Chapter 2
War and the Food Quest in Small-Scale Societies: Settlement-Pattern Formation in Contact-Era New Guinea

Paul Roscoe

Settlement patterns are one of the more robust archaeological signatures of prehistoric social life, and archaeologists have invested a lot of effort in understanding the processes and conditions that create them and generate variation from one society to another. Most of this research has focused on subsistence organization, the general idea being that individuals attempt to optimize returns on physical expenditures in exploiting material resources (e.g., Butzer 1982, pp. 211–229; Kelly 2013, pp. 77–114). Recent decades have seen increased attention to military concerns and their consequences for settlement patterns and social life (e.g., Arkush 2011; Arkush and Allen 2006; Chacon and Mendoza 2007, 2012; Keeley 1996; see other chapters, this volume), but what we lack as yet is a *theory* of how war—in particular settlement defense (Roscoe 2008; Rowlands 1972)—interacts with resource exploitation in different times and places to determine settlement patterns. We have well-developed theories of optimal foraging, even optimal farming, for instance, but none of optimal defense and of how these two logics interact to regulate how people locate themselves across a landscape.

Using data on about a hundred egalitarian and trans-egalitarian communities from contact-era New Guinea, this chapter investigates how these processes interact to determine polity size, territorial area, mobility, and levels of residential nucleation. My essential point is not complex: In a context of external military threat, researchers simply cannot explain a polity's settlement patterns in terms of ecology or economy alone. They result instead from a trade-off between the defensive value of military strength and the costs of the food quest required to support it. Just how this trade-off works in particular instances, however, is considerably more intricate, varying markedly with resource productivity, population density, and the military implications of the terrain.

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In an effort to make a complicated argument less burdensome for the reader, I begin with a simple model of the forces that determine polity size, territorial area, and levels of residential nucleation. At first blush, the results appear to fare poorly against the New Guinea data. Closer investigation, however, allows us to unpack several further formative variables that appear to vindicate the model, sufficiently at least to warrant its testing against further ethnographic and archaeological data.

2.1 A Simple Model of War, the Food Quest, and Settlement-Pattern Formation

Numerous scholars have attempted to define war, the conventional view converging around a characterization that it is armed, "organized," lethal fighting between "communities" or "groups" (for a review, see van der Dennan 1995, pp. 70–78). Quite what kind of "community" or "group" these definitions envisage is rather unclear, but to the extent they are identified more precisely it is as *political* units, communities, or polities, or more precisely yet as politically *autonomous* or *independent* communities.

As venerable as it is, this definition leaves some important questions unaddressed. What *is* an (autonomous) political community? What defines it? Unfortunately, the definitional literature is all but mute about these questions, reflecting perhaps a tendency among Euro-American social scientists to consider the emergence and theoretical status of sociopolitical groups analytically unproblematic because they unreflectingly take them to be regulatory agencies (Harrison 1993, p. 22). An answer can be found, though, in an oddity about our conceptions of war. We tend to conceptualize war as an offensive rather than a defensive act—as an ambush, a raid, or an aggressor marching its army against a foe rather than as a settlement scrambling to fend off an attack or repel an enemy army at its gates. Yet, in many small-scale societies, it was defensive, not offensive, warfare that routinely engaged the maximal, autonomous units. Throughout lowland and much of highland New Guinea, for instance, it rarely happened that the entire complement of a village community (the largest autonomous political unit in these regions) combined to attack an enemy. Women, of course, seldom engaged in offensive combat in any case, but it was equally unusual to find all the able-bodied males of these communities combining to attack en masse. Rather, it was a subset of the village's males—a clan or, more commonly yet, a subclan—that launched offensive war if only because terrain and vegetation restricted the viable size of ambush parties and because the interests motivating attacks were seldom shared by every village member.

Things were very different in defensive warfare. Throughout New Guinea, an attack was *always* met with a coordinated, united response from every able-bodied member of an autonomous political unit, be it a village community or one of the large clan communities of the Central and Western Highlands. Every capable male in the community rushed to defend those in jeopardy, while every capable woman snatched up children and valuables and sought safety. Why should this be? Why was it that the autonomous political community always acted as a collectivity in defense, when it so often failed to do so in offense? As I have argued elsewhere, and as the ethnographic record of New Guinea makes clear, the answer is simple: In an environment of military threat, the political community was first and foremost a collectivity dedicated to mutual defense (Roscoe 1996, pp. 650–654, 2009, pp. 80–85).

If the reader is unconvinced by this argument from ethnography, the same conclusion can be derived by an entirely different train of reasoning. It is a commonplace observation in our disciplines that, in small-scale societies, communities nucleate their settlements for defensive purposes—to protect themselves against attack (e.g., Rowlands 1972; for New Guinea, see Roscoe 2009, pp. 82–83). What gets overlooked, however, is that nucleation can only succeed as a defensive measure if those who do the nucleating also act *as a defensive group*, as an organization dedicated to mutual security against external military threat. Settlement members must both commit to fighting off attacks and organize themselves to ensure they can do so. Whatever else it is, in other words, the political group inhabiting a settlement that has nucleated for defensive security must necessarily also be a group dedicated to *defensive* warfare.

2.1.1 Territorial Size

Let us define war, then, as lethal fighting between political communities (or polities) that are themselves cooperative organizations formed for the precise objective of defending against that violence. A simple model of the relationships between war, the food quest, and settlement-pattern formation then follows. Consider, first, the territorial area commanded by a small-scale political community. Because inferior fighting capacity can be existentially catastrophic, a unit formed for military defense is under constant pressure to increase its military strength. Military strength is a complex product of several factors (Roscoe 2009, pp. 90–94), but in small-scale societies, warrior numbers and their distribution in space are particularly critical. The more warriors a polity can deploy to repulse an attack, and the more women it can rely on to whisk children and valuables to safety in the process, the stronger its defensive capacity. A political unit dedicated to shared defense, therefore, has a chronic interest in maximizing the size of its membership.

Military strength also depends on the *rapidity* with which warriors and women can achieve their respective defensive tasks. This was the motive behind settlement nucleation, which increased a political community's defensive strength against an attack under cover of night, when its members are sleeping and arguably at their most vulnerable (Roscoe 1996, pp. 650–654, 2009, pp. 80–88). [During the day, when they disperse from their settlements out to their foraging or farming lands, their settlements provide little security, and they are obliged to make other defensive arrangements (Roscoe 2009, pp. 85–87).] By arranging to sleep in close proximity to one another—by nucleating their residences, in other words—a slumbering population can increase the speed and scale of its response once an attack has been detected.

There is a cost, though, to maximizing military strength. A large, tightly nucleated population increases military strength, but it also increases the travel costs of the food quest. To begin with, the tighter the polity's nucleation, the greater the fraction of its subsistence resources located in the countryside around it, which in turn increases the average travel costs associated with subsistence routines. Second, as the number of its members increases, the polity has to grow in territorial extent if it is to house and feed the additional numbers, which again increases subsistence travel costs. The greater the productivity of a polity's subsistence regime and the heavier the travel costs its members are willing to shoulder, the higher the polity's military strength can rise. At some point, however, the costs become so great that members are no longer able or willing to bear them; further increases in territorial area, settlement nucleation, and polity population then come to a halt.

We can construct a simple model of these processes. If we hypothesize that, across small-scale societies, people tolerate much the same travel costs and commute at much the same pace to their subsistence resources, then the territorial area (T) that they are prepared to defend and exploit will be given by:

$$T = k \times \left({}^{V_c}\!/_{t_c} \right)^2$$

where V_c is mean commuting speed, t_c is the average maximum commuting cost tolerated, measured in travel time, and k is a constant dependent on territory shape (e.g., circular, hexagonal, or polygonal).

Researchers within and beyond archaeology have devoted a lot of attention to figuring out t_c, the maximum travel time that people are willing to devote to commuting to and from their workplace.[1] These efforts yield widely differing

[1]Based on limited ethnographic data (Chisholm 1968, p. 131; Lee 1969, p. 61), some archaeologists and geographers have proposed that foragers will tolerate commutes of up to 2 h from a residential site but cultivators no more than 1 h (Roper 1979, pp. 123–124; Stone 1991, p. 343; Vita-Finzi and Higgs 1970). For their part, transportation researchers (e.g., Ausubel et al. 1998: Marchetti 1994; Roth and Zahavi 1981; Zahavi 1979) find that, across the developed and developing world, *mean* daily travel time budgets (averaged over the year and across a population) fall around 1 h (i.e., ½ an hour each way), with some evidence that this has been so for many centuries (Marchetti 1994, pp. 76–77). This research is not without its critics, but even they concede that commuting times do seem to have "some stability" across time and space (Mokhtarian and Chen 2004). The few precise measurements we have, moreover, indicate that the mean may be somewhat higher in small-scale cultivator communities. Hipsley and Kirk (1965), cited in Dufour (1984, p. 44), determined that New Guinea highlanders in the Pari area had a one-way mean of 0.83 h; Dufour (1984, p. 44) found Yapú women of the Amazon averaged 0.71 h. [Some previous work (Craig and Chagnon 2006, p. 55; Dufour 1984, p. 44) cites Norgan et al.'s (1974, p. 334) findings that, among the Kaul and Lufa of New Guinea, walking times totaled 1.70 and 2.48 h, respectively. Closer inspection of the data, though, reveals that these measurements refer not just to mean commute times to and from subsistence resources but also time spent walking around once there (Norgan et al. 1974, p. 337)]. Mean commuting times, however, are not the *maximum*

results, but they suggest that humans are willing to tolerate a maximum, one-way commute that is between about 0.75 and 1.2 h.[2]

To translate these maximum tolerated travel times into territorial areas, we need to know the average pace at which members of small-scale communities commute between home and worksite. This task is no easier to estimate than their commuting times, but what evidence we have indicates that a burdened member of the average small-scale community would probably average between 3 and 4 km/h.[3]

Footnote 1 (continued)

mean commuting times people will tolerate—i.e., the average commute time to the farthest flung subsistence resources. If subsistence resources are homogenously distributed and exploited, however, it can be shown that this maximum is 1.5 times the mean. (The mathematically inclined can verify for themselves that to a first approximation and given a circular territory:

$$t_{\mu} = \frac{\left(\int_0^{t_{\mathrm{mx}}} \frac{2\times\pi\times V_{\mathrm{c}}^2\times t^2}{a_t}\cdot \mathrm{d}t\right)}{\left(\frac{\pi\times V_{\mathrm{c}}^2\times t_{\mathrm{mx}}^2}{a_t}\right)} = 2t_{\mathrm{mx}}/3$$

with previous notation and where t_{μ} is mean travel time, t_{mx} is maximum travel time, and a_t is the average subsistence area worked/day). In practice, of course, subsistence resources are not homogenously distributed. People usually try to locate their settlements so that their most productive resources, or those they exploit most intensively, are closest to their residences, and vice versa, a practice that translates into a maximum commute greater than 1.5 times the mean. On the other hand, commuting time measurements all refer to peacetime conditions. Small-scale societies, though, were usually either at war or under military threat, a circumstance likely to reduce their tolerance for venturing far from the security of their settlements and, hence, decrease their maximum mean commutes.

[2]Anecdotal reports on New Guinea foragers and cultivators suggest a lower tolerance for maximum commutes. People are said to prefer to camp out overnight when they are more than about a ½–¾ of an hour from home (Oosterwal 1961, p. 57; Schieffelin 1976, p. 40; Townsend 1969, pp. 37, 78). Because these estimates are based on impression rather than measurement, I do not use them here.

[3]There is wide agreement that, on level terrain, unburdened humans can walk at about 4.4–5.5 km/h on a sustained basis, 5 km/h commonly being taken as the mean (e.g., Cole and King 1968, p. 253; Haggett 1972, p. 253; Jarman et al. 1982; Marchetti 1994; Tobler 1993). In small-scale societies, though, people are commonly burdened in commuting between home and worksite, and there is no guarantee that the terrain they traverse is flat or that their travel between home and worksite is in a straight line. Women in particular commonly bring infants and children along and carry heavy loads of food or firewood home. Many communities also live on complex terrain, ground that is hilly rather than flat, marshy rather than firm, or forested rather than open. We have only limited information on the degree to which loads and complex terrain slow walking speeds. Haggett (1972, p. 253) found in urban environments that a woman carrying a child traveled at 2.6 km/h. In small-scale communities, though, people may not be so slow. Dufour (1984, p. 40) found that, carrying a child, Yapú women (on relatively flat terrain) walked at about 3 km/h and bearing 15–20 kg loads at 4 km/h. !Kung women, carrying 10–15 kg on flat terrain, walked at about 4–5 km/h, though men carrying meat loads of 20–30 kg walked at just 3–4 km/h, with frequent rests (Lee 1979, p. 193). The optimal walking speed for Luo and Kikuyu women carrying loads up to 20 % of their weight was a little over 3 km/h (Maloiy et al. 1986). Haggett also reckoned that, in urban environments, a 10 % uphill slope slows normal walking speed by about 20 %, and a 20 % slope by 40 % (traveling downhill increases speed, though probably not in the same proportion). We have no information, however, on how slope (or for that matter soft or forested terrain) affects walking time in small-scale communities. Nor do we know the degree to which paths across complex terrain oblige people to deviate from straight-line travel between home and worksite.

Combining these estimates, the maximum average distance people in small-scale societies are willing to travel to procure subsistence resources falls somewhere between 2.25 and 4.8 km. [This range of figures compares to estimates by Chisholm (1968, p. 131) and others that agricultural activity is concentrated within a 1–2 km radius of a central settlement, falling off sharply at greater distances and terminating at 5 km (for summaries, see Roper 1979, p. 121; Stone 1991, p. 343).] Assuming a circular territory, these uncertainties translate into a territorial area of about 16–72 km^2, with a midpoint at about 40 km^2.

2.1.2 Polity Size

With territorial area (T) known, it is a straightforward matter to compute P, the numerical size to which people are content to let their polity grow. If we assume that people have much the same mean per capita consumption across small-scale cultures, then, to a first approximation:

$$P = S_{\mathrm{p}} \times T/m$$

where S_{p} is mean subsistence productivity/unit area and m is average per capita consumption.[4]

2.1.3 Residential Nucleation Versus Residential Dispersal

From a purely economic point of view, the optimal settlement pattern in small-scale, subsistence-based communities should be residential dispersal; in this pattern, each subsistence unit surrounds itself with its own subsistence resources, thereby minimizing its commuting costs. In a context of military threat, however, people are willing to bear a substantially greater economic cost by nucleating their residences in order to reduce the potentially catastrophic risks associated with military attack. Are there circumstances, though, that might shift the balance of this trade-off? Are there conditions that might prompt a polity to disperse its residences to minimize its commuting costs despite the presence of external military threat? The question seems perverse because it implies that, in some circumstances, nucleation has little or no defensive advantage. Yet, there are at least two circumstances in which this could be the case.

First, a polity might prefer residential dispersal over nucleation as a defensive strategy if it reduces the enemy's chances of locating its members. In the extreme, if foes are unable to locate their prey at all, the strategy is ideal because the enemy

[4]The model is approximate because: (a) In a nucleated settlement, some fraction of the travel to subsistence resources involves travel within the residential area of the settlement to resources distributed around it; and (b) the residential area itself is not available for subsistence exploitation.

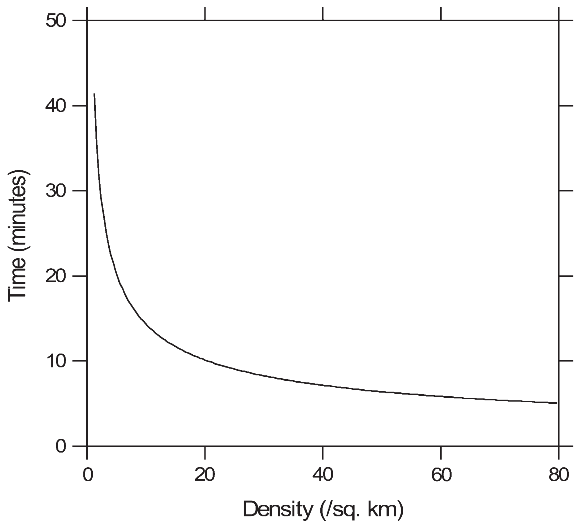

Fig. 2.1 Minimum time by density for 100 dispersed defenders on firm, flat, open terrain to rally to site of an attack. (Assumed speed 10 miles/h or 16.7 km/h; warriors comprise 20 % of population)

is then unlikely to try [e.g., see Steward and Faron (1959, pp. 429–430) on the Guayaki [Aché] of the Amazon]. In small-scale communities, three conditions favor dispersal as a military strategy: very low densities, heavily obstructed landscapes, and mobility. Low densities reduce a polity's military exposure because flows of information that might otherwise betray its whereabouts to an enemy are minimal. Heavily obstructed terrain—land that is highly dissected or blanketed in dense vegetation—is defensively advantageous because it reduces the chances that enemy surveillance will reveal the site's location. And these probabilities sink yet further if the prey population is highly mobile.

The second set of conditions under which a polity can afford to abandon nucleation in favor of residential dispersal is virtually the reverse of this first set. High-density, sedentary communities can adopt a dispersed settlement pattern because the marginal costs to their defense are outweighed by the gains in subsistence commuting. As population density rises, the average distance between individuals (and residences) necessarily decreases. This increased proximity, in turn, accelerates the scale and rapidity with which members of a polity can muster a defensive response against an attack. Figure 2.1 illustrates the point by plotting the time 100 warriors distributed homogenously across a firm, flat, open landscape would take to assemble at the site of an attack at different population densities.[5] At densities below 2 people/km^2, such a force would need more than half an hour to assemble,

[5]The *minimum* time, T_N, needed for N warriors to rally to the site of an attack is given by:

$$T_N = (1/V_a) \times \sqrt{N/(m \times D \times \pi)}$$

where V_a is mean running speed, m is the proportion of the population that can serve as warriors, and D is population density.

leaving antagonists time to wreak considerable damage before having to flee or be repulsed. At these densities, therefore, nucleation has considerable defensive value.

As population density rises, however, so too does the capacity of a dispersed population to muster a large and rapid military response. At densities above 60 people/km^2, for instance, 100 defenders spread homogenously across a landscape could be fully assembled within 6 min, leaving attackers hardly any time to inflict harm before they had to flee. At some point, in other words, density reaches a level at which the military advantages of nucleation over dispersal cease to outweigh the subsistence advantages of dispersal over nucleation. At this juncture, it is in agents' best interests to abandon residential nucleation in favor of dispersal into smaller residential units surrounded by their subsistence resources.

In an ideal world, we would be able to test the above hypotheses about polity size, territory, and nucleation using quantitative predictions and data. In practice, there are far too many theoretical and empirical unknowns to make any precise predictions. What we can do, however, is make comparative predictions:

1. Regardless of subsistence regime, territorial areas will be approximately constant—on the order of 40 km^2, but in any case between about 16 and 72 km^2.
2. Polity size will increase in direct proportion to subsistence productivity.
3. Very low-density, mobile communities on heavily obstructed terrain and high-density, sedentary communities will disperse their residences. Communities with intermediate densities, however, will nucleate their residences.

To test these kinds of comparative predictions, we require cross-cultural data, and in this paper, I evaluate the predictions against a database of about a hundred New Guinea communities. New Guinea is arguably the finest of all ethnographic theaters for examining social and cultural processes in small-scale society. Because it has attracted only limited archaeological attention (but see Hayden 1995), few archaeologists will be familiar with its ethnography or the quality of the data it provides. Before moving to test our hypotheses, therefore, it is well to begin with a brief overview of the island and its ethnographic record.

2.2 Contact-Era New Guinea

As "[t]he Last Unknown" (Errington and Gewertz 1995), New Guinea came under colonial control at a propitious anthropological moment, providing a sudden abundance of fresh field sites as the production of anthropologists boomed in the wake of World War II. The result is an ethnographic record of recently contacted, small-scale societies that is all but unparalleled in its breadth and documentary depth (Roscoe 2000). Even so, this evidence is not without its flaws, prime among them that no anthropologist ever made initial contact with the people he or she studied, and only a handful conducted research prior to their "pacification." By the time fieldworkers arrived to study them, in fact, most communities had already been reshaped, often dramatically, by the colonial presence.

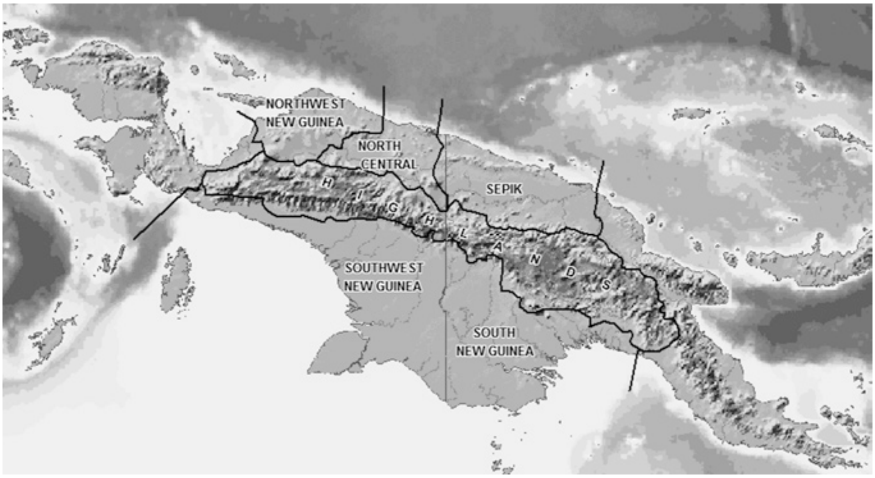

Fig. 2.2 The New Guinea study area and its subregions. The Bird's Head in the west and the southeast of New Guinea are not included in the study. Subregions of the study area are labeled

To reconstruct New Guinean lifeways in the contact-era,[6] therefore, the anthropological record has to be supplemented with historical documents produced by those who were present at the time. These sources—early explorers, gold prospectors, labor recruiters, missionaries, and patrol officers—commonly lacked anthropological training, but many were privileged to make first contact with New Guineans, and a number subsequently lived for months or even years with local populations, some even becoming fluent in their languages.

Accessing and presenting this expanded documentary record is challenging, and it is impossible to survey the whole island (Roscoe 2000, pp. 80–81). As a compromise, the dataset I use is limited to five key regions of mainland New Guinea: the Sepik Basin; the South and Southwest coast (collectively, the South Coast); the Northern (Northwest and North Central) sector of West Papua (Irian Jaya); and the Highlands that run down the center of the island (Fig. 2.2). Although it represents only a subset of New Guinea's societies, this dataset still embraces more than half of its cultures and covers the spectrum of its environmental, demographic, subsistence, and political diversity. The Sepik, in addition, is home to the Yangoru Boiken, a horticultural people among whom I have conducted over two years of fieldwork.

New Guinea is characterized by an extraordinary variety of ecological zones, from swamplands, rivers, and coasts, through grass plains and foothills, to high mountain valleys and peaklands (see Fig. 2.2). At contact, its inhabitants had developed an extraordinary diversity of subsistence regimes that can be divided into two major types—wetland and dryland—and seven major regimes.

[6]The contact-era is defined as the period between initial engagement with foreign agents and the point at which that contact began significantly to affect social and cultural life.

Wetland subsistence was confined almost exclusively to the lowlands, where seasonal freshwater flooding creates ideal conditions in many areas for the sago palm (*Metroxylon sagu*.), the staple of all wetland subsistence. Good quality sago starch, leached from the pith of the palm's trunk, is an abundant and reliable source of dietary calories, yielding this harvest for minimal inputs of labor. Commonly, an individual can produce an entire day's caloric requirements with less than 30-min work, and the product can be stored for weeks or even months (e.g., Flach 1997; Flach 1980, pp. 117–118, 120).

Rich though it is in calories, sago yields virtually no protein, fat, or other nutrients (Ruddle et al. 1978, pp. 57, 61–67). Populations reliant on sago as a staple, therefore, are critically dependent on other resources to meet their full dietary needs. In New Guinea, these resources principally came from either hunting or fishing, accounting for two of the island's seven major subsistence regimes. The first—sago and hunting—combined sago gathered from wild or planted palms with hunted game—wild pigs (*Sus scrofa*), the occasional cassowary (*Casuarius* spp.), and a vast array of other terrestrial, arboreal, and avian species. The second regime, restricted to the environs of major estuaries, rivers, and lakes, combined wild or planted sago with aquatic fauna—primarily fish and shellfish.

As Fig. 2.3 shows, population levels in these sago-dependent, wetland communities were among the lowest in New Guinea.[7] Sago-and-hunting populations had the lowest densities, most falling below 1 person/km^2 and only a few exceeding 3/km^2. With the possible exception of the Upper Tor groups (Oosterwal 1961, p. 57), though, it was hunting, not sago stocks, that limited densities (Townsend 1969, p. 78). Communities that combined sago with fishing appear to have had richer faunal reserves (e.g., Eyde 1967, pp. 10, 22–23). Even so densities were rarely more than two to three times those of sago-and-hunting regimes. It seems, in fact, that New Guinea's sago-dependent, wetland populations were stuck in a subsistence cul-de-sac, unable to intensify their production of food to support higher densities. They could not easily intensify hunting or fishing production, the subsistence activity limiting their population levels, while their water-logged environments prevented them from increasing subsistence production through cultivation or pig production.

Things were different in dryland environments, where cultivation and animal domestication were viable on more than a trivial scale, and intensification allowed population densities to rise beyond the wetland ceiling. Four of these dryland communities were sago-and-fishing villages that were located in wetlands but had

[7]**Sago+hunting** (n = 19): median = 0.8, mean = 1.3, s.d. = 1.4/km^2; **Sago+fishing** (n = 21): median = 2.9, mean = 4.4, s.d. = 5.3/km^2; **Sago+horticulture+hunting** (n = 9): median = 4.8, mean = 8.0, s.d. = 8.5/km^2; **Sago+horticulture+fishing** (n = 4): median = 5.7, mean = 7.3, s.d. = 4.8/km^2; **horticulture+hunting** (n = 9): median = 4.4, mean = 4.9, s.d. = 6.2/km^2; **horticulture+livestock** (n = 20): median = 18.5, mean = 25.2, s.d. = 17.6/km^2; and **agriculture+livestock** (n = 21): median = 49.1, mean 48.2, s.d. = 24.9/km^2.

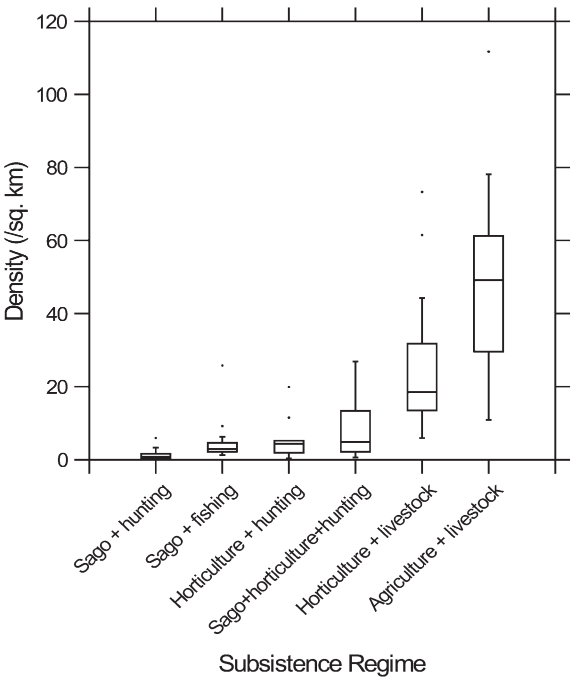

Fig. 2.3 Subsistence regime and population density in contact-era New Guinea ($n = 103$). *Note* Horticulture = main crop cultivated for one to two years on the same plot, followed by a minimum of 10 years' fallow; agriculture = main crop cultivated for more than two years on the same plot, or for one to two years on the same plot followed by less than 10 years' fallow

access to arable ground in the hinterlands. Because there were so few of these communities, however, they have been dropped from subsequent analysis. Of the remainder, communities that relied on horticulture and hunting, or combined sago with small-scale horticulture and hunting, had mean and median densities only slightly greater than those of fishing and sago populations. Most dryland populations, though—those that combined banana (*Musa* spp.) or tuber cultivation with pig-rearing—had considerably higher densities, ranging from 5.9 to as high as 111.1 people/km^2.

Taking population density as a proxy for subsistence productivity, therefore, we can order the productivity of the six New Guinea subsistence regimes on which we have sufficient data as follows: sago+hunting < sago+fishing < sago+hunting+horticulture < horticulture+hunting < horticulture+livestock < agriculture+livestock (see footnote 7).

Notwithstanding the dramatic differences in New Guinea's subsistence regimes and population densities, political structure and organization were everywhere much the same, differing principally in scale (Fig. 2.4). At the core was the political community or polity, an autonomous unit variously referred to in the literature by terms such as the "longhouse" (or "longhouse community"), the "residential hamlet" (or "hamlet group"), the "clan," and the "village" (or "village group"). Perhaps a thousand languages were spoken in contact-era New Guinea, but there were probably more than twenty thousand of these political communities.

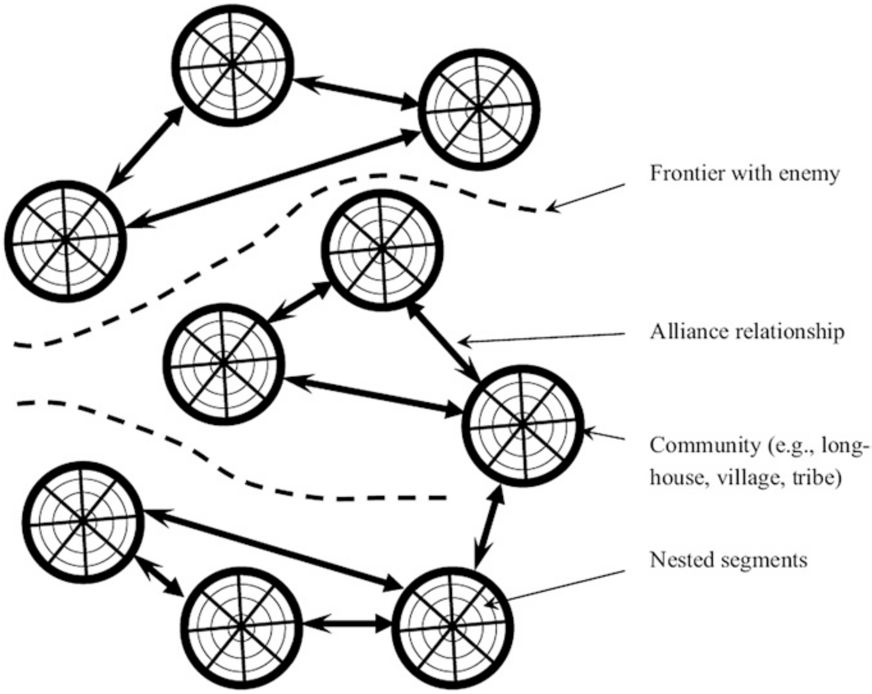

Fig. 2.4 Schematic diagram of New Guinea political structure and organization

Corroborating the argument made earlier, the ethnographic record makes quite clear that the polity was a mutual defense organization, its members depending on one another for military support in the event of a surprise attack, an enemy advance, or a challenge to battle (Roscoe 2009, pp. 82–85).

In most areas of New Guinea, polities enjoyed relations of peace (i.e., alliances) with a handful of neighboring polities, relations that were based on the mutual interest that closely proximate communities have in reducing an existential threat on their doorstep (Roscoe 2009, pp. 87–88). The diplomacy on which these relations depended, however, was by no means always successful, and a political community was invariably either permanently or at least episodically at war with one or more other polities within its vicinity (see Fig. 2.4).

As was the case for many other small-scale societies of the world (Keeley 1996, pp. 195–196), warfare exacted a heavy toll on New Guinea communities. Typically, between 12 and 35 % of New Guineans could expect to die in war, with figures in some areas perhaps reaching 50–60 % (Roscoe 2008, p. 508). Treachery apart, the most common form of lethal violence was ambush—a small-scale, surprise assault on a settlement by night or at dawn, or against people out and about their subsistence or social routines during the day. In low-density areas, large-scale raiding was also practiced, with fisher–forager populations commonly launching massive canoe-borne, headhunting raids that could wipe out entire hinterland settlements. In the open valleys of the Highlands, large scale battles rather than raiding complemented ambush. After several months to a year or so, these battles would usually culminate in peace negotiations, though occasionally they ended in slaughter, with the victors pressing deep into the territory of the vanquished, raping, massacring, burning houses, slaughtering pigs, destroying crops, and putting to flight whoever survived.

2.3 Territorial Areas and Polity Size in New Guinea

On first inspection, our predictions about subsistence regimes, territorial areas, and polity sizes seem to fare poorly against the New Guinea data. Figure 2.5 graphs territorial areas (computed as polity size over density) against subsistence regime, the latter arranged in order of rising productivity. *Contra* prediction, territorial areas differ markedly across subsistence regimes, varying inversely with subsistence productivity. Furthermore, only in three cases—sago+fishing, horticulture+hunting, and sago+horticulture+hunting—do either mean or median territorial sizes or both fall within the predicted bounds of 16–72 km^2.[8]

Figure 2.6 reveals that prediction fares only marginally better with respect to polity size.[9] According to the model, polity size should increase directly with subsistence productivity. This prediction holds, but the correlation is low ($r = 0.467$, $p < 0.001$, using density as a proxy for subsistence productivity). It is particularly striking that sago-and-fishing communities should rival the size of horticulture–livestock polities and even approach those of agriculture–livestock communities, when the productivity of the former regimes, as indexed by their densities (see Fig. 2.3), suggests they are markedly less productive than the latter.

Figures 2.5 and 2.6, in sum, provide rather disappointing support for the predictions of our warfare/food-quest model. The main challenge is the seemingly inverse relation between subsistence productivity and territorial area. Instead of remaining constant across subsistence regimes as the model predicts, the low-productivity, sago-based regimes have very large territories, while those of high-productivity regimes—horticulture or agriculture combined with livestock production—are very small. The implication, on first inspection, is that populations dependent on different subsistence regimes balanced the costs of the food quest

[8] **Sago+hunting** (n = 15): median = 75, mean = 98, s.d. = 83 km^2; **sago+fishing** (n = 18): median = 65, mean = 83, s.d. = 59 km^2; **sago+horticulture+hunting** (n = 9): median = 20, mean = 24, s.d. = 15 km^2; **horticulture+hunting** (n = 8): median = 11, mean = 27, s.d. = 40 km^2; **horticulture+livestock** (n = 17): median = 11, mean = 12, s.d. = 6 km^2; and **agriculture+livestock** (n = 18): median = 6, mean = 7, s.d. = 4 km^2.

[9] **Sago+hunting** (n = 17): median = 45, mean = 55, s.d. = 33; **sago+fishing** (n = 18): median = 210, mean = 283, s.d. = 208; **sago+horticulture+hunting** (n = 9): median = 86, mean = 126, s.d. = 90; **horticulture+hunting** (n = 9): median = 48, mean = 69, s.d. = 66; **horticulture+livestock** (n = 17): median = 222, mean = 227, s.d. = 99; and **agriculture+livestock** (n = 18): median = 297; mean = 315, s.d. = 146.

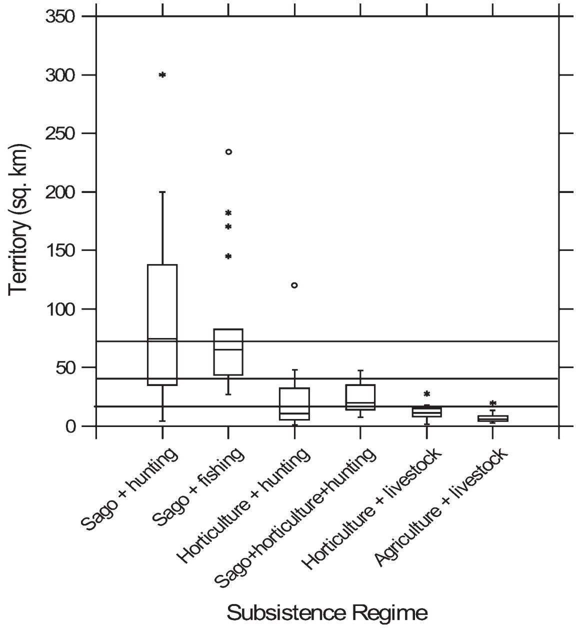

Fig. 2.5 Subsistence regime and territory area ($n = 85$). *Horizontal lines* mark territories of 16, 40, and 72 km^2

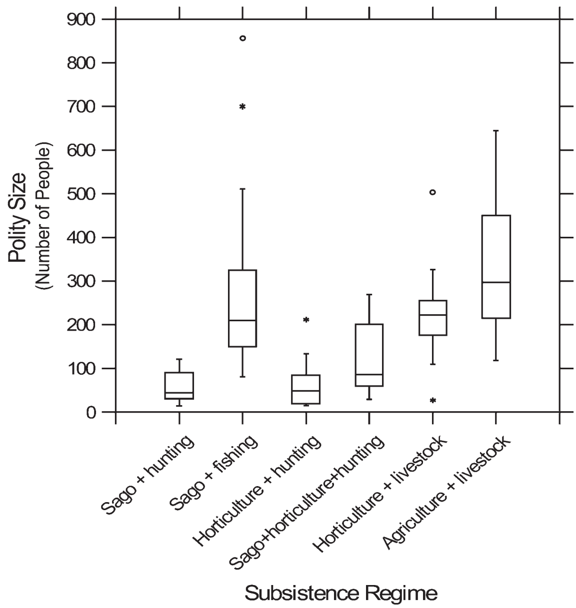

Fig. 2.6 Variation of polity size with subsistence regime ($n = 88$)

and the benefits of military security differently. Those dependent on low-productivity regimes were willing to bear unusually heavy commuting costs in order to bolster their military strength, while those dependent on high-productivity regimes were concerned markedly more with travel costs than with defensive strength.

A closer investigation, to which we now move, reveals that these appearances are probably deceptive. People across New Guinea's subsistence regimes did balance commuting costs and defensive benefits similarly. In the case of sago-and-hunting polities, though, it is simply that the data do not capture a critical complexity in their settlement pattern, one that masks the fact that they actually conform to the model. In the case of sago-and-fishing communities, the model fails to take into account that people mainly traveled by dugout canoe. As for dryland polities—those that depended on cultivation coupled with hunting or livestock—people appear to have balanced military security and travel costs like everyone else, but those whose densities were above about 40 people/km^2 passed a threshold that changed their settlement-pattern calculus entirely. In these communities, the ability to render mutual defensive aid superseded commuting times as the limiting factor on the size of polity territory and population size.

2.4 The Sago-and-Hunting Regime: Terrain, Defense, and Dispersal

Archaeologists interested in catchment analysis sometimes conclude that hunter–gatherers exploit larger territories than do cultivators. At first glance, the New Guinea data seem to confirm this generalization. Many of the communities that subsisted on sago and hunting were actually hunter–gatherer groups (Roscoe 2002, 2005), and as we have just seen, their mean territories were some three to twelve times larger than those of cultivator communities (see Fig. 2.5).

Whatever the case elsewhere in the world, however, the New Guinea data are misleading. Over the course of a year, most sago-and-hunting polities deployed two settlement patterns: one a short-lived nucleation, and the other a dispersed, default state. The data on polity population and territorial areas presented so far refer to the first pattern, but the second configuration was actually the more representative. When we take this complication into account, we find that the polity size and territorial areas of New Guinea's sago hunters fall into line with prediction.

The Bahinemo polity of Gahom illustrates this "pulsating" settlement pattern (Fig. 2.7). For a small portion of the year—perhaps a few weeks—members gathered in a single, central settlement, often sited defensively on a ridge or hilltop rising out of the surrounding wetlands, which provided its members' subsistence.[10] The first patrol officer to visit Gahom, for instance, found the village:

> situated on the crest of a hill several hundred feet high, and from this actual site a fine panoramic view of the surrounding countryside was gained. To gain access to the village it was necessary to climb up the face of this hill, and one could not enter without being observed from above. From the ground the village could not be sighted, being screened by vegetation. It's [sic] location must have been very carefully selected, and it forms what would be an ideal natural fortress against possible plunder or attack (AMB 6-1962/63, p. 13).

[10] **Bahinemo**—AMB (6-1962/63, p. 13), **Bisis**—Gewertz (1977, p. 189), **Mari**—Gewertz (1977, p. 189), **Sanio-Hiowe**—Townsend (1978, pp. 28, 66), **Yerekai**—Behrmann (1922, p. 121), Gewertz (1977).

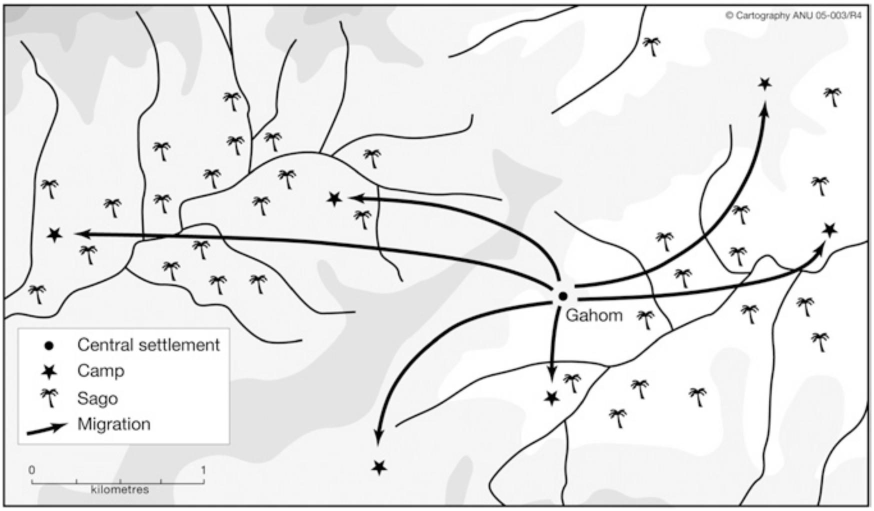

Fig. 2.7 The "pulsating" settlement pattern of the Bahinemo (Sepik New Guinea)

For the majority of the year, though, polity members lived not in this central settlement but in small, one or two family subsistence units that moved from one bush camp to another as game (or sago) in the environs became depleted (Roscoe 2005, p. 262).

Not every sago-and-hunting polity pursued this "pulsating" system. The Mander of the Upper Tor and the Sanio–Hiowe of the Sepik Hills pursued a logistical strategy, foraying out daily from the central settlement to their resources (though in the Sanio case, people moved every few weeks from one such settlement to another) (Oosterwal 1961, p. 57; Townsend 1978). The Waf of the Upper Tor Valley, by contrast, appear to have had no central settlement. Instead, they pursued a strategy of residential mobility, spending all—or nearly all—of their time in small, dispersed, subsistence units that moved every few weeks from one bush camp to another (Oosterwal 1961, p. 57).

The "pulsating" settlement pattern was the norm, however, and it appears to have mediated an intrinsic conflict between economic and military imperatives on the one hand and social and ceremonial demands on the other. Dispersal was the default setting and seems to have been economically advantageous. Both sago, the plant staple, and game, the faunal staple, were more or less homogenously distributed across these wetland landscapes, and by dispersing into small camps and shifting from one place to another as subsistence resources were exhausted, polity members could minimize mean commute times to their resources.

In other circumstances, these small bush-camp groups would have been exceptionally vulnerable to military attack. But for these groups, and these groups alone in New Guinea, dispersal was militarily as well as economically advantageous. With a median density of just 0.8 people/km^2 (mean of 1.3/km^2), these were the lowest density groups in New Guinea. Furthermore, their floodplain forest and sago swamp environments were also among the most obstructed. The German geographer, Walter Behrmann, who toured the Sepik's floodplain forests in the early 1910s, described an "entangled abundance of woven aerial roots," "the abundance of trunks and roots that block the way," and "an abundance of hindrances to advancing in these pathless forests" (Behrmann 1917, p. 74; my translation). In 1932, an Australian patrol, trying to hack its way through a sago swamp north of the Sepik River, had penetrated no more than about a mile by the end of the day and, after a sleepless night knee-deep in water, abandoned the project as hopeless (SD A3-1932/33, p. 9).

In this kind of environment, a small, mobile, low-density population is effectively invisible to its enemies. "The natives hide themselves, their houses and their plantations in the middle of the forest so that they are only found by accident," Behrmann (1922) observed of these remote regions. "This concealment protects them from their enemies" (Behrmann 1922, p. 201; my translation). The Nimo-Wasuai, hunters and sago planters of the Upper May River, observed one Australian Patrol Officer, were "a semi nomadic type and move from place to place in order to find food and escape from their enemies" (AMB 3-1958/59, p. 9; for the Abau, see also GR 6-1951/52, p. 7; for the Bisis, Mari, and Yerekai, see Gewertz 1977, p. 189). Many a Patrol Officer in these wetland forests abandoned his efforts to track down offenders against the Administration's pacification program because it was simply impossible to find them (e.g., AMB 3-1968/69).

If dispersal into small mobile units was both militarily and economically advantageous, then why would New Guinea's sago-and-hunter communities consider aggregating in a central settlement from time to time? The reasons, it seems, were social and ceremonial. These were the sites where communities aggregated temporarily to plan their raids and other cooperative ventures, conduct initiations and other life cycle rituals, and promote courting and other activities that depended on copresence (AMB 6-1962/63, p. 13; Oosterwal 1961, pp. 31–32). Many of these sites were defensively located, but people did not gather in them because they afforded protection. They gathered there for other, social reasons, but because they were temporarily exposed to an elevated military threat while in residence, they chose a defended location.

When we take the duality of this settlement-pattern structure into account, we can explain why sago-and-hunting polities had such large territorial areas. Our population figures refer to the total polity, the people whom the Australian Administration summoned to the community's central settlement to be accounted for in a census. In the normal course of events, however, these members were dispersed across the landscape in small camps. The effective polity, in other words, was not a community that averaged 57 people exploiting an area of 98 km^2 from a central site. Rather, it was a bush camp that comprised just one or two families—8 to 10 people at most—exploiting a territory of some 14–17 km^2. It was a territory, in other words, that brings these sago-hunting systems into line with the lower bound of our predictions.

2.5 The Sago-and-Fishing Regime: Canoes, Clumped Resources, and Defensive Nucleation

In contrast to sago-and-hunting communities, sago-and-fishing villages resorted to nucleation rather than dispersal for military security. The remarkable feature of these aquatically adapted, wetland communities, in fact, was the sheer *number* of people who clustered together. Although densities under sago-and-fishing regimes were only marginally greater than those of sago-and-hunting communities, these aquatically adapted villages had median and mean populations of 210 and 283, respectively, some of which were the largest conurbations anywhere in New Guinea. Nubuai, a Waropen settlement on the northwest coast, for instance, numbered at least 1700 people at contact, and the two contact-era village complexes that made up the Numai-speaking Koriki "tribe" had at least 3960 inhabitants between them (Roscoe 2006, p. 40). As we would expect, the territories that supported these populations were considerably larger than those of dryland, terrestrially adapted communities (Fig. 2.8).

Being large and nucleated, these communities were formidable targets; unless enemies managed to muster a massive numerical superiority, they were rarely attacked directly (Eyde 1967, p. 73; Harrison 1993, p. 39; Williams 1924, p. 107). But how could people who were dependent on such a low-productivity subsistence regime—many of these aquatically adapted communities were actually complex forager communities (Roscoe 2002, 2005)—support such large conurbations and exploit the resources of such extensive territories?

There appear to be two complementary answers to these questions. To begin with, the limiting subsistence resource in these sago-dependent villages was the faunal staple—fish, crustaceans, waterfowl, and the like, which are spatially clumped in or around rivers, lakes, estuaries, and oceans, and often further

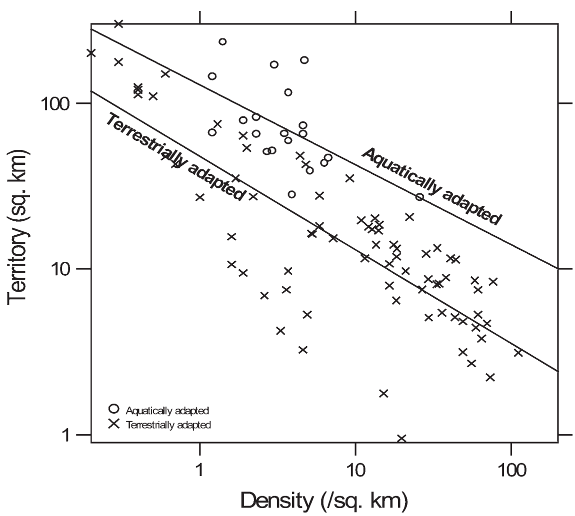

Fig. 2.8 Variation of territory size with population density, aquatically and terrestrially adapted groups. *Circles* represent aquatically adapted, wetland communities, crosses dryland, terrestrially adapted ones. Data plotted on logarithmic scales to reduce skewness toward large values. ($n = 95$)

concentrated in feeding and breeding grounds. In New Guinea, the vegetation bordering waterways—mangrove in tidal reaches, elephant grass (*Pennisetum purpureum*), and other reeds edging freshwater—is particularly rich in faunal resources, as are mudflats, spots at the mouths of tributaries, and estuary reaches subject to tidal mixing. By nucleating their settlements close to particularly rich patches of faunal resources, therefore, sago-and-fishing communities could optimize both the defensive advantages of nucleation and the economic efficiency with which they extracted their critical subsistence resource.

Resource clumping helps to explain why sago-and-fishing communities could nucleate, but what accounts for their size and their sprawling territories? The answer appears to be the dugout canoe. Without exception, these were waterborne people who paddled along watercourses rather than walking along paths. The effect of this mode of transportation on their subsistence commuting costs is hard to gauge. No useful data exist on the comparative energetics of walking and canoeing, either in New Guinea or elsewhere. No figures exist either on the average speeds of New Guinea canoes, and what little historical information is to be found elsewhere suggests that, at best, average canoe speeds are no more than 1–2 km/h faster than the 3–4 km/h calculated earlier for burdened, land-based travel.[11] These are small differences, but if the speed advantage of the canoe came at no greater energetic cost than walking per unit time or distance, then a waterborne people could exploit a territory that was as much as 225 % larger than a terrestrially adapted people for the same commuting costs.

Without further data on energy expenditures in travel, this conclusion must remain hypothetical. The further advantage of the canoe, however, lies in the energetics of load transportation, and here, we are on a sounder footing. Little (1987, p. 60) estimates that, in Mexico, four men in a 10-m dugout canoe could have paddled a 780-kg cargo five times more economically over water than they could have done transporting it on foot over land. If New Guinea canoes offered the same order of efficiencies for subsistence procurement, then sago-and-fishing communities could have exploited significantly larger territories than their land-based counterparts for the same commuting costs.

[11] Studies of historically known canoe voyages in North America indicate travel speeds of between 2 and 5.6 km/h traveling upstream and between 2.4 and 13.75 km/h downstream (Livingood 2012, p. 179; see also Little 1987). Long-distance river journeys in contemporary canoes, some of them record-setting attempts, average current-adjusted speeds between 4.7 and 6.4 km/h, with one clocking in at 12.3 km/h. Modern river trips that made no attempt on a record, though, averaged only 3.6 to 4.4 km/h (Livingood 2012, pp. 179–180). These estimates do not control for the number of paddlers in a canoe. This is important because, in contrast to travel over land, the energy put into canoe travel is scalable: All other things being equal, the more paddlers, the greater a canoe's speed. In the days of war, New Guineans commonly commuted between their homes and subsistence resources in large canoe-borne parties with at least two and commonly many more paddlers in each vessel (Eyde 1967, pp. 50–52, 68, 71–72, 348; Harrison 1993, p. 34). The commuting speeds of New Guinea's sago-and-fishing people, in other words, may have been toward the upper rather than the lower bounds of historical estimates, in which case they could have exploited a larger territory for the same commute time.

These are speculative conclusions, but the balance of the evidence does suggest that, for the same time and energy commuting costs, New Guinea's aquatically adapted communities were able to exploit larger subsistence areas by canoe than could land-based populations traveling on foot. If their average maximum commuting range was just 1.4 times that of terrestrially adapted communities, in fact, it would account for their greater mean territorial size (83 km^2) relative to expectation (40 km^2), increasing in direct proportion the nucleated polity population they could support (see Figs. 2.5 and 2.6).

2.6 Horticulture, Hunting, and Livestock Regimes: Nucleation, Dispersal, and Defense

In turning to the other set of New Guinea communities that deviated significantly from the predictions of the basic model—most of the horticulture–livestock communities and almost all of the agriculture–livestock ones—we found that these intensive subsistence regimes had territorial areas below even the most minimal expectations (see Fig. 2.5). This is puzzling because it suggests these groups were less concerned with defensive security than their counterparts who were exploiting less productive subsistence regimes. It is as though low-productivity groups were willing to commute substantial distances to procure the resources necessary to bolster their military strength, while these intensive cultivators sat around at home and let their security suffer. In an environment of constant military threat, of course, it is implausible that people would be so cavalier about their defensive security, and closer investigation casts yet further doubt on the idea. What distinguished these intensive cultivators from their lower intensity counterparts was not a disregard for security, but their high population densities, which transformed their settlement-pattern calculus.

As population density rises, recall that people become ever more closely packed together and are therefore increasingly capable of swiftly mustering a large defensive response in the event of an attack (see Fig. 2.1). At some point, in fact, they will find that they can radically reduce their commuting costs at no more than a marginal cost to their defensive readiness if they abandon nucleation altogether and disperse into small residential units, each surrounded by a patch of land sufficient to raise the crops and livestock on which they depend (Fig. 2.9).

With this switch from nucleation to dispersed homesteads, subsistence-commute costs are so radically reduced that they no longer limit the size to which a political community can grow. Does this mean, then, that polities suddenly explode in size? After all, if military security depends on numbers, and if commuting costs no longer constrain the number of people who can combine for defensive purposes, it would make sense for large swathes of these small residential units to unite into one gigantic community. As the ethnographic record tells us, of course, this did not happen; it did not happen because it would have been impossible. Although territorial boundaries (and polity populations) are no longer constrained

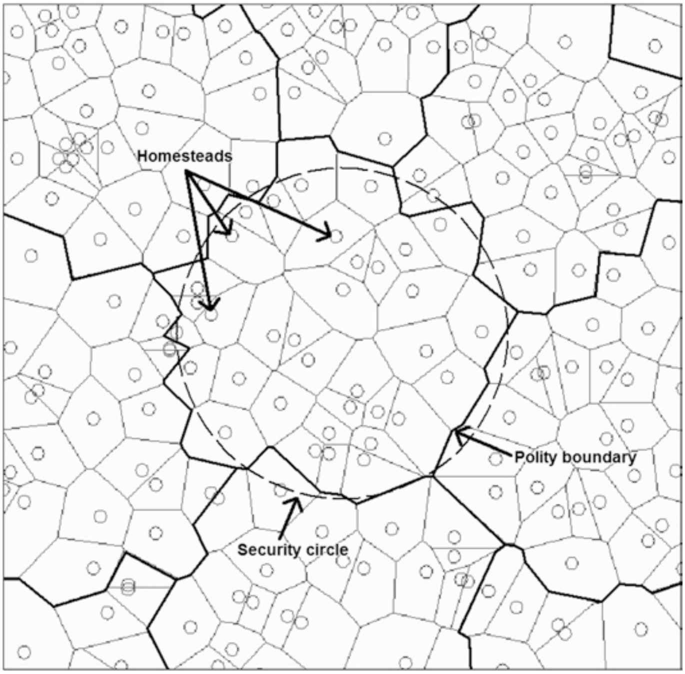

Fig. 2.9 Dispersed settlement pattern with security circle

at high densities by subsistence-commute costs, they nonetheless fall under the control of a second constraint: military response times.

If, as we have argued and as the evidence strongly confirms, polities are mutual defense units, then they necessarily comprise members who are not only willing to render one another mutual defensive aid in the event of an attack but also *able* to do so. For a polity to be a functional defensive unit, in other words, warriors must be located close enough together to be able to render one another effective defensive support. If they are unable to provide this aid—if, for instance, they are situated too far apart—then the mutual interest uniting the polity evaporates, leaving it vulnerable to fission (Roscoe 2013; see, by contrast Bandy 2004; Johnson 1978, 1982). Let us call this area within which community members are able to render one another effective military aid the *security circle* (see Fig. 2.9). Those who live within this security circle share a common defensive interest that unites them as a group; those who live beyond it share no such interest and will form a separate polity based on its own security circle.

Under this new calculus, a political community's territorial area is defined by a security circle, the diameter of which is the maximum distance that a warrior can be from the point of an attack and still arrive in time to render effective military aid. Beyond that distance, mutual military aid is impossible, no bonds of defensive mutuality exist to unite people, and the result is a political fault line. The area of a security circle, therefore, is approximately given by:

$$T_S = \pi \times (V_a \times t_a)^2$$

where T_s is security circle area, V_a is the velocity at which a warrior can run to the site of an attack, and t_a is the time between an attack being detected and when it ends.

So much for theory. In practice, it is difficult to estimate T_s to anything more precise than an order of magnitude. For one thing, it is all but impossible to establish on the evidence available what constitutes *effective* military aid—that is, assistance sufficient to provide a unifying motive for collective defensive action. If warriors are spaced so far apart that they are unable to reach the site of an attack until the action is *nearly* over, will the limited aid they can provide be sufficient to ensure defensive reciprocity or not? For another thing, response times are affected by terrain. Polities that dwell on an open landscape such as a prairie can detect a daylight advance by their enemy and begin to respond much earlier than if they inhabit a terrain blanketed in heavy forest. On firm and flat terrain, moreover, warriors can rally more quickly than across soft or heavily dissected land such as swamplands or mountains. In rugged terrain, even the configuration of ridge top complexes affects response times; other things being equal, more warriors can respond more rapidly to the site of an attack if a ridge complex has a star shape than if it is a single, long ridge (Roscoe 1996; Tuzin 1976, p. 87). Finally, there is the dialectic of military practice. The time between an attack being detected and when it ends, t_a, depends on the speed with which the community under attack can muster an equal and opposite response. If the speed of the response is slow, attackers can prolong their assault. In our high-density intensive cultivation communities, however, the defensive response can be swift; attackers are therefore obliged to hit and then run (e.g., Bergmann 1971, vol. 1, p. 195; Meggitt 1977, pp. 74–76, 93; Roscoe 1996, pp. 651–652; Strathern and Stewart 2000, p. 45).

Assuming a firm, flat, open terrain and that warriors can run at an average speed of about 10 miles/h (17 km/h), the area of a security sphere (T_s) will be smaller than a territory defined by subsistence commuting so long as attacks average no longer than 15–30 min (with previous data and equations, and assuming circular territories). If we assume that such an attack lasted 10 min on average, then warriors could viably render one another mutual defensive aid over a straight-line distance of up to 2.8 km, or within a territory of about 6.2 km^2, which is surprisingly close to 7 km^2, the average territorial area of New Guinea's *agriculture and livestock* communities. If attacks lasted 15 min, the straight-line distance would be 4.3 km and the territorial area 14.2 km^2, close to the 12 km^2 average for the territorial area of the country's *horticulture and livestock* communities. These calculations provide encouraging evidence, in sum, that, at high densities, New Guinea settlement patterns switched from nucleation to dispersed homesteads because their determining calculus changed from a system that traded military strength off against subsistence commuting costs to one governed by the physical exigencies of rendering mutual military aid.

Although they had no idea of its causes, early European travelers in highland New Guinea were struck by the results of this density-induced shift from a nucleated to a dispersed residential organization. Traveling from the moderately populated Eastern Highlands into the densely populated valleys of the Central and Western Highlands, they noticed an abrupt settlement-pattern change from nucleated (and usually palisaded) villages to a dispersed hamlet system. "The most interesting feature of these people," Taylor (1933, p. 53) wrote as he trekked into Chimbu territory, "are [sic] that they make the chessboard type of garden, and that they do not build villages but live in small farm houses instead. When one crosses the Chimbu River the change is immediate, and from then on to Mt. Hagen this type of garden and manner of living persist" (see also Hide 1981, p. 210). "About 10 km east of the Chimbu river," the missionary, William Bergmann (1971, vol. 2, p. 1; see also 1971, vol. 1, pp. 13, 28), observed, "is the borderline for villages and from there on toward Mt. Hagen one finds only the hamlet system." Puzzled by the transition, Bergmann (1971, vol. 2, p. 2) wondered whether Central Highlanders were "somewhat more 'individualists'" than those to their east.

The transition, I propose, had nothing to with individualism and everything to do with a rational evaluation of defensive costs and energetic benefits at high densities. Just how high population density has to be for the transition to occur is difficult to determine, partly because there are so many variables at work but more so because, as Fig. 2.1 demonstrates, rising density erodes the value of nucleation continuously rather than discontinuously. That said, inspection of the Highlands data suggest that the dispersed, hamlet system began to emerge when densities reached about 40 people/km^2.[12]

2.7 Conclusions

To summarize a winding tale, I have sought to demonstrate that, in a context of military threat, settlement patterns in most small-scale societies are determined by a trade-off between the defensive value of military strength and the commuting costs of the food quest. The particular way in which this trade-off manifests itself, however, is sensitive to a range of conditions, including the intensity of subsistence production, population density, transportation technologies, and the military implications of the terrain.

[12]Readers with more than passing familiarity with New Guinea ethnography may object that a number of lowland, horticulture-and-livestock communities, notably those in the Maprik District—including the Central, Eastern, and Wosera Abelam, and the Yangoru Boiken—had densities rivaling those of the "dispersed" communities in the Highlands, yet their settlements were commonly referred to as "villages," implying that they were nucleated. As I have pointed out elsewhere (Roscoe 1994, pp. 205–207), closer inspection undermines this claim. While it is true that these polities can be classified as "villages" in a *social* sense (as in "village group"), their residents were not markedly more *physically* aggregated than those of the Central and Western Highlands [compare, e.g., settlement maps in Lea (1964) and Roscoe (1996, p. 652) to those in Brown and Brookfield (1967), Bulmer (1960, Map III), and Waddell (1972, p. 29)].

Several specific findings may prove of sufficient interest to archaeologists to warrant further testing and investigation. In low-density, low-productivity subsistence regimes, where commuting between home and subsistence resources is on foot, mean territorial areas tend toward the lower end of expectation—on the order of 15–30 km^2 (see above for the sago+hunting, sago+horticulture+hunting, and horticulture+hunting subsistence regimes). This pattern differs in societies that use canoes in the food quest, which have markedly larger territorial areas—on the order of 83 km^2 (reflecting a commuting radius some 160–240 % larger than in foot-borne communities).

At high densities, in more intensive subsistence regimes, however, a further factor emerges to affect the settlement-pattern calculus: military response times. In these communities, settlement patterns shift from residential nucleation to residential dispersal, subsistence commuting costs cease to determine territorial areas, and territory and polity size are dependent instead on the time it takes a community to muster a military response to an attack. Under most if not all military conditions, these response times result in territorial areas that are smaller than those in low-intensity subsistence regimes—less than 12 km^2.

Finally, this transition in small-scale societies carries an interesting corollary for more politically centralized ones. Politically complex systems generally have more intensive subsistence regimes and denser populations than egalitarian and trans-egalitarian societies. We should therefore expect their territories (and populations) to be determined by the extent of their security spheres rather than by the costs of subsistence commuting. With their greater technological and organizational capacity to organize sentinels, faster modes of transport and communication, and so on, we would expect the scale of these spheres to expand dramatically, thereby explaining perhaps why subsistence production, population density, polity territories, and political complexity appear to have increased in tandem in the course of human prehistory (Feinman 2013; Roscoe 2013).

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