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Stargazing in traditional water management: a case study in northern Oman

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Summary
This paper presents some of the results of the author's first year of doctoral research. Despite the availability of watches, stars are still used in some villages in northern Oman to time the allocation of water for irrigation by an age-old method of tapping groundwater by gravity flow. It appears that the use of stars survives mainly in smaller settlements still dependent on agriculture for livelihoods, where light pollution is less severe than in the towns, and where the community adheres to traditional practices. Many of the stars have different names to those given in the literature on Arabic stars, and the stars used for timing water vary somewhat from one village to another. The method of stargazing also varies among villages: in some the stars are watched rising above the horizon and in others the time is known by the rising or setting of the star above or below a man-made marker, or on its reaching the zenith. A number of stars are identified by their international classification, possibly for the first time.

Keywords: Oman, *aflāj*, stars, water, irrigation

Background and methodology

Ancient oasis settlements in Oman are frequently found where groundwater is available for the cultivation of crops (e.g. Orchard & Stanger 1994: 86–87), possibly using irrigation systems similar to those in use today. The country is largely arid, but in the north the Ḥajar mountains run parallel to the coast, and here rainfall is higher, sufficient to recharge groundwater that can be used for growing crops all year round.

I first became interested in the use of stars in Oman in March 2005 when I took part in the Al-Ḥajar archaeological project, which was investigating oasis settlements in the north of the country.[1] My role was to collect information on the management of traditional irrigation systems in use today. These systems direct groundwater from a source area to fields by gravity flow, and are called *aflāj* (sg. *falaj*).

The allocation of *falaj* water among farmers once depended almost entirely on the use of the sun and the stars to track the passage of time. This practice, and particularly the use of stars, is fast disappearing: of approximately fifteen *aflāj* visited in March 2005, stars were used only for one. All knowledge about this dying art may soon be lost, and it is therefore important to the cultural heritage of Oman and the Arabian Peninsula to record where, how, and why stars are still used.

I visited Oman in September 2005 to consult Omani organisations on the scope of the research and to establish the degree of support available. The information presented here is largely the result of the ensuing seven weeks' fieldwork carried out between January and May 2006.

It was initially envisaged that data would be collected both from *falaj* systems still using the stars and those that do not. However, it soon became apparent that memories alone, while interesting and valuable in their own right, do not allow a detailed description of the method of stargazing to be recorded. It was therefore decided, at least initially, to work in villages where stars are still used. It was also decided to focus on the area south of the Ḥajar mountains, which is slightly less affected by modern developments, such as irrigation by pumped wells, than in the north.

None of the *falaj* systems in towns visited during the research, including Adam, Bahlaʾ, al-Ḥamraʾ, Izkī, Mintirib, Muḍayrib, Muḍaybī and Sinaw, still use stars. It appears that their use survives only in villages still highly dependent on agriculture. The villages selected for the study are in two separate areas (Fig. 1). The first is close to the mountains, near the market town of Bahlaʾ, where the Al-Ḥajar archaeological project was based. Qaryah Benī Ṣubḥ, the only settlement in this area found to be using stars, is included in the study. The second area is around the town of Muḍaybī in the Sharqīyah region where four villages — al-Fatḥ, Zāhib,

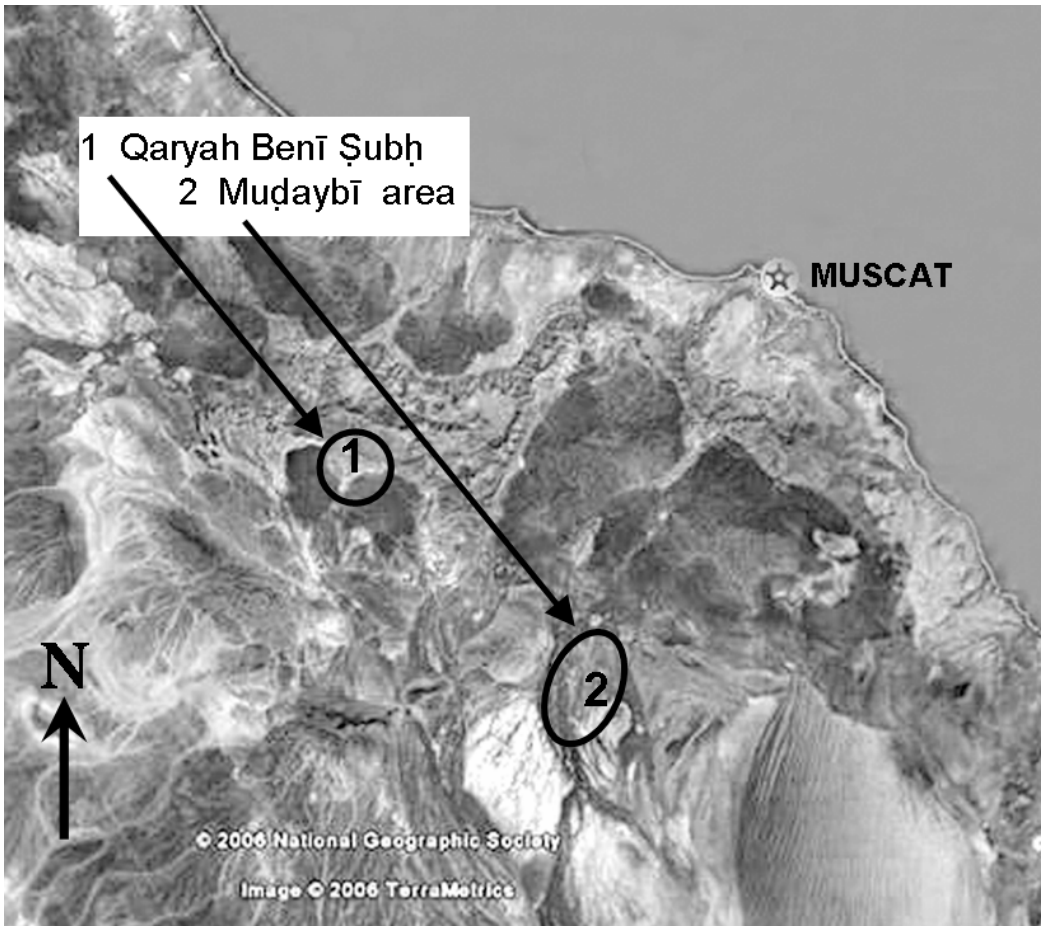

FIGURE 1. *The location of the study areas.*

Sudayrah, and Barzamān — use stars and are included in the study. Sheikh Sultān b. Rāshid al-Ḥajrī of Mintirib says that stars are no longer used anywhere in Bedīyah District, east of the study area (pers. comm. January 2006). This means that Barzamān, the village furthest south in this study, is possibly the furthest south in Oman still using stars to allocate *falaj* water.

Introductions to *falaj* officials were most frequently made by a representative of the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) in the area, either in person or by telephone. Following the introduction, I usually carried out interviews on my own, partly in order not to put too much strain on the resources of the MRMWER but mainly to develop my own relationships with the villagers. In common with many Muslim countries, in Oman foreign females are free to mix with both men and women in their houses, resulting in a relaxed atmosphere during interviews. The interviews were relatively informal, carried out either in people's houses or gardens between cups of coffee with dates and fruit, or in the village, often at the locations used for stargazing, where the method of watching the stars was demonstrated to me.

Sources of information

There are numerous literature sources describing *falaj* building and organization in Oman, of which perhaps the best known is Wilkinson (1977), who describes the development of *aflāj* from *c.* 700 BC. Books and pamphlets published by the MRMEWR are a valuable source of information on the distribution and construction of *aflāj* (e.g. MRMEWR 2002). However, most of the available literature, quite naturally, focuses on water resources and provides little detail on the method of stargazing or the identification of the stars other than by a local name.

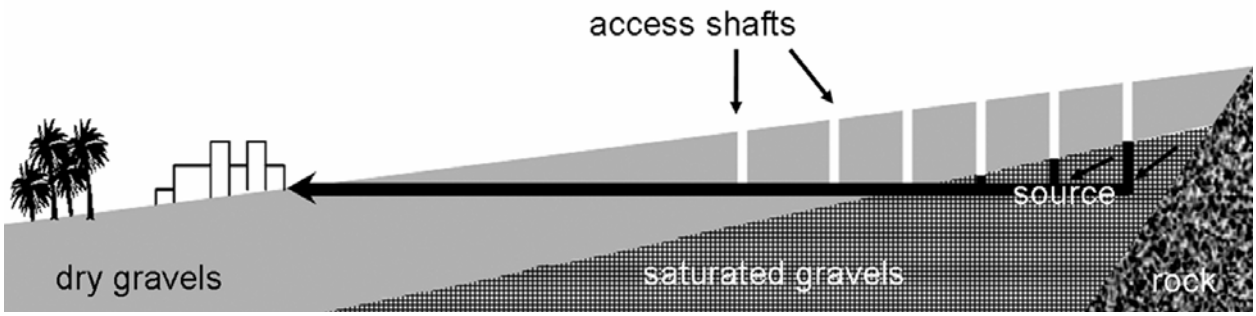

FIGURE 2. *A schematic cross-section of a* falaj.

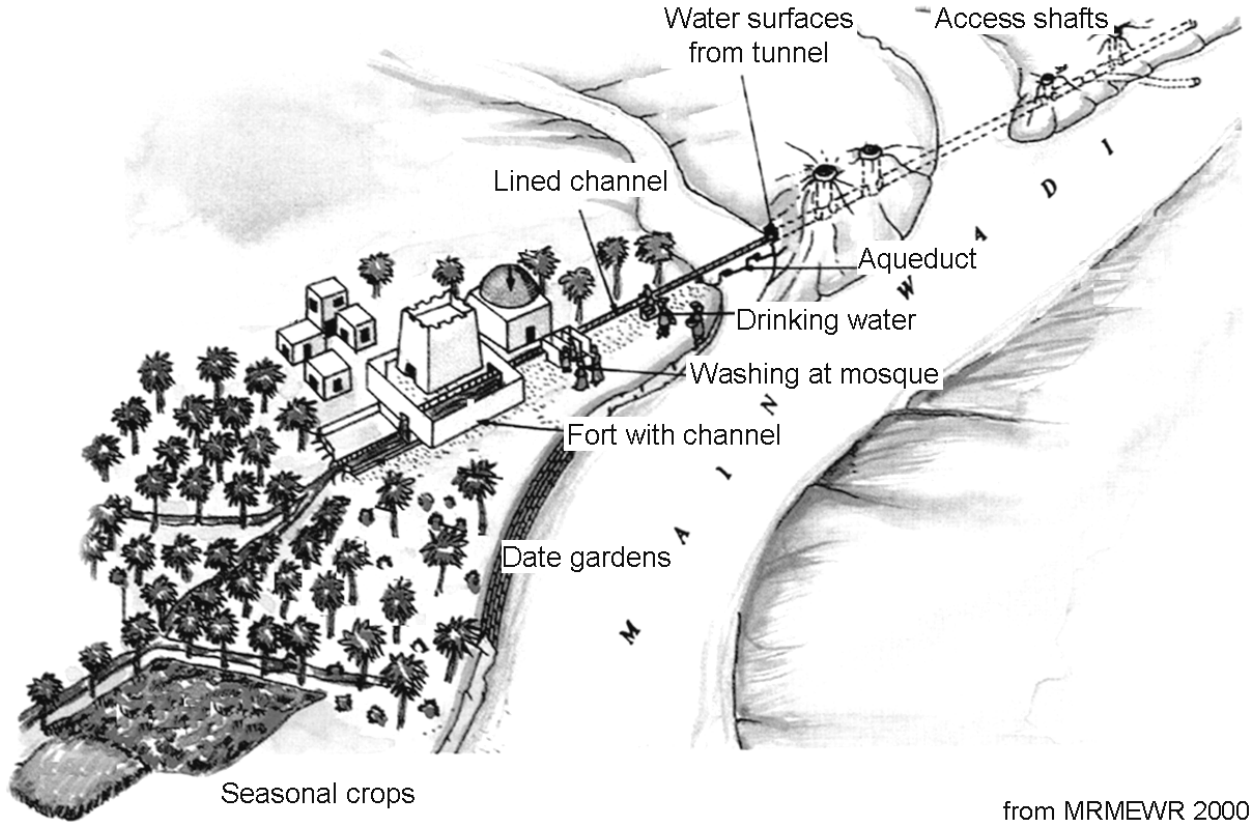

FIGURE 3. *A schematic plan of a* falaj.

Wilkinson provides lists of stars used in a few settlements. Al-ᶜAbrī ([1980]) is also widely referred to by Omani authors. He gives lists of stars used in several villages and describes where the stars formerly used in al-Ḥamraᵓ could be seen in the sky. More recent works include al-Shaqsī (1996), who also listed the stars formerly used in al-Ḥamraᵓ and al-Ghafrī (2004), who gives star lists and the approximate divisions of time they represent in three villages, in addition to those presented by al-ᶜAbrī. Al-Siyābī (2000; pers. comm.) gives the names of the twenty-four stars formerly used near Rusayl. It seems that the only attempt before this study to identify these stars by their international designations was by al-Shaqsī, who brought astronomers from the

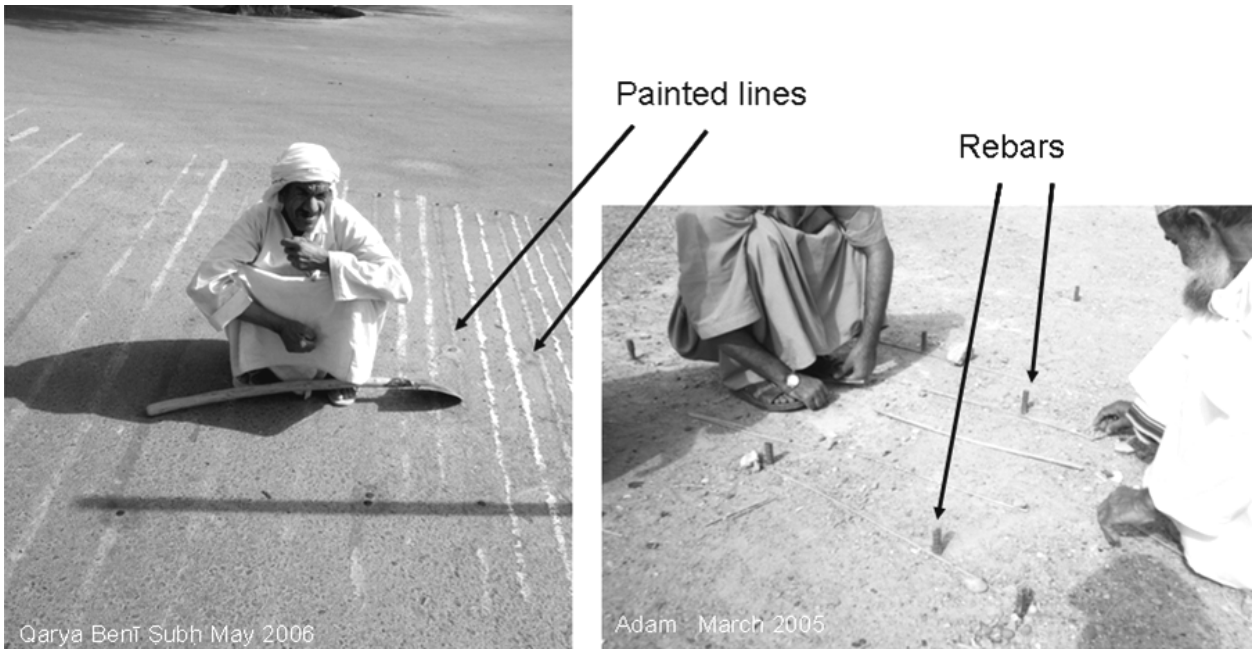

FIGURE 4. *Sundials in Qaryah Benī Ṣubḥ (left) and Adam (right).*

Royal Court to al-Ḥamraʾ. This failed because the night was cloudy. He also took a stargazer, Khamīs al-Ṣubḥī, to the astronomers in Muscat but that also failed because in Muscat, Khamīs did not recognize the stars used in his village.

Given the paucity of published records, the main source for this study is data collected in the field, interviewing *falaj* managers and stargazers, and watching the stars with them when it is not too cloudy. For star identification, an astronomy software package called *Starry Night* (Imaginova 2005) has been used. For star names, reference is also made to Badr (1998). Badr's work is an encyclopaedia of Arabic star names, including those given by al-Ṣūfī (d. 525/1130–1131), who translated (from Greek to Arabic) and updated Ptolemy's Almagest in the tenth century, and provided older Arabic names for stars used for navigation in the Book on the Constellations of the Fixed Stars (*Kitāb ṣuwar al-kawākib al-thābitah*).

Additional information, especially on star names, was collected in some other towns and villages that no longer use stars, including Misfāt al-ʿAbrīyīn near Qaryah Benī Ṣubḥ, and Mintirib and Muḍayrib in the Sharqīyah region.

Falaj construction and water use

It appears that *aflāj* were constructed initially when drier conditions made irrigation necessary. At least six *falaj* systems dated to *c.* 1000 BC have been identified in the United Arab Emirates and Oman (al-Tikrītī 2002: 137). One *falaj* system excavated near Bahlaʾ is attributed to the third millennium BC (Orchard & Orchard 2006). It appears that there was a major development of the *falaj* network during Achaemenid times in the first millennium BC (Wilkinson 1977: 130) and again in the Sasanian period (mid-third to mid-seventh centuries AD). According to Wilkinson (1997: 50), the area of land irrigated by *aflāj* was at its maximum in the late Sasanian period. Another major period of construction and repair was from the mid-seventeenth to mid-eighteenth centuries, when Oman was politically stable (Wilkinson 1977: 50). An inventory carried out by the Ministry of Water Resources (currently the MRMEWR) in the late 1990s found *c.* 4000 *falaj* systems, of which *c.* 3000 were still in use (MRMEWR 2002: 16). They extend more than 100 km south from the mountains into areas with practically no rainfall.

In classical Arabic, the term *falaj* has many meanings, including "to divide into shares" and "running water" (Lane 1968, vi: 2436), which relate to its present-day use in Oman where it is applied to the whole system of tapping groundwater, bringing it to the surface, and distributing it to fields by gravity flow. The groundwater is often taken from wadi gravel deposits, which have a higher storage capacity and therefore give more reli

English	Classical Arabic	Omani *	Classification
Algenib	al-Janb		γ Pegasi
		al-Janb	δ + ε + ρ Hydrae
Botain	al-Buṭayn		δ (+ ε + ρ) Arietis
Zosma		al-Buṭayn	δ Leonis
Vega	al-Naṣr al-Wāqiᶜ	al-Chūī **	α Lyrae
Arcturus	al-Sammāk	al-Dhakarayn	α Boötis
Meissa (λ only)	al-Haqᶜa	al-Shubcha	λ + φ^1 + φ^2 Orionis
Alhena	al-Hanᶜa ***	al-Jawzaʾ	γ Geminorum
Denebola	al-Ṣarfa	al-Sufaᶜ	β Leonis
* names from Qaryah Benī Ṣubḥ.			
** "K" is often replaced by "ch" in this area: al-Chūī and al-Shubcha are also called al-Kūī and al-Shubka.			
*** al-Hanᶜa is two stars: γ + ξ Geminorum, but Alhena and al-Jawzaʾ refer only to the brightest.			

FIGURE 5. *English, Arabic, and Omani star names.*

able yields than the bedrock. A tunnel is dug back from the area to be cultivated at a shallow angle to intercept the water table. Access shafts provide for the removal of spoil and for ventilation. The part of the tunnel and shafts below the water table is the source area. From here, the water flows under gravity along the tunnel, and when it meets the surface the channel is divided to distribute water to the fields, where date palms are probably the most important crop. Movable dams of stone, metal, or cloth are used to block some channels while others are running. A schematic section of a *falaj* is shown in Figure 2, and a plan indicating the distribution of water and its use in Figure 3.

Abstraction of water by *aflāj* is a sustainable method of water use since the amount of water that flows to the fields cannot exceed the amount of groundwater recharge. Because the water flows continuously and is a precious resource, it is used at night as well as by day so that it is not wasted. There is, therefore, a need to distribute the water at night, and to time the distribution.

The first possible use of the water is from the access shafts. If these are left open they are free for anyone, not only the *falaj* community, to use for drinking or for watering animals. They are little used these days, as most travellers buy water from pumped wells if needed. The water usually reaches the surface just above the main settlement, and formerly in many cases provided all the water needs of the villagers. Drinking water for humans was taken first, then for animals, followed by ritual washing at the mosque, baths, and one or more places for washing corpses. The *falaj* channels are still used by some people for washing and bathing.

Formerly, all building and repair works were either carried out or paid for by the *falaj* community, but nowadays they can usually only afford to carry out routine maintenance, such as cleaning silt from the channels. It is too expensive to construct new systems. Pumped wells are widely used and have contributed to lower groundwater levels and the drying up of some *aflāj*. However, the government provides funds for repairing existing systems and even for support wells to pump groundwater into the distribution channels.

Timing the allocation of water

Despite the presence of oil, Oman did not really open up to the outside world until 1970, when His Majesty, Sultan Qaboos, overthrew his father. Until then, watches were not generally available and the stars and sun were used to tell the time. This late development may explain in part why traditional practices survive in places.

In the study area, the water shares are based on the time that water flows to the fields. A twenty-four-hour day is divided into two parts variously called *bādah* (Wilkinson 1974: 17), *bāddah* (e.g. al-Salīmī & Abdul-Fattāh 1997: م), or *baddah* (al-Ghafrī 2004: 40) related to major divisions of water such as blocks for renting for *falaj* maintenance. It is also divided into forty-eight *āthār* (sg. *athar*). A day-time *athar* is the time it takes for a shadow to lengthen by a man's foot, nominally half an hour. The *athar* may be subdivided but one twenty-fourth of an *athar*, a little more than 1 minute, is considered the smallest practicable division for irrigation (al-Ghafrī 2004: 48). Another measurement of time is the *sahm* (pl. not known), which is 45 minutes and is used instead of the *athar* in some villages.

The sun is still used by many *falaj* communities,

FIGURE 6. *The horizon for watching stars at Qaryah Benī Ṣubḥ.*

even where they have stopped using the stars. The sundial comprises a marker pole and lines oriented approximately north–south, which divide the day into *āthār* or *sahms* (Fig. 4). They are relatively easy to use: the shadow of a pole can usually be seen even when it is a bit cloudy. Farmers come to the dial to wait their turn, despite the fact that many of them wear, and presumably use, watches.

At night, stars appear to circle the earth and their movement can be used to tell the time. It is tempting to surmise that the system of time telling with stars for the distribution of irrigation water has been used in Oman for millennia, but this is not necessarily the case. In Misfāt al-ᶜAbrīyīn, stars were only used from about 115 years ago until the 1970s. Their use, as I was told by Masᶜūd b. Sālim al-Haṭālī and his brother Khalfān (pers. comm. May 2006), was introduced when the *falaj* system was extended and reorganized. Before that, with a relatively small area to cultivate, there was no need to divide the night-time allocation of water: where there is more than enough water, all that may be needed is to flood the land to a certain depth. Even where timing is necessary, there are other methods of telling the time at night, such as the water clock which was formerly used in Nizwā (Abercrombie 1981: 367) and is still used in one or two villages in the mountains (al-Ghafrī 2004: 54).

Star names

In the Arab world, stars are used for navigation at sea (Agius 2005: 156–157) and in the desert (Badr 1998: 3); for agricultural calendars (Varisco 1997), marking certain seasons when the weather is likely to be propitious for activities such as planting or harvesting a crop; for astrology (Varisco 2000: 641 ff.); and for telling the time at night. This paper deals only with stars as used for telling the time.

There are differences between the classical Arabic star names given in the literature (e.g. Badr 1998) and the names used in Oman. Some stars are relatively easy to identify by their Arabic name. However, in Oman, only a few of the stars used for timekeeping, including Thurayyā (the Pleiades) and al-Dubrān (Aldebaran), cannot be confused with any other star.

The same name may be given to more than one star or constellation, often to stars rising at about the same time. Al-Shaᶜaraʾ, the shining one, is usually identified as Sirius (α Canis Majoris). However, Procyon (α Canis Minoris) to the north of Sirius, is also called al-Shaᶜaraʾ. Al-Sammāk, the fisherman, is Arcturus (α Boötis) to the north and Spica (α Virginis) to the south.

Star	Classification	English name	*Āthār*			
			number	length, minutes		
al-Chūchabayn	α + β Arietis	Hamal + Sheratan	3	25	25	40
al-Thurayyā	Pleiades	Pleiades	2	30	30	
al-Debrān	α Tauri	Aldebaran	2	35	35	
al-Shubcha	λ + φ^1 + φ^2 Orionis	Meissa (λ)	2	20	30	
al-Jawzaʾ	γ Geminorum	Alhena	2	40	35	
al-Shaʿaraʾ	α Canis Minoris	Procyon	2	30	50	
al-Janb	δ, ε + ρ Hydrae		2	20	30	
al-Dharaʿīn	α + γ Leonis	Regulus + Algieba	2	30	25	
al-Buṭayn	δ Leonis	Zosma	2	20	20	
al-Sufāʿ	β Leonis	Denebola	2	30	50	
al-Mīathāb	ε Virginis	Vindemiatrix	2	30	30	
al-Dhakarayn	α Boötis	Arcturus	3	20	20	30
al-Ghafur	α Coronae Borealis	Alphecca, Gemma	2	45	45	
al-ʿAqrab	γ Draconis	Eltanin	3	30	20	20
al-Chūī	α Lyrae	Vega	3	40	40	35
al-Mūfī	α Cygni	Deneb	2	20	20	
al-Ghurāb	α, β, δ + λ^2 Delphini	Sualocin (α) Rotanev (β)	2	40	35	
al-Adam	ε Pegasi	Enif	2	20	25	
Italics: times not verified						

FIGURE 7. *The main stars in Qaryah Benī Ṣubḥ.*

In the study area it is usually the northern star that is used in timekeeping, but the stargazers in Zāhib near Muḍaybī changed from Procyon to Sirius some forty years ago to make the timing system easier for farm workers from the Indian sub-continent to use.

Many Arabic star names are for parts of the body, and stars such as al-Janb (the side or flank), al-Buṭayn (the little belly) and al-Qalb (the heart) are therefore found in many different constellations. English names derived from these refer to only one star in one constellation. Stars with such names in Oman are, therefore, often not the same as stars with English names derived from Arabic. In fact it appears that a number of stars used for telling the time for the allocation of water in Oman are known only by a local name. A few examples of Omani star names that are different to classical Arabic names are given in Fig. 5.

Why stars are still used

The ready availability of watches means that there is now little technical reason to use the stars. Why people stopped using stars is, therefore, easier to establish than why they are still used. In many villages and towns visited (Misfāt al-ʿAbrīyīn, Birkat al-Mawz, Muḍayrib) the use of the stars and sun stopped in the 1970s when watches became generally available. In others, the sundial continued to be used while the use of stars died out, and today the sundial is still used by many *falaj* communities. Even where the stars are still used, on cloudy nights it appears that watches are used almost everywhere. Some of the reasons given for not using the stars are:

— people who know the system are dying out, and many who still live have failing eyesight;

— the system of stargazing is difficult to learn and few people are interested in learning: many who would have carried out this function now have an education and prefer better-paid employment;

— light pollution has reduced the visibility of the stars.

Several of the people met during the course of this work who are knowledgeable about the stars are in their late eighties, and age is certainly a factor: for example, in Mintirib the use of stars stopped when the main stargazer Muḥammad b. Ḥamad b. Saʿīd (family name not given) died in 1995. Light pollution now affects many settlements to a greater or lesser degree, and even where stars are still used it makes it more difficult for a beginner to see and recognize the stars. This appears to be the main reason why people stopped using the stars in Sinaw near Muḍaybī and at Rusayl near Muscat. Knowl

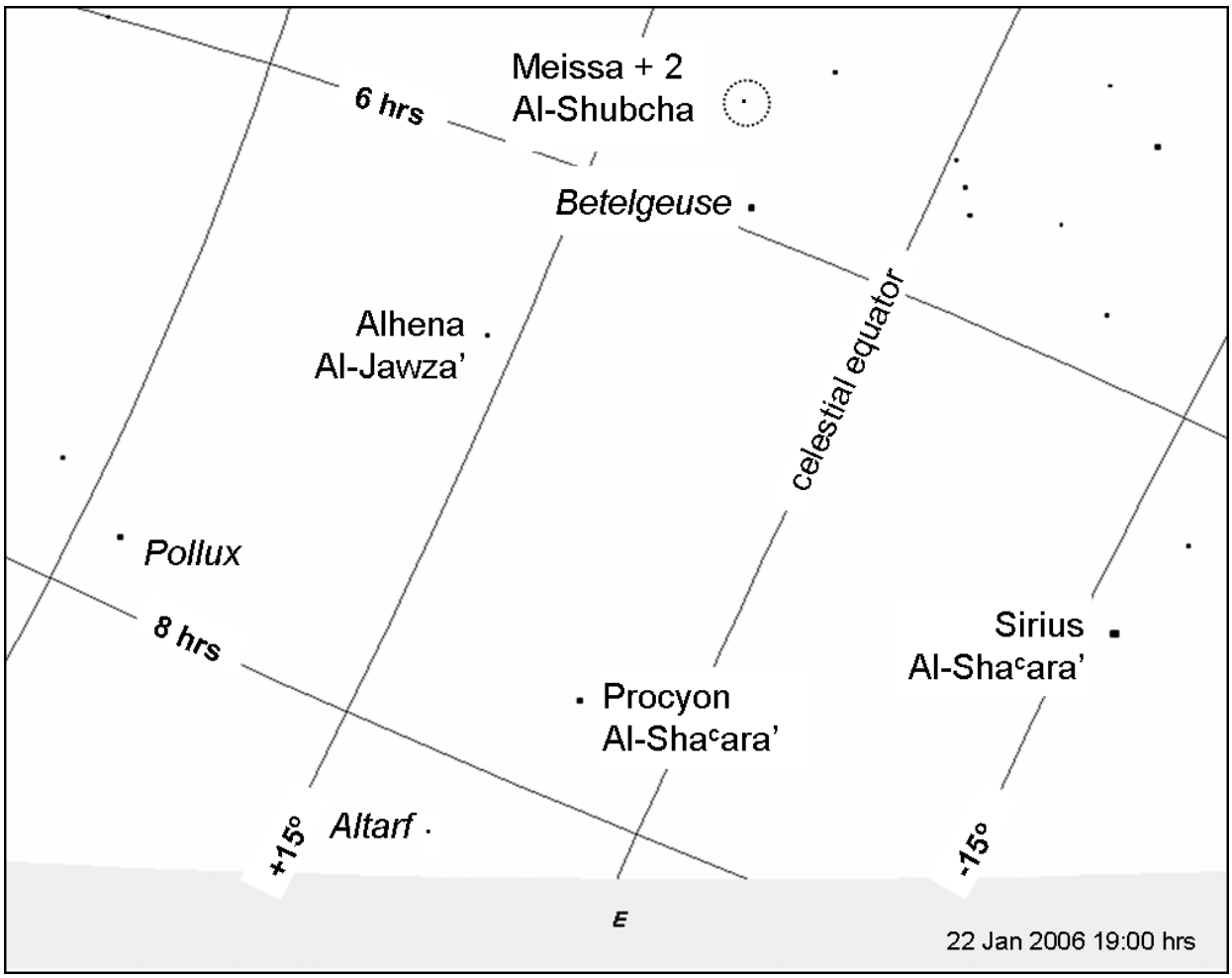

FIGURE 8. *The night sky looking east from Qaryah Benī Ṣubḥ.*

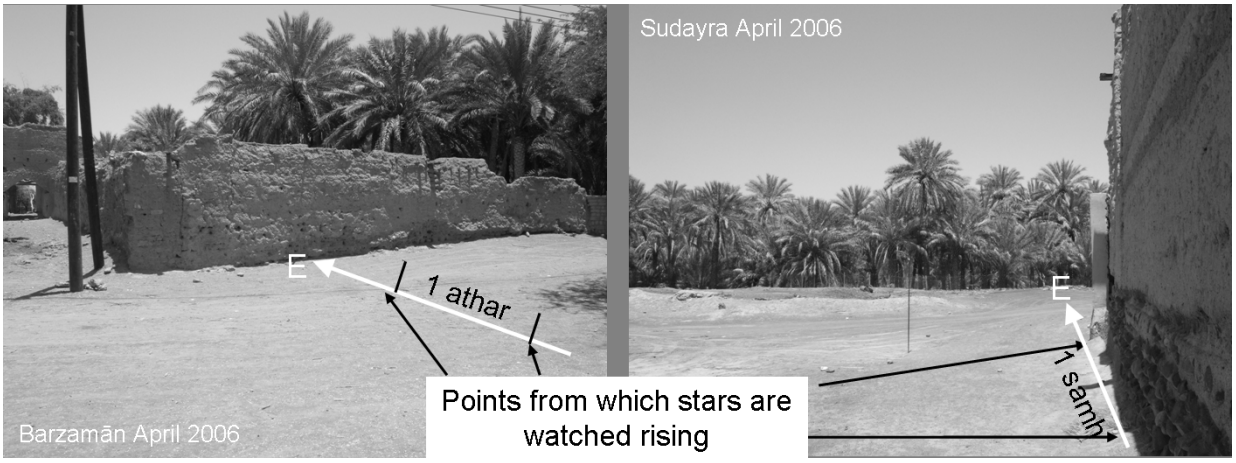

FIGURE 9. *Stargazing points at Barzamān (left) and Sudayrah (right).*

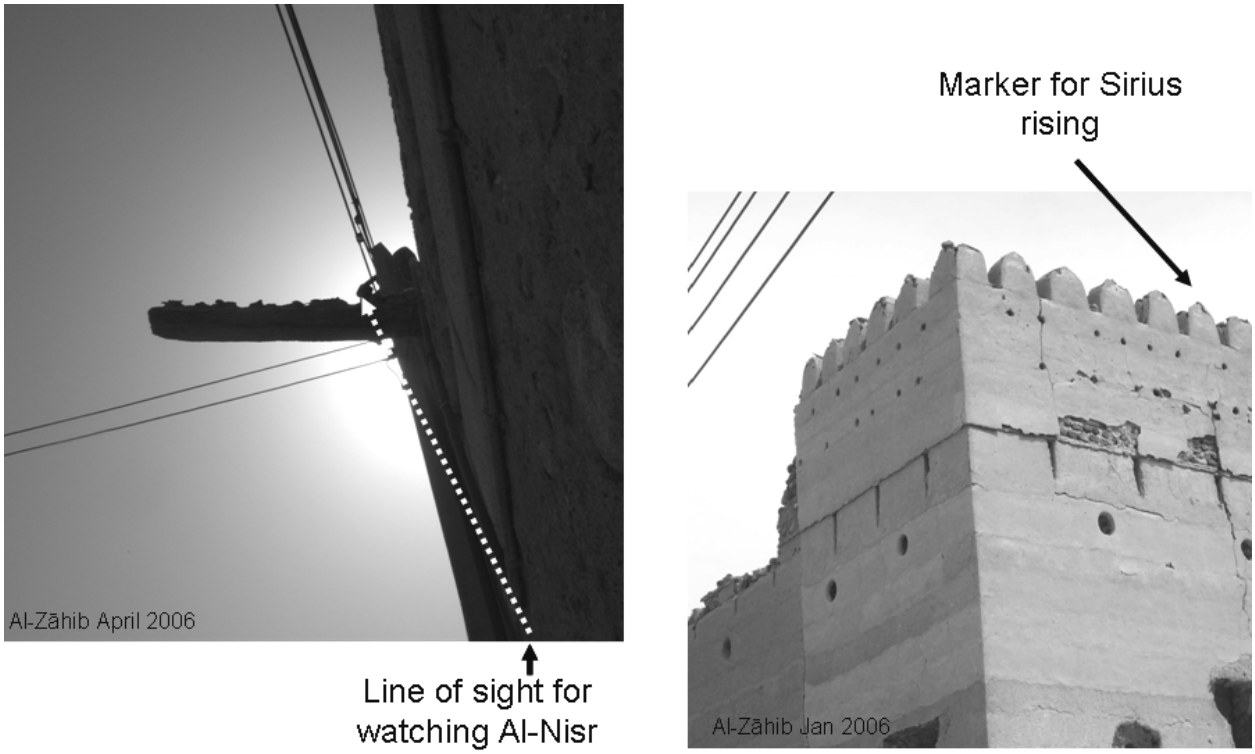

FIGURE 10. *Stargazing points at Zāhib.*

edge of the stars was handed down orally from generation to generation, and now few of the younger generation, who have had access to a formal education, plan to spend their lives in their village. However, the example of Zāhib, where expatriate farm workers new to the village learn and use the system, shows that there is no reason, with the exception of light pollution, why stargazing cannot continue if that is what people using the *falaj* want.

Methods of stargazing

The method of stargazing differs from village to village. In Qaryah Benī Ṣubḥ stars are watched rising above the horizon. In other villages walls, palm trees, and posts attached to buildings are used to mark the rising, setting, or zenith of stars.

In Qaryah Benī Ṣubḥ, twenty-one main stars are used with dividers and other stars, totalling approximately fifty. In the Muḍaybī area and beyond, twenty-four stars are used, but there are minor differences in the twenty-four stars used in different villages.

Qaryah Benī Ṣubḥ

In Qaryah Benī Ṣubḥ, the time between the rise of different stars above the horizon is used for the division of water. There are three stargazing points in the village, in order to be accessible to farm workers in the area being irrigated at the time. Fig. 6 shows the horizon used for watching the stars, viewed from one of these points.

Rāshid bin Khamīs al-Ṣubḥi is the official stargazer in Qaryah Benī Ṣubḥ. The stargazer before Rāshid was his father Khamīs, and Rāshid is now teaching the system to his brother and son. He stays out all night, sometimes taking a nap between stars, sometimes cleaning the irrigation channels, and farmers come to him for information as needed. It appears that most people know enough about the stars to carry out their own distribution of water, but they check with Rāshid when they are unsure. Rāshid is also one of the two people responsible for the daytime allocation of water using the sundial.

Fig. 7 shows the names of the main stars identified to date in Qaryah Benī Ṣubḥ and the time that they represent. The time difference between the main stars ranges from 40 to 90 minutes. These spaces are split into *āthār* lasting from 20 to 50 minutes, often using

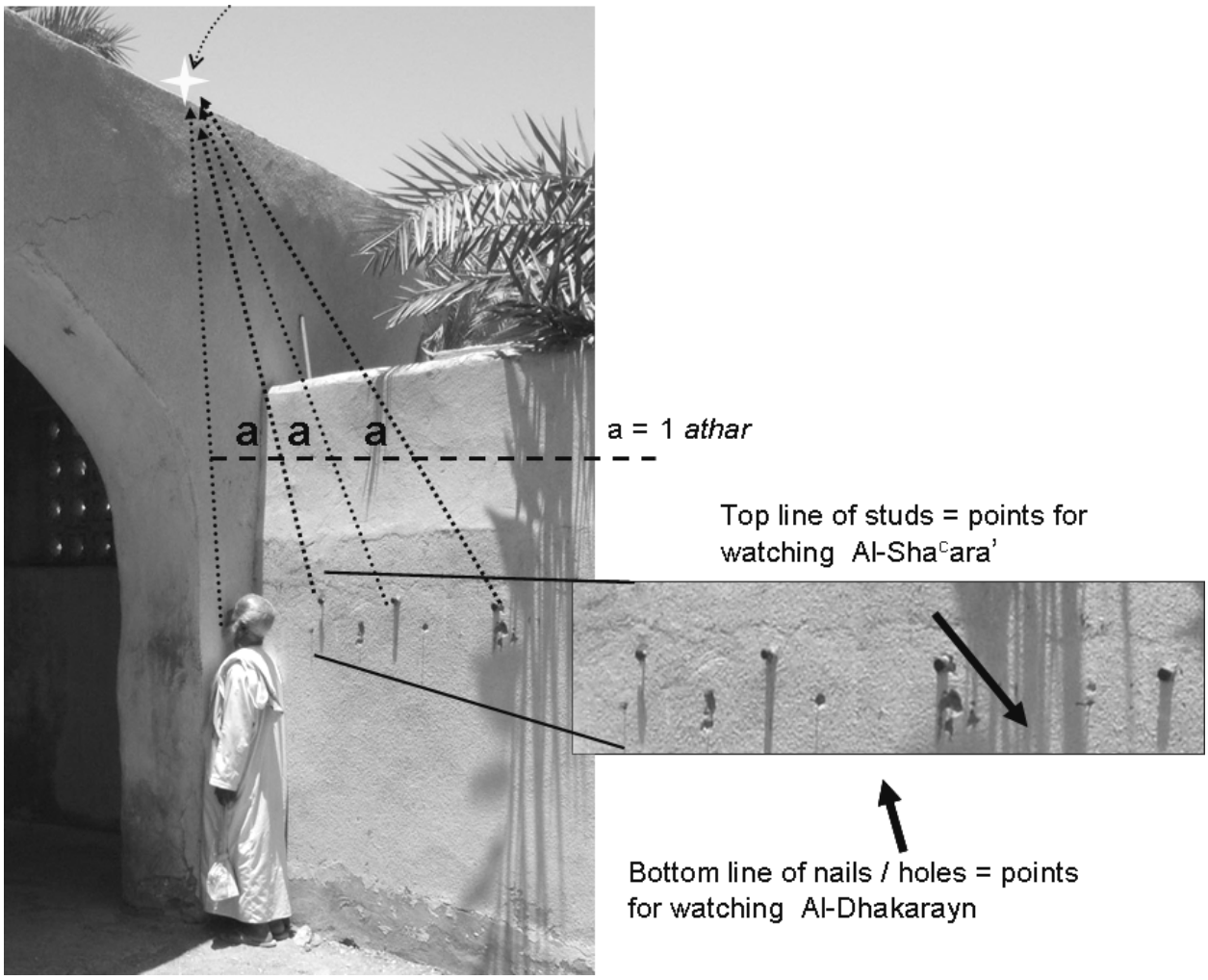

FIGURE 11. *Stargazing points at al-Fatḥ.*

"divider" stars, which are not given individual names. They are known only as the divider (*manṣaf*, pl. *manāṣif*) of the previous star. Additional stars may be used as part of the time-telling process but they are not *athar* dividers, and not all *āthār* are divided by stars. It is unclear how the main stars are selected, but it is certainly not on the basis of brightness. For example, Betelgeuse, the brightest star in Orion is used as the divider between al-Shubcha and al-Jawzaᵓ; Pollux is the second brightest star in Gemini and is used as a divider between al-Jawzāᵓ and al-Shaᶜaraᵓ (Procyon). Neither Betelgeuse nor Pollux are given names.

On the whole, divider stars are selected to mark the divisions between *āthār*. For example, the three *āthār* between al-Dhakarayn and al-Ghafur are divided by two stars. The first and second *āthār* are each 20 minutes long while the third is 30 minutes. The first divider rises 20 minutes after al-Dhakarayn, and the second 20 minutes later, i.e. 30 minutes before the rise of al-Ghafur. (2) However, in a few cases the timing of the divider stars seems to bear little relation to the *athar* divisions. For example, between al-Chūī and al-Mūfī there are three *āthār*, the first two each 40 minutes and the third 35 minutes long, but the division between the stars is as follows:

al-Chūī – 20 minutes – 1st divider (Sheliak – β Lyrae) – 10 minutes – 2nd divider (Sulafat – γ Lyrae) – 30 minutes – 3rd divider (δ Cygni) – 30 minutes – 4th divider (o^1 Cygni) – 15 minutes – 5th star (Sadr – γ Cygni, not an official divider) – 10 minutes – al-Mūfī.

Figure 8 is a picture is taken from the *Starry Night* software and shows the sky looking east from Qaryah

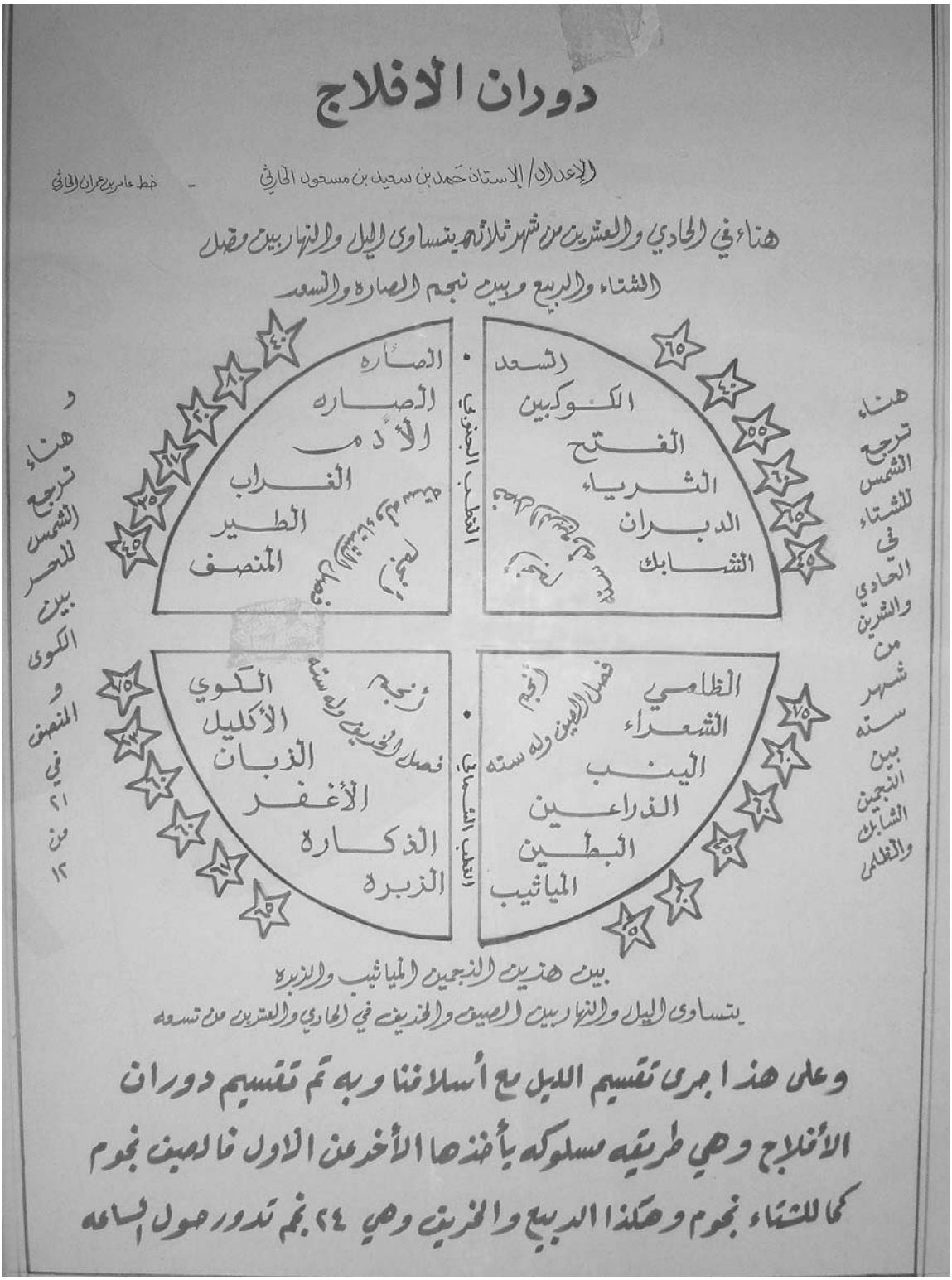

FIGURE 12. *The star chart from Muḍayrib.*

Benī Ṣubḥ in January 2006. Main stars are shown in normal type, divider stars in italics. At the top is the star cluster Meissa with two other stars in Orion, known here as al-Shubcha, and more formally as al-Shābik. This is followed by Alhena, known as al-Jawzāʾ, and then Procyon (al-Shaʿaraʾ), with Betelgeuse and Pollux used as dividers. Altarf is the divider between al-Shaʿaraʾ and al-Janb, which had not yet risen. Sirius is also shown although it is not used in Qaryah Benī Ṣubḥ. The horizon was also used formerly in Misfāt al-ʿAbrīyīn near al-Ḥamraʾ, and in Sinaw near Muḍaybī. At Misfāh four small towers were built on a ridge forming the horizon to mark some of the main stars, to assist people with poor eyesight.

The Muḍaybī area

In the Muḍaybī area, a range of methods is used for stargazing. The main difference with Qaryah Benī Ṣubḥ is that here the observer moves, watching the same star from different points. The locations are selected to divide the time into equal lengths such that the night-time *athar* lasts half an hour. In two of the four villages included in the study, local horizons comprising a wall in Barzamān and palm trees in Sudayrah are used to watch stars rising. The observer moves forwards, stopping at points where the star will rise one *athar* or one *sahm* later than at the previous point (Fig. 9).

In al-Fatḥ and Zāhib there are highly complex systems using the tops of walls or posts sticking out from walls, viewed from different points, looking east, west, and directly upwards to the zenith. The complexity of the systems means that plans of the buildings used are needed before the method can be recorded in detail. In Zāhib, two sides of an alley are used. On the south is the wall of a ruined house, which has numerous vertical scratches marking the points at which the observer stands. On the north wall of the alley, a few hollows at shoulder height are the points from which al-Dhakarayn is watched. Altogether there are approximately forty points from which to watch. A horizontal pole sticking out into the alley from the ruined house is the main marker (Fig. 10). Some stars are watched rising above the pole from points to the west, while from points to the east of the pole stars are watched setting. The star al-Nisr is watched from two points close to the pole, one to the west and one to the east, so that the observer is looking upwards, almost at the zenith. The top of the tower on the house is used to watch Sirius (al-Shaʿaraʾ) rising (Fig. 10).

In al-Fatḥ, a small mosque and its surrounds are used for stargazing. There are many points for watching from, both inside and outside the mosque. At the location shown in Fig. 11, the observer (Ḥāmdūn b. Ḥamad al-Ḥabsī) looks west, watching stars setting behind the wall. He starts at the wall and then moves back, eastwards, so that the same star is seen setting at a later time. This part of the mosque is used for watching al-Shaʿaraʾ and al-Dhakarayn.

In the Muḍaybī area, there are no official stargazers, but people take it in turns when their water is due. However, there are usually one or two people credited with greater knowledge, who are responsible for teaching the method or resolving disputes. In al-Fatḥ there was a main stargazer who died in 2005, so the system may once have been similar to that in Qaryah Benī Ṣubḥ.

Each evening the stars rise four minutes earlier, so different stars are used in different seasons. Fig. 12 is a chart entitled *dawrān al-aflāj* (The Falaj Cycle), which was painted by Ḥamad b. Saʿīd al-Ḥārthī, in Muḍayrib in the 1980s. It shows the twenty-four stars used in this area over the course of one year, with six stars in each quarter, meaning that six different stars will be the first to rise in that period. The star shapes around the circumference contain the number of minutes between the stars, ranging from 20 to 80 minutes. Several of the stars have the same names as those used in Qaryah Benī Ṣubḥ, and may indeed be the same. Some, with different names, are probably different stars. However, al-Ẓalmī on this chart is at almost the same place time-wise between al-Shābik and al-ShaʿarAʾ as al-Jawzāʾ is in Qaryah Benī Ṣubḥ, indicating that al-Ẓalmī and al-Jawzāʾ may be the same star Alhena (γ Geminorum).

Conclusions

The results of the research to date go some way towards answering where and how stars are still used in parts of northern Oman. As to why, so far the main answer appears to be an adherence to tradition, not just for its own sake but also because the time divisions are known and accepted. Stargazing has survived in only a few villages still highly dependent on *falaj* irrigation and where light pollution is not excessive. Many of the stars have different names to those provided in the literature on Arabic stars, and the stars used for timing water vary somewhat from one village to another. Most of the stars used in Qaryah Benī Ṣubḥ have been identified according to their international classification.

Methods of stargazing vary among villages, even those only a few miles apart. In some villages the stars are watched rising above the horizon while in others the time is known by the rising or setting of the star above or below a man-made marker, or on its reaching the

zenith. The method is transmitted orally from generation to generation, and to incomers: a detailed knowledge of astronomy is not needed, nor is it necessary to be literate to be an effective stargazer. The qualities that are needed are experience and attentiveness to detail.

In future fieldwork it is planned firstly to complete the identification of stars in the study areas, and secondly to survey the structures used for stargazing. It is intended to record the methods used in sufficient detail to replicate them, even if the buildings are destroyed. Information about the *falaj* organization, water ownership, and the distribution of water by day and by night will be collected, to provide a more complete context for stargazing.

With relatively few villages included in the study, it will be not possible to take a broader perspective on the findings without some sort of cultural inventory of the *falaj* systems throughout the country. This task is beyond the means of a single researcher and should be carried out by the interested Ministries. Such an inventory would provide a framework for past, present, and future research.

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Notes

1 An archaeological project directed by Jocelyn Orchard, Jeffrey Orchard, and Jennifer Scarce operating in northern Oman since 1980.

2 For star names, the Library of Congress transliteration system is used in order to facilitate comparison with other works.

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