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SURVEY OF THE REGION OF I LACERTA

BY

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GODDARD SPACE FLIGHT CENTER

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SURVEY OF THE REGION OF I LACERTA

INTRODUCTION

The following is a final report on that part of research under grant NsG-670 entitled, "Studies in the O-B Association I Lacerta."

Evolutionary effects in the region of the O-B Association I Lacerta have been investigated by Blaauw (1958). He noted that the region between α (1900) = 22^h 26^m and 22^h 46^m and δ(1900) = +36° and +41° contained most of the O-B stars, and he referred to this as the most concentrated region of the association. Examining the distribution of association members in the spectral range 09 to B3, he found that the 09 to B1 stars are present only in the most concentrated region of the association. In addition, the B stars in the dispersed area of the association are systematically brighter than those in the concentrated area. Blaauw's suggestion that the B stars in the dispersed area are slightly evolved is corroborated by Crawford's (1961) Hβ photometry of eighteen B2 to B3 stars in the dispersed area.

The purpose of the present study is to determine the distribution of spectral types A0 and later in the region of the association I Lacerta, to see if there is any clustering and to determine the relative distributions in the concentrated area as compared to the dispersed area. Hardie and Seyfert (1959) observed seventy-seven B5 to A7 stars in the concentrated area of the association. Most of the A stars (37 of 43) lie above the zero age main sequence. No velocities are available for these stars, and they were selected as possible members because of their presence in the concentrated area of the association. Therefore, the A stars above the main sequence may simply be foreground stars and may not indicate an evolutionary effect. From Hβ photometry of 16 of the Hardie and Seyfert stars, Crawford (1961) concludes that 9 of 11 stars above the main sequence are probably non-member foreground stars.

OBSERVATIONS

The region investigated is indicated by the areas enclosed in the solid lines in Figure 1. The total area of the sky covered is 91.42 square degrees. The concentrated area of the association as defined by Blaauw is indicated on Figure 1 and corresponds almost exactly to our Area A. Photographic magnitudes and spectral classifications were assigned for virtually all stars with $8.5 < m_{pg} < 13.0$ in areas A, B and C. In a few cases it was not possible to measure double stars because of their proximity to one another. For a majority of the stars observed, neither proper motions, radial velocities or distances are available; hence it is not possible to determine membership. Should the present study reveal any clustering or significant density variations between the concentrated and dispersed areas of the association for stars of a given spectral class, then subsequent studies would be required to determine membership for these select groups of stars. The distance modulus of I Lacerta is variously given as $8\overset{m}{.}3$ (Morgan, Whitford and Code 1953), $8\overset{m}{.}4$ (Hardie and Seyfert 1959), $8\overset{m}{.}6$ (Blaauw 1958). If we take a distance modulus of $8\overset{m}{.}4$, then an A0 star on the zero age main sequence will have $m_{pg} \cong 9\overset{m}{.}8$ and a G0 will have $m_{pg} \cong 13\overset{m}{.}7$, these

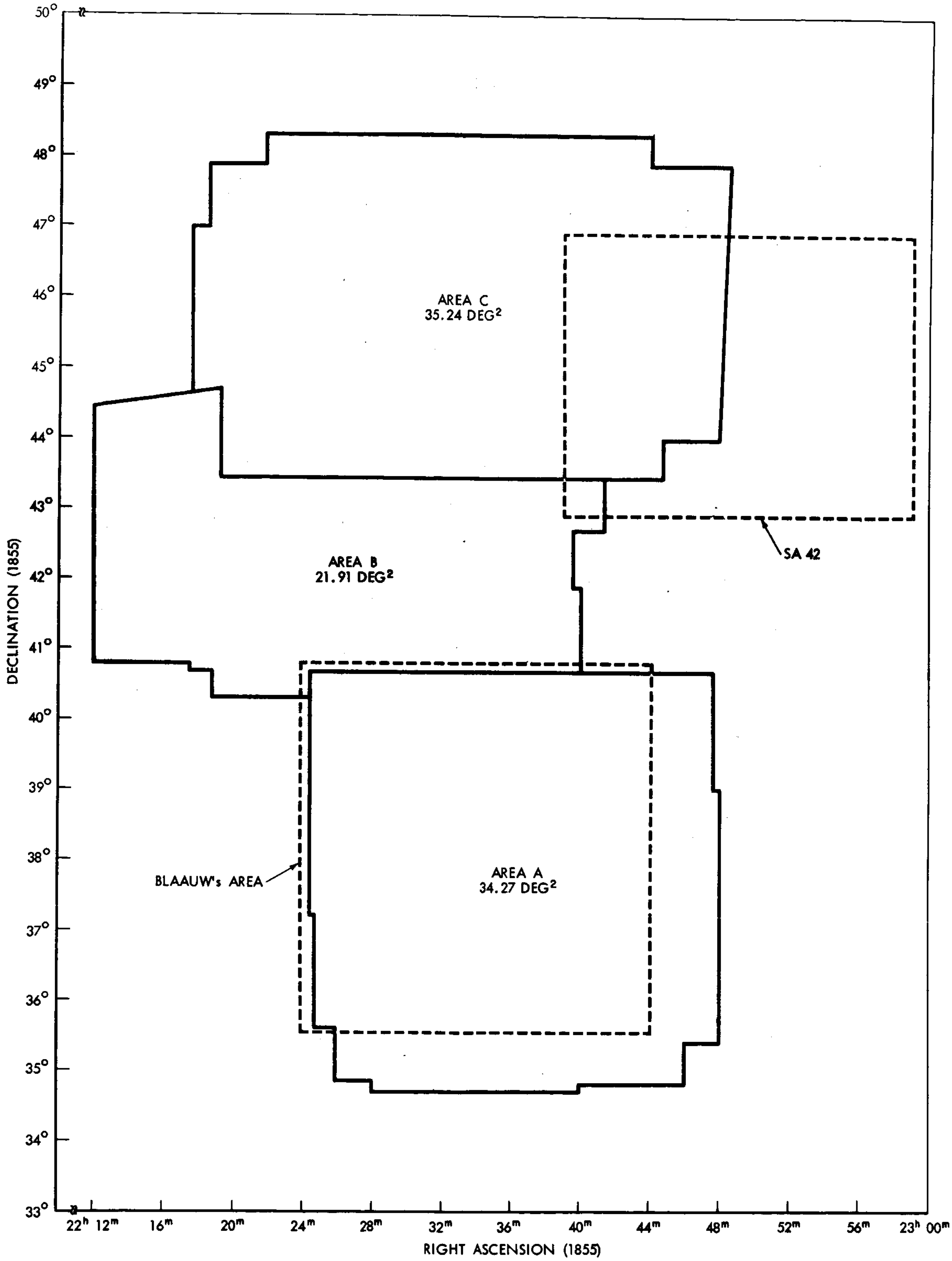

Figure 1. I Lacerta, Areas Surveyed

magnitudes being corrected for absorption. A reasonable mean value for the total visual absorption to the association is about $0^m.3$ (Blaauw and Morgan 1953, Hardie and Seyfert 1959). The magnitude range of this survey will, therefore, cover main sequence stars earlier than approximately F5 at the distance of the association.

Spectral classes were determined by using color-equivalents according to the Tikhoff method (Tikhoff 1937). This is a method of out-of-focus photography for obtaining the spectrum of a star as a continuous series of concentric rings of varying density. The 16-inch Metcalf refracting telescope of the Agassiz Station of Harvard College Observatory, which has large chromatic aberration, was used for obtaining this plate material. An opaque occulting disk, eight inches in diameter, was placed over the center of the objective lens so that an out-of-focus image appears as an annulus. For light of a given wavelength the radius of the annulus is proportional to the diameter of the occulting disk and the distance of the plate from the true focus for that particular wavelength. The telescope was focused for blue light and Kodak 103 a E emulsions were used. This emulsion has a greater sensitivity to red light and has a decrease in sensitivity between λ5000 -5500 Å, which helped in the separation of the blue and red light. A B star appears, therefore, as a bright central dot (representing the blue light) with a much less dense cloud about the dot (representing the red light); a K star appears as a dense ring. By the general appearance of the Tikhoff images and particularly by estimates of the relative densities from the center to the edge of the image it is possible to classify a star. Standards for this classification were taken from Kapteyn's Selected Area 42 which overlaps the region under investigation as indicated in Figure 1. The Bergedorfer Spektraldurchmusterung gives spectral classes for all stars with $m_{pg} < 12.5$. A comparison of the Bergedorfer, Henry Draper and MK spectral classifications is given in Table 1. The B-V colors there are from Harris (1963). All stars were, therefore, classified by comparing their Tikhoff images with Tikhoff images of stars of about the same magnitude for which objective prism classifications are available in the Bergedorfer Spektraldurchmusterung. Reddening corrections have not been applied. Judging from the data given by Harris (1955) and Hardie and Seyfert (1959), reddening does not vary smoothly with position in I Lacerta, although Johnson (1953) indicates that the color excess is uniform within three degrees of 10 Lac [$22^h\ 32^m.8$, $+38°\ 22'$ (1855)]. In addition to apparent variation of reddening within the association, there exists the further problem that a given star in the field may not be at the distance of the association and hence undergoes an unknown amount of reddening. If we assume that the amount of reddening forms a random distribution about some mean value and that, for a large sample, fluctuations will average out, then one can apply a uniform reddening for all stars of a given magnitude and color, since such stars are on the average at the same distance. This is essentially what we have done in determining spectral classes directly from Tikhoff images. In other words, if all stars of a given magnitude and color, including the standard stars in SA 42, have exactly the same color excess, then the classification of all stars by comparison of their Tikhoff images with the Tikhoff images of standard stars would give a color-corrected classification. Also since the measured stars have not always been of exactly the same magnitude as the standard stars to which they were compared, we assume that there is no large variation of color with luminosity class for stars of a given spectral class. Altogether four 8 x 10 inch plates of Tikhoff images cover the total area surveyed. SA 42 overlaps with but one of these plates. Transfers, therefore, had to be made to the other plates by using secondary standards.

In order to estimate the accuracy of the classifications in the area which overlaps directly with SA 42, classifications of 128 standards in SA 42 were made from their Tikhoff images and the differences from the Bergedorfer classifications were determined. No systematic difference was detected. From these measurements we find that a probable error of 3.5 subclasses is associated with the determination of spectral classes from the Tikhoff images, where the probable error is defined as

$$0.6745 \left(\sum \frac{\Delta^2}{n} \right)^{\frac{1}{2}}$$

where Δ is the difference between the Bergedorfer classifications and that from the Tikhoff images. Since four plates of Tikhoff images were used, only one of which overlaps with SA42, there were three transfers for which secondary standards were used. In order to estimate the accuracy of these transfers, 30 stars on the average in the overlap region for each pair of overlapping plates were measured and the difference in the classification on the separate plates determined. In no case was there a systematic difference greater than one subclass. This measure of systematic difference was taken as $\sum \frac{\Delta}{n}$, where Δ is the difference in the classification on the two separate plates, and n the number of stars measured in the overlap region. The average probable error associated with these transfers is 3 subclasses, the largest probable error 3.2 subclasses. The probable error for each of the individual transfers is given in Table 2.

In addition 1,524 stars scattered over the entire area of the survey were classified by two independent observers. The probable error determined from the residuals of the two classifications is 3.4 subclasses. No systematic difference was detected. The comparison of the classifications of these two independent observers for each of the areas A, B and C (see Figure 1) is given in Table 3. In no case was a trend of residuals with spectral classes detected. Table 3 is a further indication that there is no loss in accuracy by transfers from plate to plate. The probable error, therefore, of the tie-in to the Bergedorfer classification system is about 3 subclasses for the total area of the sky surveyed.

Hardie and Seyfert have assigned MK spectral types to 77 A and B stars in our area A. A comparison between their MK classification and our Tikhoff classification is given for 52 of these stars in columns two and three of Table 4. The remainder of Table 4 concerns photometry and will be referred to later. It is not possible from the Tikhoff images to distinguish between spectral types earlier than B9. Our classification "B", therefore, refers to all stars earlier than A0. Now the Tikhoff classifications in area A are the result of three transfers over paired plates. Table 4 shows that this transfer is accurate with the probable error quoted and that the assumption of uniform reddening, at least for these early type stars is valid. Unfortunately MK classifications of later type stars in this field and in the magnitude range of our survey are not now available.

Magnitudes for virtually all stars were determined from photometric measurements of images on plate reproductions of the Palomar Sky Survey with the Cuffey-type astrophotometer of GSFC. Magnitudes for a few stars which had nonmeasurable images on the Palomar plates were determined by eye estimates of the images on the Tikhoff plates.

The astrophotometer used was built for GSFC by Astro Mechanics, Inc., of Austin, Texas, and is a precision instrument designed to measure star brightness directly from stellar photographic plates. It is a double beam design with null balance (see Optical Schematic, Figure 2). The measuring beam passes through a slit, a collimating lens, an iris diaphragm and an objective lens (lower objective) which forms an image of the iris on the emulsion surface of the stellar plate. This image of the iris on the photographic plate is picked up by an upper objective lens and is projected on the viewing screen by means of a beam splitter. Part of the measuring beam striking the beam splitter passes through to the condensing lens, then through the mechanical chopper, and strikes the

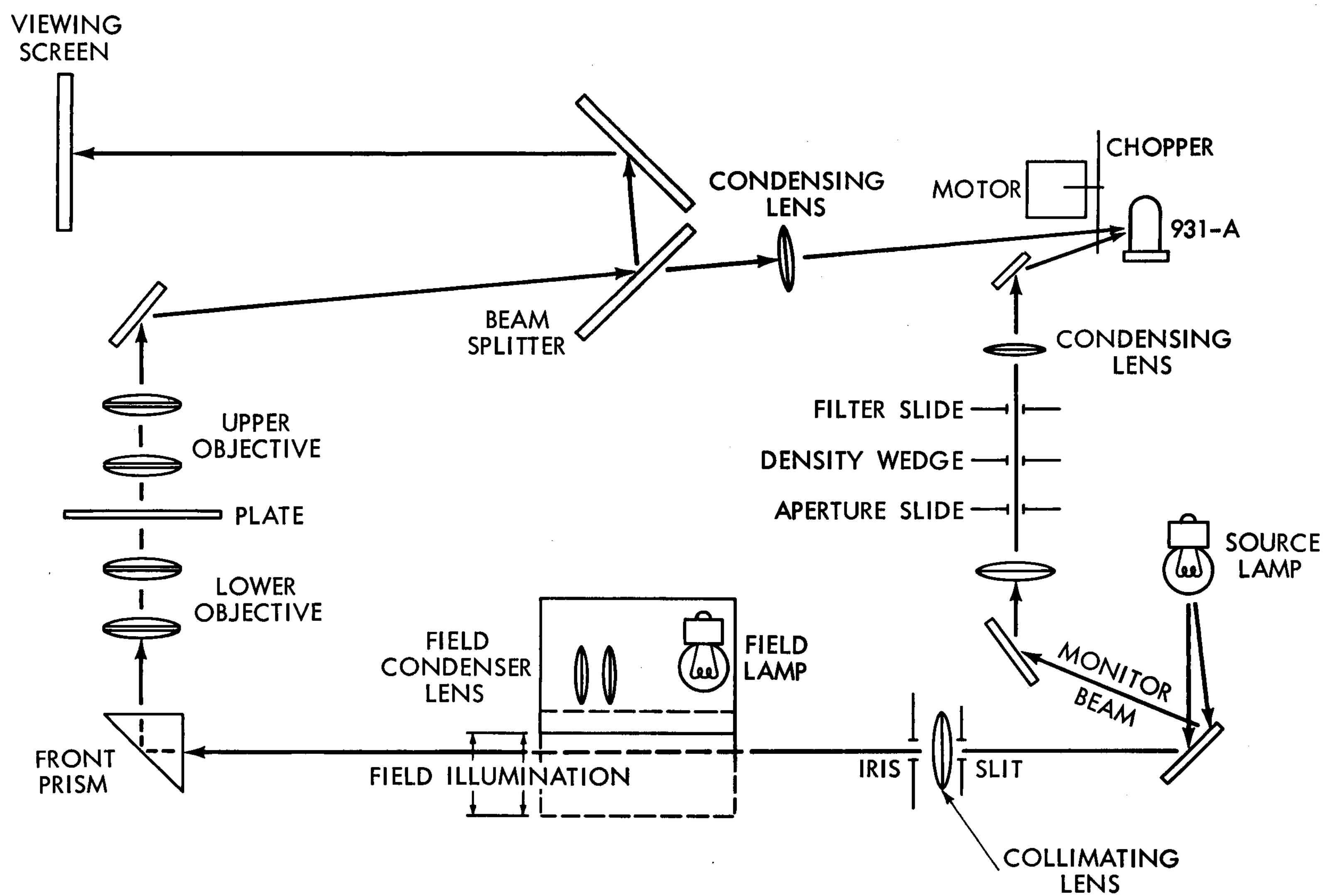

Figure 2. Optical Schematic of Astrophotometer

upper half of the photomultiplier cathode. For inspection, identification and centering of a star image, a sizable area of the star plate may be viewed by shifting the beam from the field lamp into the path of the measured beam, which illuminates the area (of the star plate) centered between the upper and lower objectives. When the field beam is moved out of the path of the measuring beam, the viewer sees only the field area controlled by the iris for a single star measurement.

The monitoring beam emitted by the source lamp is attenuated by a filter slide having two fixed density plates and by a variable density wedge. Six apertures in a linear slide plate control the spot size of the monitoring beam. This beam passes through two lenses and the mechanical chopper to the lower portion of the photomultiplier cathode described above. The output of the photomultiplier is then fed to the amplifier and null meter. The iris aperture, which is the essential measuring element, can be varied from a diameter of about 0.040 to 1.35 inches. When the measuring beam is balanced to the same intensity as the monitoring beam, a reading of the iris aperture is taken by means of the counter located below the viewing screen.

Since we wish to compare our star counts in given spectral class and magnitude intervals with counts available in the Bergedorfer Spektraldurchmusterung for nearby areas of the sky, we have standardized our magnitudes to those of the Bergedorfer Spektraldurchmusterung for SA 42. The Bergedorfer magnitudes are on the International Photographic System. A comparison of the

Bergedorfer to the Henry Draper and Mt. Wilson Catalogs is given in Table 5. This is taken from Van Rhijn (1938). Altogether reproductions of five Palomar plates were required to cover the area of our survey. The distribution of these plates over the area of the survey is shown in Figure 3. A list of these plates is given in Table 6. As can be seen in Figure 3, Palomar plate 537 overlaps SA 42 and also overlaps with all other Palomar plates used in this survey. Thus the following procedure was used for transferring the magnitude sequence from SA 42 over the total area of our survey. Photometric measurements were made on Palomar plate 537 of a total of 386 stars which are in Selected Area 42 and have magnitudes in the Bergedorfer catalog. The relationship of these photometric measurements to the Bergedorfer magnitudes was determined. The distribution of these stars according to spectral class is given in Table 7. Separate solutions were made for the relationship of Bergedorfer magnitudes to photometric measurements for these different spectral class intervals, and there was no evidence of a dependence on spectral class. On the other hand there does exist a magnitude dependence, and it was found that the best calibration was obtained by two straight line solutions: one for $m_{pg} \geq 9.5$; one for $m_{pg} < 9.5$. Accordingly, least squares solutions yielded the following relationships of the photometric readings on Palomar plate 537 to the Bergedorfer magnitudes, m_{pg}:

$$m_{pg} = 0.006168\ pr_{238} - 9.939, \quad m_{pg} \geq 9.5$$

$$m_{pg} = 0.00347\ pr_{537} - 1.152, \quad m_{pg} < 9.5$$

The probable error associated with the determination of magnitudes from these

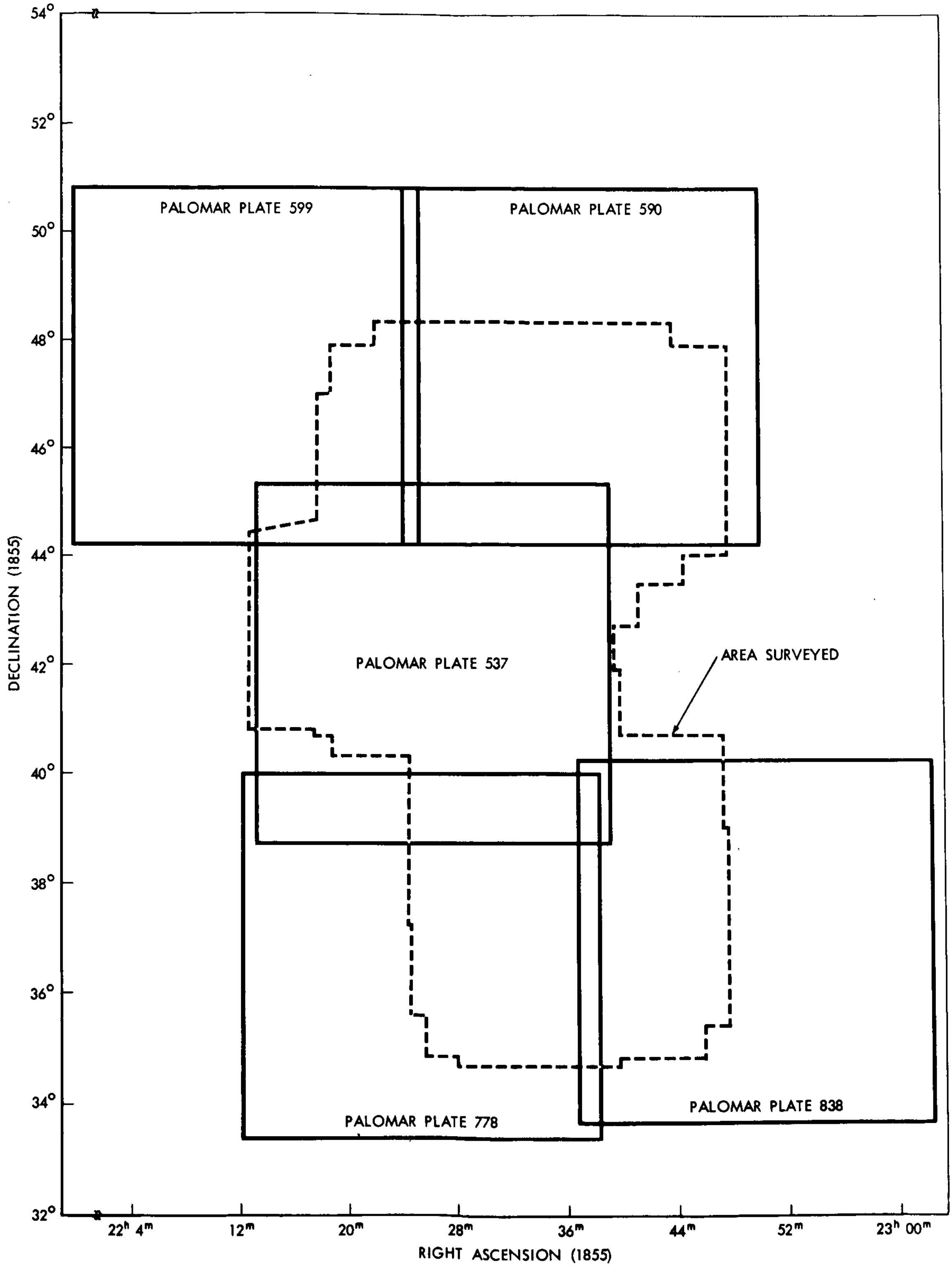

Figure 3. Location of Palomar Plates

equations is $0^{m}.101$. Furthermore, the photometric readings on all other plates were reduced to photometric readings on Palomar plate 537 by measures of stars in the overlap region of each of the other Palomar plates with Palomar plate 537. This was done separately for each of the other four plates. A straight line solution was found for the relationship of the readings on each of the plates to the readings on Palomar plate 537. Table 8 contains the data on these transfers. The probable error listed there in column three is obtained from the equation

$$0.6745 \sum \left(\frac{\Delta^2}{n}\right)^{\frac{1}{2}}$$

where Δ is the residual, the observed—computed photometric reading. The equation above is multiplied by the factor 0.006168 to put it on a magnitude scale. In the course of this investigation the astrophotometer was returned to the shop for repairs. Approximately 35% of the photometric measurements were made before this time. The measurements before and after these repairs were made by two different observers and in the course of the repairs the scale factor of magnitudes per unit photometer reading was decreased by a factor of 2 or 3. Essentially, therefore, we have two different photometric systems. From a group of 72 stars measured on both systems, a straight line conversion was found. The associated probable error for this transfer is $0^{m}.084$.

It is to be noted that the plates of the Palomar Sky Survey do not overlap by more than about $0^{\circ}.6$ or about 3.2 cm. The plate transfers necessarily had to be done, therefore, near the plate edge. The following test for a distance-from-center effect on the photometry was made. Palomar plate 590 is the only one which overlaps sufficiently with SA 42 so that a group of standard stars is available both towards the center and towards the edge of the plate. Therefore, a photometric equation relating m_{pg} to photometric readings was determined separately for two groups of stars defined by the parameters given in Table 9. The photometric equations were identical within the accuracy of the photometry. Our conclusion is that the average probable error to be associated with the magnitude measurements in this survey is approximately $0^m.100$.

Photoelectric magnitudes have been determined for a select number of stars in our area A by Hardie and Seyfert (1959). In Table 4 we have a comparison of their V magnitudes to V magnitudes determined from our photometry. Column five lists our V magnitudes determined by the following equation (Allen, 1963):

$$V = m_{pg} - (B-V) + 0.11$$

Column six lists the Hardie and Seyfert magnitudes uncorrected for absorption, column seven the Hardie and Seyfert magnitudes corrected for absorption. The differences support the quoted probable error of our photometry, $0^m.100$. It is to be recalled that these stars are at the bottom of the area that we have surveyed and that the photometry has involved transfers from SA 42 at the top of the area surveyed.

RESULTS

The results of this survey are presented in Tables 10-16. The format of each of these tables is an array giving counts of stars for each half-magnitude interval (ordinate) and spectral class intervals of 5 subclasses (abscissa). The dotted line which runs horizontally through each array indicates the limiting magnitude of this survey. The boxes in each array indicate the approximate location of the zero-age main sequence for each spectral class interval. The information used for drawing these boxes is given in Table 17. In this table for each spectral class listed in column one, the color and absolute visual magnitudes for the zero age main sequence are given in columns two and three, respectively. These are taken from Blaauw (1963). The corresponding apparent photographic magnitude for main sequence stars is listed in column four and determined in the following manner. We adopt a distance modulus of $m_v-M_v = 8\overset{m}{.}4$ and a total photographic absorption of $A_{pg} = 0\overset{m}{.}4$. We then determine m_{pg} from the following equation taken from Allen (1963):

$$m_{pg} = m_v + (B-V) - 0.11 + A_{pg}$$

Table 10 gives the raw counts for the number of stars in each of the respective areas A, B and C (see Figure 1). Tables 11 to 13 give the number of stars per 12.25 deg^2 for each of these areas. The normalization factor of 12.25 deg^2 was selected for convenient comparison to counts in the Bergedorfer Spektraldurchmusterung. In Table 14 we list the ratio of the counts in area A to the counts in area B, and in Table 15 the counts in area A to the counts in area C as these are listed in Tables 11 to 13. In Table 16 we list the ratio of the counts in area A to the average of the counts in areas B and C. In each of the Tables 14, 15 and 16 we have used the following notation to facilitate analysis. To the left of each column we make the following designations:

- if the ratio is less than 0.5

+ if the ratio is greater than 1.5

0 if the raw counts for each of the areas included in the ratio is greater than 5 stars and the ratio < 0.5 or > 1.5

An examination of Tables 14, 15 and 16 leads to the following conclusions concerning the relative distributions in area A, which is almost coincident with Blaauw's concentrated area, and areas B and C, in the dispersed area of the association. Area A shows a deficiency of bright B stars and an excess of faint B stars with respect to areas B and C. If our estimate is correct that a B9V star in the association will have $m_{pg} = 9^{m}.67$, then the deficiency of bright B stars occurs on or about the main sequence, the excess about a magnitude or so below the main sequence. This is difficult to understand. There are various possible explanations. The main sequence may occur at fainter magnitudes than we have estimated. If this is the case the respective counts in areas A, B and C would tend to corroborate Blaauw's evolutionary hypothesis (Blaauw 1958) that the bright stars in the dispersed area of the association have evolved off the main sequence. The effect, on the other hand, may actually represent the distribution of foreground stars. Another possibility is that a significant proportion of the stars classified as B may actually be early A type stars. A comparison of columns two and three of Table 4 tends to support this possibility. As mentioned previously, the classification "B" indicates all stars earlier than A0. The probable error for the classification of late B and early A stars is about 3.5 subclasses. If this last alternative is the true one, then area A has with respect to areas B and C an excess of early A stars on and slightly below the main sequence and a deficiency of A stars above the main sequence. Even independently of this alternative being true, area A already shows an excess of A stars below the main sequence. Indeed the excess of A stars near the main sequence in area A appears to extend to late A and early F stars. This is, at least in appearance, the same evolutionary trend discussed by Blaauw for O and B stars, namely, that the concentrated part of the association contains a larger number of main sequence stars. This trend appears to extend now to A and perhaps early F stars. We must emphasize that this is only an apparent effect. Further observation, especially of distances, radial velocities and proper motions, will be necessary in order to determine whether this is a true effect within the association or whether it is simply attributable to distributions among the field stars. What we have concluded thus far in comparing area A to areas B and C taken together appears to be independently true for each of the areas B and C. In other words, the trends which appear for the B to F4 stars in Table 16 appear likewise in Tables 14 and 15.

The only conclusions we would wish to draw with respect to spectral types later than F4 is that area C with respect to the rest of the area surveyed has a deficiency of F5 to F9 stars in the magnitude range $11\overset{m}{.}0$ to $12\overset{m}{.}5$ and an excess of stars later than K0 and fainter than $10\overset{m}{.}0$. These are undoubtedly effects in the distribution of the field stars.

We wish now to compare the counts in our areas to those in Selected Areas (SA) 43 and 67. The galactic coordinates for the center of each of our areas A, B and C and for SA 43 and 67 are given in Table 18. The counts for SA 43 and 67, reproduced from the Bergedorfer Spektraldurchmusterung are given in Tables 19 and 20. These are to be compared to our Tables 11, 12 and 13. We see that for the total area of our survey there is an excess of A0 to A4 stars, the counts being on the average two to three times the counts in SA 43 and three times the counts in SA 67 in the range $10\overset{m}{.}5 < m_{pg} < 12\overset{m}{.}0$. The most outstanding feature, however, is the great paucity of stars later than F5 and fainter than about $m_{pg} = 9\overset{m}{.}5$. This paucity of stars later than F5 is even quite clear when comparison is made to SA 67 which is ten degrees or more further from the galactic plane than the areas of our survey.

In fact, if we compare counts in our area A, which is centered at $\ell_{II} = 95°$, $b_{II} = -17°$, to counts in the Bergedorfer catalog for a galactic latitude zone of $-15°$, which includes counts from SA 20, 21, 22, 42 and 43 and extends from $\ell_{II} = 102°$ to $143°$, we find the same evidence for a lack of late type stars in area A. This is indicated in Table 21 where we have listed the ratio of the counts in area A to those in the galactic latitude zone, $b_{II} = -15°$. The same trend is indicated for our areas B and C.

The tentative conclusions that we have drawn with respect to the clustering of A stars near the main sequence in area A suggests that, among the several further observational problems indicated by this survey, studies be first made of area A which would include the following:

1. Objective prism classification of all A stars.
2. Magnitude determinations of these A stars either photoelectrically or, if this were not feasible, photographically using a good photoelectric sequence.
3. Radial velocity determinations using, perhaps, the Fehrenbach prism method.
4. Proper motions. First epoch plates 30 to 40 years old are, we believe, available in the Harvard College Observatory Plate Library.

Our counts (see Table 10) indicate that area A contains a total of 397 A stars in the range $9^{m}_{.}0 < m_{pg} < 13^{m}_{.}0$. Hopefully the projected study would determine association membership and provide a clearer picture of the dwarf A star population in I Lacerta.

The authors wish to express their gratitude to Harvard College Observatory for the use of plate material, and in particular to M. Kaufman. We also thank L. Hooper, S. Duck and D. Morrison at GSFC for assistance in this work.

Table 1
Comparison of Spectral Classification Systems

Bergedorfer	HD	MK	B-V (main sequence)
A0	A0	A0	0.00
A2	A2	A2	0.06
A6	A5	A5	0.15
A8	A8	A8	0.25
F0	F0	F0	0.33
F2	F2	F2	0.38
F4	F4	F5	0.45
F7	F8	F8	0.53
G0	G0	G0	0.60
G1	G2	G2	0.62
G3	G5	G6	0.65
G6	G8	G8	0.70
G8	K0	K0	0.72
K0	K2	K3	0.81
K4	K5	K5	1.08

Table 2
Plate Transfers for Spectral Classification
from Tikhoff Images

Transfer from	Number of stars in overlap region	Probable error (subclasses)
Area C to B	30	3.2
Area B to A	29	2.9
Top to Bottom of Area A	38	2.9

Table 3
Comparison of the Classifications of Two Independent Observers
Listed by Areas

Area	Number of stars measured by two observers	Probable error (subclasses)
A	128	3.0
B	46	3.4
C	1350	3.5

Table 4
Comparison of Our Spectral Classification and
Photometry with Hardie and Seyfert

BD Number	MK Sp	Tikhoff Estimate	(Coyne) m_{pg}	V	(Hardie and Seyfert) V	Vo
35°4851	A0	A0	11.28	11.39	11.28	10.9
36°4863	A2	B	9.55	9.60	9.11:	8.8:
36°4864	A1	A2	10.51	10.59	10.55	9.5
36°4868	B9	B	10.34	10.51	10.50	10.1
36°4869	A1	B	10.19	10.27	10.01	8.8
36°4871	A1	B	9.75	9.83	9.74	9.2
36°4881	A3	B	10.09	10.11	10.06	9.5
36°4884	B9	B	10.17	10.34	10.40	9.9
36°4896	A1	B	9.77	9.85	9.68	9.4
36°4910	A0	B	9.70	9.81	9.88	9.6
36°4912	A0	B	10.14	10.25	10.24	9.9
36°4917	A5	B	9.63	9.59	9.80:	9.5:
36°4922	B8	B	9.40	9.60	9.24	8.9
36°4930	B9	B	10.42	10.59	10.24	9.7
36°4932	A3	B	9.65	9.67	9.10	8.4

Table 4 (Continued)
Comparison of Our Spectral Classification and Photometry with Hardie and Seyfert

BD Number	MK Sp	Tikhoff Estimate	(Coyne) m_{pg}	(Coyne) V	(Hardie and Seyfert) V	(Hardie and Seyfert) Vo
37°4598	B7	A3	9.92	10.15	10.15	9.8
37°4607	A3	A0	10.64	10.66	10.97	10.7
37°4626	A5	B	10.48	10.44	10.85	10.8
37°4627	A5	A0	10.76	10.72	10.82	10.5
37°4632	A0	B	9.53	9.64	9.84	9.6
37°4635	A3	B	10.40	10.42	10.50	9.9
37°4636	A0	B	9.72	9.83	10.09	9.8
37°4637	A2	B	9.71	9.76	9.51	8.7
37°4638	A0	B	10.46	10.57	10.70	10.2
37°4640	A1	B	9.77	8.85	9.97	9.7
37°4648	B8	B	9.70	9.90	9.77	9.4
37°4650	A1	A2	9.69	9.77	9.92	9.5
37°4654	A0	B	9.96	10.07	10.24	10.0
37°4655	A6	A5	9.51	9.45	9.66	9.4
37°4659	B8	B	9.73	9.93	10.14	9.8
38°4786	A0	B	9.60	9.71	9.59	9.4
38°4833	A5	A0	9.50	9.46	9.12	8.9
38°4834	B9	B	9.71	9.88	9.58	9.2
38°4837	A0	B	10.77	10.88	10.76:	10.3:
38°4849	B7:	B	9.11	9.34	8.66	8.3
38°4852	B9	B	9.66	9.83	9.08	8.6
38°4859	A0	A0	9.67	9.78	9.60	9.2
38°4883	B8	B	9.61	9.81	9.48	9.1
39°4861	A5	A0	10.5	10.46	10.92	10.9

Table 4 (Continued)
Comparison of Our Spectral Classification and
Photometry with Hardie and Seyfert

BD Number	MK Sp	Tikhoff Estimate	(Coyne) m_{pg}	(Coyne) V	(Hardie and Seyfert) V	(Hardie and Seyfert) Vo
39°4862	B9	A7	9.40	9.57	9.76	9.4
39°4868	A3	B	9.2	9.22	9.61	9.5
39°4886	B7	B	8.18	8.41	8.52	8.2
39°4890	B8	A0	9.23	9.43	9.49	9.3
39°4894	A2	B	9.15	9.20	9.03	8.8
39°4907	B9	A0	9.62	9.79	10.13	9.9
39°4917	A1	B	9.71	9.79	9.94	9.7
39°4920	B8	A0	9.68	9.88	9.94	9.6
39°4926	B8p	B	9.42	9.62	9.28	8.6
39°4943	A1	B	10.03	10.11	9.99	9.9
39°4945	B8::	A0	11.27	11.47	11.44:	11.2:
40°4845	B7	B	8.94	9.17	9.09	8.7
40°4922	A5	A2	10.83	10.79	10.48	10.1

Table 5
Comparison of Photographic Magnitude Systems

m_{pg} (Bergedorfer)	Δm (Mt. Wilson - Bergedorfer)	Δm (HD - Bergedorfer)
<10.0	+0.25	+0.22
10.0 - 11.0	+0.03	+0.12
11.0 - 12.0	+0.01	+0.02
>12.0	-0.01	+0.06

Table 6
List of Palomar Plates Used

Palomar Plate Number	Plate Center (1855)	
	α	δ
599	$22^h\ 06^m$	+48°
590	22 40	48
537	22 30	42
778	22 24	36
838	22 52	36

Table 7
Distribution by Spectral Type of Stars
Used in Photometric Calibration

Spectral Class	Number of Stars in SA 42 Used for Calibration
Earlier than A0	24
A0 - A4	44
A5 - F5	61
F5 - G5	167
Later than G5	90
Total	386

Table 8
Data for Transfer of Photometric Measurements on Palomar Plates

Palomar Plate Number	Number of stars measured in overlap with P. P. 537	Probable error (photographic magnitudes)
599	46	$0\overset{m}{.}083$
590	30	0.115
778	47	0.113
838	47	0.077

Table 9
Groups of Stars Used for Investigation
of Edge Effect in Photometry

Group	Number of Stars	Distance from Plate Center (Degrees)	Distance from Edge		Area Deg^2
			Deg	Cm	
One	24	2.0	2.0	10.7	0.5
Two	16	3.5	0.4	2.1	0.5

Table 10
Counts of Stars in Respective Areas of I Lacerta

AREA A

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4	1								
8.5– 8.9	2								
9.0– 9.4	9	3	2				2		
9.5– 9.9	44	17	8	1	3	3	7		3
10.0–10.4	43	19	4	12	6	14	11	8	2
10.5–10.9	26	59	28	19	16	15	32	8	4
11.0–11.4	10	74	35	31	25	24	33	18	9
11.5–11.9	2	67	37	16	41	45	46	27	9
12.0–12.4		25	17	14	18	24	37	14	11
12.5–12.9			2	1	4	8	15	12	5
13.0–13.4						1	1	5	1
13.5–13.9							1		
TOTAL	137	264	133	94	113	134	185	92	44

1196

Table 10 (Continued)
Counts of Stars in Respective Areas of I Lacerta

AREA B

	B	A0-A4	A5-A9	F0-F4	F5-F9	G0-G4	G5-G9	K0-K4	K5-
8.0- 8.4									
8.5- 8.9	3	1		1	1				
9.0- 9.4	17	4	2	2		1	2		
9.5- 9.9	34	13	5	6	11	6	10	4	
10.0-10.4	12	29	7	7	9	2	14	7	7
10.5-10.9	7	41	14	10	14	19	15	8	6
11.0-11.4	3	53	17	28	24	17	27	16	5
11.5-11.9	2	26	39	18	29	25	32	27	4
12.0-12.4		4	7	7	15	20	48	23	12
12.5-12.9		1		1	6	3	18	13	13
13.0-13.4				1			4	3	7
13.5-13.9								1	1
TOTAL	78	172	91	81	109	93	170	102	55
									951

AREA C

	B	A0-A4	A5-A9	F0-F4	F5-F9	G0-G4	G5-G9	K0-K4	K5-
8.0- 8.4									
8.5- 8.9	5							1	1
9.0- 9.4	13	6	3	4					
9.5- 9.9	41	19	4	4	4	3	8	10	4
10.0-10.4	19	27	11	10	13	5	17	18	4
10.5-10.9	10	71	15	24	20	20	20	25	10
11.0-11.4	5	97	36	36	17	29	52	34	23
11.5-11.9	8	38	21	24	17	45	79	65	35
12.0-12.4	3	11	6	4	14	30	60	60	43
12.5-12.9	1	1	1	1	2	4	17	40	29
13.0-13.4							2	4	8
13.5-13.9								1	
TOTAL	105	270	97	107	87	136	255	258	157
									1472

Table 11
Number of Stars Per 12.25 deg^2 in Area A

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4	0.36								
8.5– 8.9	0.71								
9.0– 9.4	3.22	1.07	0.71				0.71		
9.5– 9.9	15.73	6.08	2.86	0.36	1.07	1.07	2.50		1.07
10.0–10.4	15.37	6.79	1.43	4.29	2.14	5.00	3.93	2.86	0.71
10.5–10.9	9.29	21.09	10.01	6.79	5.72	5.36	11.44	2.86	1.43
11.0–11.4	3.57	26.45	12.51	11.08	8.94	8.58	11.80	6.43	3.22
11.5–11.9	0.71	23.95	13.23	5.72	14.65	16.08	16.44	9.65	3.22
12.0–12.4		8.94	6.08	5.00	6.43	8.58	13.23	5.00	3.93
12.5–12.9			0.71	0.36	1.43	2.86	5.36	4.29	1.79
13.0–13.4						0.36	0.36	1.79	0.36
13.5–13.9							0.36		

Table 12
Number of Stars Per 12.25 deg^2 in Area B

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4									
8.5– 8.9	1.68	0.56		0.56	0.56				
9.0– 9.4	9.51	2.24	1.12	1.12		0.56	1.12		
9.5– 9.9	19.01	7.27	2.80	3.36	6.15	3.36	5.59	2.24	
10.0–10.4	6.71	16.22	3.91	3.91	5.03	1.12	7.83	3.91	3.91
10.5–10.9	3.91	22.93	7.83	5.59	7.83	10.63	8.39	4.47	3.36
11.0–11.4	1.68	29.64	9.51	15.66	13.42	9.51	15.10	8.95	2.80
11.5–11.9	1.12	14.54	21.81	10.07	16.22	13.98	17.90	15.10	2.24
12.0–12.4		2.24	3.91	3.91	8.39	11.18	26.84	12.86	6.71
12.5–12.9		0.56		0.56	3.36	1.68	10.07	7.27	7.27
13.0–13.4				0.56			2.24	1.68	3.91
13.5–13.9								0.56	0.56

Table 13
Number of Stars Per 12.25 deg^2 in Area C

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4									
8.5– 8.9	1.74							0.35	0.35
9.0– 9.4	4.52	2.09	1.04	1.39					
9.5– 9.9	14.25	6.60	1.39	1.39	1.39	1.04	2.78	3.48	1.39
10.0–10.4	6.60	9.39	3.82	3.48	4.52	1.74	5.91	6.26	1.39
10.5–10.9	3.48	24.68	5.21	8.34	6.95	6.95	6.95	8.69	3.48
11.0–11.4	1.74	33.72	12.51	12.51	5.91	10.08	18.08	11.82	8.00
11.5–11.9	2.78	13.21	7.30	8.34	5.91	15.64	27.46	22.60	12.17
12.0–12.4	1.04	3.82	2.09	1.39	4.87	10.43	20.86	20.86	14.95
12.5–12.9	0.35	0.35	0.35	0.35	0.70	1.39	5.91	13.91	10.08
13.0–13.4							0.70	1.39	2.78
13.5–13.9								0.35	

Table 14
Comparison of Area A to Area B

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4									
8.5– 8.9	- 0.43								
9.0– 9.4	⊖ 0.34	- 0.48	0.64				0.64		
9.5– 9.9	0.83	0.84	1.02	- 0.11	- 0.17	- 0.32	⊖ 0.45		
10.0–10.4	⊕ 2.29	⊖ 0.42	⊖ 0.37	1.10	⊖ 0.43	+ 4.47	0.50	0.73	- 0.18
10.5–10.9	⊕ 2.37	0.92	1.28	1.21	0.73	0.50	1.36	0.64	- 0.43
11.0–11.4	+ 2.13	0.89	1.32	0.71	0.67	0.90	0.78	0.72	1.15
11.5–11.9	0.64	⊕ 1.65	0.61	0.57	0.90	1.15	0.92	0.64	1.44
12.0–12.4		⊕ 3.99	⊕ 1.55	1.28	0.77	0.77	⊖ 0.49	⊖ 0.39	0.59
12.5–12.9				0.64	- 0.43	+ 1.70	0.53	0.59	⊖ 0.25
13.0–13.4							- 0.16	1.07	- 0.09
13.5–13.9									

- Ratio is < 0.50
+ Ratio is > 1.50
○ Raw count of stars in each Area is ≥ 5 (See Table 10), and ratio is < 0.50 or > 1.50

Table 15
Comparison of Area A to Area C

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4									
8.5– 8.9	- 0.41								
9.0– 9.4	0.71	0.51	0.69						
9.5– 9.9	1.10	0.92	+ 2.06	- 0.26	0.77	1.03	0.90		0.77
10.0–10.4	⊕ 2.33	0.72	⊖ 0.37	1.23	⊖ 0.47	⊕ 2.88	0.67	⊖ 0.46	0.51
10.5–10.9	⊕ 2.67	0.85	⊕ 1.92	0.81	0.82	0.77	⊕ 1.65	⊖ 0.33	- 0.41
11.0–11.4	⊕ 2.06	0.78	1.00	0.89	⊕ 1.51	0.85	0.65	0.54	⊖ 0.40
11.5–11.9	- 0.26	⊕ 1.81	⊕ 1.81	0.69	⊕ 2.48	1.03	0.60	⊖ 0.43	⊖ 0.26
12.0–12.4		⊕ 2.34	⊕ 2.91	⊕ 3.60	1.32	0.82	0.63	⊖ 0.24	⊖ 0.26
12.5–12.9			+ 2.06	1.03	+ 2.06	+ 2.06	0.91	⊖ 0.31	⊖ 0.18
13.0–13.4							0.51	1.29	- 0.13
13.5–13.9									

\- Ratio is < 0.50
\+ Ratio is > 1.50
○ Raw count of stars in each Area is ≥ 5 (See Table 10), and ratio is < 0.50 or > 1.50

Table 16
Comparison of Area A to Average of Areas B and C

	B	A0–A4	A5–A9	F0–F4	F5–F9	G0–G4	G5–G9	K0–K4	K5–
8.0– 8.4									
8.5– 8.9	- 0.42								
9.0– 9.4	⊖ 0.46	0.50	0.66				1.28		
9.5– 9.9	0.95	0.88	1.37	- 0.15	- 0.28	- 0.49	0.60		+ 1.54
10.0–10.4	⊕ 2.31	0.53	⊖ 0.37	1.16	⊖ 0.45	+ 3.50	0.57	0.56	- 0.27
10.5–10.9	⊕ 2.51	0.89	⊕ 1.53	0.97	0.77	0.61	1.49	⊖ 0.43	- 0.42
11.0–11.4	⊕ 2.09	0.83	1.14	0.79	0.92	0.88	0.71	0.62	0.60
11.5–11.9	- 0.37	⊕ 1.73	0.91	0.62	1.32	1.09	0.72	0.51	⊖ 0.45
12.0–12.4		⊕ 2.95	⊕ 2.03	⊕ 1.89	0.97	0.79	0.55	⊖ 0.30	⊖ 0.36
12.5–12.9			+ 4.11	0.79	0.71	+ 1.86	0.67	⊖ 0.41	⊖ 0.21
13.0–13.4							- 0.24	1.16	- 0.11
13.5–13.9									

- Ratio is < 0.50
+ Ratio is > 1.50
○ Raw count of stars in each Area is $\geq$ 5 (See Table 10), and ratio is < 0.50 and > 1.50

Table 17
Photographic Magnitudes for Main Sequence Stars at the Distance of the Association I Lacerta

Spectral Class	B-V	M_V	m_{pg}
B0	-0.30	-3.30	+5.09
B9	-0.06	+1.04	+9.67
A0	0.00	+1.55	+10.24
A5	+0.15	+2.25	+11.09
F0	+0.33	+3.10	+12.12
F5	+0.45	+3.83	+12.97
G0	+0.60	+4.80	+14.09
G5	+0.68	+5.28	+14.65
K0	+0.81	+5.94	+15.44
K5	+1.18	+7.56	+17.43

Table 18
Galactic Coordinates for the Center of the Areas Studied

Area	ℓ_{II}	b_{II}
A	95°	-17°
B	97°	-13°
C	100°	-10°
SA 43	113°	-16°
SA 67	98°	-27°

Table 19
Number of Stars Per 12.25 deg^2 in SA 43

	B0-5	B6-9	A0-4	A5-9	F0-4	F5-9	G0-4	G5-9	K0-4	K5-9
$0^{m}.0$- $8^{m}.5$	3	4	2	1		1		2		
8.5- 9.0		1	2	1		2				2
9.0- 9.5	1	2	5	1	4	4	1	6	2	1
9.5-10.0		6	5	4	4	8		4	3	1
10.0-10.5		5	10	5	12	6	10	8	4	2
10.5-11.0		2	5	1	7	18	12	13	15	5
11.0-11.5			9	11	8	48	23	13	20	4
11.5-12.0		2	16	15	13	37	51	21	24	4
12.0-12.5			6	13	7	39	70	22	21	4
12.5-13.0		1	11	32	7	111	278	94	73	12
13.0-13.5	1		5	11	5	78	273	71	56	13
13.5-14.0								1		
TOTAL	5	23	76	95	67	352	718	255	218	48

Table 20
Number of Stars per 12.25 deg^2 in SA 67

	B0-5	B6-9	A0-4	A5-9	F0-4	F5-9	G0-4	G5-9	K0-4	K5-9
$0^m.0-8^m.5$			4		4	1		2	2	1
8.5- 9.0			3		2		2	1	2	1
9.0- 9.5						3	3	3	2	
9.5-10.0			3		1	4	1	6	3	
10.0-10.5			5		2	12	5	7	5	2
10.5-11.0			2	1	3	19	9	13	5	2
11.0-11.5			7	3	4	26	19	20	20	3
11.5-12.0			3	2	2	15	30	35	23	3
12.0-12.5			5	6	8	21	29	58	21	3
12.5-13.0			7	7	7	34	81	98	31	5
13.0-13.5			2	4	8	31	113	113	18	10
13.5-14.0								1		
TOTAL			41	23	41	166	292	357	132	30

Table 21
Ratio of the Number of Stars per deg^2; Area A Compared to Latitude Zone, $\ell_{II} = -15°$, of Bergedorfer Catalog

	B-A4	A5-F4	F5-G4	G5-K4
8.5- 9.4	0.38			
9.5-10.4	1.40	0.48	0.47	0.41
10.5-11.4	1.39	1.16	0.30	0.52
11.5-12.4	0.78	0.44	0.20	0.37

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