INFLUENCE OF TEMPERATURE ON ADULT BIOLOGY AND POPULATION GROWTH OF *BRACON KIRKPATRICKI* (WILKINSON)

by

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STATEMENT BY AUTHOR

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BIOGRAPHICAL SKETCH

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In June of 1971, he accepted an appointment of graduate assistant in research with the Department of Entomology, The University of Arizona, in Tucson, Arizona. He received a Master of Science degree in Entomology in 1974.

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ABSTRACT

The influence of temperature on adults of *Bracon kirkpatricki* (Wilk.), a braconid parasite of the pink bollworm, was studied in order to quantify potential population growth responses. The parasite was studied at constant temperatures of 20, 25, 30, 32.5, and 35°C, and under truncated day-night temperature models of 33-14, 36-20, and 36-28°C. Data were collected on daily fecundity and survival of individual adult females for each regime, and additional data were collected on developmental time, survival, and sex ratio of the immature stages for the day-night regimes. Data on the immature stages were already available for the constant temperatures. The combined data on the immature and adult stages of *B. kirkpatricki* were used to construct life tables for the calculation of several population growth statistics: the intrinsic rate of natural increase (r_m), net reproductive rate (R_o), mean generation time (T), finite rate of natural increase (λ), and stable age distribution.

Rising temperatures generally caused the rate of population growth, as indicated by r_m, to rise. Increased values of r_m resulted mainly from the influence of rising temperature in shortening developmental periods and increasing daily fecundity during the initial period of adult longevity. The largest increases in r_m occurred between 20 and 25°C in the constant temperature regimes and between nocturnal temperatures of 20 and 28°C in the day-night regimes. Above 25°C, r_m continued to rise to a peak value at 32.5°C followed by a slight decline at 35°C.

INTRODUCTION

The pink bollworm (Pectinophora gossypiella [Saunders]) is one of the most important pests of cotton in the southwestern United States. Yield losses and control costs for this pest on western irrigated cotton have been estimated as high as $15 million per year. Intensive use of insecticide for pink bollworm control has also intensified other insect pest problems. Development of non-chemical means for controlling the pink bollworm has thus become increasingly important (Bryan et al., 1973a).

Bracon kirkpatricki (Wilkinson) has been known as an effective parasite[1] of the pink bollworm since its discovery (Kirkpatrick, 1927) in Kenya, Africa. Investigations into the use of this parasite for control of pink bollworm in Arizona were initiated in 1968 by the Cotton Insects Biological Control Investigations Laboratory (Entomology Res. Div., A.R.S., U.S.D.A., Tucson, Arizona) (Bryan et al., 1971). The parasite lacks the ability to over-winter in Arizona; however, U.S.D.A. researchers feel that it can still exert a significant effect on pink bollworm populations through a program of periodic field releases. The major

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[1] The term "parasite" used in this thesis is synonymous with the term "parasitoid" preferred by some authors.

emphasis of investigations to date have been on frequent inundative releases but there is some doubt concerning the economic feasibility of this approach when used on a large scale. It is thought that inoculative releases might be more practical. Planning for research on inoculative releases and other field programs has been hindered by a lack of data on the potential population growth responses of the parasite under various temperature conditions. Although the effects of several temperatures on the development and survival of the immature stages has been worked out (Bryan et al., 1971), data on the effects of temperature on adult longevity and fecundity have been lacking. The present study was therefore undertaken to provide specific quantitative data on the influence of several temperature regimes on population growth of B. kirkpatricki as determined by fecundity and longevity.

LITERATURE REVIEW

Distribution

Bracon kirkpatricki (Wilkinson) was first described by Wilkinson (1927) and was reported as a parasite of the pink bollworm in Kenya and Tanzania by T. W. Kirkpatrick (1927). It is widespread in the tropical regions of Africa, having been reported from the Sudan (King, 1929), Somaliland (Chiaromonte, 1930), Uganda (Hargreaves, 1932), the Ivory Coast (Delattre, 1947), Malawi, Angola, and Senegal (Cross, McGovern, and Mitchell, 1969). *B. kirkpatricki* relegates the pink bollworm to the status of a minor pest of cotton in the coastal regions of East Africa (Anderson, 1928) but was reported to be much less effective in suppressing the pest in interior regions such as Uganda (Taylor, 1936).

Kirkpatrick (1927) suggested the importation of *B. kirkpatricki* into other cotton growing regions but mentioned an apparent lack of cold tolerance and inability to enter diapause which might prevent establishment of the species in areas having a definite winter season. The parasite was sent to Egypt (Anderson, 1928), Barbados (Bedford, 1930), and the United States (Noble and Hunt, 1937). The parasites sent to the United States were propagated in Presidio, Texas, and released in the Presidio area (Noble and Hunt, 1937), northern Mexico (Rude, 1937), Mississippi (Cross et al., 1969), and Puerto Rico (McGough and Noble, 1955). In all cases to date, lack of winter hardiness has prevented B. kirkpatricki from establishing new populations outside of its indigenous range.

Description

Adults of B. kirkpatricki are relatively small wasps (2-6 mm long) of the family Braconidae. The female is generally larger, with a conspicuous ovipositor. Both sexes have red-gold heads and thoraces, with slightly darker antennae and black eyes. The abdomen has a red-gold dorsum with a dirty white sternum. A complete description is given in Wilkinson (1927).

A comprehensive description of the immature stages of B. kirkpatricki is given by Azab, Tawfik, and Nagui (1968). The eggs are elongated, white, and smooth, tapering toward one end with a slight curvature. The eggs average 0.87 mm in length and 0.19 mm in width. There are four larval instars differing in size, number and placement of setae, and size and shape of mandibular teeth. The first instar larva is nearly transparent with later instars taking on the color of the host. The pupa develops within a white silken coccoon spun by the last instar larva. The newly formed pupa is white but gradually darkens to the general color of the adult.

Biology

The adult female parasite is attracted to the host by its movement or possibly by some chemical substance. The host must be separated from the parasite by some physical barrier since the parasite will not attack an exposed larva; it is then stung and paralyzed (C. G. Jackson, 1971). *B. kirkpatricki* can easily penetrate a bloom petal or the calyx of a cotton square but is unable to penetrate the boll (Bryan et al., 1971). Parasitization of pink bollworm larvae within bolls and seeds was reported by Kirkpatrick (1927) but it was believed the parasite used an exterior opening created by the host larva. Once the host is paralyzed, the female deposits one or more eggs on or near it (C. G. Jackson, 1971).

The gregarious larvae feed externally through lacerations made with their mandibles. The fourth instar larva completes its feeding and spins a coccoon between two closely adjacent surfaces where it then discharges the meconium and pupates. The adults emerge by chewing through the coccoon and one of the adjacent surfaces. Mating occurs soon after emergence with oviposition commencing several days later (C. G. Jackson, 1971).

Studies on the time required for development of *B. kirkpatricki* at several constant temperatures were reported by Bryan et al. (1971). Development time ranged from 22.4 days at 20°C to 7.9 days at 35°C on the pink bollworm with slightly shorter developmental periods resulting when reared on the beet armyworm.

Rearing

B. kirkpatricki was first reared in the laboratory by Kirkpatrick (1927), using field collected pink bollworms as hosts. Noble and Hunt (1942) reared the parasite year round by using the Mediterranean flour moth, *Anagasta kuehniella* (Zeller), as the host when pink bollworms were not available. The boll weevil, *Anthonomus grandis* Boheman, was found to be a suitable host by Cross et al. (1969). Bryan, Jackson, and Stoner (1969) found the beet armyworm, *Spodoptera exigua* (Hubner), to be an excellent host as well as being more economical than the pink bollworm in a large mass rearing program.

Current Field Release Programs

Research on field releases of *B. kirkpatricki* for control of the boll weevil has been in progress in Mississippi since 1966 (Cross et al., 1969). Variable results on the parasitization of boll weevil larvae in this program have been atrributed to factors such as the dissociation of laboratory reared parasites from cotton plants and incomplete knowledge of optimum parameters for scheduling releases. However, as of 1969, researchers were confident that these problems could be overcome and the program has been continued

Studies on the use of B. kirkpatricki for control of the pink bollworm in Arizona were initiated in 1968 (Bryan et al., 1971). Over-wintering studies have indicated little probability of the parasite becoming established in Arizona (C. G. Jackson, 1971); although efficient mass rearing techniques have made large numbers of parasites available for testing of inundative releases. Bryan et al. (1971, 1973a, 1973b) have found B. kirkpatricki to be most efficient during early to mid-season when the pink bollworm population is concentrated in the squares and blooms of the cotton plant. Testing of early-season inoculative releases is planned for the 1974 season (C. G. Jackson, 1974).

The primary objective of the present study is to provide specific data on the potential population growth responses of B. kirkpatricki over a probable range of temperatures to aid in the planning and evaluation of field release programs of this parasite in Arizona and elsewhere.

METHODS AND MATERIALS

Host Rearing

The beet armyworm, Spodoptera exigua (Hubner), was used as the host species for B. kirkpatricki in this study. This host culture was maintained using the rearing technique reported by Patana (1969). Larvae were reared in 16-oz cups filled approximately one-third with lima bean-agar diet (Shorey, 1963). Pupae were surface sterilized by washing with 0.3% sodium hypochlorite solution followed by 10% sodium thiosulfate solution and distilled water rinses to remove any chlorine residues. Adults were kept in gallon jars provided with strips of white paper towel for oviposition. The moths were fed 10% sucrose solution through a procaine tube inserted through the cover of the jar. Eggs were collected daily and surface sterilized in the same manner as the pupae. The larvae were secured within the larval rearing cups by taping sections of paper towel with attached egg masses to the inner surface of cardboard lids and then placing the lids onto the cups. Up to 100 larvae were introduced into each cup in this manner. The beet armyworm culture was maintained at ambient laboratory temperature (70-75°F).

Parasite Rearing

B. kirkpatricki was reared by the technique of Bryan et al. (1969) using S. exigua as host. Ideally, the main target species, P. gossypiella, should have been used as the host for this study, but the requirement for large numbers of host individuals made the easily reared beet armyworm a more practical choice.

Cages for the adult parasites were made from plastic petri dishes as described by Bryan et al. (1969). The inverted lower portion of the petri dish was dipped in ethyl acetate to soften the plastic and then pressed onto nylon organdy so that the fabric bonded to the dish as the plastic re-hardened. A small hole in the top of the cage provided an opening for introduction of the wasps and for insertion of a feeder vial consisting of a 1/2-dram vial equipped with a cellulose sponge wick (Stoner and Bryan, 1970). The feeder vial was used to present 10% sucrose solution to the wasps. Host larvae were exposed for parasitization by placing them within the inverted petri dish lid (separated from the lid by a paper towel), covering them with a layer of cheesecloth, and then fitting the cage into the lid such that the host was held firmly against the organdy cage bottom (Figure 1). The organdy cage bottom and the layer of cheesecloth provided the barrier needed for the parasite to attack the host.

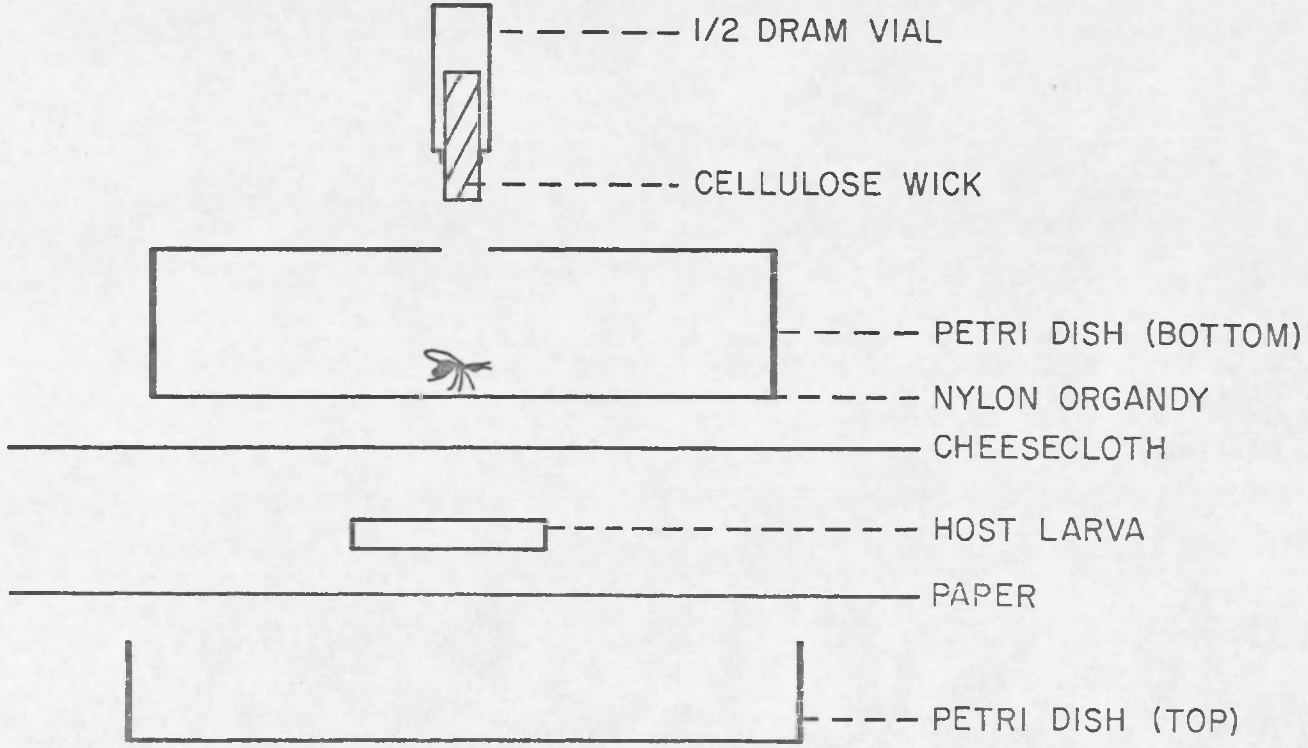

Figure 1. Apparatus used in presentation of host larvae for parasitization by *B. kirkpatricki*.

For general rearing, large numbers of the parasite were held in 140 mm diameter petri dish cages. Approximately 30 late-instar beet armyworm larvae at a time were exposed under a parasite cage for one hour. Parasitized larvae were retained between paper towel and cheesecloth and held at 30°C in 1-gallon ice cream cartons fitted with trap jars. Screen cones fitted on the lip of each trap jar provided a simple means of collecting and retaining the emerging parasite adults. The wasps moved readily into the jars due to negative geotaxic and positive phototaxic responses.

Temperature Studies

Fecundity and longevity of *B. kirkpatricki* were studied under five constant temperature regimes and three fluctuating day-night temperature regimes. Constant temperature levels of 20, 25, 30, 32.5, and 35°C were chosen to provide continuity with previous work in which the influence of these temperatures on immature development was studied (Bryan et al., 1971). The fluctuating temperature conditions consisted of 33-14, 36-20, and 36-28°C regimes with 12-12, 13-11, and 14-10 hr. (day-night) light regimes, respectively. The alternating temperatures operated in a truncated pattern with the lower temperature of each regime occurring during the dark phase. The truncated regimes were patterned after temperature models reported by Philipp and

Watson (1971) for low, medium, and high temperature periods of the growing season in central Arizona.

All temperature regimes were maintained in temperature cabinets consisting of refrigerators equipped with heating coils, with the exception of the 20°C regime which was maintained in an Environator®. Each cabinet was provided with a fan blowing across a pan of water to maintain high humidity. Conditions maintained for the eight temperature regimes are summarized in Table 1.

Newly emerged B. kirkpatricki females were isolated in 90 mm diameter petri-dish cages to collect data on individual fecundity and longevity. One or two males were introduced into each cage to insure mating. The number of females observed under each regime is indicated in Table 1. One late-instar beet armyworm larva was exposed under each cage for 24 hr. Following exposure, it was noted whether the host had been stung (paralyzed) and the number of parasite eggs was counted. These data were collected throughout the "functional" longevity of each female. Functional longevity was considered to be the last day on which the parasite paralyzed its host. This functional longevity was used rather than actual longevity (determined by death of parasite) since that period prior to death in which the parasite exerted no influence on the host was considered to be of no significance in terms of the organism's role as a biological control agent.

Table 1. Summary of environmental conditions and sample sizes for experimental temperature regimes.

Temperature Regime		Mean Temperature[a] (°C)	Mean Relative[a] Humidity (%)	Photoperiod (hr)	Sample Size
20		19.8 ± 0.7	64.4 ± 3.6	11	25
25		25.1 ± 0.6	72.4 ± 24.7	13	26
30		29.8 ± 0.8	67.4 ± 14.0	15	26
32.5		32.6 ± 0.8	54.5 ± 14.0	15	30
35		35.0 ± 2.7	37.9 ± 5.0	15	27
33-14	Day	32.7 ± 1.4	58.1 ± 14.6	12	15
	Night	14.3 ± 1.3	73.7 ± 12.7		
36-20	Day	36.2 ± 1.4	51.0 ± 11.7	13	16
	Night	19.9 ± 1.4	67.0 ± 14.4		
36-28	Day	36.3 ± 0.9	64.1 ± 14.9	14	16
	Night	27.6 ± 0.6	93.0 ± 6.8		

[a] ± standard deviation.

Additional data were collected for each of the day-night regimes to determine immature survival, sex ratio, and developmental period. For several days the parasite eggs and paralyzed hosts from each of the test groups were transferred to petri dishes and held under the same conditions as the parents. The petri dishes were inspected daily for adult emergence and the number of adults of each sex and date of emergence were recorded. Comparable data for the constant temperature regimes were available from Bryan et al. (1971).

Statistical Analysis

The mean and standard deviation were calculated for pre-oviposition, longevity, and fecundity, for each temperature regime. These data were grouped within each data category according to constant or day-night regimes, and subjected to one-way analysis of variance. Groups yielding significant results were further analyzed by the Least Significant Difference (LSD) technique. All analyses were performed using the 95% confidence level as the standard. Calculations were made according to procedures described by Steel and Torrie (1960).

Data on the responses of immature and adult *B. kirkpatricki* to the various temperature conditions were organized into life tables (Appendices C through M) and used to calculate population growth statistics for each experimental regime. Population growth statistics were calculated by means of a computer program composed by B. D. Frazer (1973) and modified for use on the CDC-6400 system by C. E. Mason (1973) (Appendix B). Statistical values calculated by this program included the intrinsic rate of natural increase (r_m), net reproductive rate (R_o), mean generation time (T), finite rate of natural increase (λ), and stable age distribution.

The intrinsic rate of natural increase (r_m) is the instantaneous growth coefficient of a population with stable age distribution growing in an unlimited environment. The statistic "r_m" is calculated by the equation:

$$\Sigma\, e^{-r_m x}\, l_x m_x = 1$$

in which x equals the pivotal age group, l_x equals the probability of survival to age x, and m_x equals the number of female offspring produced per age x (see Appendix A for further explanation of terms).

The net reproductive rate (R_o) is the factor by which a population will multiply per generation and is calculated by the equation:

$$R_o = \Sigma\, l_x m_x.$$

The mean generation time (T) indicates the mean time from birth of parents to birth of offspring and is calculated by the equation:

$$T = \frac{\log_e R_o}{r_m} .$$

The finite rate of natural increase (λ) is the multiplication factor per female per unit time and is calculated by the equation:

$$\lambda = e^{r_m} .$$

The stable age distribution is that age distribution which would be approached by a population with stable birth and death rates growing in an unlimited environment.

Detailed descriptions and discussions of these population statistics are provided by Southwood (1971), Watson (1964), Andrewartha and Birch (1954), and Birch (1948).

RESULTS

Longevity

Figure 2 presents survivorship curves for the five constant temperature regimes. Mean longevities and ranges for the constant temperature regimes are summarized in Table 2. Mean longevity ranged from 60.5 ± 25.2 days at 20°C to 33.2 ± 11.3 days at 35°C. Longevity decreased significantly between 20 and 25°C, and also between 25 and 30°C. No significant decreases were seen between 30, 32.5, and 35°C.

Figure 3 presents the survivorship curves for the three day-night temperature models. Mean longevities and ranges for the day-night models are summarized in Table 3. Longevity varied from 61.1 ± 17.7 days at 33-14°C to 35.0 ± 8.1 days at 36-28°C. Longevity decreased steadily with increasing temperature but was not significantly different between 33-14 and 36-20°C. The reduction in longevity was significant between 36-20 and 36-28°C.

Pre-Oviposition

Pre-oviposition data for the constant temperature regimes are summarized in Table 4. Mean pre-oviposition periods varied from 6.9 ± 3.0 days at 20°C to 2.5 ± 1.1 days at 35°C. A significant reduction in the pre-oviposition period occurred between 20 and 25°C. No significant

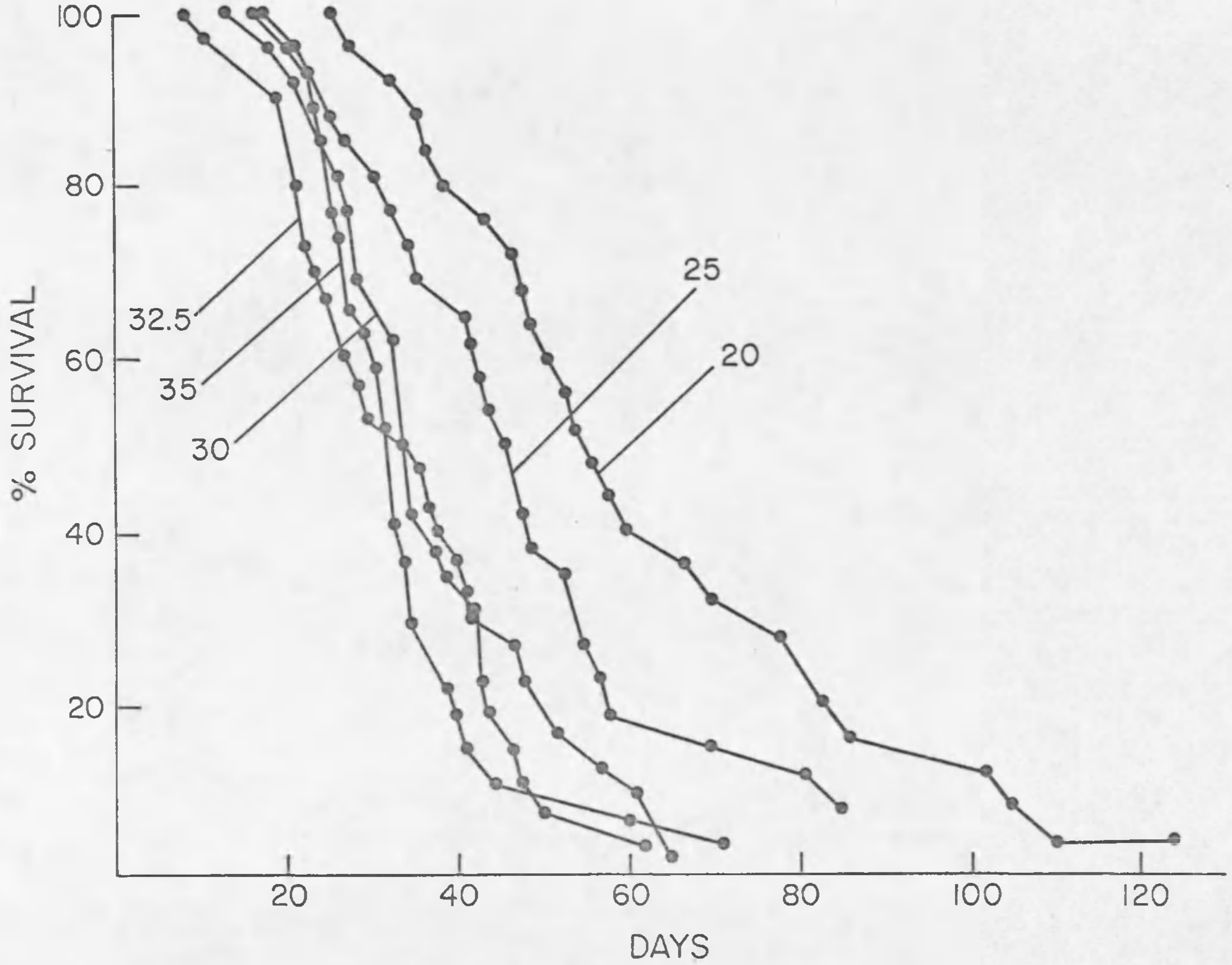

Figure 2. Survival of adult female _B_. _kirkpatricki_ at several constant temperatures.

Table 2. Mean longevity of *B. kirkpatricki* at five constant temperature regimes.

Temperature Regime	Mean Longevity (Days)[a]	Range (Days)	LSD ($\alpha = 0.05$)[b]
20	60.5 ± 25.2	26-124	A
25	47.6 ± 20.9	18-110	B
30	34.5 ± 10.9	14-62	C
32.5	34.2 ± 15.6	9-65	C
35	33.2 ± 11.3	17-71	C

[a] ± standard deviation.

[b] Significant difference indicated by one-way analysis of variance ($\alpha = 0.05$).

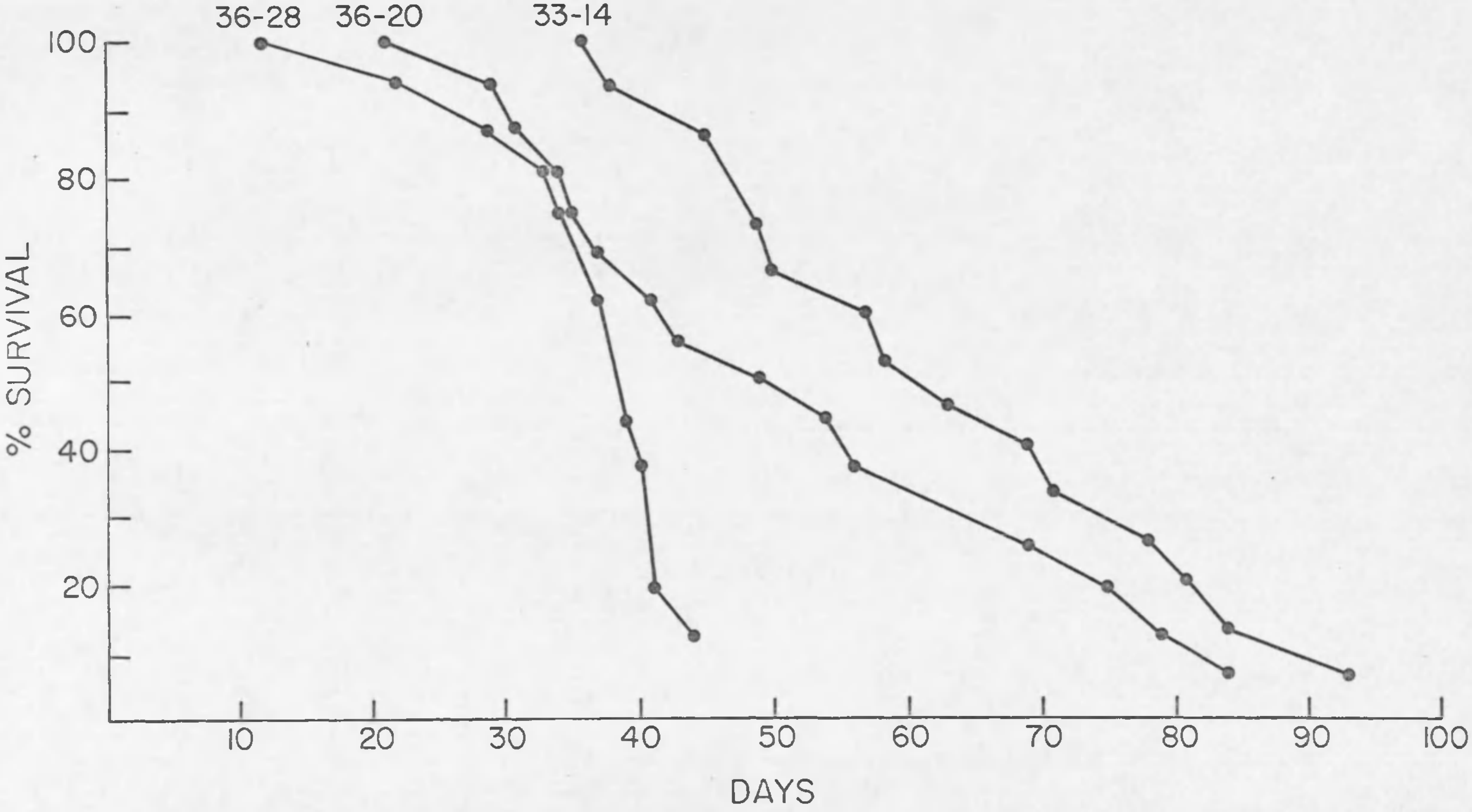

Figure 3. Survival of adult female B. kirkpatricki under three day-night temperature models.

Table 3. Mean longevity of *B. kirkpatricki* for three day-night temperature regimes.

Temperature Regime	Mean Longevity (Days)[a]	Range (Days)	LSD ($\alpha = 0.05$)[b]	
33-14	61.1 ± 17.7	36-73	A	
36-20	49.6 ± 19.1	21-84	A	
36-28	35.0 ± 8.1	12-44		B

[a] ± standard deviation.

[b] Significant difference indicated by one-way analysis of variance ($\alpha = 0.05$).

Table 4. Mean pre-oviposition periods of *B. kirkpatricki* at five constant temperature regimes.

Temperature Regime	Mean Pre-oviposition (Days)[a]	Range (Days)	LSD ($\alpha = 0.05$)[b]	
20	6.9 ± 3.0	2-15	A	
25	3.5 ± 1.1	2-6		B
30	2.8 ± 1.1	1-5		B
32.5	2.5 ± 0.9	1-6		B
35	2.5 ± 1.1	1-5		B

[a] ± standard deviation.

[b] Significant difference indicated by one-way analysis of variance ($\alpha = 0.05$).

differences were seen between the 25, 30, 32.5, and 35°C regimes, but a trend of reduced pre-oviposition time was seen along this range.

A summary of the pre-oviposition data for the day-night models appears in Table 5. Pre-oviposition ranged from 4.1 ± 2.0 days at 36-20°C to 2.4 ± 1.7 days at 36-28°C. Pre-oviposition time was nearly equal for the 33-14 and 36-20°C regimes, followed by a significant reduction for the 36-28°C regime.

Table 5. Mean pre-oviposition periods of *B. kirkpatricki* for three day-night temperature regimes.

Temperature Regime	Mean Pre-oviposition (Days)[a]	Range (Days)	LSD ($\alpha = 0.05$)[b]	
33-14	4.0 ± 1.3	1-6	A	
36-20	4.1 ± 2.0	1-9	A	
36-28	2.4 ± 1.7	1-7		B

[a] ± standard deviation.

[b] Significant difference indicated by one-way analysis of variance ($\alpha = 0.05$).

Fecundity

Data on mean fecundity under constant temperature conditions are summarized in Table 6. Mean fecundity varied from 182.9 ± 139.0 at 25°C to 87.3 ± 62.1 at 20°C; within a pattern of decreasing fecundity from 25°C through 30, 32.5, and 35°C, followed by the minimum level at 20°C. Significant differences within this pattern are indicated in Table 6.

Table 6. Mean fecundity of *B. kirkpatricki* at five constant temperature regimes.

Temperature Regime	Mean Fecundity[a]	Range	LSD (α = 0.05)[b]		
20	87.3 ± 62.1	22-235	A		
25	182.9 ± 139.0	30-589			C
30	161.8 ± 80.1	33-272			C
32.5	143.1 ± 55.1	38-240		B	
35	110.3 ± 42.8	34-198	A	B	

[a] ± standard deviation.

[b] Significant difference indicated by one-way analysis of variance (α = 0.05).

Mean fecundity figures for the day-night models are summarized in Table 7. Fecundity ranged from 102.2 ± 62.1 at 36-20°C to 89.6 ± 58.1 at 36-28°C. Analysis of variance indicated no significant differences among these data.

Table 7. Mean fecundity of B. kirkpatricki for three day-night temperature regimes.[a]

Temperature Regime	Mean Fecundity[b]	Range
33-14	100.6 ± 42.8	50-174
36-20	102.2 ± 62.1	11-243
36-28	89.6 ± 58.1	6-220

[a] No significant difference indicated by one-way analysis of variance ($\alpha = 0.05$).

[b] ± standard deviation.

Population Growth

Data on adult fecundity and longevity were combined with data on immature development, immature mortality, and sex ratio of emerging adults, to construct life tables for the various sets of experimental conditions (Appendices C through M). Data on the immature stages of B. kirkpatricki reared under the three day-night models were generated and are summarized in Table 8. Similar data were available for the constant temperatures (Table 9). A summary of the population growth statistics calculated from these life table data for the various temperature conditions is presented in Table 10.

Population growth, as indicated by r_m (Table 10), increases with temperature up to a peak at 32.5°C followed by a slight decrease at 35°C. The largest increase in r_m occurs between 20 and 25°C.

Two sets of values are presented for the day-night models in Table 10. The first set of figures was calculated using discrete immature survival and sex ratio figures observed for each regime (Table 8). However, it was felt that the technique used in the collection of these data allowed too much chance for error, and, as such, population growth values calculated from adjusted data would be more representative. Population growth statistics for the day-night regimes were, therefore, calculated a second time using a pooled immature survival figure of 31.25% and assuming a 1:1

Table 8. Development of *B. kirkpatricki* on beet armyworm under three day-night temperature regimes.

Temperature Regime	Number of Parasites: Eggs	Adults ♂	Adults ♀	% Emergence	% Females	Developmental Period of Females (Days)[a]
33-14	718	120	81	27.99	36.55	14.3 ± 0.7
36-20	989	247	90	34.07	26.94	10.7 ± 1.3
36-28	782	130	118	31.71	45.21	8.7 ± 0.7

[a] ± standard deviation.

Table 9. Development of *B. kirkpatricki* on beet armyworm at five constant temperature regimes.[a]

Temperature ± 1.5°C	Number of Parasites: Eggs	Adults ♂	Adults ♀	% Emergence	% Females	Immature Developmental Period (Days)[b]
20	187	50	42	49.20	45.65	21.1 ± 1.4
25	182	66	84	82.42	56.00	12.4 ± 0.6
30	193	61	58	61.66	48.73	8.8 ± 0.5
32.2	190	60	74	70.53	55.22	8.0 ± 0.4
35	166	49	70	71.69	58.82	7.6 ± 0.5

[a] From Bryan et al. (1971).

[b] ± standard deviation.

Table 10. Comparative population statistics of *B. kirkpatricki* at various temperature conditions.

Temperature Regime	r_m	R_o	T	λ
20	0.0652	19.85	45.83	1.07
25	0.1536	84.65	28.90	1.17
30	0.1856	49.44	21.02	1.20
32.5	0.2234	56.16	18.03	1.25
35	0.2094	46.44	18.33	1.23
Observed Data[a]				
33-14	0.0651	10.85	36.61	1.07
36-20	0.0729	9.61	31.05	1.08
36-28	0.1186	12.95	21.60	1.13
Adjusted Data[b]				
33-14	0.0794	16.58	35.38	1.08
36-20	0.0943	16.36	29.65	1.10
36-28	0.1233	14.12	21.48	1.13

[a] Calculated from discrete immature survival and sex ratio figures observed for each regime.

[b] Calculated from pooled immature survival figures and assuming 1:1 sex ratio.

sex ratio. These adjustments resulted in increased values of r_m for each of the day-night regimes. Values of r_m (Table 10) for the day-night models increased steadily with rising temperature in both sets of calculations. In both cases the increase from 36-20 to 36-28°C was greater than the increase from 33-14 to 36-20°C.

Stable age distributions are included with the life table data for each of the experimental regimes (Appendices C through M).

Miscellaneous Observations

Several aspects of the host preferences of *B. kirkpatricki* were observed during the course of this research. Preliminary tests indicated that the parasite will accept third instar, fourth instar, and diapausing pink bollworm larvae, but will not accept pink bollworm pupae. Similar rejection occurred in the fecundity-longevity tests where the parasites rejected beet armyworm larvae which had taken on pre-pupal characteristics. Feeding on diapausing pink bollworm larvae had no noticeable effect on the rate of development and did not cause development of diapause in the parasites.

DISCUSSION

The data on adult biology of B. kirkpatricki indicate a pronounced reaction to lower temperatures. This temperature effect is most evident in the fecundity data for the constant temperature regimes (Table 6) in which minimum fecundity occurs at 20°C with maximum fecundity occurring at 25°C. The other data comparisons for the constant temperatures show a similar effect with the greatest differences occurring between 20 and 25°C (Tables 2 and 4). This effect is somewhat obscured by the presence of two temperatures acting on the parasites in the day-night models, but the difference in performance of the parasite is still most noticeable when nocturnal temperature differs from 20 to 28°C (Tables 3, 5, and 7). When different temperatures affect the parasite at different times of the day, the lower nocturnal temperature seems to exert the dominant influence. These data indicate the presence of a threshold temperature between 20 and 25°C below which the functioning of the parasite is significantly inhibited. The consistency with which this threshold temperature affects the over-all performance of B. kirkpatricki indicates an effect on some basic component of the insect's physiology, such as the influence of temperature on metabolic rate (Bursell, 1970).

Comparison of longevity and fecundity for the constant temperature regimes (Tables 2 and 6, respectively) indicates a noticeable relationship at the upper levels of the temperature range. Mean longevity levels off and remains nearly equal for the 30, 32.5, and 35°C regimes, but mean fecundity decreases at an accelerated rate. Inspection of age specific fecundity data for these regimes (Appendices E, F, and G) indicates progressive shortening of the initial high fecundity period with each increase in temperature. Bursell (1970) links this type of senescent effect to the high rate of metabolism associated with high temperatures (i.e., 30 to 40°C).

Of the population statistics presented in Table 10, only one, the intrinsic rate of natural increase (r_m), will be used in this discussion. The intrinsic rate of natural increase has been singled out because this statistic accounts for nearly all aspects of an organism's life cycle (i.e., immature development time, immature mortality, sex ratio, fecundity schedule, and adult mortality schedule) with a system for weighting these data according to age. The net reproductive rate accounts for much of these data but ignores the time element; mean generation time indicates an important temporal relationship but little else; and the finite rate of natural increase is simply a reflection of r_m.

A vital requirement for the calculation of these population statistics is that the test organism be maintained in an unlimited environment (i.e., no obvious restraints on population growth other than the experimental variables). An attempt was made to meet this requirement within these experiments by providing ample supplies of sucrose solution for the adult parasites and by presenting large host larvae for parasitization.

Since r_m is a synthesis of all the biological data available for B. kirkpatricki, this statistic would be expected to reflect the previously described phenomena associated with rising temperatures. Values of r_m reflect the effect of minimum threshold temperature by showing the greatest increases between 20 and 25°C for the constant temperature regimes and between nocturnal temperatures of 20 and 28°C for the day-night models. However, r_m does not reflect the negative results expected from the observed reduction in fecundity at higher temperatures. This can be explained by the fact that increased temperature causes a decrease in total fecundity, but also results in increased daily fecundity for the initial portion of adult longevity. In the calculation of r_m, preferential weighting is placed on this heavy initial fecundity, as well as on the shortened developmental time at higher temperatures, causing the values of r_m to rise. The slight decrease in r_m following a peak at 32.5°C possibly indicates conformity of these data with the general response of an insect population to increasing temperature described by Bursell (1970) in which population growth peaks near the upper limit of its temperature range followed by a rapid decline to zero at the upper critical limit.

Philipp and Watson (1971) constructed life tables and calculated population growth statistics for the pink bollworm held at several temperature conditions (Table 11). Comparison of values of r_m calculated for the pink bollworm with those calculated for B. kirkpatricki are presented in in Figures 4 and 5. Figure 4 compares the available values of r_m obtained for constant temperature conditions. This comparison between parasite and host is not completely accurate since calculations for P. gossypiella were made assuming 1:1 sex ratio. This difference in methodology possibly strengthens the comparison in favor of B. kirkpatricki since the data for the pink bollworm may have been somewhat inflated and yet the parasite still shows vastly superior growth potential.

Figure 5 presents values of r_m for parasite and host for three truncated day-night temperature models. This comparison is considered more meaningful than the constant temperature comparison since the day-night models come closer to simulating natural conditions encountered by the insects. Other factors strengthening the comparison in Figure 5 are the use of a standard 1:1 sex ratio for both species and the subjection of both host and parasite to nearly identical temperature conditions. Figure 5 clearly

Table 11. Comparative population statistics of the pink bollworm held at various temperatures (considering immature mortality).[a]

Temperature °C	r_m	R_o	T
24	0.0482	12.50	50.80
28	0.0810	23.97	39.21
32	<0.0001	0.37	--
33-14	0.0222	3.51	56.55
37-19	0.0322	2.35	53.40
37-28	0.0574	10.77	42.42

[a] From Philipp and Watson (1971).

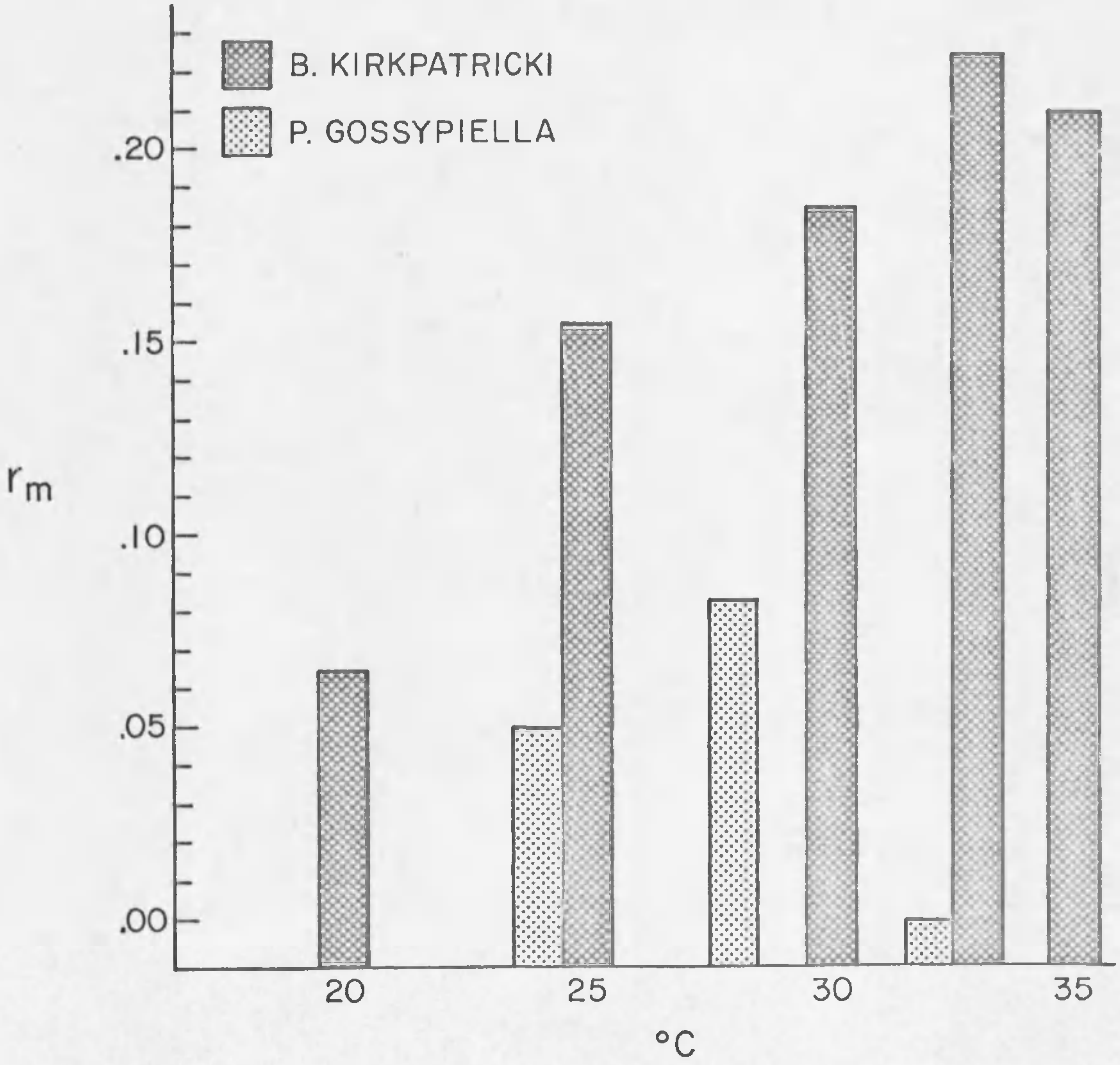

Figure 4. Comparison of intrinsic rate of natural increase (r_m) for the pink bollworm and its parasite, Bracon kirkpatricki, held at various constant temperature conditions -- Data from Philipp and Watson (1971).

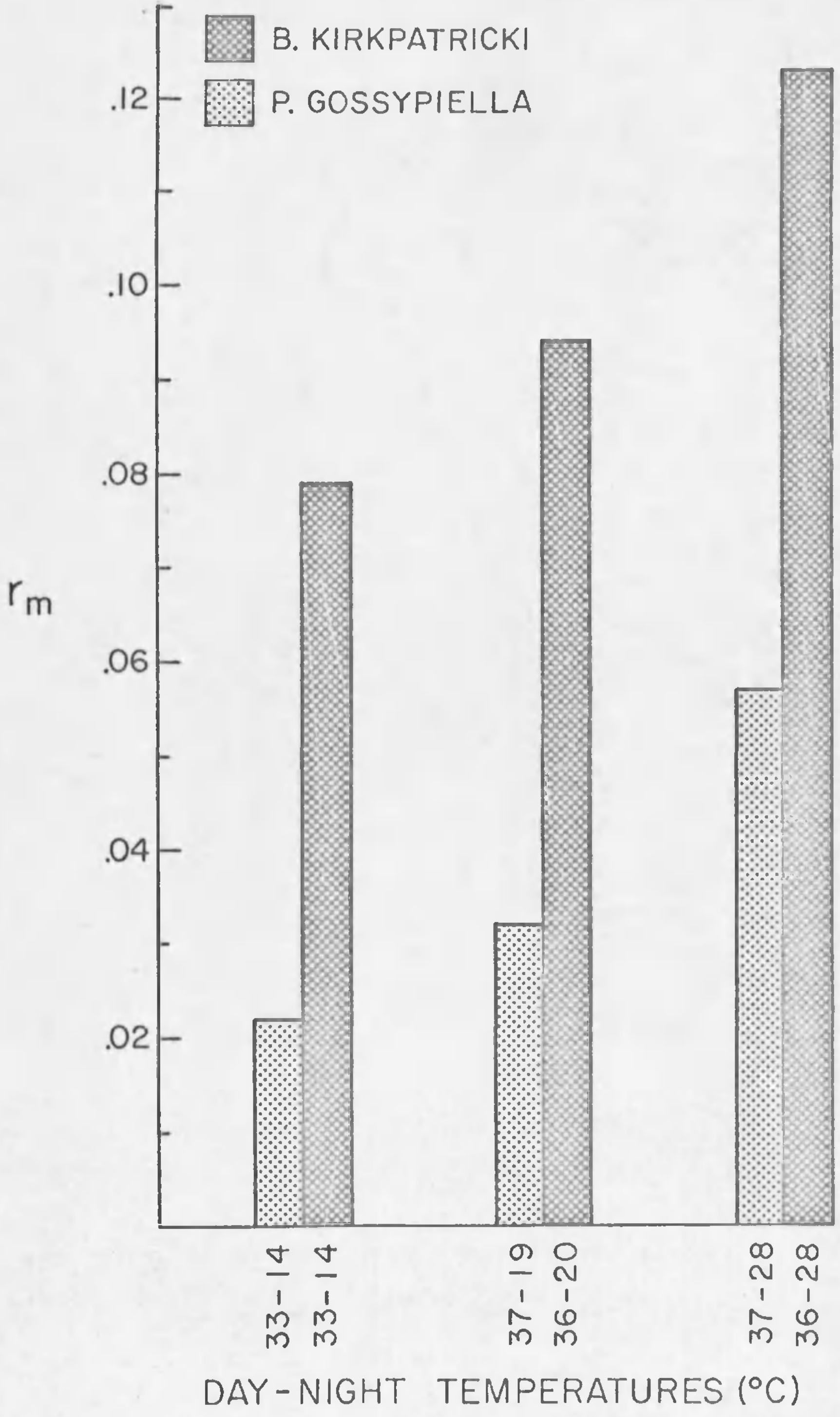

Figure 5. Comparison of intrinsic rate of natural increase (r_m) for the pink bollworm and its parasite, Bracon kirkpatricki, held under three day-night temperature models -- Data from Philipp and Watson (1971).

shows that both parasite and host respond to higher temperatures with increasing rates of population growth, with the parasite consistently showing higher growth potential than its host over this range of temperature conditions.

The higher rate of population growth of _B_. _kirkpatricki_ over _P_. _gossypiella_, plus the prolonged longevity of the adult parasite, indicate good possibilities for controlling early-season pink bollworm populations with inoculative releases of the parasite. It must be pointed out that these data were generated under laboratory conditions in which plentiful food was available to the adults and that the parasite and its host were artificially brought together. Similar results under field conditions would be dependent on the presence of adequate nectar sources plus the ability of the parasite to locate a sufficient number of hosts, often under low host-density conditions. Proper timing of release to allow for nectary development on the young cotton plants would insure sufficient food sources for the adult parasites. Releases into adjoining alfalfa fields is an alternate approach suggested by Bryan (1974). Mass releases of _B_. _kirkpatricki_ in field cage tests produced 74 to 81% control of the pink bollworm (Bryan et al., 1971). Inundative field releases of the parasite resulted in up to 30% parasitization of naturally occurring pink bollworm populations, with the actual levels of host mortality believed to be higher than the levels detected (Bryan et al., 1973a, 1973b). These parasitization data indicate successful host searching behavior by _B_. _kirkpatricki_ in inundative release programs, and provide some encouragement concerning the possible searching capacity to be expected in inoculative release programs.

SUMMARY

The influence of temperature on adults of *B. kirkpatricki*, a braconid parasite of the pink bollworm, was studied in order to quantify potential population growth responses. The parasite was studied at constant temperatures of 20, 25, 30, 32.5, and 35°C and under truncated day-night temperature models of 33-14, 36-20, and 36-28°C. Data were collected on daily fecundity and survival of individual adult females for each regime, and additional data were collected on developmental time, survival, and sex ratio of the immature stages for the day-night regimes. Data on the immature stages were already available for the constant temperatures.

Rising temperature caused mean longevity to decrease significantly between 20 and 25°C, and also between 25 and 30°C, with longevity being nearly equal for 30, 32.5, and 35°C. Mean longevities for the day-night regimes decreased steadily with rising temperatures, with significant difference occurring between 36-20 and 36-28°C.

Significant reductions in mean pre-oviposition periods occurred between 20 and 25°C, with a trend of reduced pre-oviposition time (no significant differences) occurring among the constant temperatures from 25 to 35°C. Pre-oviposition periods were nearly equal for the 33-14 and

36-20°C regimes, with a significant reduction occurring at the 36-28°C regime.

Mean fecundity increased from the minimum level at 20°C to the maximum at 25°C, followed by gradual decreases in fecundity as temperature increased above 25°C. Mean fecundities for the three day-night regimes were nearly equal.

The combined data on the immature and adult stages of B. kirkpatricki were used to construct life tables for the calculation of several growth statistics: the intrinsic rate of natural increase (r_m), net reproductive rate (R_o), mean generation time (T), finite rate of natural increase (λ), and stable age distribution.

Rising temperatures generally caused the rate of population growth, as indicated by r_m, to rise. Increased values of r_m resulted mainly from the influence of rising temperature in shortening developmental periods and increasing daily fecundity during the initial period of adult longevity. The largest increases in r_m occurred between 20 and 25°C in the constant temperature regimes and between nocturnal temperatures of 20 and 28°C in the day-night regimes. Above 25°C, r_m continued to rise to a peak value at 32.5°C, followed by a slight decline at 35°C.

APPENDIX A

COMPUTATION OF LIFE TABLE DATA

Data used in life table construction consists of age (x), the probability of survival to a specific age (l_x), and age-specific production of female progeny (m_x).

Age is expressed in terms of pivotal age groups, determined by the interval at which fecundity and mortality data are collected. For this thesis, data were collected daily, therefore, x expresses the age of B. kirkpatricki in days. The value of x for which life table data first appears indicates the time required for development from egg to adult.

The probability of survival to age x (l_x) was computed by multiplying the observed adult survival at age x by the level of immature survival for that regime. Both of these factors were expressed as decimals between 1.0 and 0.

Age-specific production of female progeny (m_x) was computed for each "x" by multiplication of mean daily fecundity by the observed sex ratio for each regime. Sex ratio was obtained from the data on immature development and survival for each regime and was expressed as the proportion of females in each population of emerging adults (written as a decimal between 1.0 and 0).

APPENDIX B

PROGRAM LOTKA

Developed by B. D. Frazer, University of British Columbia

Modified by C. R. Mason, The University of Arizona, for use on CDC-6400 computer system

Methods of Computation

Intrinsic rate of natural increase (r_m) is determined such that

$$\Sigma e^{-r_m x} l_x m_x = 1.$$

An initial value of r_m is computed from $r_m = \log_e R_o/T$; where $R_o = \Sigma l_x m_x$ and $T = \Sigma x l_x m_x / \Sigma l_x m_x$. This is the "approximation" method of Andrewartha and Birch (1954). This initial value is output as the first r_m. This r_m is then used to compute $\Sigma e^{-r_m x} l_x m_x$. A new value of r_m is computed depending on the value of that sum, and the sum is then recomputed. The computation stops when an r_m is found which produces a sum such that (sum) - 1.0 $\leq$ 0.0001. Once this r_m is found, various statistics are computed from it:

T, the mean generation time = $\log_e R_o/r_m$

DT, the doubling time = $\log_e 2.0/r_m$

λ, the finite rate of increase = e^{r_m}

The program also computes the stable age distribution for each data block. The main program (LOTKA) calls for three subroutines:

Subroutine RDATA reads the data cards.

Subroutine BIRCH computes r_m and R_o.

Subroutine STATS computes the additional statistics.

The Data Deck: Card Set-Up for RDATA

Card #1: Columns 1-5 = time; if data were collected daily or weekly, time = 1., if collected every three days time = 3. A decimal point must be included or the figure must be right justified.

Columns 6-10 = ICARD; the number of data cards in the current block not including cards 1 and 2.

Card #2: Variable format input card: This card specifies the format in which the l_x and m_x values are to be read.

Cards 3 through (ICARD + 2): The data cards. Each card contains an l_x and an m_x value. The first card is for the smallest x. The l_x value is always to the left of the m_x value. To account for immature development time, include a card with $l_x = 0.0$ for each age unit spent in the immature form.

Cards 1 through (ICARD + 2) constitute one data block. Any number of data blocks can be run consecutively. To stop the computer, set up CARD 1 with time = -1.0 (or use a blank card) and place this card at the end of all data blocks.

PROGRAM LOTKA

```
      PROGRAM LOTKA(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL LX(300),MX(300),LXMX(300)
      LOGICAL FLIP,ARBIT
      IRUN = 0
  100 IRUN = IRUN + 1
      FLIP = .FALSE.
      ARBIT = .FALSE.
      CALL RDATA(LX,MX,TIME,ICARD,IRUN)
      X = TIME / 2.0
      WRITE(6,5) IRUN
    5 FORMAT(1H1,16X,≠ DATA BLOCK NUMBER≠,I3)
      DO 10 I = 1,ICARD
   10 LXMX(I) = LX(I) * MX(I)
      SUM1 = 0.0
      SUM2 = 0.0
      Y = X
      DO 20 I = 1,ICARD
      SUM1 = SUM1 + LXMX(I)
      SUM2 = SUM2 + (Y * LXMX(I))
   20 Y = Y + TIME
      SUM2 = SUM2 / SUM1
      R = ALOG(SUM1) / SUM2
   21 CALL BIRCH(X,R,LXMX,SUM,ICARD,TIME)
      WRITE(6,22) R,SUM
   22 FORMAT(1H0,10X,≠R =≠,F15.7,3X,≠SUM =≠,F15.7)
      IF(ABS(SUM - 1.0).LE.0.0001) GO TO 30
      IF(ARBIT) GO TO 25
   23 RR = R
      SUMR = SUM
      R = R + 0.001
      IF(FLIP) R = R - 0.002
```

```
      ARBIT = .TRUE.
      FLIP = .FALSE.
      GO TO 21
   25 SLOPE = (SUM - SUMR) / (R - RR)
      RI = ((1.0 - SUM) / SLOPE) + R
      IF(RI.GT.0..AND.R.LT.0..OR.RI.LT.0..AND.R.GT.0.) FLIP=.TRUE.
      RR = R
      R = RI
      SUMR = SUM
      IF(FLIP) GO TO 23
      GO TO 21
   30 CALL STATS (R,TIME,LXMX,LX,MX,ICARD ,IRUN,SUM1)
      GO TO 100
      END
```

SUBROUTINE RDATA

```
      SUBROUTINE RDATA(LX,MX,TIME,ICARD,IRUN)
      DIMENSION FMT(20)
      REAL LX(300),MX(300)
      READ(5,100) TIME,ICARD
  100 FORMAT(F5.0,I5)
      IF(TIME.LT.1) CALL EXIT
      IF(ICARD.GT.300) GO TO 300
      READ(5,200) FMT
  200 FORMAT(20A4)
      READ(5,FMT) ((LX(I),MX(I)),I = 1,ICARD)
      IF(LX(ICARD).EQ.0.0) GO TO 302
      RETURN
  300 WRITE(6,301) IRUN
  301 FORMAT(1H1,10X,≠ERROR.... MORE THAN 300 CARDS IN BLOCK≠,I3)
      CALL EXIT
  302 WRITE(6,303)
  303 FORMAT(1H1,10X,≠ERROR....LAST LX VALUE MUST NOT BE EQUAL TO ZERO.
     1REMOVE LAST CARD.≠)
      STOP
      END
```

SUBROUTINE BIRCH

```
      SUBROUTINE BIRCH(X,R,LXMX,SUM,ICARD,TIME)
      REAL LXMX(300)
      Y = X
      SUM = 0.0
      DO 10 I = 1,ICARD
      Z = -(R*Y)
      SUM = SUM + (EXP(Z) * LXMX(I))
   10 Y = Y + TIME
      RETURN
      END
```

SUBROUTINE STATS

```
      SUBROUTINE STATS (R,TIME,LXMX,LX,MX,ICARD,IRUN,RO)
      REAL LX(300),MX(300),LXMX(300),STAB(300),ACC(300)
      GT = ALOG(RO)/R
      DT = ALOG(2.0)/R
      FIN = EXP(R)
      WRITE(6,100) IRUN,ICARD,R,RO,GT,DT,FIN
  100 FORMAT(1H1,50X,≠DATA BLOCK≠,I4,3X,≠WITH≠,I4,≠DATA CARDS≠,/,1H0,50X
     1,≠THE INTRINSIC RATE =≠,F12.7,/,1H0,50X,≠THE NET REPRODUCTIVE RATE
     1 ≠,  F12.7,/,1H0,50X,≠THE GENERATION TIME =≠,F12.7,/,1H0,50X,≠THE
     1DOUBLING TIME =≠,F12.7,/,1H0,50X,≠THE FINITE RATE =≠,F12.7,/,1H0,
     18X,≠X≠,9X,≠LX≠,8X,≠MX≠,13X,≠LXMX≠,10X,≠PROPORTION OF≠,4X,
     1≠ACCUMULATED≠,/,1H0,57X,≠INDIVIDUALS OF≠,3X,≠PERCENTAGE≠,/,1H0,57X
     1,≠AGE X IN THE≠,5X,≠CONTRIBUTION≠,/,1H0,58X,≠STABLE AGE≠,8X,≠TO RM
     1 BY≠,/,1H0,57X,≠DISTRIBUTION≠,10X,≠TIME X≠)
      X = TIME/2.0
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 I = 1,ICARD
      Y = EXP(-R*X)
      SUM1 = SUM1 + (LXMX(I) * Y * 100.0)
      ACC(I) = SUM1
      SUM2 = SUM2 + (Y * LX(I))
      X = X + TIME
   10 CONTINUE
      SUM2 = 1.0 / SUM2
      M = ICARD - 1
      DO 20 I = 1,M
      J = I + 1
      STAB(I) = (LX(I) + LX(J)) / 2.0
   20 CONTINUE
      STAB(ICARD) = LX(ICARD) / 2.0
```

```
      X = TIME / 2.0
      DO 30 I = 1,ICARD
      Y = -(R*X)
      STAB(I) = STAB(I)*SUM2*EXP(Y)*100.0
      X = X + TIME
30    CONTINUE
      X = TIME / 2.0
      DO 40 I = 1,ICARD
      WRITE(6,200) X,LX(I),MX(I),LXMX(I),STAB(I),ACC(I)
200   FORMAT(1H0,2(5X,F6.2),5X,F9.4,5X,F12.4,2(8X,F7.3))
      X = X + TIME
40    CONTINUE
      RETURN
      END
```

APPENDIX C

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* AT 20°C AND 11 HR PHOTOPERIOD

Immature development = 21 days
Immature survival = 49.20%
Females in population = 45.65%

r_m = 0.0652
R_o = 19.8489
T = 45.8262
λ = 1.0674

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
21	0.00	0.0000	0.0000	0.000	3.528
22	0.49	0.0000	0.0000	0.000	6.610
23	0.49	0.0000	0.0000	0.000	6.193
24	0.49	0.0000	0.0000	0.000	5.802
25	0.49	0.1096	0.0539	1.091	5.436
26	0.49	0.1096	0.0539	2.113	5.092
27	0.49	0.2922	0.1437	4.667	4.771
28	0.49	0.5478	0.2695	9.151	4.470
29	0.49	0.5843	0.2874	13.633	4.188
30	0.49	0.6938	0.3413	18.619	3.923
31	0.49	0.5478	0.2695	22.306	3.676
32	0.49	0.8217	0.4042	27.489	3.444
33	0.49	0.9678	0.4761	33.208	3.226
34	0.49	1.2052	0.5928	39.880	3.023
35	0.49	0.7852	0.3862	43.953	2.832
36	0.49	1.2052	0.5928	49.809	2.653
37	0.49	1.0956	0.5389	54.796	2.486
38	0.49	1.0043	0.4940	59.080	2.329
39	0.49	1.1139	0.5479	63.531	2.182
40	0.49	0.5661	0.2785	65.650	2.044
41	0.49	0.8947	0.4401	68.788	1.915
42	0.49	0.9130	0.4491	71.788	1.794
43	0.49	1.0591	0.5210	75.048	1.681
44	0.49	0.9313	0.4581	77.734	1.575
45	0.49	0.5843	0.2874	79.313	1.475
46	0.49	0.5478	0.2695	80.700	1.382
47	0.49	0.8399	0.4131	82.692	1.269
48	0.47	0.8537	0.4031	84.513	1.165
49	0.47	0.6254	0.2953	85.763	1.068
50	0.45	0.8354	0.3780	87.261	0.980
51	0.45	0.8126	0.3677	88.627	0.918

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
52	0.45	0.5341	0.2417	89.468	0.860
53	0.45	0.7167	0.3243	90.526	0.806
54	0.45	0.3789	0.1715	91.049	0.738
55	0.43	0.6026	0.2609	91.796	0.676
56	0.43	0.3104	0.1344	92.156	0.634
57	0.43	0.6208	0.2687	92.831	0.580
58	0.41	0.8902	0.3678	93.697	0.518
59	0.39	0.6391	0.2515	94.251	0.474
60	0.39	0.5021	0.1976	94.660	0.433
61	0.37	0.4565	0.1706	94.990	0.395
62	0.37	0.2876	0.1075	95.185	0.370
63	0.37	0.4565	0.1706	95.474	0.347
64	0.37	0.6984	0.2611	95.890	0.325
65	0.37	0.6711	0.2509	96.264	0.296
66	0.35	0.7121	0.2522	96.616	0.270
67	0.35	0.5843	0.2070	96.887	0.253
68	0.35	0.7852	0.2781	97.228	0.230
69	0.33	0.4565	0.1527	97.403	0.204
70	0.31	0.7395	0.2328	97.654	0.179
71	0.30	0.9906	0.2923	97.949	0.162
72	0.30	0.7806	0.2304	98.166	0.147
73	0.28	0.9130	0.2515	98.389	0.133
74	0.28	0.8765	0.2415	98.589	0.120
75	0.26	0.9906	0.2534	98.786	0.104
76	0.24	0.5706	0.1347	98.884	0.094
77	0.24	0.6071	0.1433	98.982	0.084
78	0.22	0.3332	0.0721	99.028	0.075
79	0.22	0.7076	0.1531	99.119	0.067
80	0.20	0.3195	0.0629	99.154	0.060
81	0.20	0.5021	0.0988	99.206	0.054
82	0.18	0.4565	0.0808	99.246	0.048
83	0.18	0.7624	0.1350	99.308	0.045
84	0.18	0.8126	0.1439	99.371	0.042
85	0.18	0.5569	0.0986	99.410	0.039
86	0.18	1.0134	0.1795	99.479	0.037
87	0.18	1.3193	0.2336	99.562	0.034
88	0.18	0.8126	0.1439	99.609	0.030
89	0.16	0.8537	0.1344	99.651	0.027
90	0.16	0.7989	0.1257	99.688	0.025
91	0.16	0.4565	0.0719	99.708	0.022
92	0.14	0.8491	0.1169	99.738	0.019
93	0.14	0.8491	0.1169	99.766	0.018
94	0.14	0.7806	0.1075	99.790	0.017
95	0.14	1.1093	0.1528	99.822	0.016
96	0.14	0.7806	0.1075	99.843	0.015
97	0.14	0.7806	0.1075	99.863	0.014

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
98	0.14	0.3241	0.0446	99.871	0.013
99	0.14	0.9130	0.1257	99.891	0.010
100	0.10	1.1869	0.1168	99.909	0.008
101	0.10	0.9130	0.0898	99.922	0.008
102	0.10	0.9130	0.0898	99.934	0.007
103	0.10	0.6391	0.0629	99.942	0.007
104	0.10	1.4608	0.1437	99.959	0.006
105	0.08	0.2282	0.0180	99.961	0.005
106	0.08	0.6847	0.0539	99.966	0.004
107	0.08	0.7989	0.0629	99.972	0.004
108	0.06	0.9130	0.0539	99.977	0.003
109	0.06	0.1506	0.0089	99.978	0.003
110	0.06	0.7578	0.0447	99.981	0.003
111	0.06	0.0000	0.0000	99.981	0.002
112	0.06	0.6071	0.0358	99.984	0.002
113	0.06	0.4565	0.0269	99.986	0.002
114	0.06	0.4565	0.0269	99.987	0.002
115	0.06	0.3013	0.0178	99.988	0.002
116	0.06	0.6071	0.0358	99.990	0.002
117	0.06	0.0000	0.0000	99.990	0.002
118	0.06	0.3013	0.0178	99.991	0.002
119	0.06	0.3013	0.0178	99.992	0.001
120	0.06	0.6071	0.0358	99.993	0.001
121	0.06	0.6071	0.0358	99.995	0.001
122	0.06	0.3013	0.0178	99.995	0.001
123	0.06	1.0636	0.0628	99.998	0.001
124	0.04	0.4565	0.0180	99.998	0.001
125	0.04	0.4565	0.0180	99.999	0.001
126	0.04	0.0000	0.0000	99.999	0.000
127	0.02	0.9130	0.0180	99.999	0.000
128	0.02	0.9130	0.0180	100.000	0.000
129	0.02	0.4565	0.0090	100.000	0.000
130	0.02	0.9130	0.0180	100.000	0.000
131	0.02	0.4565	0.0090	100.000	0.000
132	0.02	0.0000	0.0000	100.000	0.000
133	0.02	0.0000	0.0000	100.000	0.000
134	0.02	0.4565	0.0090	100.000	0.000

APPENDIX D

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* AT 25°C AND 13 HR PHOTOPERIOD

Immature development = 12 days
Immature survival = 82.42%
Females in population = 56.00%

r_m = 0.1536
R_o = 84.6521
T = 28.8968
λ = 1.1660

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
12	0.00	0.0000	0.0000	0.000	8.363
13	0.82	0.0000	0.0000	0.000	14.344
14	0.82	0.0000	0.0000	0.000	12.302
15	0.82	0.2576	0.2123	2.289	10.550
16	0.82	0.7112	0.5862	7.710	9.048
17	0.82	1.5736	1.2970	17.996	7.760
18	0.82	2.0272	1.6708	29.361	6.655
19	0.82	1.6576	1.3662	37.330	5.707
20	0.82	2.1952	1.8093	46.381	4.895
21	0.82	2.3240	1.9154	54.599	4.198
22	0.82	2.2400	1.8462	61.392	3.600
23	0.82	2.5648	2.1139	68.063	3.087
24	0.82	1.6128	1.3293	71.660	2.648
25	0.82	2.3464	1.9339	76.149	2.271
26	0.82	2.3240	1.9154	79.961	1.947
27	0.82	1.9152	1.5785	82.656	1.670
28	0.82	2.1952	1.8093	85.305	1.432
29	0.82	1.7416	1.4354	87.107	1.228
30	0.82	1.8312	1.5093	88.732	1.032
31	0.79	2.2624	1.7900	90.385	0.867
32	0.79	1.9712	1.5596	91.620	0.744
33	0.79	2.1952	1.7368	92.800	0.638
34	0.79	2.5536	2.0204	93.977	0.524
35	0.73	2.8728	2.0836	95.018	0.430
36	0.73	2.4360	1.7668	95.775	0.369
37	0.73	2.5816	1.8724	96.463	0.316
38	0.73	3.0912	2.2420	97.160	0.271
39	0.73	2.0944	1.5191	97.580	0.229
40	0.70	2.3408	1.6400	97.960	0.193
41	0.70	1.9600	1.3732	98.233	0.161
42	0.67	2.5592	1.7085	98.524	0.135

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
43	0.67	2.4528	1.6375	98.763	0.116
44	0.67	2.6376	1.7609	98.984	0.097
45	0.63	2.9120	1.8480	99.183	0.081
46	0.63	2.8280	1.7946	99.348	0.068
47	0.60	2.3016	1.3849	99.458	0.056
48	0.60	2.8616	1.7218	99.575	0.047
49	0.57	2.2400	1.2739	99.649	0.038
50	0.54	2.4024	1.2870	99.713	0.032
51	0.54	2.3408	1.2540	99.767	0.027
52	0.54	2.0104	1.0770	99.806	0.023
53	0.54	2.7664	1.4820	99.853	0.020
54	0.51	1.9600	1.0016	99.880	0.016
55	0.48	2.0552	0.9824	99.902	0.013
56	0.45	2.2792	1.0145	99.923	0.010
57	0.41	1.7248	0.7108	99.935	0.008
58	0.41	2.0272	0.8354	99.947	0.007
59	0.35	1.6800	0.5816	99.954	0.005
60	0.35	2.0888	0.7231	99.962	0.004
61	0.31	2.5200	0.7893	99.969	0.003
62	0.29	2.1784	0.6285	99.974	0.003
63	0.29	2.8000	0.8078	99.980	0.002
64	0.29	1.8032	0.5202	99.983	0.002
65	0.29	2.8000	0.8078	99.987	0.002
66	0.22	2.4024	0.5345	99.989	0.001
67	0.22	2.2400	0.4984	99.991	0.001
68	0.19	1.7752	0.3366	99.992	0.001
69	0.19	2.4248	0.4597	99.993	0.001
70	0.16	3.8080	0.5963	99.995	0.000
71	0.12	3.3600	0.4153	99.995	0.000
72	0.12	3.6400	0.4499	99.996	0.000
73	0.12	3.6400	0.4499	99.997	0.000
74	0.12	3.9200	0.4845	99.997	0.000
75	0.12	2.9400	0.3634	99.998	0.000
76	0.12	3.3600	0.4153	99.998	0.000
77	0.12	4.7600	0.5883	99.999	0.000
78	0.12	2.6600	0.3288	99.999	0.000
79	0.12	2.5200	0.3115	99.999	0.000
80	0.12	3.7800	0.4672	99.999	0.000
81	0.12	2.1000	0.2596	99.999	0.000
82	0.12	4.6200	0.5710	100.000	0.000
83	0.10	4.1048	0.4060	100.000	0.000
84	0.10	3.7296	0.3689	100.000	0.000
85	0.10	1.1200	0.1108	100.000	0.000
86	0.10	5.6000	0.5538	100.000	0.000
87	0.10	3.5448	0.3506	100.000	0.000
88	0.10	2.2400	0.2215	100.000	0.000

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
89	0.10	3.9200	0.3877	100.000	0.000
90	0.10	2.0496	0.2027	100.000	0.000
91	0.10	1.3048	0.1290	100.000	0.000
92	0.10	1.4896	0.1473	100.000	0.000
93	0.10	2.0496	0.2027	100.000	0.000
94	0.07	2.8000	0.1845	100.000	0.000
95	0.07	0.2800	0.0185	100.000	0.000
96	0.07	2.2400	0.1476	100.000	0.000
97	0.07	3.0800	0.2030	100.000	0.000
98	0.03	4.4800	0.1478	100.000	0.000
99	0.03	2.8000	0.0924	100.000	0.000
100	0.03	4.4800	0.1478	100.000	0.000
101	0.03	2.2400	0.0739	100.000	0.000
102	0.03	4.4800	0.1478	100.000	0.000
103	0.03	4.4800	0.1478	100.000	0.000
104	0.03	2.2400	0.0739	100.000	0.000
105	0.03	3.3600	0.1109	100.000	0.000
106	0.03	1.6800	0.0554	100.000	0.000
107	0.03	3.3600	0.1109	100.000	0.000
108	0.03	1.6800	0.0554	100.000	0.000
109	0.03	2.2400	0.0739	100.000	0.000
110	0.03	2.2400	0.0739	100.000	0.000
111	0.03	0.5600	0.0185	100.000	0.000
112	0.03	2.2400	0.0739	100.000	0.000
113	0.03	0.0000	0.0000	100.000	0.000
114	0.03	0.0000	0.0000	100.000	0.000
115	0.03	3.9200	0.1294	100.000	0.000
116	0.03	1.1200	0.0370	100.000	0.000
117	0.03	2.2400	0.0739	100.000	0.000
118	0.03	0.0000	0.0000	100.000	0.000
119	0.03	1.6800	0.0554	100.000	0.000
120	0.03	2.2400	0.0739	100.000	0.000
121	0.03	2.2400	0.0739	100.000	0.000
122	0.03	2.2400	0.0739	100.000	0.000

APPENDIX E

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* AT 30°C AND 15 HR PHOTOPERIOD

Immature development = 9 days
Immature survival = 61.66%
Females in population = 48.73%

r_m = 0.1856
R_o = 49.4403
T = 21.0211
λ = 1.2039

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
9	0.00	0.0000	0.0000	0.000	10.273
10	0.62	0.0000	0.0000	0.000	17.067
11	0.62	0.1316	0.0811	1.156	14.176
12	0.62	0.9015	0.5559	7.736	11.775
13	0.62	1.6081	0.9916	17.484	9.781
14	0.62	2.7532	1.6976	31.348	8.124
15	0.62	2.5096	1.5474	41.845	6.748
16	0.62	3.2259	1.9891	53.053	5.606
17	0.62	4.0299	2.4848	64.682	4.656
18	0.62	3.1090	1.9170	72.135	3.868
19	0.62	2.6801	1.6525	77.471	3.213
20	0.62	2.4365	1.5023	81.501	2.668
21	0.62	2.3634	1.4573	84.748	2.217
22	0.62	1.9882	1.2259	87.016	1.841
23	0.62	2.1197	1.3070	89.026	1.499
24	0.59	2.9628	1.7537	91.265	1.219
25	0.59	3.0992	1.8344	93.210	1.013
26	0.59	2.4755	1.4652	94.501	1.841
27	0.59	2.6704	1.5806	95.658	0.699
28	0.59	2.1051	1.2460	96.415	0.568
29	0.57	2.0320	1.1528	96.997	0.462
30	0.57	2.6801	1.5204	97.635	0.384
31	0.57	2.2952	1.3021	98.088	0.300
32	0.50	2.3634	1.1803	98.430	0.233
33	0.50	2.4852	1.2411	98.728	0.194
34	0.50	3.0164	1.5064	99.029	0.161
35	0.50	2.5973	1.2971	99.244	0.134
36	0.50	2.2269	1.1121	99.397	0.108
37	0.47	2.4365	1.1569	99.530	0.083
38	0.43	2.8946	1.2317	99.647	0.062
39	0.38	2.8020	1.0712	99.731	0.049

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
40	0.38	3.1821	1.2165	99.811	0.040
41	0.38	1.7640	0.6744	99.848	0.034
42	0.38	2.6217	1.0023	99.893	0.025
43	0.31	1.9882	0.6130	99.916	0.017
44	0.26	2.2611	0.5854	99.934	0.012
45	0.23	2.5827	0.6051	99.950	0.010
46	0.23	2.1928	0.5138	99.961	0.008
47	0.23	2.1928	0.5138	99.970	0.006
48	0.22	2.4365	0.5258	99.978	0.005
49	0.19	3.7327	0.7133	99.987	0.004
50	0.19	2.5193	0.4814	99.992	0.003
51	0.19	1.3985	0.2673	99.994	0.002
52	0.14	2.0320	0.2881	99.996	0.001
53	0.12	2.5340	0.2970	99.998	0.001
54	0.09	2.4365	0.2254	99.999	0.001
55	0.09	1.7055	0.1578	100.000	0.001
56	0.09	0.9746	0.0902	100.000	0.000
57	0.07	0.8089	0.0548	100.000	0.000
58	0.05	0.7309	0.0360	100.000	0.000
59	0.05	0.4873	0.0240	100.000	0.000
60	0.02	3.8984	0.0963	100.000	0.000

APPENDIX F

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* AT 32.5°C AND 15 HR PHOTOPERIOD

Immature development = 8 days
Immature survival = 70.53%
Females in population = 55.22%

r_m = 0.2234
R_o = 56.1645
T = 18.0329
λ = 1.2503

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
8	0.00	0.0000	0.0000	0.000	12.673
9	0.71	0.0000	0.0000	0.000	20.272
10	0.71	0.1104	0.0779	0.933	16.214
11	0.71	1.8057	1.2736	13.133	12.968
12	0.71	3.1641	2.2316	30.231	10.372
13	0.71	3.7163	2.6211	46.293	8.295
14	0.71	2.9984	2.1148	56.658	6.635
15	0.71	3.0371	2.1421	65.055	5.307
16	0.71	3.7550	2.6484	73.358	4.244
17	0.71	3.3132	2.3368	79.218	3.344
18	0.68	3.8820	2.6557	84.544	2.633
19	0.68	3.0095	2.0588	87.847	2.030
20	0.63	3.4568	2.1944	90.662	1.563
21	0.63	3.5783	2.2715	92.993	1.250
22	0.63	3.1089	1.9735	94.612	1.000
23	0.63	3.4181	2.1698	96.037	0.800
24	0.63	3.2745	2.0787	97.128	0.640
25	0.63	2.7997	1.7772	97.874	0.512
26	0.63	2.2088	1.4021	98.345	0.409
27	0.63	2.2309	1.4162	98.725	0.327
28	0.63	2.8167	1.7880	99.110	0.247
29	0.56	2.3468	1.3241	99.337	0.186
30	0.56	2.3910	1.3490	99.522	0.142
31	0.51	2.0818	1.0719	99.640	0.106
32	0.49	1.6566	0.8179	99.712	0.082
33	0.47	2.3192	1.0961	99.789	0.060
34	0.42	1.9934	0.8436	99.837	0.046
35	0.42	1.8995	0.8039	99.873	0.037
36	0.42	1.9327	0.8179	99.902	0.028
37	0.40	2.4683	0.9923	99.931	0.021

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
38	0.37	1.7229	0.6440	99.946	0.016
39	0.35	2.5733	0.9073	99.962	0.012
40	0.35	1.9879	0.7009	99.973	0.010
41	0.35	1.8057	0.6367	99.980	0.008
42	0.35	1.6953	0.5978	99.986	0.006
43	0.33	2.0100	0.6663	99.991	0.005
44	0.33	1.3805	0.4576	99.994	0.004
45	0.30	1.7394	0.5276	99.996	0.003
46	0.28	1.5185	0.4284	99.998	0.002
47	0.26	2.1591	0.5635	99.999	0.002
48	0.26	1.4081	0.3675	100.000	0.001
49	0.23	1.7670	0.4112	100.000	0.001
50	0.21	2.2695	0.4802	100.000	0.001
51	0.19	1.9327	0.3680	100.000	0.000
52	0.19	1.5185	0.2891	100.000	0.000
53	0.19	1.7229	0.3280	100.000	0.000
54	0.19	1.3087	0.2492	100.000	0.000
55	0.19	1.5848	0.3017	100.000	0.000
56	0.16	0.8670	0.1406	100.000	0.000
57	0.12	0.4418	0.0530	100.000	0.000
58	0.12	0.4418	0.0530	100.000	0.000
59	0.12	0.4418	0.0530	100.000	0.000
60	0.12	0.5522	0.0662	100.000	0.000
61	0.09	0.4141	0.0380	100.000	0.000
62	0.09	0.5522	0.0506	100.000	0.000
63	0.09	0.6902	0.0633	100.000	0.000
64	0.09	0.5522	0.0506	100.000	0.000
65	0.09	0.5522	0.0506	100.000	0.000
66	0.07	1.6566	0.1168	100.000	0.000
67	0.07	0.9167	0.0646	100.000	0.000
68	0.07	0.9167	0.0646	100.000	0.000
69	0.07	0.3645	0.0257	100.000	0.000

APPENDIX G

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* AT 35°C AND 15 HR PHOTOPERIOD

Immature development = 8 days
Immature survival = 71.69%
Females in population = 58.82%

$r_m = 0.2094$
$R_o = 46.4365$
$T = 18.3311$
$\lambda = 1.2329$

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
8	0.00	0.0000	0.0000	0.000	11.687
9	0.72	0.0000	0.0000	0.000	18.958
10	0.72	0.3059	0.2193	3.001	15.376
11	0.72	1.2882	0.9235	13.249	12.472
12	0.72	2.3116	1.6572	28.166	10.116
13	0.72	2.5704	1.8427	41.619	8.205
14	0.72	2.4822	1.7795	52.156	6.655
15	0.72	2.0234	1.4506	59.123	5.398
16	0.72	3.4410	2.4669	68.733	4.378
17	0.72	3.0057	2.1548	75.541	3.551
18	0.72	4.1409	2.9686	83.149	2.880
19	0.72	2.6116	1.8723	87.041	2.336
20	0.72	2.2234	1.5940	89.728	1.895
21	0.72	2.1352	1.5307	91.821	1.537
22	0.72	2.1528	1.5433	93.533	1.246
23	0.72	2.0469	1.4674	94.853	1.011
24	0.72	1.8528	1.3283	95.822	0.820
25	0.72	2.4410	1.7500	96.858	0.652
26	0.69	2.3293	1.6030	97.627	0.518
27	0.69	1.0411	0.7165	97.906	0.420
28	0.69	1.8528	1.2751	98.309	0.341
29	0.69	2.5588	1.7610	98.760	0.272
30	0.67	1.7881	1.1921	99.008	0.217
31	0.67	2.1175	1.4117	99.246	0.172
32	0.64	2.2528	1.4373	99.442	0.134
33	0.61	1.6646	1.0144	99.555	0.101
34	0.55	2.4057	1.3279	99.674	0.076
35	0.53	2.5587	1.3574	99.773	0.057
36	0.47	2.6116	1.2358	99.846	0.043
37	0.45	2.3175	1.0466	99.896	0.034
38	0.45	2.0411	0.9218	99.932	0.027

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
39	0.42	1.8352	0.7763	99.957	0.020
40	0.37	1.5117	0.5636	99.971	0.013
41	0.29	1.5528	0.4564	99.980	0.009
42	0.27	1.9411	0.5150	99.989	0.006
43	0.22	1.3940	0.2998	99.993	0.004
44	0.16	0.8823	0.1391	99.995	0.003
45	0.16	1.9587	0.3089	99.998	0.002
46	0.16	0.8823	0.1391	99.999	0.002
47	0.16	0.8823	0.1391	99.999	0.001
48	0.14	0.7058	0.0961	100.000	0.001
49	0.11	0.5882	0.0632	100.000	0.001
50	0.08	0.0000	0.0000	100.000	0.000
51	0.08	0.1941	0.0153	100.000	0.000
52	0.08	0.3882	0.0306	100.000	0.000
53	0.05	0.2941	0.0148	100.000	0.000
54	0.05	0.0000	0.0000	100.000	0.000
55	0.05	0.0000	0.0000	100.000	0.000
56	0.05	0.0000	0.0000	100.000	0.000
57	0.05	0.5882	0.0295	100.000	0.000

APPENDIX H

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 33-14°C AND 12 HR PHOTOPERIOD (DATA COMPUTED FROM OBSERVED IMMATURE SURVIVAL AND SEX RATIO FIGURES)

Immature development = 14 days
Immature survival = 27.99%
Females in population = 36.55%

r_m = 0.0651
R_o = 10.8518
T = 36.6113
λ = 1.0673

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
14	0.00	0.0000	0.0000	0.000	3.475
15	0.28	0.0000	0.0000	0.000	6.511
16	0.28	0.0475	0.0133	0.485	6.101
17	0.28	0.0731	0.0205	1.183	5.716
18	0.28	0.3874	0.1084	4.652	5.356
19	0.28	0.8772	0.2455	12.012	5.018
20	0.28	0.8260	0.2312	18.505	4.702
21	0.28	0.4861	0.1361	22.085	4.405
22	0.28	0.5848	0.1637	26.121	4.128
23	0.28	0.5592	0.1565	29.736	3.867
24	0.28	0.8260	0.2312	34.740	3.623
25	0.28	0.8260	0.2312	29.429	3.395
26	0.28	0.5336	0.1494	42.267	3.181
27	0.28	0.7785	0.2179	46.146	2.980
28	0.28	0.7785	0.2179	49.780	2.792
29	0.28	0.7529	0.2107	53.074	2.616
30	0.28	0.8041	0.2251	56.370	2.451
31	0.28	0.7785	0.2179	59.359	2.297
32	0.28	1.2171	0.3407	63.738	2.152
33	0.28	0.8516	0.2384	66.609	2.016
34	0.28	0.6323	0.1770	68.606	1.889
35	0.28	1.1184	0.3130	71.916	1.770
36	0.28	0.5336	0.1494	73.396	1.659
37	0.28	0.8516	0.2384	75.608	1.554
38	0.28	0.8260	0.2312	77.619	1.456
39	0.28	0.8041	0.2251	79.453	1.364
40	0.28	1.1696	0.3274	81.952	1.278

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
41	0.28	0.6798	0.1903	83.314	1.198
42	0.28	0.7785	0.2179	84.774	1.122
43	0.28	0.7310	0.2046	86.059	1.051
44	0.28	0.6323	0.1770	87.100	0.985
45	0.28	1.1696	0.3274	88.905	0.923
46	0.28	0.8260	0.2312	90.099	0.865
47	0.28	0.5848	0.1637	90.891	0.810
48	0.28	0.6323	0.1770	91.694	0.759
49	0.28	0.9722	0.2721	92.850	0.711
50	0.28	0.3399	0.0951	93.229	0.643
51	0.26	0.7054	0.1836	93.914	0.581
52	0.26	0.5482	0.1427	94.412	0.524
53	0.24	1.0965	0.2639	95.276	0.471
54	0.24	0.6762	0.1628	95.776	0.442
55	0.24	0.3655	0.0880	96.029	0.414
56	0.24	0.5044	0.1214	96.356	0.388
57	0.24	0.6469	0.1557	96.748	0.363
58	0.24	0.5044	0.1214	97.035	0.340
59	0.24	0.5044	0.1214	97.304	0.295
60	0.20	0.4971	0.1016	97.515	0.254
61	0.20	0.9137	0.1867	97.878	0.238
62	0.20	2.1930	0.4480	98.695	0.223
63	0.20	0.2668	0.0545	98.788	0.199
64	0.18	0.3289	0.0607	98.885	0.169
65	0.17	0.5263	0.0884	99.017	0.151
66	0.17	0.3655	0.0614	99.103	0.141
67	0.17	0.2412	0.0405	99.157	0.132
68	0.17	0.3655	0.0614	99.232	0.124
69	0.17	0.2412	0.0405	99.279	0.116
70	0.17	0.4057	0.0681	99.353	0.109
71	0.17	0.1608	0.0270	99.380	0.096
72	0.15	0.6396	0.0949	99.470	0.079
73	0.13	0.2595	0.0334	99.500	0.069
74	0.13	0.3143	0.0405	99.534	0.064
75	0.13	0.6250	0.0805	99.597	0.060
76	0.13	0.3655	0.0471	99.631	0.056
77	0.13	0.6250	0.0805	99.686	0.049
78	0.11	0.6067	0.0680	99.730	0.043
79	0.11	0.6689	0.0749	99.775	0.040
80	0.11	1.0344	0.1159	99.840	0.038
81	0.11	0.2412	0.0270	99.855	0.035
82	0.11	0.1827	0.0205	99.865	0.033
83	0.11	0.0585	0.0066	99.868	0.028
84	0.09	0.5848	0.0540	99.891	0.024
85	0.09	0.0731	0.0068	99.894	0.020
86	0.07	0.6396	0.0466	99.912	0.017

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
87	0.07	0.0000	0.0000	99.912	0.016
88	0.07	0.5482	0.0399	99.925	0.015
89	0.07	0.4569	0.0333	99.936	0.014
90	0.07	0.2741	0.0200	99.942	0.013
91	0.07	0.3625	0.0264	99.949	0.012
92	0.07	0.1827	0.0133	99.952	0.010
93	0.06	1.0965	0.0614	99.967	0.008
94	0.06	0.4861	0.0272	99.973	0.008
95	0.06	0.3655	0.0205	99.978	0.006
96	0.04	0.3655	0.0133	99.980	0.004
97	0.04	0.7310	0.0266	99.985	0.004
98	0.04	0.7310	0.0266	99.990	0.003
99	0.02	0.7310	0.0123	99.992	0.002
100	0.02	0.7310	0.0123	99.994	0.002
101	0.02	0.3655	0.0061	99.995	0.001
102	0.02	1.8275	0.0307	99.999	0.001
103	0.02	0.0000	0.0000	99.999	0.001
104	0.02	0.3655	0.0061	100.000	0.001
105	0.02	0.3655	0.0061	100.000	0.001

APPENDIX I

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 36-20°C AND 13 HR PHOTOPERIOD (DATA COMPUTED FROM OBSERVED IMMATURE SURVIVAL AND SEX RATIO FIGURES)

Immature development = 11 days
Immature survival = 34.07%
Females in population = 26.94%

r_m = 0.0794
R_o = 16.5800
T = 35.3817
λ = 1.0826

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
11	0.00	0.0000	0.0000	0.000	0.000
12	0.00	0.0000	0.0000	0.000	0.000
13	0.00	0.0000	0.0000	0.000	0.000
14	0.00	0.0000	0.0000	0.000	4.199
15	0.31	0.0000	0.0000	0.000	7.758
16	0.31	0.0650	0.0203	0.594	7.166
17	0.31	0.1000	0.0313	1.438	6.619
18	0.31	0.5300	0.1657	5.569	6.114
19	0.31	1.2000	0.3751	14.208	5.647
20	0.31	1.1300	0.3532	21.723	5.217
21	0.31	0.6650	0.2079	25.808	4.819
22	0.31	0.8000	0.2501	30.347	4.451
23	0.31	0.7650	0.2391	34.357	4.111
24	0.31	1.1300	0.3532	39.827	3.798
25	0.31	1.1300	0.3532	44.880	3.508
26	0.31	0.7300	0.2282	47.895	3.240
27	0.31	1.0650	0.3329	51.959	2.993
28	0.31	1.0650	0.3329	55.713	2.765
29	0.31	1.0300	0.3220	59.066	2.554
30	0.31	1.1000	0.3439	62.374	2.359
31	0.31	1.0650	0.3329	65.332	2.179
32	0.31	1.6650	0.5205	69.604	2.013
33	0.31	1.1650	0.3642	72.365	1.859
34	0.31	0.8650	0.2704	74.258	1.717
35	0.31	1.5300	0.4783	77.352	1.586
36	0.31	0.7300	0.2282	78.716	1.465
37	0.31	1.1650	0.3642	80.725	1.353

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
38	0.31	1.1300	0.3532	82.526	1.250
39	0.31	1.1000	0.3439	84.146	1.155
40	0.31	1.6000	0.5002	86.321	1.067
41	0.31	0.9300	0.2907	87.489	0.985
42	0.31	1.0650	0.3329	88.725	0.910
43	0.31	1.0000	0.3126	89.796	0.841
44	0.31	0.8650	0.2704	90.653	0.776
45	0.31	1.6000	0.5002	92.115	0.717
46	0.31	1.1300	0.3532	93.070	0.662
47	0.31	0.8000	0.2501	93.694	0.612
48	0.31	0.8650	0.2704	94.317	0.565
49	0.31	1.3300	0.4158	95.203	0.522
50	0.31	0.4650	0.1454	95.488	0.465
51	0.29	0.9650	0.2805	95.998	0.414
52	0.29	0.7500	0.2180	96.364	0.368
53	0.27	1.5000	0.4032	96.989	0.327
54	0.27	0.9250	0.2486	97.345	0.302
55	0.27	0.5000	0.1344	97.523	0.279
56	0.27	0.6900	0.1855	97.749	0.258
57	0.27	0.8850	0.2379	98.018	0.238
58	0.27	0.6900	0.1855	98.211	0.220
59	0.27	0.6900	0.1855	98.390	0.188
60	0.23	0.6800	0.1552	98.528	0.159
61	0.23	1.2500	0.2852	98.762	0.147
62	0.23	3.0000	0.6846	99.281	0.136
63	0.23	0.3650	0.0833	99.340	0.119
64	0.21	0.4500	0.0928	99.400	0.100
65	0.19	0.7200	0.1351	99.481	0.088
66	0.19	0.5000	0.0938	99.533	0.081
67	0.19	0.3300	0.0619	99.564	0.075
68	0.19	0.5000	0.0938	99.608	0.069
69	0.19	0.3300	0.0619	99.635	0.064
70	0.19	0.5550	0.1041	99.677	0.059
71	0.19	0.2200	0.0413	99.693	0.051
72	0.17	0.8750	0.1450	99.742	0.042
73	0.14	0.3550	0.0510	99.758	0.036
74	0.14	0.4300	0.0618	99.777	0.033
75	0.14	0.8550	0.1229	99.810	0.031
76	0.14	0.5000	0.0719	99.828	0.028
77	0.14	0.8550	0.1229	99.856	0.024
78	0.13	0.8300	0.1037	99.878	0.021
79	0.13	0.9150	0.1144	99.901	0.019
80	0.13	1.4150	0.1769	99.933	0.018
81	0.13	0.3300	0.0413	99.940	0.016
82	0.13	0.2500	0.0313	99.945	0.015
83	0.13	0.0800	0.0100	99.946	0.013

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
84	0.10	0.8000	0.0826	99.957	0.011
85	0.10	0.1000	0.0103	99.958	0.009
86	0.08	0.8750	0.0711	99.966	0.007
87	0.08	0.0000	0.0000	99.966	0.007
88	0.08	0.7500	0.0610	99.972	0.006
89	0.08	0.6250	0.0508	99.977	0.006
90	0.08	0.3750	0.0305	99.979	0.005
91	0.08	0.5000	0.0407	99.982	0.005
92	0.08	0.2500	0.0203	99.984	0.004
93	0.06	1.5000	0.0938	99.990	0.003
94	0.06	0.6650	0.0416	99.992	0.003
95	0.06	0.5000	0.0313	99.994	0.002
96	0.04	0.5000	0.0203	99.995	0.002
97	0.04	1.0000	0.0406	99.997	0.002
98	0.04	1.0000	0.0406	99.999	0.001
99	0.02	1.0000	0.0188	100.000	0.001
100	0.02	1.0000	0.0188	100.000	0.001

APPENDIX J

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 36-28°C AND 14 HR PHOTOPERIOD (DATA COMPUTED FROM OBSERVED IMMATURE SURVIVAL AND SEX RATIO FIGURES)

Immature development = 9 days
Immature survival = 31.71%
Females in population = 45.21%

r_m = 0.0729
R_o = 9.6098
T = 31.0479
λ = 1.0756

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
9	0.00	0.0000	0.0000	0.000	0.000
10	0.00	0.0000	0.0000	0.000	0.000
11	0.00	0.0000	0.0000	0.000	3.995
12	0.34	0.0000	0.0000	0.000	7.429
13	0.34	0.0323	0.0110	0.443	6.907
14	0.34	0.2344	0.0799	3.428	6.422
15	0.34	0.2694	0.0918	6.618	5.970
16	0.34	0.3206	0.1092	10.148	5.551
17	0.34	0.4553	0.1551	14.808	5.160
18	0.34	0.5711	0.1946	20.243	4.798
19	0.34	0.8755	0.2983	27.989	4.460
20	0.34	0.6385	0.2175	33.241	4.147
21	0.34	0.7408	0.2524	38.906	3.855
22	0.34	0.8082	0.2754	44.653	3.584
23	0.34	0.5038	0.1716	47.983	3.333
24	0.34	0.4714	0.1606	50.880	3.098
25	0.34	0.8917	0.3038	55.975	2.881
26	0.34	0.8405	0.2864	60.439	2.678
27	0.34	0.7247	0.2469	64.018	2.490
28	0.34	0.6897	0.2350	67.185	2.315
29	0.34	0.6924	0.2359	70.141	2.152
30	0.34	0.6008	0.2047	72.525	2.001
31	0.34	0.8082	0.2754	75.507	1.860
32	0.34	0.6546	0.2230	77.753	1.678
33	0.32	0.7543	0.2416	80.014	1.512
34	0.32	0.8244	0.2641	82.312	1.405
35	0.32	0.7893	0.2528	84.358	1.307

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
36	0.32	0.6816	0.2183	86.000	1.215
37	0.32	0.6816	0.2183	87.527	1.129
38	0.32	0.7004	0.2243	88.986	1.050
39	0.32	0.7355	0.2356	90.410	0.976
40	0.32	0.5927	0.1898	91.477	0.874
41	0.30	0.5388	0.1597	92.311	0.781
42	0.30	0.8082	0.2396	93.475	0.701
43	0.28	0.8297	0.2290	94.510	0.628
44	0.28	0.6223	0.1718	95.231	0.584
45	0.28	0.5604	0.1547	95.835	0.523
46	0.26	0.3125	0.0798	95.124	0.449
47	0.24	0.4176	0.0982	96.456	0.400
48	0.24	0.5873	0.1381	96.889	0.353
49	0.21	0.4580	0.0967	97.171	0.311
50	0.21	0.5388	0.1138	97.480	0.289
51	0.21	0.1886	0.0398	97.580	0.268
52	0.21	0.6196	0.1309	97.887	0.238
53	0.19	0.6277	0.1198	98.148	0.210
54	0.19	0.5846	0.1115	98.374	0.184
55	0.17	0.8082	0.1376	98.633	0.162
56	0.17	0.3475	0.0592	98.727	0.150
57	0.17	0.4041	0.0688	98.849	0.140
58	0.17	0.8971	0.1528	99.080	0.130
59	0.17	0.4472	0.0762	99.187	0.121
60	0.17	0.5388	0.0918	99.307	0.106
61	0.15	0.1536	0.0230	99.335	0.092
62	0.15	0.0781	0.0117	99.348	0.085
63	0.15	0.3071	0.0460	99.397	0.079
64	0.15	0.3071	0.0460	99.442	0.074
65	0.15	0.7301	0.1094	99.541	0.063
66	0.13	0.1778	0.0224	99.560	0.054
67	0.13	0.2694	0.0340	99.587	0.042
68	0.09	0.6735	0.0574	99.629	0.031
69	0.09	0.8082	0.0689	99.675	0.029
70	0.09	0.4041	0.0344	99.697	0.027
71	0.09	0.8082	0.0689	99.738	0.025
72	0.09	0.6061	0.0516	99.766	0.023
73	0.09	0.0673	0.0057	99.769	0.022
74	0.09	1.0776	0.0918	99.812	0.020
75	0.09	0.6061	0.0516	99.835	0.019
76	0.09	0.4714	0.0401	99.851	0.018
77	0.09	1.1449	0.0975	99.888	0.016
78	0.09	0.8082	0.0689	99.912	0.015
79	0.09	0.8082	0.0689	99.935	0.014
80	0.09	0.8082	0.0689	99.956	0.012
81	0.06	0.8971	0.0580	99.972	0.009

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
82	0.06	0.2694	0.0174	99.977	0.009
83	0.06	0.3583	0.0232	99.982	0.008
84	0.06	0.1778	0.0115	99.985	0.007
85	0.06	0.0000	0.0000	99.985	0.007
86	0.06	0.o472	0.0289	99.991	0.005
87	0.04	0.5388	0.0220	99.995	0.004
88	0.04	0.1347	0.0055	99.996	0.004
89	0.04	0.0000	0.0000	99.996	0.003
90	0.04	0.5388	0.0220	99.999	0.002
91	0.02	0.0000	0.0000	99.999	0.001
92	0.02	0.5388	0.0110	100.000	0.001

APPENDIX K

LIFE TABLE AND STABLE AGE DISTRIBUTION OF <u>BRACON KIRKPATRICKI</u> HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 33-14°C AND 12 HR PHOTOPERIOD (DATA COMPUTED FROM POOLED IMMATURE SURVIVAL FIGURE AND ASSUMING 1:1 SEX RATIO)

Immature development = 14 days
Immature survival = 31.25%
Females in population = 50%

r_m = 0.0943
R_o = 16.3629
T = 29.6513
λ = 1.0988

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
11	0.00	0.0000	0.0000	0.000	5.080
12	0.00	0.0000	0.0000	0.000	9.245
13	0.00	0.0000	0.0000	0.000	8.414
14	0.00	0.0000	0.0000	4.000	7.657
15	0.31	0.5000	0.1563	8.371	6.968
16	0.31	0.5950	0.1860	12.686	6.341
17	0.31	0.8450	0.2641	18.262	5.771
18	0.31	1.0600	0.3314	24.628	5.252
19	0.31	1.6250	0.5080	33.510	4.779
20	0.31	1.1850	0.3704	39.404	4.349
21	0.31	1.3750	0.4298	45.628	3.958
22	0.31	1.5000	0.4689	51.807	3.602
23	0.31	0.9350	0.2923	55.312	3.278
24	0.31	0.8750	0.2735	58.297	2.983
25	0.31	1.6550	0.5174	63.435	2.715
26	0.31	1.5600	0.4877	67.843	2.471
27	0.31	1.3450	0.4204	71.301	2.248
28	0.31	1.2800	0.4001	74.296	2.046
29	0.31	1.2850	0.4017	77.032	1.862
30	0.31	1.1150	0.3485	79.193	1.695
31	0.31	1.5000	0.4689	81.838	1.542
32	0.31	1.2150	0.3798	83.788	1.361
33	0.29	1.4000	0.4113	85.710	1.200
34	0.29	1.5300	0.4495	87.621	1.092
35	0.29	1.4650	0.4304	89.287	0.994
36	0.29	1.2650	0.3717	90.595	0.905
37	0.29	1.2650	0.3717	91.786	0.823

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
38	0.29	1.3000	0.3819	92.900	0.749
39	0.29	1.3650	0.4010	93.965	0.682
40	0.29	1.1000	0.3232	94.745	0.597
41	0.27	1.0000	0.2720	95.343	0.523
42	0.27	1.5000	0.4080	96.159	0.459
43	0.25	1.5400	0.3899	96.869	0.403
44	0.25	1.1550	0.2924	97.353	0.367
45	0.25	1.0400	0.2633	97.750	0.321
46	0.23	0.5800	0.1360	97.937	0.270
47	0.22	0.7750	0.1672	98.145	0.235
48	0.22	1.0900	0.2351	98.413	0.203
49	0.19	0.8500	0.1647	98.583	0.175
50	0.19	1.0000	0.1938	98.765	0.159
51	0.19	0.3500	0.0678	98.823	0.145
52	0.19	1.1500	0.2229	98.997	0.126
53	0.18	1.1650	0.2040	99.142	0.109
54	0.18	1.0850	0.1900	99.264	0.094
55	0.16	1.5000	0.2344	99.402	0.080
56	0.16	0.6450	0.1008	99.456	0.073
57	0.16	0.7500	0.1172	99.513	0.066
58	0.16	1.6650	0.2602	99.628	0.060
59	0.16	0.8300	0.1297	99.680	0.055
60	0.16	1.0000	0.1563	99.738	0.047
61	0.14	0.2850	0.0392	99.751	0.040
62	0.14	0.1450	0.0199	99.757	0.037
63	0.14	0.5700	0.0784	99.778	0.033
64	0.14	0.5700	0.0784	99.798	0.030
65	0.14	1.3550	0.1863	99.841	0.025
66	0.12	0.3300	0.0382	99.849	0.021
67	0.12	0.5000	0.0578	99.860	0.016
68	0.08	1.2500	0.0976	99.877	0.012
69	0.08	1.5000	0.1172	99.895	0.011
70	0.08	0.7500	0.0586	99.903	0.010
71	0.08	1.5000	0.1172	99.918	0.009
72	0.08	1.1250	0.0879	99.929	0.008
73	0.08	0.1250	0.0098	99.930	0.007
74	0.08	2.0000	0.1562	99.945	0.007
75	0.08	1.1250	0.0879	99.953	0.006
76	0.08	0.8750	0.0683	99.959	0.006
77	0.08	2.1250	0.1660	99.971	0.005
78	0.08	1.5000	0.1172	99.979	0.005
79	0.08	1.5000	0.1172	99.986	0.004
80	0.08	1.5000	0.1172	99.992	0.003
81	0.06	1.6650	0.0989	99.997	0.003
82	0.06	0.5000	0.0297	99.999	0.002
83	0.06	0.6650	0.0395	100.000	0.002

APPENDIX L

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 36-20°C AND 13 HR PHOTOPERIOD (DATA COMPUTED FROM POOLED IMMATURE SURVIVAL FIGURE AND ASSUMING 1:1 SEX RATIO)

Immature development = 11 days
Immature survival = 31.25%
Females in population = 50%

$r_m = 0.1186$
$R_o = 12.9523$
$T = 21.6033$
$\lambda = 1.1259$

x	l_x	m_x	l_xm_x	Cumulative contribution to r_m (%)	Stable age distribution (%)
9	0.00	0.0000	0.0000	0.000	6.493
10	0.00	0.0000	0.0000	0.000	11.535
11	0.00	0.0000	0.0000	0.000	10.245
12	0.32	0.6194	0.1964	10.184	9.100
13	0.32	0.9042	0.2867	16.698	8.082
14	0.32	0.9585	0.3039	22.831	7.179
15	0.32	2.3464	0.7440	36.166	6.376
16	0.32	1.1574	0.3670	42.009	5.663
17	0.32	2.1475	0.6810	51.637	5.030
18	0.32	1.3292	0.4215	56.930	4.468
19	0.32	1.6456	0.5218	62.751	3.968
20	0.32	1.2704	0.4028	55.742	3.525
21	0.32	2.3193	0.7355	73.213	3.037
22	0.30	1.8400	0.5485	77.500	2.614
23	0.30	1.7180	0.5121	81.056	2.322
24	0.30	2.1384	0.6375	84.986	2.062
25	0.30	1.5643	0.4663	87.540	1.832
26	0.30	1.1122	0.3315	89.152	1.627
27	0.30	0.5696	0.1698	89.886	1.445
28	0.30	1.3834	0.4124	91.469	1.283
29	0.30	1.5055	0.4488	92.998	1.140
30	0.30	1.5055	0.4488	94.357	1.012
31	0.30	1.0534	0.3140	95.201	0.866
32	0.28	1.3247	0.3655	96.074	0.739
33	0.28	0.9675	0.2669	96.640	0.657
34	0.28	1.2930	0.3567	97.312	0.583

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
35	0.28	1.0670	0.2944	97.805	0.518
36	0.28	1.1935	0.3293	98.294	0.460
37	0.28	0.8409	0.2320	98.601	0.409
38	0.28	0.8093	0.2233	98.863	0.350
39	0.26	0.8680	0.2229	99.095	0.300
40	0.26	0.7640	0.1962	99.276	0.267
41	0.26	0.3843	0.0987	99.357	0.237
42	0.26	0.6601	0.1695	99.481	0.202
43	0.24	0.9042	0.2150	99.620	0.158
44	0.20	1.0398	0.2044	99.738	0.127
45	0.20	0.8590	0.1689	99.824	0.113
46	0.20	0.8138	0.1600	99.897	0.086
47	0.14	0.7731	0.1078	99.941	0.063
48	0.14	0.3210	0.0448	99.957	0.052
49	0.12	0.2984	0.0350	99.968	0.032
50	0.06	0.7505	0.0452	99.980	0.016
51	0.04	1.3563	0.0517	99.993	0.011
52	0.04	0.0000	0.0000	99.993	0.010
53	0.04	0.9042	0.0345	100.000	0.004

APPENDIX M

LIFE TABLE AND STABLE AGE DISTRIBUTION OF *BRACON KIRKPATRICKI* HELD UNDER TRUNCATED DAY-NIGHT TEMPERATURE MODEL OF 36-28°C AND 14 HR PHOTOPERIOD (DATA COMPUTED FROM POOLED IMMATURE SURVIVAL FIGURE AND ASSUMING 1:1 SEX RATIO)

Immature development = 9 days
Immature survival = 31.25%
Females in population = 50%

r_m = 0.1233
R_o = 14.1171
T = 21.4793
λ = 1.1312

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
9	0.00	0.0000	0.0000	0.000	6.746
10	0.31	0.0000	0.0000	0.000	11.927
11	0.31	0.6250	0.1954	5.356	10.544
12	0.31	0.6850	0.2141	10.545	9.321
13	0.31	1.0000	0.3126	17.242	8.240
14	0.31	1.0600	0.3314	23.518	7.285
15	0.31	2.5950	0.8112	37.100	6.440
16	0.31	1.2800	0.4001	43.023	5.693
17	0.31	2.3750	0.7424	52.738	5.033
18	0.31	1.4700	0.4595	58.053	4.449
19	0.31	1.8100	0.5658	63.840	3.933
20	0.31	1.4050	0.4392	67.810	3.477
21	0.31	2.5650	0.8018	74.219	2.982
22	0.29	2.0350	0.5979	78.443	2.554
23	0.29	1.9000	0.5582	81.930	2.258
24	0.29	2.3650	0.6948	85.767	1.996
25	0.29	1.7300	0.5083	88.248	1.765
26	0.29	1.2300	0.3614	89.807	1.560
27	0.29	0.6300	0.1851	90.513	1.379
28	0.29	1.5300	0.4495	92.029	1.219
29	0.29	1.6650	0.4892	93.488	1.078
30	0.29	1.6650	0.4892	94.777	0.953
31	0.29	1.1650	0.3423	95.575	0.811
32	0.27	1.4650	0.3985	96.396	0.689
33	0.27	1.0700	0.2910	96.926	0.609
34	0.27	1.4300	0.3890	97.552	0.539

x	l_x	m_x	$l_x m_x$	Cumulative contribution to r_m (%)	Stable age distribution (%)
35	0.27	1.1800	0.3210	98.009	0.476
36	0.27	1.3200	0.3590	98.461	0.421
37	0.27	0.9300	0.2530	98.742	0.372
38	0.27	0.8950	0.2434	98.981	0.318
39	0.25	0.9600	0.2431	99.193	0.271
40	0.25	0.8450	0.2140	99.357	0.239
41	0.25	0.4250	0.1076	99.430	0.212
42	0.25	0.7300	0.1848	99.541	0.180
43	0.23	1.0000	0.2344	99.666	0.140
44	0.19	1.1500	0.2229	99.770	0.112
45	0.19	0.9500	0.1841	99.847	0.099
46	0.19	0.9000	0.1744	99.911	0.075
47	0.14	0.8550	0.1176	99.949	0.055
48	0.14	0.3550	0.0488	99.963	0.045
49	0.12	0.3300	0.0382	99.972	0.027
50	0.06	0.8300	0.0493	99.983	0.013
51	0.04	1.5000	0.0563	99.995	0.009
52	0.04	0.0000	0.0000	99.995	0.008
53	0.04	1.0000	0.0375	100.000	0.004

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