldots n = \sum_{1}^{n} n_i$$

T = total catch
n_i = number caught on i^{th} occasion

(2)

$$\sum_{i=1}^{k} (i - 1) y_i = (1 - 1)n_1 + (2 - 1)n_2 + \ldots + (k_i - 1)n_i$$

k = number of occasions
y_i = the catch on the i^{th} occasion

(3)

$$R = \frac{\sum_{i=1}^{k} (i - 1) y_i}{T}$$

(4)

$$R = \frac{q}{p} - \frac{kq^k}{(1 - q^k)}$$

p = probability of capture on a single occasion
q = 1 - p

(5)

$$P = \frac{T}{(1 - q^k)}$$

P = total population

(6)

$$\text{S.E. of } P = \sqrt{\frac{P(P - T)\,T}{T^2 - P(P - T)\,[(kp^2)/(1 - p)]}}$$

S.E. = standard error of population

EXAMPLE

In a laboratory experiment, 2,000 beetles were placed in a wheat medium and a removal trapping method was started. At ten minute intervals, for fifty minutes, beetles were removed from the wheat. The number of beetles removed in order of time were:

322, 241, 250, 214, 142

How many beetles were there initially in the box, calculated by the removal method?

q = .8457 (calculated by trial and error)
Estimated population: 2,060
Confidence limits (95%) 1727 to 2394

Reference: Ecological Methods by T.R.E. Southwood, 1966 Methuen and Company Ltd.

		X	X	X		
					5	
1.	PRESS: END					
2.	ENTER PROGRAM					
3.	PRESS: CONTINUE			1	0	0
4.	ENTER DATA			N_i		
5.	PRESS: CONTINUE (Return to step 4.)					
6.	PRESS: SET FLAG (after last data point)					
7.	PRESS: CONTINUE					
	DISPLAY			2	0	0
8.	PRESS: Y, Z on printer					
9.	ENTER DATA (estimate of less than 1)					
10.	PRESS: CONTINUE					
	DISPLAY			0	R data	R q est
11.	If $y \neq z$, PRESS: CONTINUE and re-estimate q					
12.	If $y = z$, PRESS: SET FLAG					
13.	PRESS: CONTINUE					
	DISPLAY			0	0	P est
14.	PRESS: END					
15.	ENTER PROGRAM B					
16.	PRESS: CONTINUE					
	DISPLAY			P est	P-1.96SE	P+1.96SE

EXAMPLE

Input Data	322.
	241.
	250.
	214.
	142.
(i + 1)	5.
	0.
	0.
q_{est}	.8457
R_{data}	1.66883
R_{calc}	1.66895
	0.
P_{est}	2060.25735
	0.
	0.
95% Confidence Limits	2393.60034
	1726.91437
P_{est}	2060.25735

00	CLR	20
01	1	01
02	XTO	23
03	d	17
04	STP	41
05	PNT	45
06	IFG	43
07	2	02
08	4	04
09	AC+	60
0a	RDN	31
0b	d	17
0c	XEY	30
0d	1	01
10	-	34
11	RDN	31
12	X	36
13	CLX	37
14	AC+	60
15	CLX	37
16	RDN	31
17	d	17
18	XEY	30
19	1	01
1a	+	33
1b	YTO	40
1c	d	17
1d	CLX	37
20	XEY	30
21	GTO	44
22	0	00
23	4	04
24	d	17
25	UP	27
26	1	01
27	-	34
28	YTO	40
29	d	17
2a	RCL	61
2b	DIV	35
2c	XTO	23
2d	a	13
30	YTO	40
31	b	14
32	CLR	20
33	2	02
34	STP	41
35	PNT	45
36	PNT	45
37	AC+	60
38	LN	65
39	UP	27
3a	d	17
3b	X	36
3c	XEY	30
3d	UP	27
40	RUP	22
41	LN	65
42	+	33
43	RDN	31
44	EXP	74
45	XEY	30
46	EXP	74
47	UP	27
48	1	01
49	XEY	30
4a	-	34
4b	YTO	40
4c	c	16
4d	RDN	31
50	DIV	35
51	RUP	22
52	1	01
53	XEY	30
54	f	15
55	-	34
56	f	15
57	XEY	30
58	DIV	35
59	RDN	31
5a	XEY	30
5b	-	34
5c	b	14
5d	UP	27
60	CLX	37
61	STP	41
62	PNT	45
63	PNT	45
64	IFG	43
65	6	06
66	b	14
67	CLR	20
68	GTO	44
69	3	03
6a	4	04
6b	a	13
6c	UP	27
6d	c	16
70	DIV	35
71	CLX	37
72	UP	27
73	PNT	45
74	PNT	45
75	END	46

00	RDN	31
01	AC+	60
02	a	13
03	-	34
04	X	36
05	e	12
06	X	36
07	YTO	40
08	b	14
09	1	01
0a	UP	27
0b	f	15
0c	-	34
0d	d	17
10	X	36
11	RDN	31
12	UP	27
13	X	36
14	f	15
15	DIV	35
16	RUP	22
17	XEY	30
18	a	13
19	DIV	35
1a	RDN	31
1b	X	36
1c	DN	25
1d	RDN	31
20	X	36
21	RDN	31
22	XEY	30
23	-	34
24	b	14
25	XEY	30
26	DIV	35
27	RDN	31
28	√	76
29	UP	27
2a	1	01
2b	.	21
2c	9	11
2d	6	06
30	X	36
31	RUP	22
32	DN	25
33	e	12
34	+	33
35	RUP	22
36	-	34
37	e	12
38	PNT	45
39	END	46