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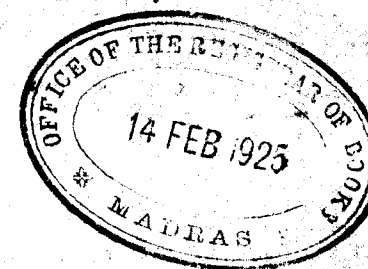
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JOURNAL

OF THE

Indian Institute of Science.

CONTENTS.



CONTRIBUTIONS TO THE SCIENTIFIC STUDY OF THE LAC INDUSTRY.

BY

Gilbert J. Fowler, S. Mahdihassan and M. Sreenivasay

PARTS IX—X.

DR. M. O. FORSTER, F.R.S., CHAIRMAN OF EDITORIAL BOARD.

JOURNAL
OF THE
INDIAN INSTITUTE OF SCIENCE.

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INDUSTRY.

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PARTS IX—X.

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PART IX.

THE INFLUENCE OF METEOROLOGICAL CONDITIONS ON
THE LIFE-CYCLE OF THE MYSORE LAC INSECT.

By M. Sreenivasaya and M. Basappa.

The influence of climatic factors on insect life is of great significance, especially among those species which are bi- or tri-voltine in character, since the conditions of climate under which each generation is reared vary according to the season. The Mysore lac insect is not strictly tri-voltine since three generations occur in little over thirteen months. Accordingly thirteen years must elapse before the conditions recur which obtain for any single generation which may be the subject of study. This period of thirteen years may be termed the grand life-cycle.

Fortunately there occur in Mysore several broods which swarm at intervals of a month, a fortnight and even a week and which thus represent the behaviour of successive generations in the course of the grand life-cycle of thirteen years. The necessary data for the study of this cycle can thus be obtained in a much shorter period of time than would otherwise be possible.

METHODS OF OBSERVATION.

At Doraisanipalya trustworthy records of the dates of the swarming of larvae and emergence of males have been maintained since 1920. Tree No. 191 on the experimental area was inoculated for the purpose and kept under observation. Weekly visits were paid to the area and when it was seen, from the development of the cells, that the males would emerge, or the larvae would swarm within a day or two, an infected shoot was brought over from the area and kept in the laboratory under observation. The date was then noted on which the first male, or larva as the case might be, came out. The observed dates may be taken as being correct to a day.

At other centres, observations could not be carried out with great accuracy on account of distance and difficulty of access. Reliance had to be placed on the reports of field-men, checked in the laboratory

by watching sticks brought in from these areas before the probable local date of swarming. The dates of male-emergence have not been recorded for these centres. The dates of swarming are believed to be correct to within four days.

SELECTIONS OF DATA FROM GOVERNMENT METEOROLOGICAL REPORTS.

The meteorological data have been taken from the Annual Reports of the Government of Mysore. For the Doraisanipalya area the data for temperature and humidity recorded at the Bangalore Central Observatory have been adopted. The figures for rainfall have been taken from those of the Lalbagh Station, which is only four miles distant from Doraisanipalya.

For other centres the figures of the nearest recording stations have been adopted for rainfall, but for temperature data the figures of the Bangalore Observatory have been taken advisedly, since the localities under observation are all situated on the same plateau, and the temperature does not vary appreciably with a slight change of altitude. On the other hand, relative humidity figures, which are not available for these centres, are affected by local conditions such as the proximity of a tank, a river, a hill or high vegetation. No general data would have value, therefore, and consequently they have not been considered. The results of the observations are set out in tables I and II.

DISCUSSION OF THE TABLES.

The various crops detailed in tables I and II may be broadly distinguished as pre-monsoon, monsoon, and post-monsoon. The pre-monsoon crops obtain an average monthly rainfall of 1.5 to 2.1 inches and pass through a mean temperature varying from 76° to 78° F. The range of temperature is high during this period. These crops receive sufficient rains during the post-embryonic period when the vital activities of the insect are at the highest point.¹ They generally take the least time to mature.

The monsoon crops receive abundant rainfall, the monthly average varying from 4 to 5 inches, the mean temperature for the whole period being 73° to 74° F. The range of temperature is low during this season and the average humidity high. These crops take about a week longer to mature than the preceding crop.

¹ Rate of secretion by the lac insect; by M. Sreenivasaya. This *Journal*, 1924, 7, 126.

The post-monsoon crop passes through a period of low humidity, low temperature and low rainfall, the respective averages for the season being: humidity 70 to 75, mean temperature 69° to 70° F., and rainfall 2.5 inches. These crops cover the longest period, being adversely influenced during the post-embryonic stage of development, the average rainfall after fertilisation being less than 0.5 inch. The temperature and humidity are also then at their lowest.

It must be emphasised that the post-embryonic period, being the most active in the life-history of the insect, is the most susceptible to climatic factors. It will be seen that although the average rainfall for the post-monsoon crop is higher than that for the pre-monsoon crop, yet the former is poor, because of the unfavourable conditions prevailing after the emergence of the males.

CONCLUSIONS.

1. The life-cycle of the lac insect is mainly influenced by temperature. Low temperatures, particularly during the period of maturation, postpone the date of larval swarming, which is hastened with rise of temperature. The emergence of the males is similarly influenced.¹

2. Although humidity profoundly influences lac secretion and sex determination, its specific and exclusive effect on the life-cycle is not easy to trace. In this connection, however, attention may be drawn to an interesting paper by T. C. Headlee,² who noted that with low humidity there was a prolongation of the life-cycle and a low reproductive activity in the case of bean-weevils. Our observations with regard to the Mysore lac insect are in close agreement with these.

3. Rainfall influences the insect indirectly through its host, by providing abundant nutritive material.

In conclusion we wish to express our grateful thanks to Mr. C. R. Seshachar, Meteorological Reporter to the Government of Mysore for many critical suggestions and for kindly placing at our disposal some unpublished data.

¹ One of us has completed the life-cycle of the insect reared under experimental control in the laboratory within three-and-a-half months, the data being given in Table III.
² *Journ. Econ. Ent.*, 1917, 10, 31.

DORAISANIPALYA

TABLE

YEAR	1920							1921						
Month	Rainfall : Inches	Relative Humidity	Mean Temperature	Dates of swarming, emergence, etc.	Male-emergence, days after inoculation	Swarming, days after emergence	Swarming, days after inoculation	Rainfall : Inches	Relative Humidity	Mean Temperature	Dates of swarming, emergence, etc.	Male-emergence, days after inoculation	Swarming, days after emergence	Swarming, days after inoculation
January ...	...	83	69.2°	...	...	...	...	...	80	71.8°	24th	...	97	152
February ...	...	72	74.7	...	...	...	...	...	67	73.3	...	...	...	...
March ...	0.08	63	79.4	...	...	...	...	...	60	79.3	29th↑	64	...	...
April ...	...	71	81.2	29th	...	...	...	3.35	73	80.4	...	...	...	...
May ...	0.93	69	81.7	...	...	...	...	2.74	70	82.2	19th	...	51	115
June ...	2.13	81	76.5	...	...	...	...	4.54	83	76.3	...	...	...	...
July ...	0.25	83	74.8	...	...	...	...	6.35	87	74.6	10th↑	52	...	...
August ...	5.40	85	74.4	25th	...	...	118	7.08	87	74.3	...	...	...	...
September.	8.62	86	74.6	...	...	...	...	4.76	86	73.1	23rd	...	75	127
October ...	3.34	82	74.4	19th↑	55	...	...	5.40	81	73.6	...	...	...	...
November...	1.88	83	72.0	...	...	...	...	4.91	76	70.1	...	...	...	...
December...	...	75	68.7	...	...	...	...	...	79	68.4	7th↑	75	...	...

Dates marked thus ↑ are

OBSERVATIONS.

1922							1923							Byaba (Hassan) 1922		
Rainfall : Inches	Relative Humidity	Mean Temperature	Dates of swarming, emergence, etc.	Male-emergence, days after inoculation	Swarming, days after emergence	Swarming, days after inoculation	Rainfall : Inches	Relative Humidity	Mean Temperature	Dates of swarming, emergence, etc.	Male-emergence, days after inoculation	Swarming, days after emergence	Swarming, days after inoculation	Rainfall : Inches	Temperature	Dates of swarming
1.45	80	70.6°	...	...	...	...	0.38	75	69.1°	...	...	...	...	1.28	71.0	...
...	62	72.9	14th	...	69	142	...	69	73.1	...	...	...	...	...	73.3	...
...	60	79.4	...	...	...	...	1.93	71	77.1	20th	...	85	158	...	78.1	...
1.93	68	82.0	16th↑	61	...	...	3.87	71	81.1	...	...	...	...	3.16	80.2	...
1.91	76	79.9	...	...	...	...	3.02	69	80.7	11th↑	52	...	...	6.25	77.2	...
3.30	82	76.0	17th	...	62	123	2.25	79	77.2	...	...	...	...	1.95	73.7	26th
2.85	85	73.8	...	...	...	...	3.64	87	72.5	23rd	...	73	125	3.13	71.6	...
3.48	87	74.0	7th↑	51	...	...	3.93	84	73.7	...	...	...	...	0.78	72.3	...
3.34	83	74.5	...	...	...	...	9.27	87	72.6	23rd↑	62	...	...	3.13	73.5	23rd
9.87	82	73.3	18th	...	67	118	2.54	82	74.6	...	...	...	...	4.44	71.2	...
4.05	85	71.1	...	...	...	...	...	70	73.3	...	...	...	...	...	67.2	...
0.13	75	67.6	25th↑	73	...	...	...	74	71.5	2nd	...	70	132	...	...	...

those of male-emergence.

TABLE II.

Month	Kalkere West 1921			Kalkere West 1922			Kalkere East 1922			Kalkere East 1923			Kalkere East 1924	
	Rainfall	Temperature	Dates of swarming	Swarming, days after inoculation	Rainfall	Temperature	Dates of swarming	Swarming, days after inoculation	Rainfall	Temperature	Dates of swarming	Swarming, days after inoculation	Dates of swarming	Swarming, days after inoculation
January ...	...	...	...	...	0.45	70.6°	...	...	0.45	70.6°	...	...	7th	144
February ...	...	...	...	...	...	72.9	...	...	...	72.9	...	...	...	...
March ...	...	...	...	...	...	79.4	...	...	...	79.4	...	...	...	...
April ...	...	...	...	...	0.93	82.0	3rd	147	0.93	82.0	...	160	...	...
May ...	...	...	...	...	3.91	79.9	...	...	3.91	79.9	...	...	...	...
June ...	4.34	76.3	16th	...	3.30	76.0	...	...	3.30	76.0	...	...	...	...
July ...	6.35	74.6	...	...	2.85	73.8	...	...	2.85	73.8	5th	...	...	...
August ...	7.08	74.3	...	...	3.48	74.0	1st	110	3.48	74.0	...	108	...	...
September ...	4.76	73.1	...	...	3.34	74.5	...	...	3.34	74.5	16th	...	...	...
October ...	5.40	73.6	...	...	9.87	73.3	...	...	9.87	73.3	...	...	...	...
November ...	4.91	70.1	7th	144	4.05	71.1	...	...	4.05	71.1	...	...	...	...
December ...	...	68.4	...	...	0.13	67.6	26th	147	0.13	67.6	...	...	...	...

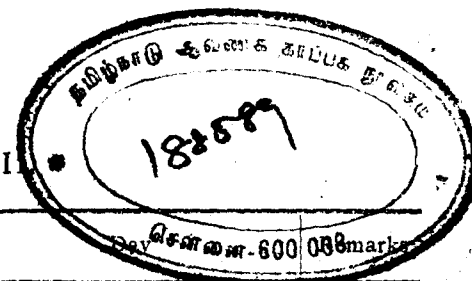
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TABLE II.

No. Experiment	Dates		Emergence after inoculation	Swarming after emergence	Swarming after inoculation	
	Inoculation	Emergence and swarming				
1. <i>Acacia Farnesiana</i> under controlled conditions.	26th July	{ Sept. 18th ↑ Nov. 11th	{ 54	54	108	The life-cycle of the insect has been shortened by 24 days under controlled laboratory conditions.
2. Corresponding crops in the forest.	23rd July	{ Sept. 23rd ↑ Dec. 2nd	{ 62	70	132	

Dates marked thus ↑ are those of male-emergence.



PART X.

THE SIGNIFICANCE OF THE CONSTITUENTS OF SOME
STICK-LACS.

By C. R. Somayajulu.

Among the many unsolved problems connected with lac-production, that of the physiological mechanism of its formation by the lac insect is not the least interesting. Two views have been put forward in explanation of the process. According to one, lac is a waste product, consisting mainly of unassimilable matter derived from the host-plant and excreted by the insect, which thus acts mainly as a mechanical separator. The second suggestion is that lac is a product of normal secretory activity, the various constituents of lac being derived from different and specific glands. The work described in the present paper was undertaken with the object of deciding, if possible, between these two views which may be termed respectively the excretion and the secretion theories, by the systematic analysis of lac incrustations of various origin.

In the selection of material for analysis, three fundamental factors controlling lac-production were kept in view, namely, the genus of the insect producing the lac, the species of the host on which it is propagated, and the season in which it is grown. If the proportion and nature of the constituents composing lac are largely a variable function of the species of host, the first hypothesis holds good, whilst the second would find support if the genus of the insect is the principal controlling factor.

PLAN OF ANALYSIS.

Since in many cases the quantities of material available for research were small, the micro-chemical methods of examination described by the author¹ in a former paper were used.

As can be seen from the appended table, the different factors were varied in the following manner :—

In section Ia, the insect and the host remaining constant, analytical data are given for lac produced in the three seasons in Mysore. In Ib, the insect (*Shorea* brood) and the season (summer)

remaining the same, the hosts were varied. In II, comparative figures are given in three sets for two insects of different genus, the host in each case remaining constant. In III, both the insect and the host were varied, the season only remaining constant.

Having regard to the known composition of stick-lac it was considered sufficient for the purpose of this work to extract the wax and higher alcohols by light petroleum, the fatty acids and certain colouring matters by ether and the resins by alcohol (96 per cent.), the main bulk of lac-dye remaining insoluble in these liquids. Each sample was extracted with the various solvents in the above sequence, the conditions of sampling, time of extraction and other treatment being similar in every case. It was found that by a further extraction with benzene subsequent to alcohol, a hard wax, identified as lacceryl laccerate could be obtained, but as in many cases this was present only in negligible amount it was not examined quantitatively. Besides determining the percentage amount of the above extracts, an endeavour was made to ascertain for each extract, such constants as the saponification value, the acid value, the iodine number, the melting point and the refractive index. In the case of the ether extract, since the residue was highly coloured, the refractive index could not be observed. In the alcoholic extract only the saponification and acid values were determined.

EXPERIMENTAL.

(a) *Sampling*.—Different samples of stick-lac obtained from various parts of the country were analysed. The pieces were first brushed to remove any dirt and loosely adhering wax-filaments, then powdered and passed through a sieve having forty meshes to the inch.

(b) *Extraction*.—One gram of each sample was then mixed with twice its bulk of fine, thoroughly cleaned glass-powder, the mixture placed in a thimble of thick filter-paper and completely extracted in a Soxhlet attached to a small round flask of about 50 c.c. capacity. Six hours' extraction over an electric heating-coil at about 70° C. was found sufficient in each case. The extracts in the flasks, after recovery of the bulk of the solvent, were dried by heating for about a quarter-of-an-hour on a water-bath, in the case of alcohol the last traces being removed by heating in vacuo over an electric bulb.

(c) *Determination of Constants*.—Small quantities of the dry material were scraped gently with a knife into suitable reaction vessels, and the analysis carried out by the micro-methods already described. In all cases the melting point determination was made three days after the introduction of the substance into the capillary tube in order to minimise the effect of previous melting.

¹ This Journal, 1924, 7, 129.

The refractive index was determined by the Abbé refractometer at 80°, since many samples of the wax melted only between 70° and 80°.

DISCUSSION OF RESULTS.

A careful examination of the results given in the appended table brings out clearly certain broad conclusions.

In section Ia, where only the season is varied, not much difference is to be observed between the constants for the three extracts. There is little variation even in the proportion of the constituents, excepting that in the case of the summer crop the wax-content is lower and the ether-insoluble resin-content is higher in comparison with the other two seasons. Resin secretion would appear to be more active than wax secretion, but the actual nature of the components does not vary.

The results under Ib, i.e. from the same insect on different host-plants, indicate some variation in the relative proportions of the constituents, while the figures for the constants of these constituents are of the same order throughout. The constants for the petrol and ether extracts do, however, differ markedly from those obtained with lac derived from *Shorea talura*, the natural host-plant of the Mysore insect.

In the case of the results grouped under II a, b and c, where the host-plant is constant and the insect is varied, the figures show marked contrasts both in the percentage of the various extracts and in their individual constants. This is especially noticeable where *L. mysorensis* and *T. lobata* are both grown on *Acacia Farnesiana*.¹

Under III, where both host-plant and insect are varied, striking contrasts are observed throughout, lending support to the secretory rather than to the excretory theory of lac-production. Such a conclusion receives striking confirmation from the results of analysis of the lac from *T. lobata*. It will be seen that in every case, independently of the host-plant concerned, the proportion of extractable matter, particularly by alcohol, is extraordinarily low.

Analysis of the residue after extraction showed the presence of large amounts of carbohydrate which give reducing sugars on hydrolysis, thus indicating a comparative deficiency in the digestive and secretive system of this insect. It has further been observed by Mr. Sreenivasaya that *Acacia Farnesiana* grown in water-culture and

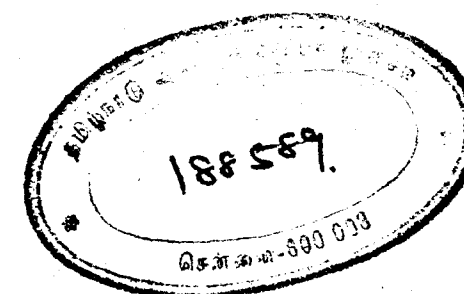
¹ The nomenclature of the insects throughout is that suggested by Mr. Mahdihassan.

inoculated with *T. lobata*, does not attract ants as is the case with other species of the lac insect, probably because there is little secretion of honey-dew formed by the breaking down of carbohydrate. This peculiarity of the insect in question is confirmed by the unpublished anatomical studies of Mr. Mahdihassan.

In conclusion, attention may be drawn to the great divergence in the saponification values of the petrol extracts from stick-lac and seed-lac respectively. This is probably due to the effect of washing, which removes the greater portion of the wax-pouches in stick-lac, leaving a smaller proportion of wax with a lower saponification value in the seed-lac.

My thanks are due to Mr. M. Sreenivasaya, who rendered valuable assistance from time to time in the course of this work.

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Indian Institute of Science,
Bangalore.



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Description of Sample			Extracts Per cent		
Genus of Insect.	Name of host and locality	Season	Petrol	Ether	Alcohol
I(a) <i>L. mysorensis</i> ...	<i>Shorea talura</i> (Bangalore)	October '22	9.62	15.52	68.12
Do.	do.	March '23	10.38	18.28	63.08
Do.	do.	July '23	3.11	19.30	73.54
(b) Do.	<i>Acacia Farnesiana</i> ...	Summer '23	5.40	17.06	77.20
Do.	<i>A. concinna</i> ...	...	4.94	21.72	72.35
Do.	<i>Butea frondosa</i> ...	...	6.50	22.52	69.46
Do.	<i>Zizyphus Jujuba</i> ...	...	4.96	23.40	69.53
Do.	<i>P. saman</i> ...	...	4.94	22.38	59.84
II(a) Do.	<i>A. Farnesiana</i> ...	...	5.40	17.06	77.20
<i>T. lobata</i> ...	do.	...	2.71	12.16	23.45
(b) <i>L. indica</i> ...	<i>Butea frondosa</i> , (Palamau)	...	3.40	22.66	24.25
<i>L. mysorensis</i> ...	do.	...	6.50	22.52	68.45
(c) Do.	<i>Zizyphus Jujuba</i> ...	...	4.96	23.40	69.53
<i>L. indica</i> ...	do. (Punjab)	...	2.87	24.68	67.46
III <i>L. mysorensis</i> ...	<i>Shorea talura</i> ...	...	10.38	18.28	63.08
<i>L. communis</i> ...	<i>Ficus mysorensis</i> ...	...	5.00	17.62	68.24
<i>L. nagoliensis</i> ...	<i>Schleichera trijuga</i> (C. P.)	...	3.12	12.40	78.74
<i>L. chinensis</i> ...	<i>Cajanus indicus</i> (Assam)	...	3.64	21.40	59.80
Do.	<i>Dipterocarpus</i> (Indo-China)	...	4.50	21.14	57.42
<i>Metatachardia conchiforata</i>	Ceylon	...	1.96	47.82	49.24
IV <i>T. lobata</i> ...	<i>A. Farnesiana</i> ...	...	2.71	17.06	23.45
Do.	<i>Santalum album</i> ...	...	2.82	18.28	21.28
Do.	<i>Mangifera indica</i> ...	...	3.10	12.16	19.64
V <i>L. mysorensis</i> ...	<i>S. talura</i> (Bangalore) Stick-lac	...	9.62	15.52	68.12
Do.	<i>S. talura</i> (Bangalore) Seed-lac	...	3.30	33.14	59.20
<i>L. communis</i> ...	<i>F. mysorensis</i> Stick-lac ...	...	5.00	17.62	68.24
Do.	do. Seed-lac ...	...	4.04	19.96	66.18

Petrol-extract						Ether-extract						Alcohol-extract		
M. P. (degrees C)	Sap. value.	Acid value.	Ester No.	Iodine No.	Refr. Index.	M. P. (degrees C)*	Sap. value.	Acid value.	Ester No.	Iodine No.	Sap. value.	Acid value.	Ester No.	
69-70	154.2	22.5	131.7	10.4	1.4442	52-53	78.6	51.8	26.8	5.5	196.2	22.5	173.7	
68-69	153.4	21.6	131.8	10.5	1.4443	53-54	76.2	51.4	24.8	5.7	194.0	21.8	173.0	
69-70	149.4	20.2	129.2	10.3	1.4442	52-53	77.6	51.0	26.6	5.7	198.2	22.2	176.0	
75-76	172.4	18.5	153.9	5.3	1.4448	53-54	73.6	46.6	27.0	4.9	195.4	18.2	177.2	
74-75	168.5	24.1	144.4	4.7	1.4449	54-55	78.2	44.6	33.6	4.9	193.2	20.8	172.4	
75-76	164.2	20.2	144.0	5.0	1.4384	52-53	73.7	42.7	31.0	4.5	194.8	21.2	173.6	
75-76	167.9	19.8	148.1	4.3	1.4424	55-56	76.4	45.8	30.6	4.3	196.1	23.8	172.3	
74-75	156.4	23.2	133.2	6.5	1.4432	53-54	73.7	46.6	27.1	4.9	195.8	22.4	173.4	
75-76	172.4	18.5	153.9	5.3	1.4448	53-54	73.6	46.0	27.6	4.9	195.4	18.2	177.2	
78-79	141.2	24.2	117.0	4.0	1.4439	66-67	80.2	24.2	56.0	5.0	199.3	24.1	175.2	
65-66	164.1	30.3	133.8	5.4	1.4464	55-56	73.7	50.7	23.0	6.2	202.2	45.8	156.4	
75-76	164.2	20.2	144.0	5.0	1.4384	58-59	73.6	33.7	39.9	4.5	196.1	33.6	162.5	
78-79	167.9	20.4	147.5	4.3	1.4424	55-56	76.4	45.8	30.6	4.3	198.2	22.5	175.7	
79-80	148.0	20.0	128.0	6.5	1.4432	63-64	78.2	35.6	42.6	4.5	194.1	26.8	167.3	
69-70	153.4	21.6	131.8	10.5	1.4448	53-54	76.2	51.4	24.8	5.7	194.8	21.8	173.0	
76-77	169.8	26.2	143.6	8.5	1.3842	53-54	80.2	49.8	30.4	5.9	199.2	22.4	176.8	
64-65	150.2	24.1	126.1	8.6	1.3940	54-55	74.2	56.8	17.4	8.4	196.6	23.2	173.4	
80-81	164.2	22.8	141.4	9.8	1.4441	62-63	78.1	62.3	15.8	10.0	195.0	21.2	174.2	
81-82	148.6	21.4	127.2	8.7	1.4442	58-59	89.2	56.4	32.8	13.4	199.0	24.0	175.0	
79-80	158.3	26.2	132.1	9.4	1.4443	61-62	78.4	43.6	34.8	9.8	192.6	21.6	171.0	
78-79	141.2	24.2	117.0	4.0	1.4437	66-67	80.2	24.1	56.0	5.0	195.8	26.4	169.4	
79-80	159.2	22.9	136.3	4.2	1.4440	68-69	78.4	26.5	52.0	5.4	197.3	24.9	172.4	
78-79	142.4	20.2	122.2	4.2	1.4441	67-68	79.3	25.2	54.1	5.3	196.2	24.2	172.9	
69-70	154.2	22.5	131.7	10.3	1.4443	53-54	78.6	51.8	26.8	5.5	198.2	22.8	175.4	
68-69	79.8	21.2	58.6	10.2	1.4441	54-55	73.2	49.3	23.9	5.8	200.0	23.4	176.6	
76-77	169.8	26.2	143.6	8.5	1.3842	53-54	80.2	49.8	30.4	5.9	199.2	22.4	176.8	
64-65	85.9	24.4	61.5	8.6	1.3844	54-55	78.4	48.6	29.8	5.6	198.6	22.0	176.6	

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