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Identifying the stars on Johann Bayer's Chart of the South Polar Sky

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The first chart of the stars in the region around the south celestial pole was published in 1603 by Johann Bayer (1572–1625) as part of his monumental star atlas called *Uranometria*. This south polar chart depicted 12 entirely new constellations that had been created only a few years earlier from stars observed during the first Dutch expedition to the East Indies in 1595–97. Bayer's chart plotted 121 stars in the 12 newly invented constellations. Five more stars formed a southern extension of the existing constellation Eridanus, while another twelve stars were left 'unformed', i.e. unattached to any constellation. Whereas Bayer famously applied Greek or Roman letters to the stars in the 48 Ptolemaic constellations, he left the stars in the newly invented constellations unlabelled. This paper attempts to identify the stars plotted on Bayer's chart. It also discusses the source of Bayer's data and the origin of the 12 new southern constellations.

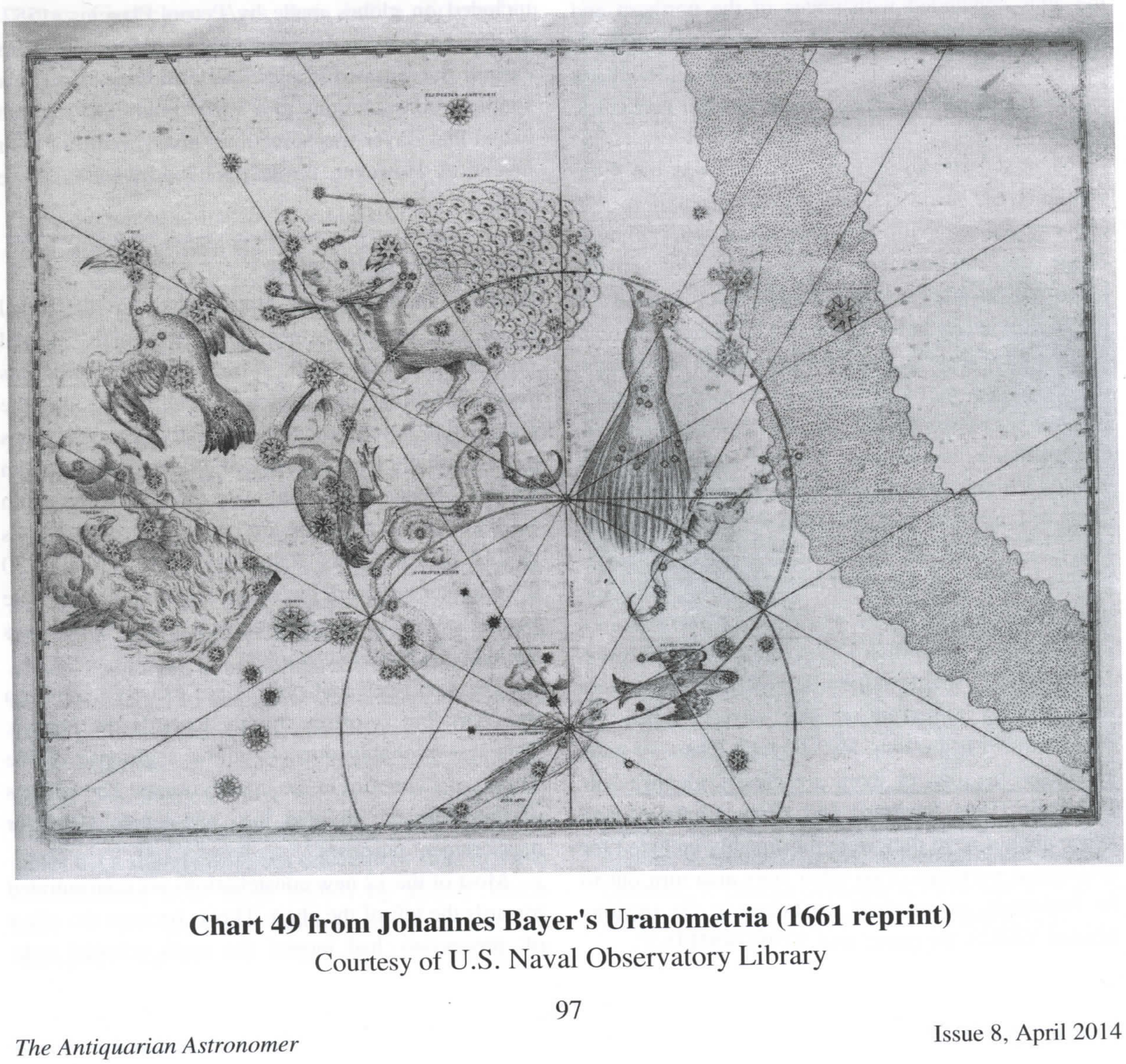

Chart 49 from Johannes Bayer's Uranometria (1661 reprint)
Courtesy of U.S. Naval Observatory Library

Introduction

Johann Bayer's *Uranometria*, subtitled *Omnium Asterismorum Continens Schemata, Nova Methodo Delineata, Aereis Laminis Expressa*, was the first of the great star atlases.[1] Published in Augsburg, Germany, in 1603, it consisted of 51 large-scale plates, with accompanying lists of stars. Over 2,000 stars were plotted from the catalogues of Tycho Brahe and Ptolemy, more than on any previous charts, and embellished with classical constellation figures as described by Ptolemy in the *Almagest*. The plates were engraved by Alexander Mair, a painter and engraver of Augsburg (c.1559–c.1620). The result was an impressive fusion of science and art that was a landmark in scientific publishing. So popular was the atlas that it was reprinted several times during the 17th century.

Unlike the great majority of star charts up until then, *Uranometria* depicted the constellation patterns as they appear from Earth, rather than in reverse view as on a globe. Hence they are far easier to match up with the real sky. Each of the 48 Ptolemaic constellations was afforded a full page of its own, and the atlas concluded with plates of the northern and southern celestial hemispheres centred on the ecliptic poles (these hemispheres differ from the other charts by being plotted in globe view rather than geocentric view).

Most sensational of Bayer's plates was the 49th, which is the main subject of our discussion. For convenience we will call this Chart 49, although Bayer did not number it as such. He actually identified his plates with a sequence of upper- and lower-case letters at the bottom right corner; Chart 49 is designated Aaa. It covers the previously blank south polar region of the sky. This area was blank because it was too far south to be seen from ancient Greece. Consequently the *Almagest*, the great star catalogue of antiquity compiled by Ptolemy around AD 150, contained no stars here and hence no constellations either.

The first reasonably extensive set of star observations in this region was made by members of a Dutch trading expedition to the Far East in the years 1595 to 1597. We do not know how many new stars they actually observed on this voyage, since the original records are long lost. Bayer's Chart 49 plots 140 stars, but two of them are clearly identified as Ptolemaic (Beta Sagittarii and Alpha Centauri) and hence are not new; they were presumably included for orientation purposes. Two other stars also turn out to be Ptolemaic, as we shall see below in the sections headed 'GRUS, the crane' and 'UNFORMED-3'.

For most astronomers in the early 17th century, Bayer's chart was their first glimpse of this part of the sky that lay forever hidden below their horizon. To them, it must have been as sensational as the first photographs of the far side of the Moon were in more recent times. Adding to the impact, the stars on the chart were divided into 12 new constellations depicting various fantastic creatures the explorers had seen on their travels, among them a spear-carrying native, all skilfully engraved by Mair. These 12 constellations are still recognized today.

Deborah Jean Warner has described Bayer's 49th chart as 'almost an afterthought', but this seems unfair.[2] Stars from several of the new constellations appear on the charts of the southernmost Ptolemaic figures, so it is clear that Bayer was intent on incorporating these newly observed stars from the outset. Chart 49 turned *Uranometria* into the first all-sky star atlas, and Bayer must have been alert to the commercial advantages this would bring.

Bayer's chart was not the very first time these new stars and constellations had been seen, since they were included on globes made by Petrus Plancius (1552-1622) and Jodocus Hondius (1563-1612) a few years earlier. But it was this atlas that introduced these new southern constellations to a wider public, to such an extent that Bayer was sometimes given credit for their invention. However, he was not the inventor, as we shall see later.

Description of the plate

Bayer's Chart 49 is plotted on an azimuthal equidistant projection, centred on the south celestial pole for the year 1600.[3] The solstitial colure runs vertically down the centre of the chart, and the equinoctial colure runs horizontally. Straight lines extend radially from the SCP at 30 degree intervals in azimuth. Beneath the south celestial pole is the south ecliptic pole. Both poles are encompassed by circles of 23.5 degree radius. Radial lines also extend at 30 degree intervals from the south ecliptic pole, but here Bayer has made a cartographical error: these lines should be curved, not straight.[4]

The south celestial pole is not exactly central on the chart, but is offset slightly towards the bottom. This was probably done to allow a glimpse of the Tropic of Capricorn in the upper corners. The borders of the plate are divided into one-degree steps for measurement purposes.[5]

Most of the 12 new constellations are concentrated towards the left of the chart. This is because the effect of precession had moved the south celestial pole nearly 10 degrees in the direction of Centaurus since ancient Greek times. As a result, the 'zone of invisibility' had changed position noticeably since the *Almagest* was compiled.

In all, Bayer's Chart 49 plots 140 stars (although two may not be true stars at all, as we shall see in the sections on Dorado and Hydrus, below). As well as the 121 stars making up the new constellations and 12 unformed ones, the chart includes five stars forming a southern extension of Eridanus, and two stars identified by Bayer as Ptolemaic, presumably included for reference. In addition, the Chart depicts the two Magellanic Clouds (termed here Nubecula Major and Nubecula Minor), which were already known; they are drawn as terrestrial-type cumulus clouds. The path of the Milky Way is a stippled band.

As noted above, *Uranometria* devoted a single plate to each of the 48 Ptolemaic constellations. Printed on the reverse of each of these was a table of its component stars, but this was not the case for Chart 49. Instead, on the back of it Bayer simply listed the names of the 12 new constellations, viz. Pavo, Toucan, Grus, Phoenix, Dorado, Piscis Volans, Hydrus, Chameleon, Apis, Apis Indica, Triangulum Australe, and Indus. Surprisingly, no one seems to have published identifications of the stars on Bayer's Chart 49 before now.

3. The star identifications

I have attempted to match the positions of the stars on Chart 49 to the real sky by comparing them with modern charts. Since considerable systematic errors are to be expected, and are indeed present, I was guided more by the relative positions of the stars than their exact coordinates. The sizes of the star images on Bayer's chart are a poor guide to their apparent magnitudes, and were of little help. It was possible to identify almost all the stars on the chart with high or reasonable confidence, the main exception being a particularly confused area in Indus.

Below I discuss the 12 new constellations alphabetically under their modern names. Where the names on the chart are different from the modern names, I add them in brackets. I then mention the five new stars added to Eridanus, and attempt to identify the 12 unformed stars on the chart.

A catalogue of the stars in the new Southern Dozen constellations was eventually published by Kepler in the *Rudolphine Tables* in 1627.[6] Kepler's tables list a slightly different selection of stars in some constellations from those shown by Bayer, which hints at an additional source of data for the *Rudolphine Tables*. We shall look at the source of Bayer's own data in the penultimate section of this paper.

It should be noted that the designations of the stars in the South Polar Region have a somewhat involved history which is beyond the scope of this paper. Briefly, Greek letters were first assigned to the stars in this area by Nicolas Louis Lacaille (1713-1762) in the 1750s. Others such as Francis Baily (1774-1844) later tinkered with the lettering, and the designations were finally tidied up by Benjamin Apthorp Gould (1824-1896) in *Uranometria Argentina,* 1879.

APUS (Apis Indica), the bird of paradise

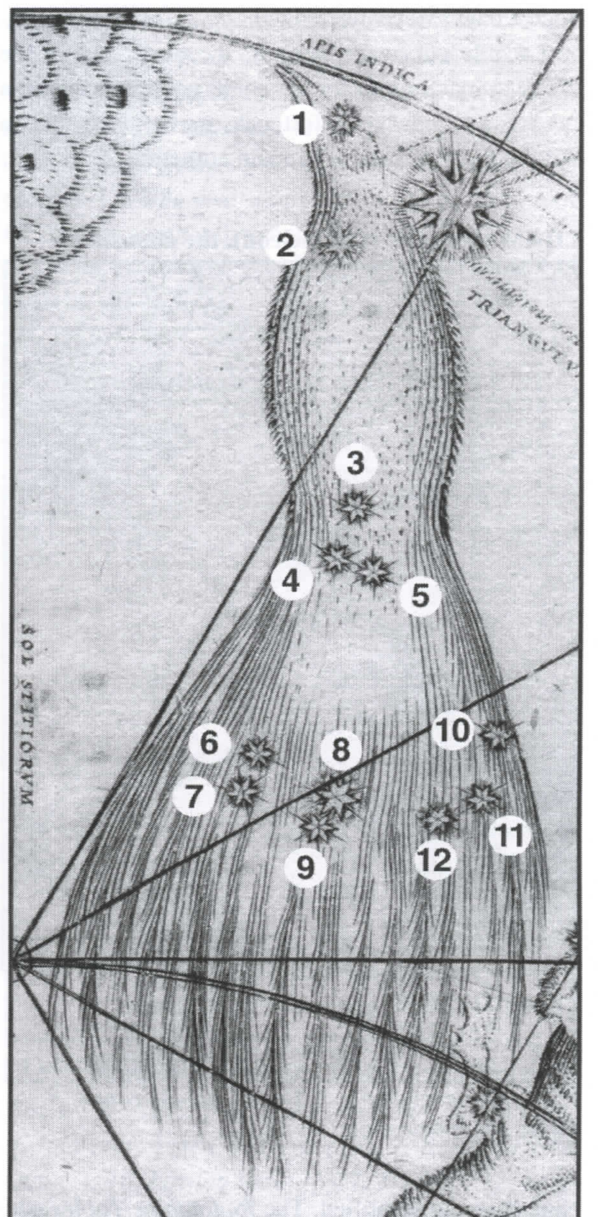

Fig.1 *1, Zeta Apodis; 2, Iota Apodis; 3, Beta Apodis; 4, Gamma Apodis; 5, Delta Apodis; 6, Rho Octantis; 7, Omega Octantis; 8, Pi Octantis; 9, Delta Octantis; 10, Alpha Apodis; 11, Epsilon Apodis; 12, Eta Apodis.*

Twelve stars, all identified. The most northerly three stars (Zeta, Iota and Beta Apodis) also appear at the bottom of Bayer's chart of Ara. In his text on the reverse of that chart, Bayer mistakenly says that these stars are part of Grus. The *Rudolphine Tables* offers a somewhat different selection of stars in the tail, and lists only 11 stars in the constellation rather than 12 as on Bayer's chart.

The word Apis, which means 'bee', is probably a misprint for Avis, and was corrected in the *Rudolphine Tables* of 1627, which named the constellation 'Apus, Avis Indica'. But the misspelling Apis Indica persisted as an alternative name until Bode's day, two centuries later.

Lacaille cut away some of the bird's tail in the 1750s to make room for his south polar constellation Octans, a somewhat unfortunate move given that in real life the bird's tail is its main attraction.

CHAMAELEON (Chameleon), the chameleon

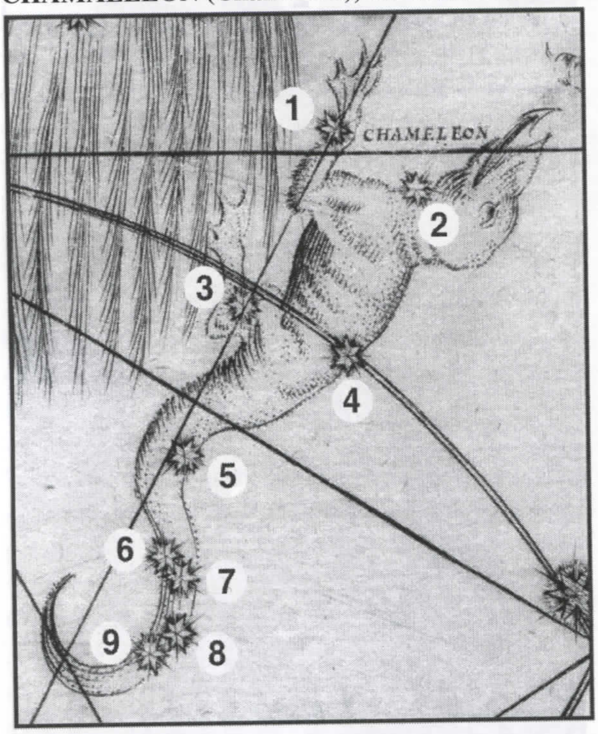

Fig. 2 *1, Beta Chamaeleontis; 2, Epsilon Chamaeleontis; 3, Delta Chamaeleontis; 4, Gamma Chamaeleontis; 5, Zeta Chamaeleontis; 6, HR 3543; 7, Eta Chamaeleontis; 8, Theta Chamaeleontis; 9, Alpha Chamaeleontis.*

Nine stars, all identified. The *Rudolphine Tables* adds a tenth star, Iota, close to Zeta; Dekker proposes that Bayer missed this star because it fell between two gores on the globe he is presumed to have copied from. Chamaeleon is positioned as though it is about to eat the fly, Musca.[7]

DORADO, the goldfish

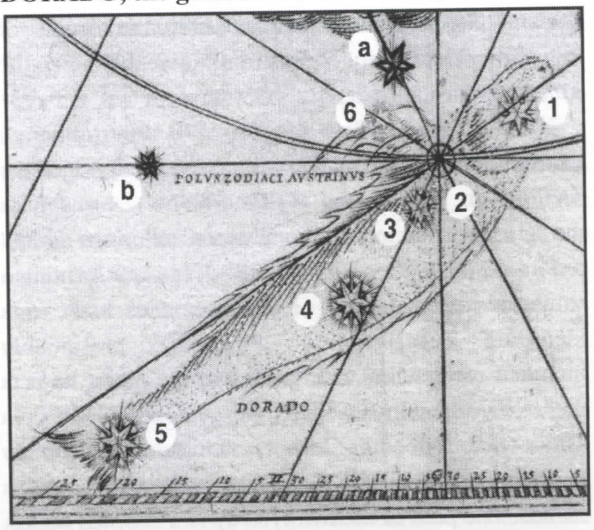

Fig. 3 *1, Nu Doradus; 2, Epsilon Doradus (faint, partly obscured by the symbol for the south ecliptic pole); 3, Delta Doradus; 4, Beta Doradus; 5, Alpha Doradus; 6, Theta Doradus (faint). The two unformed stars are: a, 30 Doradus (the Tarantula Nebula); b, Alpha Reticuli.*

Six stars, all identified; one (Epsilon) is positioned on the chart very close to the south ecliptic pole and is easy to miss. Three stars of Dorado are also shown at bottom centre of Bayer's plate of Eridanus (Chart 36). Dorado represents not the goldfish of domestic ponds but the colourful dolphinfish of tropical waters, known also as mahi-mahi. Dutch explorers saw them chasing flying fish and so Dorado was placed in the sky behind Volans, the flying fish.[8] The object near the top of Figure 3, above Theta, was not considered part of Dorado and was left unattached to any figure. I identify it as Bode's 30 Doradus, i.e. the Tarantula Nebula

GRUS, the crane

Thirteen stars, all identified. The two prominent optical doubles in the neck of Grus are clearly recorded, although the separation of the pairs is exaggerated and the orientation is wrong. Eleven stars of Grus are repeated on Bayer's chart of Piscis Notius (i.e. Piscis Austrinus), the southern fish (Chart 48). The star identified as Gamma Gruis appears to be identical with Ptolemy's 12th star in Piscis Austrinus, and hence is not new. Ptolemy describes it in the *Almagest* as 'The star on the tip of the tail'. However, Bayer visualizes the southern fish somewhat differently from Ptolemy: he straightens out its tail so that it does not include this star, thereby freeing it up for transfer to Grus. At a declination of –39° 12' for the year 1600, Gamma Gruis is the most northerly of the stars in the 12 new constellations.

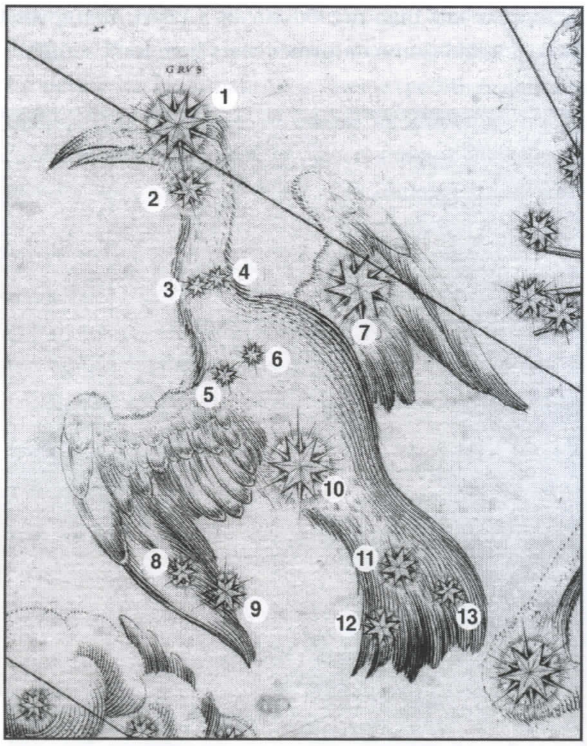

Fig. 4 *1, Gamma Gruis; 2, Lambda Gruis; 3, Mu-1 Gruis; 4, Mu-2 Gruis; 5, Delta-1 Gruis; 6, Delta-2 Gruis; 7, Alpha Gruis; 8, Theta Gruis; 9, Iota Gruis; 10, Beta Gruis; 11, Epsilon Gruis; 12, Zeta Gruis; 13, Eta Gruis.*

HYDRUS, the lesser water snake

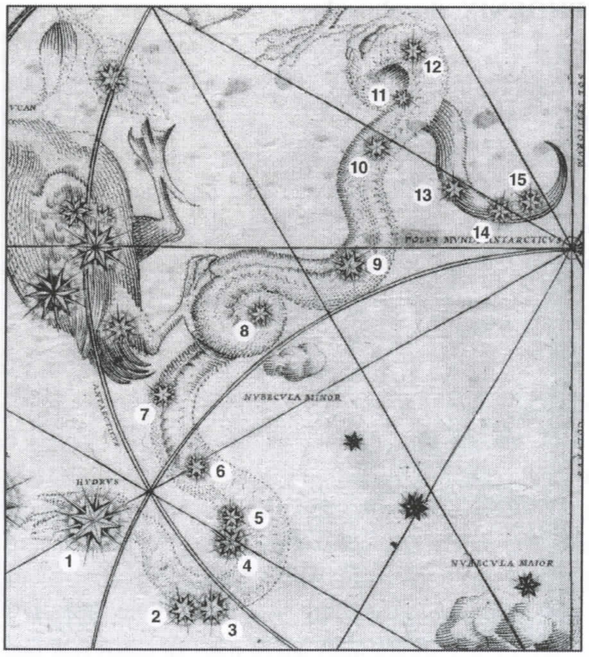

Fig. 5 *1, Alpha Hydri; 2, Nu Horologii; 3, Beta Horologii; 3, Zeta Hydri; 4, Epsilon Hydri; 6, Eta-2 Hydri; 7, Kappa Tucanae; 8, 47 Tucanae; 9, Beta Hydri; 10, Psi Hydri; 11, Nu Octantis; 12, Alpha Octantis; 13, Beta Octantis; 14, Unidentified; 15, Unidentified.*

Fifteen stars, thirteen identified. The last two in the tail are unidentifiable with any certainty, but could be Lambda Octantis and HR 7785 placed too far south. Perhaps most interesting is the eighth star along the body, which I identify as 47 Tucanae – not a star, of course, but a 4th-magnitude globular cluster. The presence of such an object in a star catalogue would not be unprecedented since the *Almagest* lists the brightest globular of all, Omega Centauri, as a star. Four stars of the head of Hydrus also appear on Bayer's plate of Eridanus, Chart 36, but go unmentioned in the text on the reverse. The *Rudolphine Tables* listed another five stars in the water snake, bringing the total to 20.

Hydrus has been considerably modified since its appearance on Bayer's chart, notably by Lacaille who rerouted it to pass between the two Magellanic Clouds, transferring some of its stars to Tucana in the process. Lacaille also shortened its tail to make room for his new south polar constellation Octans.[9]

INDUS, the Indian

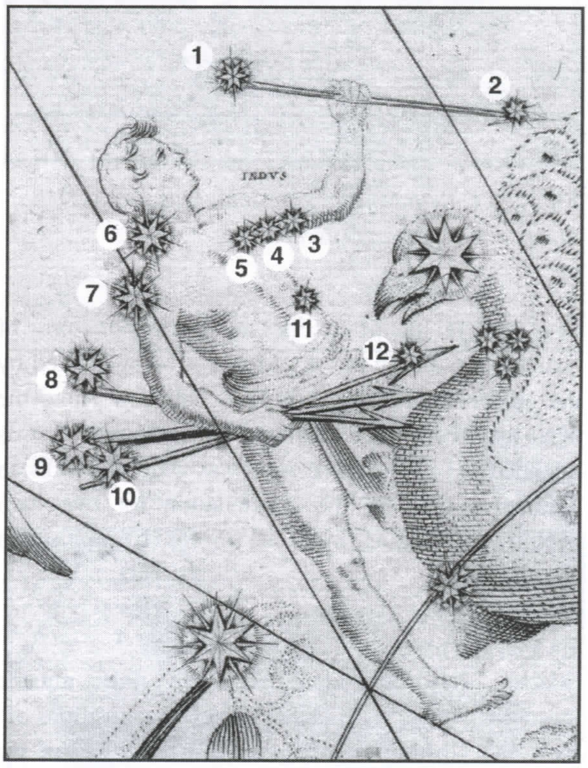

Fig. 6 *1, Alpha Indi; 2, Xi Telescopii; 3, Eta Indi; 4, Iota Indi; 5, HR 8027; 6, ?; 7, ?; 8, ?; 9, Delta Indi (?); 10, Epsilon Indi (?); 11, Mu Indi; 12, Beta Indi.*

Twelve stars, nine identified, two of them with some uncertainty. The right side of the Indian, next to Grus, is badly confused. Two stars mark his neck and shoulder and three mark the shafts of his spears, but there is nothing in the sky to match at least three of these. Even Halley's southern star chart has some spurious stars in this region. The neck and shoulder could be Theta Indi and HR 8114 misplaced some 10 degrees too far north. Presumably Delta and Epsilon Indi are involved with the ends of the spear shafts, albeit somewhat misplaced; Johann Bode thought so and used them to mark the ends of the spear shafts on the illustration of Indus in his *Uranographia* atlas (1801). Bayer portrayed the Indian face-on, but the description in the *Rudolphine Tables* reverses his left and right sides, as though turning him to be seen from behind, which is also how Bode depicted him.

MUSCA (Apis), the fly

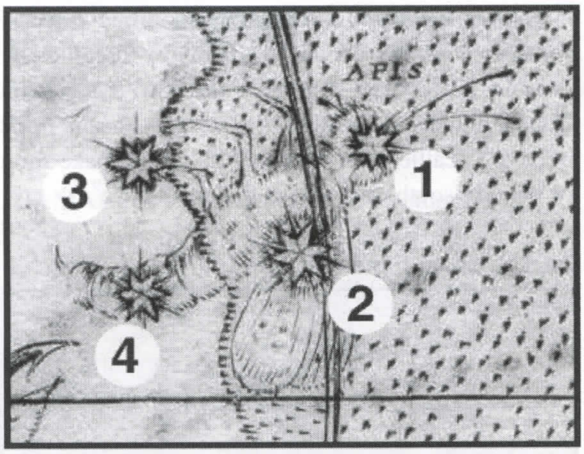

Fig. 7 *1, Beta Muscae; 2, Alpha Muscae; 3, Delta Muscae; 4, Gamma Muscae.*

Four stars, all identified. Flies are the favoured prey of chameleons, and in the sky Musca is being stalked by the chameleon. Bayer, however, called it Apis, the bee, apparently not realizing what insect it was intended to be. The name Apis was widely used as an alternative title for the constellation for over two centuries, including by Bode in his *Uranographia* atlas of 1801.

PAVO, the peacock

Sixteen stars, all identified. The only notable inaccuracy in the chart is that the relative positions of Beta and Upsilon Pavonis are reversed. Nine of the stars also appear on Bayer's plate 46, Ara. The type of bird represented is not the common blue, or Indian, peacock commonly seen in parks but its larger, more colourful, and more aggressive cousin, the Java green peacock which the Dutch explorers would have encountered in the East Indies. On Bayer's chart the peacock stands on a coil of Hydrus, but Lacaille later took away this part of Hydrus and replaced it with Octans. The *Rudolphine Tables* list more stars in the peacock's tail than are on Bayer's chart, noting that there are additional unformed stars here too.

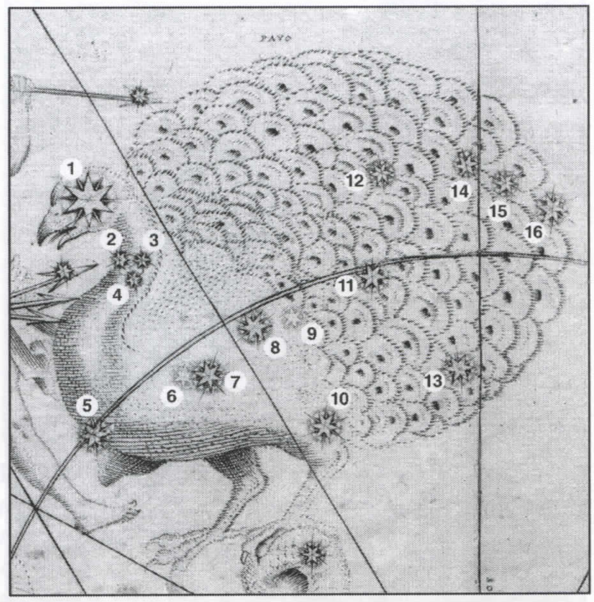

Fig. 8 *1, Alpha Pavonis; 2, Phi-2 Pavonis; 3, Phi-1 Pavonis; 4, Rho Pavonis; 5, Gamma Pavonis; 6, Upsilon Pavonis (faint); 7, Beta Pavonis; 8, Delta Pavonis; 9, Mu Pavonis (faint); 10, Epsilon Pavonis; 11, Kappa Pavonis; 12, Lambda Pavonis; 13, Zeta Pavonis; 14, Xi Pavonis; 15, Pi Pavonis; 16, Eta Pavonis.*

PHOENIX, the phoenix

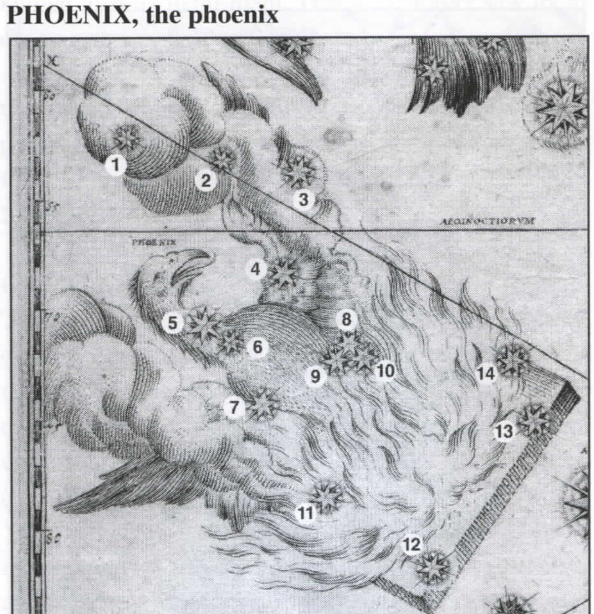

Fig. 9 *1, Beta Sculptoris; 2, Iota Phoenicis; 3, HR 8959; 4, Epsilon Phoenicis; 5, Alpha Phoenicis; 6, Kappa Phoenicis; 7, Mu Phoenicis; 8, HR 120; 9, Lambda-2 Phoenicis; 10, Lambda-1 Phoenicis; 11, Beta Phoenicis; 12, Delta Phoenicis; 13, Zeta Phoenicis; 14, Eta Phoenicis.*

Fourteen stars, all identified. Third-magnitude Gamma Phoenicis is missing, but was observed by Frederick de Houtman on a later expedition and was included in the list of stars in Phoenix in the *Rudolphine Tables* (1627). Seven stars of Phoenix are also shown on Bayer's plate of Eridanus, Chart 36.

TRIANGULUM AUSTRALE, the southern triangle

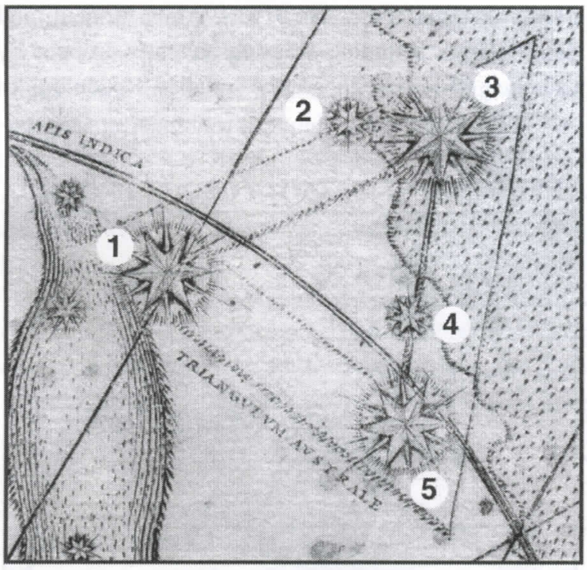

Fig. 10 *1, Alpha Trianguli Australis; 2, Delta Trianguli Australis; 3, Beta Trianguli Australis; 4, Epsilon Trianguli Australis; 5, Gamma Trianguli Australis.*

Five stars, all identified. The entire constellation also appears twice elsewhere in the atlas: on plate 41 (Centaurus) and plate 46 (Ara). Plancius had previously shown a southern triangle in a completely different position south of Argo Navis, based on sketchy reports from earlier seafarers, but it was not the Triangulum Australe shown by Bayer.

TUCANA (Toucan), the toucan

Eight stars, all identified. One of them, Epsilon Tucanae, is partly obscured by the symbol for Zeta. Bayer's illustration shows the toucan standing on part of Hydrus; the stars in that area have since been transferred from Hydrus to Tucana. Similarly, in Bayer's day the Small Magellanic Cloud (then called Nubecula Minor) was considered to be part of Hydrus, and was listed as such in the *Rudolphine Tables*, but it now lies within the boundaries of Tucana.

VOLANS (Piscis Volans), the flying fish

Seven stars, all identified. No doubt seafarers saw these fish being chased by the predatory Dorado and placed them in the sky together. Sometimes the fish landed on the decks of the ship and provided a useful supplement to the crew's diet, so the sailors had good reason to be grateful to them. All seven stars are also shown on Bayer's chart of Argo Navis (plate 40) where the fish is positioned leaping against the side of the ship. In 1844, John Herschel recommended truncating all southern constellation names to just one word. Francis Baily adopted the suggestion in the *British Association Catalogue* (1845), and Piscis Volans has been simply Volans ever since.[10]

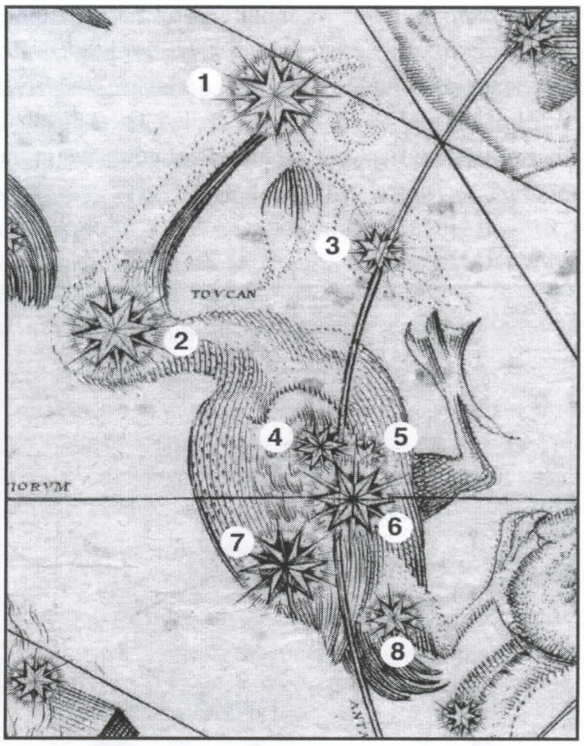

Fig. 11 *1, Alpha Tucanae; 2, Gamma Tucanae; 3, Delta Tucanae; 4, Eta Tucanae; 5, Epsilon Tucanae (partly obscured by 6); 6, Zeta Tucanae; 7, Beta Tucanae; 8, Rho Tucanae.*

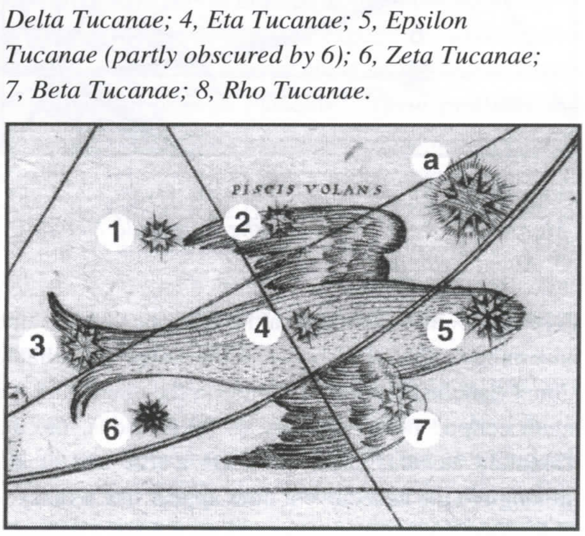

Fig. 12 *1, Zeta Volantis; 2, Kappa Volantis; 3, Gamma Volantis; 4, Epsilon Volantis; 5, Alpha Volantis; 6, Delta Volantis; 7, Beta Volantis. There is also a field star: a, Beta Carinae.*

ERIDANUS, the river

In addition to the 12 new constellations mentioned above, Bayer's Chart 49 includes a southern extension of the Ptolemaic constellation Eridanus[†]. The five stars making up this extension can also be found on Bayer's individual plate of Eridanus (Chart 36), where they are clearly labelled Iota, Kappa, Phi, Chi and Alpha. These remain their designations today.

Alpha, the southern end of the extended river, is named by Bayer as Acarnar, although we know it today as Achernar; both these names come from the Arabic *akhir al-nahr*, meaning end of the river.[12] At magnitude 0.5, Achernar is by far the brightest of the new stars on Chart 49. In the *Almagest*, the river ended at the star which Bayer labelled Theta Eridani. These five new stars of Eridanus were not listed in the *Rudolphine Tables*.

UNFORMED – 1

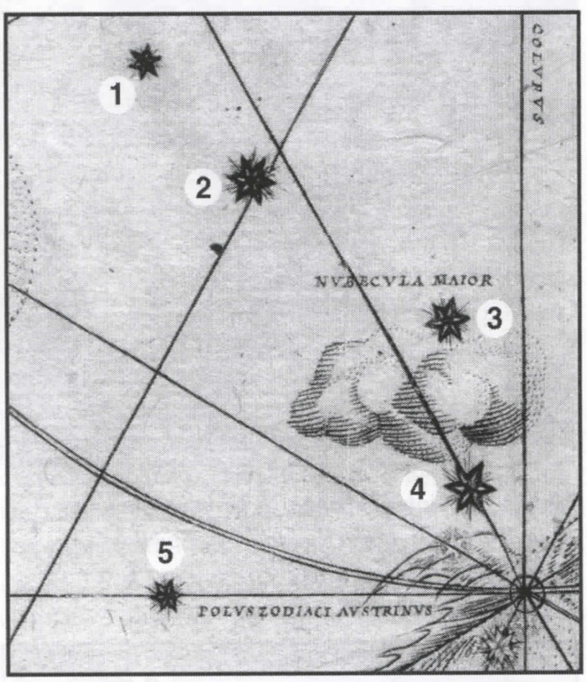

Fig. 13 *1, Nu Hydri; 2, Gamma Hydri; 3, Beta Mensae(?); 4, 30 Doradus (the Tarantula Nebula); 5, Alpha Reticuli.*

Five stars, all identified although one with some uncertainty. The 'star' between the Large Magellanic Cloud (labelled Nubecula Major on the chart) and the south ecliptic pole I identify as 30 Doradus, i.e. the Tarantula Nebula; hence it is not a true star at all, although to the naked eye it does appear like a fuzzy star. The star plotted by Bayer on the opposite side of the Large Magellanic Cloud is the only real uncertainty. It seems most likely to be Beta Mensae, with a longitude error. Bayer missed off a sixth star in this region, Beta Reticuli, even though it is marked on two earlier globes by Hondius; evidently this was simply a copying error. In 1621 Isaac Habrecht produced a globe on which he created a new constellation, Rhombus, from four of these unformed stars – Gamma Hydri, Nu Hydri, Alpha Reticuli and Beta Reticuli. Rhombus was subsequently dropped by Lacaille, who introduced the smaller Reticulum in part of the same area.[13]

[†] Knobel says that this extension of Eridanus is first shown on a Plancius map of 1594, but he is wrong; only the Ptolemaic stars are shown on that chart, and not very accurately.[11]

UNFORMED – 2

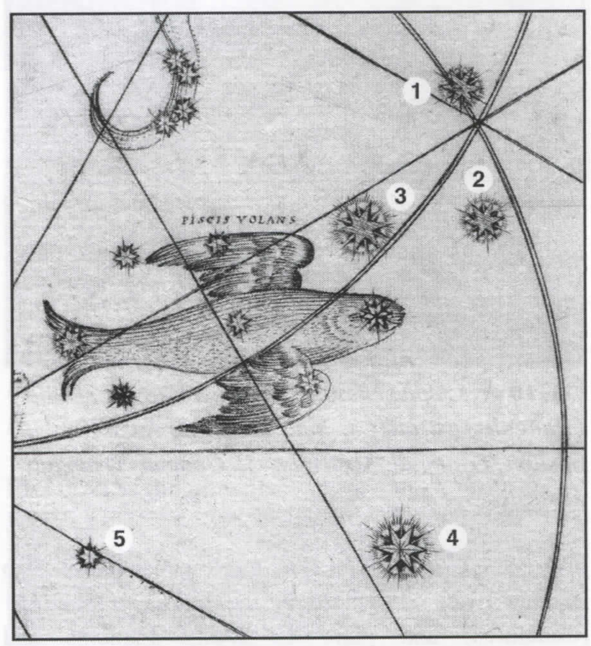

Fig. 14 *1, Omega Carinae; 2, Upsilon Carinae; 3, Beta Carinae; 4, Epsilon Carinae; 5, Alpha Pictoris.*

Five stars around Volans, all identified. Bayer incorporated four of them in his illustration of Argo Navis (Chart 40), where he labelled them d, d [again!], Nu and Mu.

UNFORMED – 3

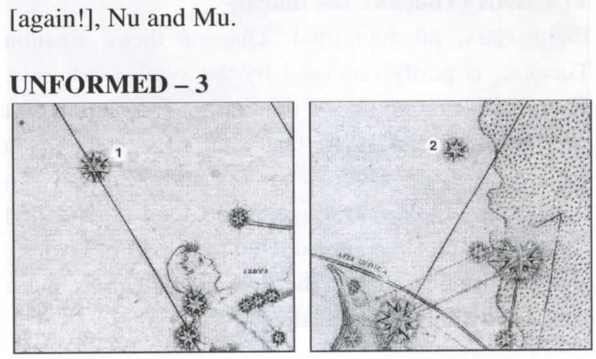

Fig. 15 *1, Alpha Microscopii; 2, Eta Arae.*

In addition to these twelve unformed stars in the lower half of the chart, there are two outliers towards the top. One is north of Indus, in the area of sky now occupied by Lacaille's Microscopium. This seems to be Alpha Microscopii, which was among six unformed stars outside Piscis Austrinus listed in the *Almagest*. Presumably Bayer recognized it as a Ptolemaic star but included it to tie-in his chart with the southernmost Ptolemaic constellations.

The other outlier on Chart 49 lies above Triangulum Australe and is Eta Arae. This one is genuinely new (i.e. non-Ptolemaic). Bayer included it on his plate of Ara where he labelled it Theta Arae. Hence Ara in Bayer's atlas contains eight stars, whereas the *Almagest* lists only seven.

ACKNOWLEDGED PTOLEMAIC STARS

As well as the two Ptolemaic stars on Chart 49 which he did not identify (see above under Grus and Unformed – 3), Bayer included two others which he clearly acknowledged as such. These are labelled 'Pes dexter Sagittarii' (right foot of Sagittarius) and 'Pes laevus Centauri' (left foot of the Centaur), i.e. Beta Sagittarii and Alpha Centauri. Alpha Centauri is, however, placed about 4 degrees too far north.

Bayer's sources

We now come to the underlying question: what was the source of Bayer's star positions for Chart 49? Bayer himself is not much help in providing answers. In the text on the reverse of Chart 49, he gives credit to the Italian explorers Amerigo Vespucci (1454-1512) and Andrea Corsali (1487-?), the Spaniard Pedro de Medina (1493-1567) and, above all, the 'skilled navigator' Petrus Theodorus. This is far from the whole story, as we shall see, and Bayer's rather vague attribution strongly suggests that he was either not fully aware of the provenance of his data or was deliberately obfuscating.

Dekker makes it clear that, contrary to Bayer's assertion, little useful knowledge of the southern stars was contributed by Vespucci, Corsali or de Medina, although she does credit Vespucci with the first known observations of the Magellanic Clouds and the Coalsack nebula.[14] In fact, as the end of the 16th century approached, knowledge of the southern skies remained disappointingly sketchy.

Petrus Plancius (1552–1622), a Dutch cartographer and theologian, was determined to see the blank area of southern sky filled in. When the first Dutch trading expedition, called the Eerste Schipvaart, sailed for the East Indies in 1595 April, Plancius instructed several members of the ships' crews to make positional observations of the southern stars. Foremost among these trusted observers was Pieter Dirkszoon Keyser (c.1540–96), the 'Petrus Theodorus' referred to by Bayer, also known as Peter Theodore. He was chief pilot on the *Hollandia* and later on the *Mauritius*. Others mentioned in accounts of the scientific programme on the voyage are Vechter Willemsz (the original pilot of the *Mauritius*), Pieter Stockmans and Frederick de Houtman (1571–1627), younger brother of the expedition's leader, Cornelis de Houtman. As well as astronomical observations, all four made measurements of the deviation of a compass needle, a technique then being assessed as a means of finding longitude.

On the outward journey, the fleet of four ships arrived at Madagascar in 1595 September and remained anchored there for several months to resupply and recover, since scurvy and malnutrition were rife. This is undoubtedly where most of the celestial observations were made. According to a contemporary account by the Dutch historian and geographer Paul Merula, Keyser observed from the crow's nest with an instrument given to him by Plancius, although he does not say what sort of instrument it was.[15] It is unlikely to have been anything as simple as a navigator's cross-staff, but could well have been a universal astrolabe, also known as an *astrolabium catholicum*, of the sort popularized by Gemma Frisius.[16]

The fleet eventually reached Sumatra in 1596 June, before moving on to Java where Keyser died. Vechter Willemsz had already died in January after leaving Madagascar, and we hear little more of any contributions by Pieter Stockmans. Of all the members of Plancius's team of observers, it was de Houtman who was to emerge as the most significant.

When the much-depleted expedition arrived home in 1597 August, the astronomical and magnetic results were handed over to Plancius.[17] There probably was no finished star catalogue as such, just a collection of disparate observations by various members of the team. It seems that de Houtman must have kept a copy of his own observations, and possibly those of the others as well, for he was to publish them six years later as part of the first-ever catalogue of the southern stars.[18]

Plancius used the star positions from the first voyage on a series of celestial globes, the first of which was engraved and published by Jodocus Hondius in 1598. An inscription on this globe, evidently written by Plancius, credits the observations of the southern stars to Keyser and 'other lovers of astronomy'. Further, it tells us that these observers used Achernar as their fundamental star, observing it repeatedly to establish its position as 9° 45' longitude (in the sign of Pisces) and 59° 30' latitude.[19] This compares favourably with a modern computation for Achernar of 339° 39' and -59° 22' for the year 1600. Hondius produced revised versions of this globe in 1600 and 1601.

Plancius passed on descriptions of the 12 new constellations to Paul Merula, the librarian of Leiden University, who included them in his *Cosmographiae Generalis* of 1605 [see Table]. But no catalogue of the stars on Bayer's chart, with coordinates and magnitudes, was published prior to the *Rudolphine Tables* in 1627, some 29 years later. We might note that some of these stars appeared in de Houtman's catalogue of 1603, but overall he observed a different selection [see Table]. To use the language of modern software development, de Houtman's catalogue was a separate fork from the Plancius–Hondius–Bayer line.

So, to return to our initial question: where did Bayer get his information on the southern stars? Warner surmised that he had a manuscript copy of Keyser's observations.[20] However, Dekker has shown that Bayer almost certainly did not use original sources at all: instead, he simply copied the star positions from the globes by Hondius published in 1600 and 1601.[21] This does not preclude the possibility that he also had some written observations from the Eerste Schipvaart, but if so he apparently made little or no use of them.

After Bayer's death, his fellow German Jakob Bartsch (c.1600-1633) passed his records on to Kepler, who published them in catalogue form in the *Rudolphine Tables*.[22] What Plancius did with the raw observations he received from the Eerste Schipvaart we do not know, but certainly they were never published.

Origin of the 12 new southern constellations

As well as the sources for the star positions, there is a second, related question of interest: who divided these newly observed stars into the 12 constellations found on the Plancius/Hondius globes and Bayer's Chart 49? Here the evidence is less clear-cut.

Usually the new Southern Dozen are credited jointly to Keyser and de Houtman, but Dekker has argued strongly that the real credit is due to Plancius, and Plancius alone.[23] She writes: 'Plancius could not withstand the temptation to make new constellations, whenever he had the opportunity to do so.' Examples are his inventions of Columba, Monoceros and Camelopardalis, as well as several others that did not stand the test of time.

However, this is not a compelling argument. In the inscription on the 1598 Hondius globe, Plancius takes credit for having instigated the observations of the southern skies carried out by Keyser et al, but makes no claim regarding the invention of the constellations. Many of Plancius's confirmed inventions had religious themes, since he was also a theologian, but none of the new Southern Dozen do.

Many cataloguers of the stars found it impossible to resist inventing new constellations, prominent examples being Johannes Hevelius (1611-1687), Nicolas Lacaille and Jérôme Lalande (1732-1807). Hence it would be no surprise if the observers on the Eerste Schipvaart felt similarly inspired.

Dekker further argues that the choice of constellations to be illustrated was strongly influenced by the 'fascinating pictures of the New World' that had already been printed on charts and in books.[24] But these sources would also have been available to the explorers on the Eerste Schipvaart. They might well have carried some of these publications with them and found inspiration therein for their constellation patterns. And they would have the advantage of having seen these things for themselves.

After Keyser died, de Houtman would certainly have had access to his observations, and might well have been the custodian of them on the voyage home. We can easily imagine de Houtman whiling away the time at sea by collating the team's observations, grouping them into constellations representing the wondrous things they had seen and planning a more extensive observational campaign of his own for some future voyage. On this scenario, Plancius would deserve credit for visualizing the Southern Dozen constellations of Keyser and de Houtman, but not actually inventing them.

Without further information, all this is speculation. The fairest thing we can say is that Keyser, de Houtman and Plancius all deserve a share of the credit for the Southern Dozen, with assistance from some other members of the crew of the Eerste Schipvaart.[25]

A final word about Frederick de Houtman. In 1598 he and his elder brother Cornelis sailed again for the East Indies, this time with Frederick captaining one of the two ships. On this voyage Cornelis was killed and Frederick was imprisoned for two years by the Sultan of Atjeh in northern Sumatra. During his incarceration Frederick studied the local Malay language and observed the southern stars. In 1603, following his return to the Netherlands, he published a Dutch–Malay dictionary with a star catalogue as an appendix – perhaps the most unlikely example of astronomical publishing in history. In the Introduction to the book he wrote: 'Also added [are] the declination of several fixed stars which during the first voyage I have observed around the South Pole; and during the second [voyage], in the island of Sumatra, improved upon with greater diligence, and increased in number.'

De Houtman's 1603 catalogue contained coordinates and magnitudes for 303 stars, of which 111 were in the Southern Dozen constellations. From his location in northern Sumatra, about 5.5° north, he would not have been able to see all the way to the south celestial pole. His statement implies that the most southerly of the stars in his catalogue were observed during the first voyage, presumably when the fleet was at Madagascar, although there would have been opportunities to observe the South Polar Region during the second voyage, too.

De Houtman never mentioned the work of Keyser, which has led to accusations that he plagiarized his deceased shipmate's observations.[26] This might have been true of the most southerly stars, too low to see from northern Sumatra, but de Houtman's catalogue contains only a handful of those. There seems no good reason to doubt that most, if not all, of de Houtman's catalogue embodies his own observations, made over the course of the two voyages.

As an aside, it is worth noting that relations between Keyser and the de Houtman brothers broke down during the Eerste Schipvaart over the proposed promotion of Keyser to captain of the *Hollandia* after her original captain died. The bad feeling engendered by this dispute may be why de Houtman failed to mention Keyser in his catalogue, and also why Plancius, for whom Keyser was a surrogate, never referred to de Houtman's observations either.

In the Introduction to his book, de Houtman stated that his motives in making this second survey and publishing the catalogue were to 'serve all sailors, who navigate south of the equinoctial line and are of interest to all lovers of astronomy or the mathematical arts'. Here, perhaps, we can see something of the same spirit as in the young Edmond Halley, who was to make a follow-up survey of the southern skies from St Helena three quarters of a century later.

So perhaps the story of the invention of the Southern Dozen is more complex than has previously been considered. Although de Houtman has been accused of plagiarism, it may actually be that the

TABLE:
Number of stars in the 12 new southern constellations as given in various early sources

Constellation	Number of stars A	B	C	D
Apus	12	12	11	9
Chamaeleon	9	10	10	9
Dorado	6	6	6[a]	4
Grus	13	13	13	12
Hydrus	15	15	20[b]	15[c]
Indus	12	12	12	11
Musca	4	4	4	4
Pavo	16	15	23	19
Phoenix	14	14	15	13
Triangulum Australe	5	4	5	4
Tucana	8	8	8	6
Volans	7	7	7	5
Total	121	120	134	111

NOTES:
A = Johann Bayer's *Uranometria*, Chart 49 (1603)
B = Paul Merula, *Cosmographiae Generalis* (1605)
C = Johannes Kepler, *Rudolphine Tables* (1627)
D = Frederick de Houtman's catalogue (1603)

[a] The *Rudolphine Tables* lists the Nubecula Major among the stars of Dorado, but I have not included it in the star total here.
[b] The *Rudolphine Tables* lists the Nubecula Minor among the stars of Hydrus, but I have not included it in the star total here.
[c] de Houtman lists the Nubecula Minor as part of Hydrus, but I have not included it in the star total here. de Houtman's catalogue has no entry for the LMC at all.

opposite is true, namely that he has received insufficient recognition for his role in creating the 12 new southern constellations.

Conclusion

The great majority of the stars on Chart 49 in Bayer's *Uranometria* star atlas can be identified with high or moderate confidence. Of the 140 stars on the chart, two are identified by Bayer as Ptolemaic. We have found that another two are also Ptolemaic: the one now known as Gamma Gruis and the unformed star north of Indus. Hence there are 136 genuinely new (i.e. non-Ptolemaic) stars plotted on the chart. Two of these 'stars' are probably not really stars at all, but deep-sky objects. If the identifications in this paper are correct, then Bayer's Chart 49 contains the first recorded observations of the globular cluster 47 Tucanae and the bright gaseous nebula in the Large Magellanic Cloud now known as the Tarantula Nebula (NGC 2070, or 30 Doradus).

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