CALENDRICA II: DATE EQUATIONS FROM THE REIGN OF AUGUSTUS

1. Introduction.

Until the beginning of Roman rule in Egypt, the Egyptian calendar had a constant year length of 365 days (twelve 30-day months followed by five "epagomenal" days). The civil calendar of Roman Egypt used the name month names and lengths as the old Egyptian calendar, but inserted intercalary days. For the period following A.D. 4 the intercalations are known to have taken place every four years, at the end of the Egyptian year that immediately preceded the Julian intercalary year. This scheme can be hypothetically projected backwards into the earlier part of Augustus' reign in two ways. (a) We can assume that intercalations in the Alexandrian calendar had always occurred at four year intervals. If so, the first four-year cycle, during which all the days except the final intercalary day still coincided with their counterparts in the old Egyptian calendar, began on Augustus 5 Thoth 1 = August 29, 26 B.C. according to our modern Julian calendar reckoning.[1] (b) Alternatively, the intercalations could have been tied to the civil Roman calendar, in such a way that intercalation took place in Egypt in the years preceding those in which the Roman calendar was intercalated.

If the Roman calendar had been correctly administered after 45 B.C. by the Roman pontifices according to the intention of Caesar's reforms, there would have been no practical distinction between hypotheses (a) and (b). But for the thirty-six years following 45 B.C., we are told by Solinus (I 46-47) and Macrobius (I 13-15) that the pontifices incorrectly intercalated every third year instead of every fourth; thereafter Augustus decreed the omission of three consecutive intercalations in order to bring the calendar back into line with the course it should have taken if the intercalations had been made at the correct intervals.[2] Hence for most dates between March, 42 B.C. and February, A.D. 4 a given date in the civil Roman calendar should come later than the same date in our Julian calendar by as many as three days. Solinus' and Macrobius' accounts appear to be precise enough to permit us to deduce which years had intercalary days, so that we can determine what name a Roman would have assigned to any given Julian calendar date.[3] Now if the Egyptian calendar's intercalations were set to occur just before the intercalations of the Roman calendar, they would of course have been attended by the same irregularities between 45 B.C. and A.D. 8. On this hypothesis, the cycle in which the Alexandrian and Old Egyptian calendars still coincided began Augustus 1, Thoth 1 = August 31, 30 B.C. in the Julian calendar = August 29, 30 B.C. in the civil Roman calendar.

Recent discussions concerning the Alexandrian calendar during the reign of Augustus begin with W. F. Snyder's often-cited paper (1943). Snyder asserted that the sparse evidence for date equivalences during the critical years was consistent with both hypotheses (a) and (b), but contended forcefully for the greater historical plausibility of hypothesis (b), on the grounds that it paralleled the other Augustan calendar reforms of the eastern Mediterranean and that it brought the reform of the Egyptian calendar to the first regnal year of Augustus. T. C. Skeat (1993) has recapitulated and expanded Snyder's arguments, and presented tables allowing conversions of dates between the Julian, Roman, and Egyptian calendars according to the hypothesis that the Egyptian calendar was irregularly intercalated in step with the Roman calendar. D. Hagedorn (1994) has responded with a vigorous defence of hypothesis (a).

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[1] In this article I reserve the name "Julian calendar" for the modern chronological time scale used in historical and scientific works for dates before the adoption of the Gregorian calendar. The calendar employed in ancient documents I call "Roman."

[2] Less precise but compatible accounts in Pliny, *NH* XVIII 211 and Suetonius, *Aug.* 31.2.

[3] See Brind'Amour (1983) 11-15 for texts and literature. The Priene inscription discussed on pp. 13–14, setting out the new Calendar of the province of Asia, seems to prescribe intercalations every three years. The inscription's presumed date, 9 B.C., was the last year in which an erroneous intercalation was made in the Roman calendar.

Up to now it seems that no one has brought to light direct documentary evidence consistent with hypothesis (b) but not with hypothesis (a). On the other hand, two attested date equivalences are known that appear to be consistent with (a) but not (b). The first is a double dating in the Egyptian (hieratic and demotic) papyrus P. Rhind I, which equates the date Augustus 21, Epeiph 10 with a "16th day". R. A. Parker pointed out that the most plausible interpretation of the "16th day" is as a date in the Egyptian lunar festival calendar; if so, the equivalent civil date should be Epeiph 10 according to hypothesis (a) but Epeiph 7 according to hypothesis (b).[4] The second date equation, adduced by Hagedorn, is in a Latin letter, P. Vind. L 1c (= CPL 247). As Hagedorn shows, the stated equivalence of July 19 with Epeiph 27 is never allowed by hypothesis (b), but according to hypothesis (a) was correct from 5 B.C. to 2 B.C.[5]

In this article I present a Greek astronomical table that provides us with secure date equations coordinating the modern chronographer's Julian calendar with the Egyptian and Roman calendars in 24 B.C. The text is of interest because it has a high degree of internal consistency, thereby assuring us that no scribal errors are involved, and the period it pertains to is much closer to the time when the reform of the Egyptian calendar occurred than either of the date equations mentioned above. The information that it yields suggests that the relationship between the Egyptian and Roman calendars in Egypt during Augustus' reign was rather more complicated than anyone would have anticipated.

2. Astronomical evidence for calendars.

Under the right circumstances astronomical texts can furnish us with two kinds of evidence concerning the regulation of calendars: simple date equations in which the same day is named by two (or more) calendars, and—particularly valuable—records of events that are both dated in the document and also independently datable in our chronological frame of reference, the Julian calendar. Such datable events might include eclipses, close passages of heavenly bodies by stars, or computed positions of the moon.

A variety of ancient astronomical table called an "ephemeris" is outstandingly suitable for fixing calendar dates in the Julian calendar.[6] At the heart of an ephemeris is a list of longitudes (zodiacal signs with numbers of degrees) of the moon computed for the evening of each successive day in a calendar month. The calendar in question is always either the civil Egyptian or the Roman calendar. In most ephemerides there was also a column listing the equivalent dates in the other of the two calendars.

A further property of ephemerides that makes them particularly useful in the present context is that they are contemporary with the dates that they cover. Unlike the other varieties of astronomical almanacs found on papyrus, the ephemerides are directed towards a prospective kind of astrology, the evaluation of days as auspicious or inauspicious for undertaking various activities. They are closely related to the Roman so-called parapegma calendars, as is evident from the prominence in them of the Roman calendar and, often, of the planetary week.[7] Some very late ephemerides go so far as to include explicit appraisals of each day, apparently derived from the relative positions of the moon and the

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[4] Parker (1950) 18. Snyder (1943) 392–393 note 14 discusses this double date and Parker's explanation of it (communicated before publication), but inexplicably dismisses its relevance: "But to be sure, the use of this lunar calendar in the Rhind Papyrus, and the calculations based upon the stated equivalence of the two statements of date, do not constitute independent contemporary evidence upon the actual employment of any of the calendars involved in our question." Brind'Amour (1983) 24-25 regards the P. Rhind double date as conclusive proof of hypothesis (a). Exact equivalences of Egyptian lunar and civil dates are derived from Parker's reconstruction of a schematic lunar calendar, the validity of which has lately been put in doubt; cf. Jones (1997), Depuydt (1998). A discrepancy of three days is, however, very implausible.

[5] Other possible years are ruled out by the fact that the Roman date is given as XIIII K(alendas) August(as), since before 8 B.C. the month was still named Sextilis. The same consideration proves that the Egyptian date in the papyrus cannot be according to the old unintercalated Egyptian calendar. P.Vind. L 1c has been republished as ChLA XLIII 1241 and SB XX 15139. G. Ballaira, *Esempi di scrittura latina dell'età romana* I (1993) reaches similar clonclusions to Hagedorn's.

[6] See Jones (1999) 40–42 and (1999a) 319–324.

[7] Degrassi (1963) 299–313; cf. Petronius, *Sat.* 30: Duae tabulae in utroque parte defixae quarum altera (habet) lunae cursum stellarumque septem imagines pictas; et qui dies boni quique incommodi essent, distinguente bulla notabantur.

planets in the zodiac. It goes without saying that tables intended to advise on the wisdom of doing something on particular days must have been produced in advance.

At present nineteen ephemerides are known from papyri. Ten of these, ranging in date from A.D. 111 to 489, preserve lunar longitudes associated with securely identifiable calendar dates in the Egyptian civil calendar, and in seven cases also in the Roman calendar. During these years the Roman calendar is directly convertible into our Julian reckoning, and Egyptian dates can be reliably translated into their Julian equivalents assuming regular intercalations at four-year intervals. The lunar longitudes in these papyri are always in excellent agreement with recomputation by modern theory for the evening of the dates given in the tables. All this gives us reason to trust the information contained in what is, by an interval of more than a century, the earliest known ephemeris, *P. Oxy.* LXI.4175.

3. Text, interpretation, and dating of the ephemeris.

P. Oxy. LXI.4175[8] is a fragment of a roll. The astronomical table is on the front, written in a small, neat hand, difficult to date precisely, but apparently of the first century B.C. or the first century A.D. On the back is part of two columns of a document from about the end of the first century B.C. or the beginning of the first century A.D. The top margin (3 cm) is partly preserved. A very unusual feature of the table is the pale pink ink or pigment used for certain of the inscribed data, indicated here by a thicker typeface.

The transcription of *P. Oxy.* LXI.4175 in Table 1 preserves the "look" of the original table to a greater extent than the edition in Jones (1999). Specifically, the widths of the tabular columns are roughly proportional to their widths in the papyrus, and the many abbreviations are not resolved. For typographical convenience, however, I have employed small raised letters to represent compendia of various sorts; the symbol for διδύμων in line 12 col. 8, for example, is a delta *above* iota. Details of the compendia are provided in the apparatus of the formal edition. They have some parallels in a first century planetary almanac from Tebtynis, PSI inv. 75D + EES 79/82 (1).[9] By mistake the traces of the symbol for ἔτοc in line 1 were overlooked in the edition. In line 6 I formerly read the damaged letter after ια as theta; I now suspect that it was a symbol for the disappearance of a planet.

The table is an "almanac-ephemeris," that is, the longitudes of the five planets on certain significant dates during the month are inscribed in five rows (lines 2–6) above the ephemeris proper (lines 8–26), which gives the calendrical data and the daily longitudes of the moon. Parts of the columns for three consecutive months are preserved, with vacant columns (iv, xii) separating them. Dating a reasonably well preserved ephemeris is an overdetermined problem: there is much more information present than we need. Thus we can establish the approximate date of this one using merely the planetary positions in lines 2–6, without having recourse to the information in lines 1 and 8–26.

The order of the planets is standard in such tables: Saturn, Jupiter, Mars, Venus, Mercury. The data for Saturn are almost entirely obliterated through abrasion. We have the following for the remaining four planets:

Jupiter: At Libra 6° on the 15th day of the second month. At Libra 14 on the 24th of the third month.

Mars: Entry (cύναψιc)[10] into Scorpio on the 30th of the second month, i.e. Scorpio 0° if the planet is in direct motion, or Scorpio 30° if it is retrograde.

Venus: Entry into Cancer on the 2nd of the second month; entry into Leo (i.e. Leo 0°) on the 27th of the second month; entry into Virgo (Virgo 0°) on the 17th of the third month.

Mercury: entry into Virgo on the 12th of the second month; at Virgo 11° on the 28th of the second month.

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[8] Text and commentary in Jones (1999) v. 1, 177–179 and v. 2, 170–173; photograph in plate VII.

[9] Manfredi & Neugebauer (1973); Jones (1998).

[10] This term for sign-entry is also found, abbreviated, in PSI inv. 75D + EES 79/82 (1), for which see the preceding note.

Longitudes in papyrus tables from before the fifth century A.D. are almost always sidereal, that is, counted from a zero point that is ostensibly fixed relative to the zodiacal stars rather than relative to the intersections of the planes of the ecliptic and equator, as in modern astronomy. A serviceable approximation to the correction required to translate these ancient longitudes into the modern tropical frame of reference can be obtained by combining a formula given by Theon of Alexandria relating Ptolemy's tropical longitudes to the traditional sidereal longitudes and a second formula compensating for the systematic error in Ptolemy's tropical longitudes.[11] Let y be the number of the year if A.D., or one minus the number of the year if B.C. Then we have:

$$\text{sidereal longitude} = \text{tropical longitude} - y \text{ minutes} + 5.8^\circ$$

We should therefore subtract about 6° from the longitudes in the papyrus before comparing with calculations according to modern theory.

To make the comparison easier, we will consider the situation of the planets on a single date, the 27th day of the second month in the papyrus. After converting the longitudes to the tropical frame of reference and estimating each planet's motion between the nearest recorded position and the 27th, we find that Venus was supposedly at Cancer 24° on this day, Mercury was less than a degree away from Virgo 5°, Mars was at most about two degrees away from Libra 24° or possibly Scorpio 24° travelling retrograde, and Jupiter was (by interpolation) about Libra 3°. We can afford to allow a tolerance of ± 10° to compensate for errors in the ancient methods of computing planetary positions. The interval between 100 B.C. and A.D. 100 is more than sufficient for searching for dates when the planets had positions approximating those in the papyrus.

It is easy to confirm, by inspecting Tuckerman's tables,[12] that the planets were within the specified intervals of longitude only during a single span of little more than ten days in 24 B.C. August 26 was about the middle of that span, with the following longitudes at 6 P.M. local time in Egypt according to modern theory:

Saturn: Virgo 3°
Jupiter: Libra 3°
Mars: Libra 27° (direct motion)
Venus: Cancer 25°
Mercury: Virgo 9°

The agreement is excellent, and we have some confirmation in that the traces of a compendium for a zodiacal sign entered or occupied by Saturn in line 2 are suggestive of Virgo. We conclude that the 27th of the second month in the papyrus table was within a few days of August 26, 24 B.C. This was close to the end of the sixth Egyptian regnal year of Augustus; and in fact above the columns for the third month (line 1) is a heading marking a seventh year, and (in pink) a theta that is almost certainly the first letter of θώθ, the first month of the year. The fact that col. xii is much wider than col. iv is an indication that col. iv merely separates months within a year, whereas col. xii separates years. All this could have been established even if the papyrus had been torn off below line 7.

4. Lunar longitudes and calendrical data in the ephemeris.

We turn now to the lower part of the ephemeris. Each month has seven columns of data, of which the second, sixth, and seventh were apparently left vacant, perhaps so that the user of the ephemeris could add information of his own (e.g. notes on the astrological interpretation of the day). The first column (v and xiii) marks, in pink, the cardinal dates of the Roman calendar: the kalends, marked with the abbre-

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[11] Cf. Jones (1999) v. 1, 343.

[12] Tuckerman (1962) and (1964). Tuckerman's tables for Mars have a systematic error that does not rise above about half a degree for the dates under consideration; accurate positions of Mars are given in Houlden & Stephenson (1986).

viated name of the month, the nones, and presumably the ides. (We note in passing that the month preceding September is Sextilis, not Augustus, which was only introduced in the calendar in 8 B.C.) The third (vii and xv) counts days in another calendar, which, since the count begins with 1 in the first line, is also the calendar according to which the ephemeris was laid out. If the later ephemerides are anything to go by, this ought to be the Egyptian civil calendar. The fourth and fifth columns (viii–ix, also i and xvi with the lost adjacent columns) contain the daily longitudes of the moon, probably computed for 6 P.M.

Since we already know that the second month in the papyrus approximately coincides with August, 24 B.C., we can easily line up the lunar longitudes in the papyrus with the dates in the Julian calendar for which they most closely agree with the moon's longitudes computed by modern theory for 6 P.M. local time and with a 6° correction for the sidereal frame of reference.[13] The results are shown in Table 2. For the third month in the papyrus, where the numbers for the degrees are lost, I have shown the dates preceding and following the moon's crossings from one zodiacal sign to the next; indications of such sign-entries can be read or inferred on lines 13, 16, 22, and 24 of the papyrus.

We may observe in the first place that the longitudes preserved in cols. i and ix of the papyrus agree within a margin of 2° with the longitudes computed by modern theory for the best-matching dates. The chronology is also consistent, that is, the number of days between any two longitudes according to the papyrus is always the same as the number of days between the dates that fit best according to modern theory. One apparent exception is in col. xvi line 16, where the moon's entry into Scorpio is one day too late to be in agreement with the rest of the table. It is not possible to tell whether this discrepancy is due to a scribal error or to a quirk of the method by which the lunar longitudes in the papyrus were computed. We may be confident that, except for col. xvi lines 15–16, the "dates of closest match" in Table 2 are the actual dates in our "ideal" Julian calendar corresponding to the longitudes in the papyrus. These dates, it should be remembered, were established wholly independently of the calendrical data in the papyrus.

According to the hypothesis that the reformed Egyptian civil calendar was intercalated every four years starting from its institution, the years Augustus 5–8 were the first four years of the reformed calendar, and all dates in the reformed calendar during those years were identical to the dates in the unreformed calendar until the first intercalary day, Augustus 8 Epagomenae 6. According to Snyder's hypothesis of irregular intercalations, on the other hand, reformed calendar dates already lagged two days behind unreformed calendar dates in Augustus 6–7.[14] As Table 2 shows, the Egyptian dates in the papyrus conflict with the reformed dates according to Snyder's hypothesis, while they could be interpreted either as unreformed dates, or as reformed dates if the hypothesis of regular intercalations is true. The fact that the unreformed calendar never appears in later ephemerides is an argument in favour of identifying the Egyptian calendar in this ephemeris as whatever version was the civil calendar at the time.

A surprise awaits us in the Roman dates. The irregularity of intercalations in the Roman calendar between 42 B.C. and A.D. 4 is not a mere hypothesis of modern chronographers, but a historical fact reported in a consistent manner by several ancient sources. Yet the Roman dates in the ephemeris are not what we would expect them to be according to the pattern of irregular intercalations generally presumed for the Roman calendar during this period. On the contrary, they agree precisely with the Julian calendar dates, that is, with the dates that they would have had in the Roman calendar if the Roman calendar had been intercalated correctly every four years from the beginning of Caesar's reform.

This can only mean that there were people in Egypt who knew how the Roman calendar ought to be regulated, notwithstanding the mistakes of the pontifices at Rome. What is more, they appear to have

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[13] For computations of lunar longitudes, for which Tuckerman's tables are inadequate, I used a computer program kindly provided by P. J. Huber.

[14] See the tables in Skeat (1993).

regarded the version of the Roman calendar with regular intercalations every four years as the actual civil calendar; otherwise, how would one have been able to put the calendrical data in the ephemeris to practical (astrological) use?

What I suppose had happened was that people in Egypt who needed to work with dates in the Roman calendar, during the latter part of Cleopatra's reign as well as immediately after the beginning of Roman rule, did not depend on bulletins from Rome to regulate the calendar, since they knew the rule according to which the intercalations were supposed to take place.[15] The Egyptians must at some point have become aware that the Roman dates that they assigned to particular days differed by one or two days from the dates according to the pontifices, but we should not assume that they would have immediately changed their reckoning to conform with the official version of the calendar. The calendar equation Roman July 19 = Egyptian Epeiph 27 discussed by Hagedorn indicates that conformity was imposed by 2 B.C.[16]

In any event, if the Egyptians were operating with a correctly intercalated version of the Roman calendar in 24 B.C., it is scarcely to believed that they would simultaneously have employed an irregularly intercalated version of the Egyptian calendar. The reason why the Egyptian reform took the year 26/25 B.C., Augustus' fifth regnal year, as its inaugural year is not known. One possibility is that this year was chosen because it coincided with the first year of the fifth Callippic Period, an astronomical cycle that, like the four-year intercalation cycle of the reformed Egyptian and Roman calendars, was built around a mean year length of 365 1/4 days.[17] There are undoubtedly other ways of accounting for the apparent delay of four years. Papyri may cast light on how the calendars were administered, but they are unlikely to give direct evidence of the reasons behind the rules.

Bibliographical abbreviations.

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[15] The possibility of anticipating intercalations anywhere in the Roman world was one of the obvious benefits of Julius Caesar's reform of the Roman calendar, no less important in the short term than its astronomical accuracy.

[16] [Added in proof.] Prof. Hagedorn suggests, as an alternative explanation for the presence of both the correctly and incorrectly intercalated Roman calendars in Egypt, that officials in Egypt originally introduced the correct intercalation, while people subsequently coming to Egypt from Italy continued to reckon by the calender with which they were familiar.

[17] Cf. the companion article to this one.

line	*longitude in papyrus*	*date of closest match*	*sidereal longitude*	*Egyptian date in papyrus*	*Egyptian date of closest match (irreg. intercal.)*	*Egyptian date of closest match (regular intercal.)*	*Roman date in papyrus (irreg. intercal.)*	*Roman date of closest match*
col. i								
9	[Aries] 5°	June 26	Aries 4°	Epeiph 2	Payni 30	Epeiph 2	?	June 24
10	[Aries] 18°	June 27	Aries 16°	Epeiph 3	Epeiph 1	Epeiph 3	?	June 25
col. viii–ix								
8	Aries 26°	July 25	Aries 24°	Mesore 1	Epeiph 29	Mesore 1	July 25	July 23
9	Taurus 8°	July 26	Taurus 6°	Mesore 2	Epeiph 30	Mesore 2	July 26	July 24
10	Taurus 19°	July 27	Taurus 18°	Mesore 3	Mesore 1	Mesore 3	July 27	July 25
11	Taurus 30°	July 28	Taurus 30°	Mesore 4	Mesore 2	Mesore 4	July 28	July 26
12	Gemini 12°	July 29	Gemini 12°	Mesore 5	Mesore 3	Mesore 5	July 29	July 27
13	Gemini 23°	July 30	Gemini 24°	Mesore 6	Mesore 4	Mesore 6	July 30	July 28
14	Cancer 5°	July 31	Cancer 6°	Mesore 7	Mesore 5	Mesore 7	July 31	July 29
15	Cancer 18°	August 1	Cancer 19°	Mesore 8	Mesore 6	Mesore 8	August 1	July 30
col. xvi								
12	[Virgo]	September 2	Virgo 20°	Thoth 5	Thoth 3	Thoth 5	September 2	August 31
13	[Libra]	September 3	Libra 5°	Thoth 6	Thoth 4	Thoth 6	September 3	September 1
15	[Libra]	September 4 (!)	Libra 19°	Thoth 8	Thoth 5	Thoth 7 (!)	September 5	September 2
16	Scorpio	September 5 (!)	Scorpio 3°	Thoth 9	Thoth 6	Thoth 8 (!)	September 6	September 3
21	[Capricorn]	September 11	Capricorn 28°	Thoth 14	Thoth 12	Thoth 14	September 11	September 9
22	Aquarius	September 12	Aquarius 11°	Thoth 15	Thoth 13	Thoth 15	September 12	September 10
23	[Aquarius]	September 13	Aquarius 25°	Thoth 16	Thoth 14	Thoth 16	September 13	September 11
24	Pisces	September 14	Pisces 8°	Thoth 17	Thoth 15	Thoth 17	September 14	September 12

Table 2. Concordance of lunar longitudes and dates in *P. Oxy.* LXI.4175 with Roman and Egyptian civil calendars.

	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii	xiii	xiv	xv	xvi
						]							∟̣ ζ **θ**[			
					[ ] π̣$^{α̣}$ [ ]								[ ] [			
					ιε ζ^{υ} ϛ								κδ ζ^{υ} ιδ . ε̣ [			
					λ cκ^{ο} cυναψ								ιζ c̣κ̣$^{ο̣}$ [			
5			]		β κ^{α} cυν^{α} κζ λ^{ε} cυνα								ιζ π^{α} c̣υ̣[			
	.]ψ̣ει				ιβ π^{α} cυνα κη π^{α} ια . ε̣c̣$^{π̣}$								ι[			
							α	κ^{ρι}	κϛ						α	[κ]$^{α̣}$
	ε						β	τ^{αυ}	η						[β]	
10	ι̣η̣						γ		ιθ						[γ]	
							δ		λ				**cεπτ**		δ	
							ε	δ^{ι}	ιβ						ε	
							ϛ		κγ						ϛ	
							ζ	κ^{α}	ε						ζ	
15					**cεξ**		η		ιη				**νων**		η	
							θ̣								θ	c̣κ̣$^{ο̣}$
															ι	
															ια	
															ιβ	
20															ιγ	
															ιδ	
															ιε	υ̣$^{δ̣}$
													[ειδ]		ιϛ	
															[ι]ζ̣	ι̣$^{χ̣}$
25															ιη̣	
															ι̣θ	

Table 1. Transcription of *P. Oxy.* LXI.4175.