# Native Astronomy in Micronesia: A Rudimentary Science

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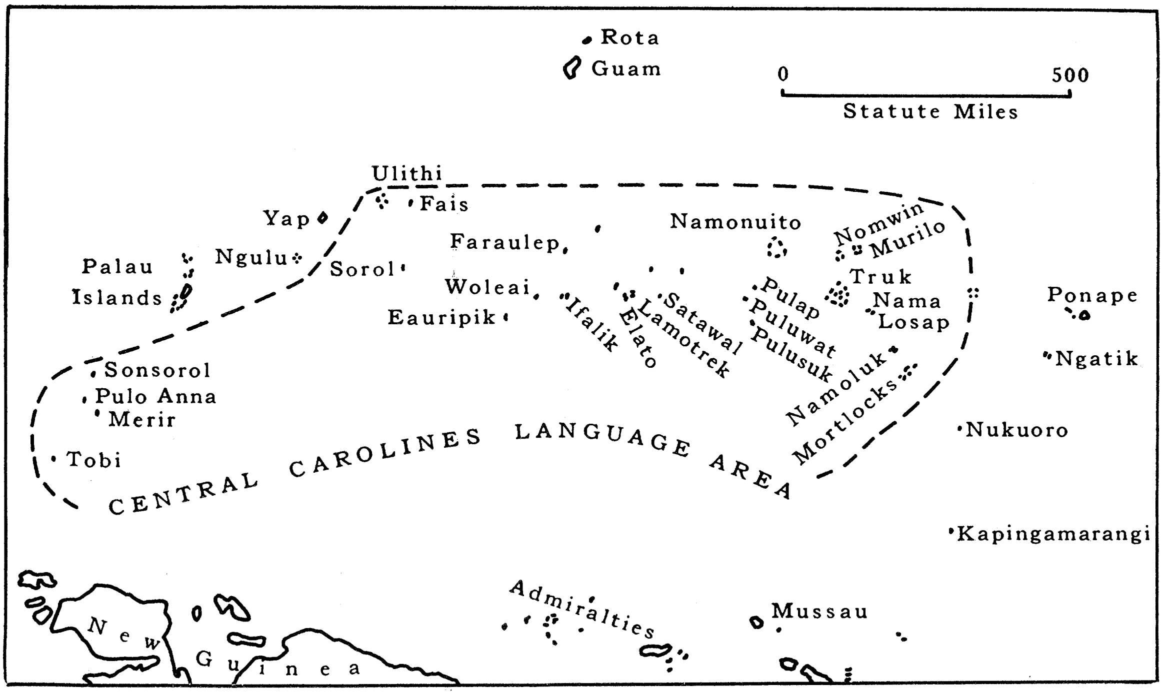
EARLY in the first world war the German governor of Truk in the Caroline Islands found himself unable to communicate with his superiors, all German shipping in the area having stopped. It happened that a canoe from Puluwat, ninety miles to the west, stopped in on a trading trip. At his interpreter's suggestion, the governor asked its navigator if he could get to headquarters on Ponape, 300 miles to the east. The navigator said he had never been there but was confident he could manage it. Not many days later he was back with replies to the governor's letters. The governor could well marvel that a simple loincloth-clad native could so confidently sail to a strange place without compass or chart and make the requisite landfall with pinpoint precision; the native, however, was merely applying a systematic body of knowledge of which he had to be master in order to qualify as a professional navigator. Astronomy formed a crucial part of this knowledge.

The more we know of it, the more interesting native astronomy in Oceania becomes as an example of a primitive science. Unlike the ancient astronomies of the Near East and Middle America, which were developed in response to the practical needs of agriculture, this one was stimulated by the exigencies of long-distance voyaging. Although the Polynesians are the best known of Pacific peoples for their intrepid sailing, their astronomy—whose remembered fragments have been investigated by Maud Makemson, of Vassar—provides few clues as to how such voyages were effected. Ancient chants speak of following particular stars, but poetic license ignores the fact that the earth's rotation would leave anyone following such advice literally sailing around in circles. If we leave the Polynesians and return to their more obscure Micronesian cousins further west in the Carolines, we find enough scattered information on their navigational methods that by pulling it together we can begin to see how navigation by stars was accomplished and what kind of an astronomy was developed for this purpose.

The Caroline Islands are a chain of tiny, scattered atolls extending east and west between the fifth and tenth parallels of north latitude for 1,500 miles. Most of them support only a few hundred people. At either end are the larger islands of Palau and Yap in the west and Kusaie in the east. In between, only the mountains of Truk and Ponape break the monotony of open ocean and occasional coral islets, so low that they are invisible from more than a few miles. Because of their meager resources, inhabitants of the low islands have always been forced to go to the few larger ones to trade. For several centuries Carolinians sailed annually to Guam in thirty-foot outrigger canoes to purchase iron tools and tobacco from the Spaniards, a voyage covering 400 miles of open sea. Native navigators have even visited such distant places as the Marshall Islands, New Guinea, and the Philippines.

Except for Palau and Yap, the various islanders




The Caroline Islands, showing the names of inhabited atolls and islands and the Central Carolines Language Area within which a more or less uniform system of astronomy is in use.

from the western end of the Carolines to the Mortlock Islands, a thousand miles to the east, all speak closely related dialects of the same language group (the central Carolinian branch of the Malay-Polynesian linguistic family). From island to island within this area the same system of astronomy is in use. It is, indeed, no exaggeration to say that regular intercourse between navigators has made possible the development of a truly international discipline, in which most of the local cultures share. It has even spread to a few neighboring islands with different linguistic affiliations. Beyond this, however, we encounter somewhat different astronomies, which indicate that what is found in the central Carolines is largely local in origin and not an import from a "higher" civilization in the Orient.

As elsewhere in Micronesia, astronomy in the Carolines is an adjunct of navigation, and knowledge of the stars is very largely restricted to professional navigators. As private, incorporeal property it is bequeathed from father to son and, among these matrilineal peoples, from mother's brother to sister's son. Anyone else must pay handsomely to learn it. Because of their knowledge, navigators stand at the peak of the native prestige hierarchy, and their persons are surrounded with numerous taboos.

There are two major aspects of the navigator's astronomy. From the location of stars he has derived a compass for expressing sailing directions, and from their movements he has developed an almanac and calendar. Stars and constellations are named only to the extent that there is a practical reason therefor, and position rather than magnitude alone is important in determining which stars are named. In this regard Carolinian astronomy resembles that of the Marshall Islands, where it is reported that many stars of first magnitude are without names, whereas many named constellations are composed of stars of from fourth to fifth magnitudes. This fact makes accurate identification of native constellations impossible without the aid of detailed star maps. It is largely responsible for the fragmentary and contradictory reports on Oceanic astronomy.

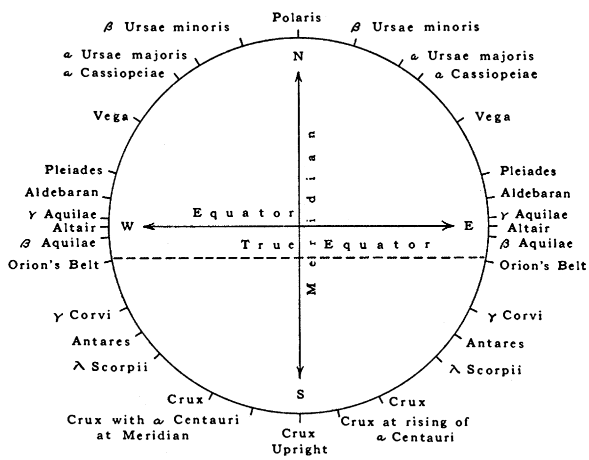
Because of their equatorial location, Carolinian navigators assume that the east-west axis of their islands forms the terrestrial equator and corresponds with the celestial equator. With visibility uninterrupted in all directions they make their observations with reference to the great circle of the horizon. The points at which stars rise and set (their azimuths) and the time order of their rising (their relative altitudes) provide the respective bases for the compass and calendar. At this latitude differences in azimuth and altitude correspond very closely with differences in declination and right ascension (celestial latitude and longitude). On an east-west axis close to the equator, a perpendicular dropped from a star to the horizon will mark roughly the same latitude, regardless of the star's altitude. It is not surprising, therefore, that native astronomers treat azimuth and altitude as the equivalent of our declination and right ascension.

The east-west orientation of the Caroline Islands makes latitudinal sailing common, and their equatorial position simplifies the use of stars for this purpose. But not all sailing is latitudinal. Native astronomy must be capable of handling any and all directions. For this purpose navigators have selected a limited number of stars whose points of rising and setting provide the necessary coordinates for expressing sailing and wind directions. To go from island A to island B, for instance, one sails from the rising of X to the setting of Y. The prevailing wind of a particular season comes from the direction of the rising of Z, so that a navigator can orient himself in the daytime on the basis of wind directions and, with a like set of correlations, on the basis of prevailing currents. There are thirty-two such points on the horizon, each pair named for a star or constellation. The system does not depend for its operation on the visibility or immediate position of the stars for which these points are named. Other stars of similar declination will serve as well. The point of Vega's rising, for example, is fixed regardless of where Vega is. It is simply the type-star for which the point is named.

Within this system there are, as with us, four cardinal points. The North Star, which is just visible above the horizon, indicates north, and the Southern Cross in its upright position at the meridian indicates south. The line between these two points forms the native meridian and divides east from west. The declination of Altair in Aquila corresponds with the latitude of the Caroline Islands. In accordance with native assumptions, therefore, its rising marks due east and its setting due west. The line between the two forms the celestial equator separating the Northern and Southern Hemispheres. East is the first of the cardinal points, and the remaining positions in the coordinate system are reckoned from Altair north and then from Altair south, first in the east and then in the west. Following this scheme, the thirty-two points are marked from east to north by the rising of Altair Aquilae, Gamma Aquilae, Aldebaran, Pleiades, Vega Lyrae, Alpha Cassiopeiae, Alpha Ursae Majoris, Beta Ursae Minoris, and finally Polaris. From east to south are the rising of Beta Aquilae, Orion's Belt, Corvus, Antares Scorpii, Kappa or Lambda Scorpii, and Crux. The next point is marked by the position of Crux at the rising of Alpha Centauri, with south indicated by Crux upright. Points on the western horizon are named for the corresponding positions of the same stars and constellations. This system forms the navigator's compass.

We may wonder how such a compass can be effective, considering the fact that its relation to the true compass changes radically in different latitudes. Again we must remember that the position of the Carolines is latitudinally confined, so that the system remains in fact fairly fixed for the whole archipelago. The finer gradations on the east-west axis of the compass are further reflections of the latitudinal emphasis in native navigation.

That this star compass is standardized throughout the central Carolines is eloquent testimony to the large volume of traffic between the islands in this wide area. Although navigators jealously guard astronomical knowledge as a part of their professional secrets, there is obviously a free exchange of information among accepted members of the profession. It is taboo for navigators to eat any food except that separately prepared for them. Abroad as well as at home, therefore, they dine apart at the navigators' mess, where conversation inevitably turns to the circumstances of the latest voyage, the course followed, and weather conditions encountered. Taboo is too frequently regarded as a manifestation of religious superstition, with little attention paid to its constructive social results. In the present instance it has unquestionably served to foster and maintain the "free international exchange of scientific information."




The star compass of Carolinian navigators consists of 32 points on the horizon where certain stars are seen to rise and set. The declination of Altair, the base star, corresponds with the latitude of the Caroline Islands. Its rising and setting, therefore, indicate due east and west.

THE MAJOR NAMED STARS AND CONSTELLATIONS IN ORDER OF THEIR RIGHT ASCENSIONS, TOGETHER WITH THE MEANINGS OF THEIR NAMES WHERE TRANSLATION IS POSSIBLE

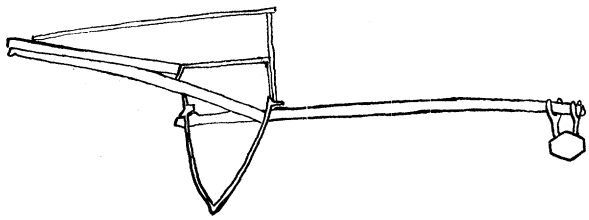
1. A large constellation called the "Fish," including Cassiopeia ("The Fish's Tail") and a number of unidentified stars to the south in Andromeda and Pisces.
2. Alpha, Beta, Gamma, and Iota Arietis, called the "Dolphin," whose swimming form it resembles on the eastern horizon.
3. The Pleiades.
4. Aldebaran and the Hyades, called "Testis."
5. Alpha and Beta Aurigae, called "North of Testis."
6. Delta, Epsilon, and Zeta Orionis (Orion's Belt), called the "Trio."
7. A large constellation called the "Bird," including Procyon (its "Northern Wing"), Sirius (its "Body"), and Eta Canis Majoris and Canopus (its "Southern Wing").
8. Alpha, Eta, Gamma, Xi Leonis, called the "Rat."
9. Alpha and Beta Ursae Majoris.
10. Crater.
11. Nu, Pi, Omicron Virginis.
12. Crux, called the "Trigger Fish."
13. Corvus, plus Spica Virginis.
14. Alpha and Beta Centauri, called the "Spear" because it is spearing Crux.
15. Arcturus.
16. Beta, Gamma, 5 Ursae Minoris, called the "Main Cluster of the North."
17. Corona Borealis, called the "Net."
18. Alpha, Tau, Sigma Scorpii.
19. Lambda, Upsilon, Kappa, Iota Scorpii.
20. Nu, Xi, Omicron Herculis, called the "Little Cluster."
21. Vega and adjacent stars in Lyra.
22. Alpha, Beta, Gamma Aquilae, called the "Main Cluster."
23. Alpha, Gamma, Nu, Xi Cygni.
24. Alpha, Beta, Gamma, Delta Delphini, called the "Bowl," the four stars resembling the outline of a native wooden bowl as seen from above.
25. Alpha Equulei.
26. Alpha Andromedae and Beta, Eta, and Mu Pegasi.
27. The Milky Way, called the "Breadfruit Road," reflecting the belief that breadfruit comes from a mythical southland whence conjurors must summon it each year if local trees are to bear well.
28. Polaris, called the "Fixed Star."

In line with this exchange it is customary for navigators to note on the star compass the relative location of all new lands encountered and to add this information to existing knowledge. As a result, the German ethnographers Damm and Sarfert obtained from a navigator on Puluwat a list covering several pages of fine print, giving sailing directions in terms of this coordinate system from every known place—including reefs—to every other known place. Each course is given both directly and with respect to a third island or reef forming a triangle with the first two, to provide another point of reference and an alternate landfall. Lands lying along a given axis of the compass are also known. This, coupled with the number of days of sailing by which they are known to be separated, has made it possible for navigators to astound Western observers with the accuracy with which they can make sketch maps of the Caroline chain. Since there are no written records, a professional navigator memorizes all this information. Thus, like the governor's courier, he can with some degree of confidence go anywhere in his world and know where he is when he sights land.

As any Western sailor knows, tacking on a fixed course requires that allowances be made for the loss of way resulting from the lateral pressure of the wind. Before we turn to the calendrical aspects of Carolinian astronomy, therefore, it will be pertinent to mention the ingenuity native canoe-builders have exercised to make possible long tacks on fixed compass points without loss of way. Their outrigger canoes are constructed with asymmetrical hulls, which are convex on the outrigger side but concave toward the keel on the opposite side. This is a feature that has long puzzled Westerners, though it has been assumed that it somehow compensates for the effect of the outrigger. Thanks to what Harry Payne Whitney learned last summer from a visiting native of Yap, we now have a fuller explanation, confirmed by the sailing performance of an architect's model which his Yapese guest constructed for him.

Carolinian canoes must sail with the outrigger always to windward. When they heel over in a stiff breeze the outrigger comes out of the water. If it were on the lee side and pushed under water, the canoe would be likely to capsize, the effect being similar to the results of "catching a crab" in rowing. On changing to an opposite tack, therefore, the lateen-rigged sail has to be reversed and what was the bow becomes the stern. Regardless of how a canoe is constructed, when its outrigger is out of water its performance cannot be the same as when its outrigger is subject to the water's resistance. It is precisely this fact on which native craftsmen have capitalized. The asymmetry they give to the keels of their sailing canoes is so calculated that when a canoe heels over it sideslips crabwise to windward. When allowed to right itself, it falls off to leeward. In sailing, therefore, a canoe's wake describes a gentle zigzag. The angle can be controlled by tightening or slackening the sheet, this being the method by which canoes are steered. In this way it is possible to sail on a given point, even on a sharp tack, without ever having to come about —an obvious advantage when navigating by stars.

Forecasting weather conditions has always been of as much concern to sailors as knowing where



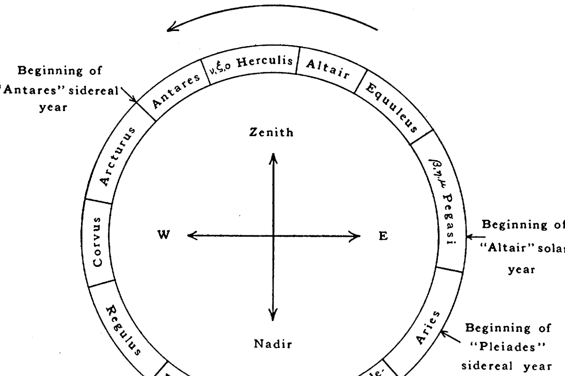
Sailing canoes in the central Carolines have asymmetrical hulls. The keel is convex on the outrigger side and concave on the other, not only in cross section but also fore and aft. The above sketch shows the hull, outrigger, and lee platform of a sailing canoe from Yap (after Müller, *Yap*, Vol. 1, 175 [1917]).

they are. It is in this context that the Carolinian calendar has had its major development. There are other contexts as well for keeping track of time. Seasonal variations in the breadfruit crop, for example, provide the basis for a feast-day calendar. The phases of the moon have given rise to a thirty-day lunar month, each day or, more properly, night of which bears a name in some way descriptive of the moon's appearance. The names used and their sequence approach uniformity in the various islands. The lunar month is divided into three periods of ten days each. The first ten, a period of darkness, are feared as the time when ghosts and sorcerers are active. The second ten days of relatively full moon during the evening hours are favored for social activities. The lunar month represents the longest day-count kept. For longer periods the calendar is a sidereal one.

Navigators use the stars to determine the time of year at which they may best undertake particular voyages. From the stars they know when to start preparing, what the prevailing winds and currents will be when they embark, and how long they can safely be away before starting home. For this purpose natives divide the year into eighteen or nineteen unequal periods based on the heliacal rising of particular stars and constellations. By correlating weather conditions with them they have developed what amounts to a sailor's almanac. It is not meant to divide the year into a fixed number of periods of equal length. It places a premium on defining as exactly as possible the times when weather conditions shift and within which they remain constant.

In addition to this almanac there is a shorter sidereal calendar, whose various local forms are all abridgments of the almanac and which contain fourteen or, more commonly, twelve time divisions. There has been an obvious attempt to equate the latter with lunar months. Divisions on the sidereal calendar are also called "moons," though they are named for stars. On most of the islands, however, the attempted correlation stops there. The divisions are of unequal length, and the names selected are those important in the almanac rather than those whose right ascensions are evenly spaced. Despite local variations, all such calendars have the same names for those "months" in which most sailing is done (Arcturus through Aries). They show less agreement for the period from May through October, when unpredictable winds, calms, and frequent overcasts make sailing hazardous. Emphasis on navigation has served to inhibit rather than promote more than a nominal equation of the lunar and sidereal cycles.

On only one island, tiny Ngulu, is there good evidence of a more serious attempt at correlation. The people of Ngulu have borrowed the central Carolinian astronomy from their neighbors, being themselves Yapese in speech. On Yap the calendrical system is different, and the year is divided into twelve or thirteen lunar months. Using the most typical abridged form of the central Carolinian almanac, the navigators of Ngulu have adapted it to the Yapese system. They divide the year into twelve lunar months, with a thirteenth for leap years, but arbitrarily name them for constellations following the sidereal calendar of their neighbors. Keeping the sidereal calendar as well, they have learned how the lunar and sidereal months of similar name change in their relationship to one another and use the extra lunar month to bring the two calendars back in phase in leap years. It is possible that the vaguer correlations in the central




The calendar most common in the central Carolines includes twelve star-months of varying length. Each month begins with the first appearance at dawn in the east of the star for which it is named. The sidereal year begins with the heliacal rising of either the Pleiades or Antares. Some calendars, therefore, name a month for the Pleiades. The solar year in the southwestern islands begins when the sun rises in the compass position marked by Altair.

Carolines proper reflect the beginning of a trend stimulated by the Yapese lunar calendar, for Yap, although not one of the central Carolinian islands, has exerted great political and cultural influence over them in recent centuries.

Native astronomy is aware of the year in a solar as well as a sidereal sense. In the westernmost islands, for example, the year is named for the constellation "Main Cluster" (Alpha, Beta, Gamma Aquilae), the rising of whose chief star, Altair, indicates due east. When the sun's position on the ecliptic is such that it rises where Altair does, the new year is said to begin. It continues to rise further to the north until it comes up in the compass position marked by the Pleiades. It then swings south until it rises in the position of Antares, whence it returns to Altair for the start of another year. Thus the "Altair year" is a solar one and begins with the native equivalent of our vernal equinox. In other islands navigators use a sidereal year, whose beginning coincides with the heliacal risings of either the Pleiades or Antares. Throughout the islands, however, native observers have noted that the sun rises and sets further to the north or south in relation to its background of stars, and that one complete cycle of this sort corresponds to the annual revolution of the skies. Since their points of reference are abstractions based on the directions in which stars rise and set rather than the stars themselves, they have not developed a zodiac of the ancient Near Eastern type, in whose twelve constellations the sun was actually seen to rise. Their knowledge in this regard, however, is no less, and if the zodiac stands as a monument to the careful observations of the Magi, the "Altair year" represents an equal achievement.

Curious as it may seem, native navigators appear to be little concerned with explanations of the heavenly bodies or their movements. They assume that the sun, moon, and stars go around the earth, which is fixed, and argue that if the sun, for example, did not move it would always seem to rise and set in the same place. But they have not deified any of the heavenly bodies, nor do they have an elaborate mythology seeking to rationalize them. The few myths reported are used more as an aid in remembering the composition and relative location of the constellations rather than as philosophical explanations of them. Practical and empirical in their approach, the Carolinian people belie the frequent assumption that man everywhere is awed by the marvels of nature and, stirred to speculate thereon, seeks to formulate a coherent theory as to the origin and meaning of the cosmos. Considering the intense native interest in divination and luck, it is equally noteworthy that the Carolines have produced no astrological systems. Rooted in navigation, aimed at determining directions and predicting the weather, native astronomy is perhaps too important for personal safety to permit its being removed from an empirical context.

The question arises as to whether we may justly consider Carolinian astronomy a science. The natives lack an adequate means for precise measurement. They have no geometry or algebra by which to express or calculate relationships. Lacking other symbolic systems, they must express everything in words, and simple diagrams sketched in the sand. They express little direct interest in theory, limiting themselves to empirical solutions to practical problems; nor have they made an attempt systematically to chart the heavens. On the other hand, their compass is a true abstraction. They have gone a long way toward systematizing their observations. They have inductively discovered that the stars rise and set in the same place on the compass in a given latitude, that a complete cycle of the sun on the ecliptic coincides with the annual revolution of the stars, and that neither can be evenly divided by lunar cycles. Moreover, they have acted on these principles, applying them to the solution of practical problems, and in the interests of systemization have begun to integrate the lunar with the solar-sidereal calendar. If less interested in theory, native astronomers have at least kept open those questions they could not solve, eschewing mythological or theological explanations. With a relatively free exchange of information they have fostered a growing discipline, which was clearly still in the process of development until within the past few decades the introduction of Western education and skills began cutting the ground from under it. Here, indeed, were the rudiments of a science.

### Bibliography


CHRISTIAN, F. W. *The Caroline Islands.* London (1899).

ERDLAND, A. *Die Marshall-Insulaner.* Münster (1914).

GIRSCHNER, M. *Baessler-Arch.,* **2,** 123 (1912).

GRIMBLE, A. *J. Polynesian Soc.,* **40,** 197 (1931).

KUBARY, J. *Mitt. Geogr. Ges. Hamburg* 1878–79, 224 (1880).

LESSA, W. A. *Am. Anthropol.,* **52,** 27 (1950).

MAKEMSON, M. *The Morning Star Rises.* New Haven, Conn.: Yale Univ. Press (1941).

THILENIUS, G. (Ed.). *Ergebnisse der Südsee-Expedition 1908–10.* Hamburg (1917–38).