Mediterranean Archaeology and Archaeometry, Special Issue, Vol. 6, No 3, pp. 153-160

Greek influence on Babylonian astronomy?

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Received: 29/4/2006
Accepted: 29/7/2006

Abstract

Astronomy in Babylonia during the first millennium BC developed out of a long tradition of observing and interpreting the sky into a science that was both observational and theoretical. It is well established that these developments influenced the practice of astronomy in neighbouring cultures in the Indus valley, Egypt and the Greco-Roman world. However, it is less clear whether there was any significant input from foreign cultures into the development of Babylonian astronomy. In this paper I examine the evidence for possible traces of Greek influence on Babylonian astronomy during the late first millennium BC. In particular, I discuss two possible cases of Greek influence that have been proposed in recent years: the naming of certain zodiacal signs and a value for the length of the year found on a Babylonian text that may be based upon Greek observations of summer solstices.

Keywords: *Babylonian astronomy, Greek astronomy, zodiac, constellations, year lengths.*

Introduction

The conquest of Babylon by Cyrus in 539 B.C. and then by Alexander the Great in 330 B.C. brought Babylonia under first Persian and then Greek rule for the major part of the second half of the first millennium B.C. During this period significant aspects of Babylonian astronomy found their way into Indian, Greek, Persian, and Egyptian hands (Pingree 1998). Transmission in the opposite direction is, however, harder to identify. Notwithstanding the caution that we must bear in mind due to the comparative paucity of contemporary written sources from outside Mesopotamia, it seems that despite the removal of indigenous rule, Babylonian scholarship remained essentially Babylonian throughout the Persian and Greek periods. For example, many Babylonian cultic activities such as temple rituals and even the important *Akîtu* new-year festival continued being performed and written about despite the Persian and Greek conquests (Linssen 2004, Pallis 1926, Bidmead 2002).

Outside of the sphere of scholars, the Greek conquest did, however, have significant impact on Babylonian life. Most important was the creation of a new city, Seleucia-on-the-Tigris some 60 miles north of Babylon, and the forced migration of most of the population of Babylon to this new capital. Babylon was not abandoned altogether, however, nor spared Greek interest. For example, a Greek theatre was built in the city shortly after Alexander's conquest and work was undertaken, or at least planned, to repair and rebuild temples in the city (Oates 1986, Downey 1988).

Contact between Greek and Babylonian scholars must have taken place during the period of Greek rule, however. Many aspects of Babylonian astronomy were transmitted to the Greek world. These include basic concepts such as the division of the zodiac into 360 degrees, several parameters which were adopted by Hipparchus (Kugler 1900, Aaboe 1955, Toomer 1988), several observations of eclipses and planetary positions used by Ptolemy (Steele 2004, Jones 2006), and large parts of Babylonian mathematical astronomy that have been found on Greek papyri from the Roman period (Jones 1999, 2002). Direct contact between individual Greek and Babylonian astronomers cannot be proved on the basis of textual evidence, but as I have described elsewhere the linguistic subtleties in understanding Babylonian astronomical texts strongly imply that this contact must have been direct and personal (Steele 2004). The question remains, therefore, did any astronomical knowledge pass in the other direction, from Greek astronomers to Babylonian astronomers? Two possible cases of Greek influence have been proposed in recent years, one relating to the naming of the signs of the zodiac, the other to the development of mathematical astronomy. My purpose in this paper is to re-examine the evidence for these claims to attempt to establish more clearly what influences may have occurred and when they are likely to have taken place.

Babylonian names for the signs of the zodiac

In the two-tablet compendium MUL.APIN, which probably dates to the end of the second or the beginning of the first millennium B.C., the moon and the five planets are said to pass through seventeen constellations. By the mid fifth century B.C., an abstract division of the sky into twelve equal parts, each of which was split into thirty degrees, replaces the earlier system of zodiacal constellations. These twelve zodiacal signs were named after twelve of the zodiacal constellations. Table 1 lists the twelve with their standard Babylonian names and the month with which they are associated in the Babylonian calendar.

The invention of the zodiac also led to the development of nativity astrology in which the life of an individual could be interpreted from the positions of the sun, moon and planets at the time of birth, most clearly demonstrated by the so-called Babylonian 'horoscopes' (Rochberg 1998). A text from Babylon, LBAT 1593, describes among other things some of the rules for interpreting the zodiacal sign in which a child is born for that child's characteristics and future (Reiner 2000). Although the text is damaged and hard to understand, it is evident that some of these interpretations are based upon associations or puns between the name of the zodiacal sign and the future of the child. For example, as translated by Reiner (2000), lines 6'–8' on the reverse read:

> *Born in the region of Libra: true or untrue, Šamaš will treat him evilly?. [Born in?] the region of Scorpius:... she will be a sorceress, she will be joyous?..., a widow, and will die by scorpion (sting), a giant?. Born in the region of Sagittarius: (he will be expert in) shooting the bow, riding horses, submerging himself? in the river, 'collecting accounts?.*

Libra, the balance, is here associated with judgement. A child born in the region of Scorpio will die by a sting from that animal. The association of Sagittarius with riding and shooting the bow also draws upon traditional Babylonian themes (contra Reiner 2000). The zodiacal sign Sagittarius is named after the god Pabilsag who is pictured on boundary stones from the Kassite period (late 2nd millennium B.C.) as a centaur shooting an arrow (see Fig. 1). Elsewhere in the same text we find a reference to a form of astral medicine:

Table 1: *The twelve signs of the Babylonian zodiac.*

Zodiacal Sign	Associated Month	Transliteration	Translation
Aries	I	HUN	The Hired Man
Taurus	II	MÚL-MÚL	The Stars (Pleiades)
Gemini	III	MAŠ-MAŠ	The Twin
Cancer	IV	ALLA	The Crab
Leo	V	A	The Lion
Virgo	VI	ABSIN	The Barleystalk
Libra	VII	RÍN	The Balance
Scorpio	VIII	GÍR-TAB	The Scorpion
Sagittarius	IX	PA	Pabilsag
Capricorn	X	MÁŠ	The Goat-fish
Aquarius	XI	GU	The Great One
Pisces	XII	*zib*.ME	The Tails

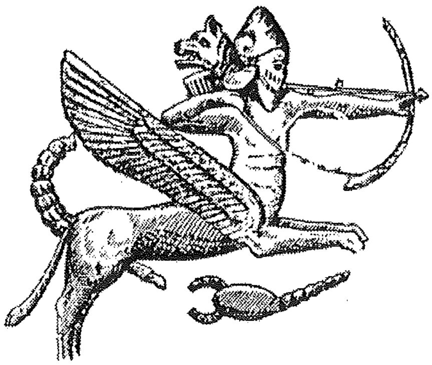

Fig. 1: *Image of Pabilsag on a boundary stone from the Kassite period (after Hinke 1907).*

> *the animal(s) of 13 and 4,37 you take one with the other, you salve, feed, and fumigate the patient with the stone, herb, and wood (respectively), the biblu (almanach?) of month I, from the 1st to the 30th...*

These lines are referring to two types of text known as *dodekatemoria* and *kalendertexte*. In both types of text are given in four columns on the left pairs which can be interpreted as months and days within the 'ideal' 360-day year, and signs and degrees around the zodiac. To the right may be found the names of cities, objects, or ingredients to be used in healing. In the *dodekatemoria*, the position within the zodiac moves on by 13 degrees every day. In the *kalendertexte* it moves by 277 degrees (written sexagesimally this is the 4,37 referred to in the text above). The *dodekatemoria* scheme of 13 degrees corresponds to the mean daily motion of the moon during an ideal month and is the basis of the 277 degree *kalendertexte* scheme which is derived by a clever mathematical manipulation of the simple lunar scheme (Brack-Bernsen and Steele 2004).

One of the best preserved *kalendertexte*, W 22704 (von Weiher 1988, no. 104), comes from the library of the well known scribe Iqīša of Uruk, as is shown by the colophon:

> *Tablet of Iqīša, firstborn son of Ištar-šuma-éreš, descendent of Ekur-zakir, the maš-maš priest. (Hand of) Ištar-šuma-éreš, his son. He who worships Anu, Enlil and Ea shall not remove it.*

Iqīša was active towards the end of the third century B.C. and was the owner of a wide range of tablets including several types of omen collections and astronomical texts. W 22704, one of two *kalendertexte* known from his library, concerns to fourth month of the Babylonian year and gives for each entry a selection of ingredients to be used in healing a sick patient. I translate the first twelve lines of this tablet below.

Throughout the remainder of the text, the ingredients cited repeat with the zodiacal signs given in the third column. These ingredients come from one or more animals in each case. In Table 2 I have rearranged the entries in the order of the zodiacal signs and listed also the animals which provide the ingredients used for healing. It is immediately appar-

First 12 lines of the Tablet.

Month IV	1	Aries	7	Sheep-blood, sheep-fat, and sheep-hair, you anoint.
Ditto	2	Capricorn	14	Goat-bood, goat-fat, and goat-hair, you anoint
Ditto	3	Libra	21	"Empty place", you anoint.
Ditto	4	Cancer	28	Crab-blood, or crab-fat, ditto.
Ditto	5	Taurus	5	Bull-blood, or bull-fat, or bull-hair, ditto.
Ditto	6	Aquarius	12	Eagle-head, feathers, and blood, ditto.
Ditto	7	Scorpio	19	"Empty place", ditto.
Ditto	8	Leo	26	Lion-blood, lion-fat, or lion-hair, ditto.
Ditto	9	Gemini	3	Rooster-head, blood, and feathers, ditto.
Ditto	10	Pisces	10	Dove-head, blood, swallow-head, blood, ditto.
Ditto	11	Sagittarius	17	Anzu(-bird?)-head, Anzu(-bird?)-feathers, Anzu(-bird)-blood, ditto.
Ditto	12	Virgo	24	šigušu-barley-flour, raven-head, and raven-feather, ditto.

ent that where the zodiacal sign is named after an animal, that animal is the source of the ingredient: Cancer, a crab; Leo, a lion; Capricorn, a goat. Pisces, zib.ME "the Tails", in the Babylonian sky was seen not as the tails of a pair of fish, but rather as those of a swallow and a fish, hence the healing ingredient comes from a bird. The only exception is for Scorpio where the text has the puzzling entry KI.KAL-tim which seems to mean "empty-place", perhaps indicating that the text from which W 22704 was copied contained nothing written here (the same phrase appears in the entries for Libra).

The association of non-animal zodiacal signs with ingredients made from particular animals can be explained in most cases by consideration of other constellations which are situated near to those after which the zodiacal signs are named. Taurus, named "The Stars (i.e. the Pleiades)" also contains the constellation the Bull of Heaven – the two constellations are drawn side by side on the Gemini tablet (VAT 7851) in a series of illustrated astrological texts (Weidner 1967) – and so is liked with ingredients derived from a bull. Gemini, the Twins, is placed near to the Rooster in texts which list stars and constellations such as BM 78161 (Hunger and Pingree 1999). Virgo, the Barleystalk, is linked in the *kalendertext* with both flour made from barley and a raven. The Raven constellation is again close to the Barleystalk and appears next to it on the Virgo tablet (VAT 7847 + AO 7847) of the illustrated astrological series (Weidner 1967). Only Sagittarius and Aries are not easily explained by looking for nearby constellations, though in the case of Sagittarius this is partly because the Anzu-bird constellation had not yet been identified, despite appearing in the "Great Star List" (Koch-Westenholz 1995).

Aries presents a more interesting issue. Aries is normally the Hired Man and not associated with sheep in earlier texts. The appearance of sheep in this text has therefore led Reiner (1995) to note that the association can only be understood in terms of the classical zodiac. Indeed, it seems in the Hellenistic period, Aries was often considered to be a ram rather than a hired man. For example, Wallenfels (1993) has identified a number of seal impressions from Hellenistic Uruk with zodiacal signs; all those he has identified with Aries contain a ram. However, it is not necessary to invoke Greek influence to account for the change in identity of Aries. As Ungnad (1941–1944), Wallenfels (1993), and Foxvog (1993) have suggested, the explanation is probably a form of philological punning common in cuneiform. The full form of "The Hired Man" is MUL.LÚ.HUN.GA, where MUL is a determinitive indicating a star or constellation and LÚ is a determinative indicating that what follows is a profession. Normally, the full name is abbreviated to HUN, but it seems that it may also have been abbreviated to LÚ, though this is unattested, and then to the homophone LU, which is found in several late astronomical texts from Uruk (Ungnad 1941–1944, Neugebauer 1947). Now, the sign LU can also be read UDU, the usual logographic writing for the Akkadian word *immeru* "ram". Thus, it seems likely that the coincidence of the possibility of

Table 2: Animals used to make the healing ingredients associated with each zodiacal sign in the kalendertext W 22704.

Zodiacal Sign	Normal Babylonian Name	Ingredient
Aries	The Hired Man	Sheep
Taurus	The Stars (Pleiades)	Bull
Gemini	The Twin	Rooster
Cancer	The Crab	Crab
Leo	The Lion	Lion
Virgo	The Barleystalk	Barley-flour, Raven
Libra	The Balance	"empty"
Scorpio	The Scorpion	"empty"
Sagittarius	Pabilsag	Anzu-bird
Capricorn	The Goat-fish	Goat
Aquarius	The Great One	Eagle
Pisces	The Tails	Dove, Swallow

reading LU as UDU and the conceptual link between the celestial hired man as the god Dumuzi (Foxvog 1993), a shepherd, led to the association of the ram with the zodiacal sign Aries.

It is of some interest to note that Iqīša *kalendertext* probably dates to c. 320 B.C. and so the change in identification of Aries with a ram by at least by some Babylonians must have taken place before this date. This probably pushes it back before the concept of equal length zodiacal signs, as opposed to zodiacal constellations, appears in the Greek world.

Babylonian mathematical astronomy

Nowhere in the texts of Babylonian astronomy do we find an explicit trace of Greek influence. No Greek astronomers are mentioned in Babylonian astronomical texts, no observations are recorded which are said to have been observed outside of central Mesopotamia, with the exception of one eclipse reported as being seen "in Susa and the open country" (Hunger 2001 no. 9), and no trace of Greek cosmological thought appears to underlie Babylonian theoretical astronomy. However, it must be remarked that Babylonian astronomical texts do not directly attribute any astronomical knowledge to contemporary individuals, with the possible exception of the occasional occurrence of the not understood phrase "*Tersitu* of Kidinnu/Nabū-(ri)mannu" (Neugebauer 1955). For any textual information of Greek influence on the astronomy of a Babylonian we must turn to classical sources. According to Strabo and others, a Babylonian named Seleucus of Seleucia-on-the-Tigris who lived in the second century B.C., was one of the few followers of Aristarchus' claim that the Earth possessed a daily rotation (Heath 1913). However, we have no reference to this individual in cuneiform sources and he is unlikely to have been a member of the Babylonian scholarly circle being based in Seleucia-on-the-Tigris. Thus, even if the classical sources are accurate in suggesting Seleucus adopted Aristarchus' astronomy, we should not interpret this as Greek influence on 'Babylonian' astronomy.

Babylonian mathematical astronomy may be split into two main areas identified by modern scholars as planetary theory and lunar theory. Planetary theory is focused on calculating the date and position in the zodiac of certain important phenomena in the planetary synodic cycle: first and last visibilities, stations, and acronychal rising. Lunar theory is aimed at calculating for each conjunction and opposition of the sun and moon the position of the moon, the magnitude of any eclipse that might take place, the time of syzygy and the visibility of the lunar crescent (which determines the beginning of the month in the Babylonian calendar). In both planetary and lunar theory, these dates, positions, etc are calculated arithmetically using combinations of step and zigzag functions based upon period relations. No physical model, or cosmological vision, is apparent in the tables of calculated numbers of procedure texts outlining how to calculate the numbers, other than an underlying idea of predictability in the movement of the heavenly bodies.

It is not known exactly when the various schemes of Babylonian mathematical astronomy were developed, but the complete lunar System A (one of two main schemes for the moon) is attested already in the late fourth century B.C. (Aaboe 1969, Steele 2002 text A), and planetary texts are known from earlier (Neugebauer and Sachs 1967). I and others have suggested that the basic systems were developed already by the fourth century, if not earlier. Thus, it is clear that the essential elements of Babylonian mathematical astronomy cannot have been influenced by Greek astronomy as at this period we have no evidence for either the practice of regular dated astronomical observation or the use of the zodiac by Greek astronomers (Goldstein and Bowen 1991, Bowen and Goldstein 1991). Thus any Greek influence must have come in the further developments and explorations of the implications of these systems which took place towards the end of the period of their use.

A possible case of Greek influence has been claimed by Rawlins (1991). The procedure text ACT No. 210 contains a value for the number of days in 18 years. The implied year-length is 365;14,44,51 and Rawlins notes that 297 such years equal almost exactly 108478 days. This number of days is exactly the interval in whole days between the summer solstice observed by "the school of Meton and Euktemon" on 27 June 432 B.C. and that observed by Hipparchus on 26 June 135 B.C., both of which are recorded in Ptolemy's *Almagest* and are among only a handful of known observations of solstices known from either Babylon or Greece. Rawlins, followed by Thurston (2002) and Britton (2002), takes this as evidence that the year length implied in ACT No. 210 was calculated from these two solstice observations.

There are several reasons for believing that Rawlins' reconstruction is at least plausible. First, the year length on ACT No. 210 is somewhat shorter than other Babylonian year lengths, implying it is a tropical year length derived from solstice or equinox data rather than positions in the sidereal zodiac used in Babylonian observations. Secondly, ACT No. 210 displays writing conventions characteristic of first century B.C. Babylonian texts. It is highly unfortunate that only part of ACT No. 210 is preserved, and any colophon originally written on the tablet is now lost. A colophon may have included the date the text was written, or have allowed an approximate date to be deduced if the scribe who copied the tablet was known from other dated texts.

Support for the possible Greek influence on ACT No. 210 comes also from the style and content of the text, which differ in many respects from other procedure texts. These include:

(1) Most procedure texts set out the procedures for calculating various columns of the lunar and solar ephemerides. However, none of the preserved sections on ACT No. 210 describe how to calculate; rather they set out and perform operations with various parameters that underlie the procedures.

(2) ACT No. 210 uniquely among known ACT procedure texts contains sections dealing with the moon and a planet. Sections 1 and 2, contrary to Neugebauer, relate to Saturn System A and should be read as follows:

Section 1 (Obv I)

1 [...] muh(?) TUR
2 [...] x 9 E-*bi*
3 [...] 14,3,45
4 [...25,31,5,3]7,30 KI 11,4
5 [...] TUR U_4-MEŠ
6 [... E]-*bi*

Section 2 (Obv II)

1 [...]-MEŠ 5,13(?)[...]
2 [...11,43,]7,30 *a-na* 1,20[+x...]
3 [...] *a-na* 4,25 MU-MEŠ KI-ú
4 [...] 50,46,4[0(?)]

Section 1 refers to Saturn on the fast arc and Section 2 to Saturn on the slow arc. Section 2 is followed by space and a double ruling to separate it from the following lunar sections, which are subdivided by single rulings.

(3) Section 3 of ACT No. 210 lists the length of the mean synodic month from System B in the form 29;31,50,8,20 days. In giving the mean synodic month in the form of fractions of days, rather than in time-degrees (UŠ), which is how the length of the month is calculated in the ephemerides, the text echoes the Greek form of writing month lengths as found, for example, in the Almagest. I know of only two other Babylonian texts which give month lengths in fractions of days: BM 36712 (Sachs and Neugebauer 1956), an early text which gives the length of the sidereal month as 27;25 days; and the so-called 'Saros Text' (Neugebauer 1957), which gives an alternative length of the mean synodic month.

The case for possible Greek influence on ACT No. 210 is compelling, if not definitive. However, what does this mean for the wider role of Greek influence on Babylonian mathematical astronomy? ACT No. 210 is an unusual, late text that may contain a parameter derived from Greek observations. However, this parameter is found no-where else in Babylonian astronomy, nor does it underlie any part of a Babylonian theory. Thus, unless further evidence appears in future investigations, we must conclude that Greek influence was neither widespread, nor especially significant, on the development of Babylonian mathematical astronomy.

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