Reports

New Directions in Kinship Study: A Core Concept Revisited[1]

SARAH FRANKLIN AND SUSAN MCKINNON
Department of Sociology, Lancaster University, Lancaster LA 1 4YL, U.K./Department of Anthropology, University of Virginia, Charlottesville, Va. 22903, U.S.A. (*sm@virginia.edu*). 15 VIII 99

The Wenner-Gren international symposium "New Directions in Kinship Study: A Core Concept Revisited"—which took place from March 27 to April 4, 1998, in Palma de Mallorca—brought together 21 scholars researching kinship within cultural anthropology, cultural studies, science studies, and biological anthropology. The aims of the conference were threefold: to reassess the widely noted displacement of kinship studies from the center of anthropological inquiry; to bring together for the first time new approaches to kinship study that have emerged at the intersection of anthropology and cultural analyses of science, gender, race, sexuality, nationalism, and transnational political economy; and to examine the ways in which kinship studies are being transfigured ethnographically and theoretically.

The participants in the symposium included Mary Bouquet (University of Utrecht), Janet Carsten (University of Edinburgh), Charis Cussins (University of Illinois), Carol Delaney (Stanford University), Gillian Feeley-Harnik (University of Michigan), Sarah Franklin (Lancaster University), Christine Gailey (Northeastern University), Corinne Hayden (University of California, Santa Cruz), Stefan Helmreich (Stanford University), Signe Howell (University of Oslo), Jonathan Marks (University of California, Berkeley), Susan McKinnon (University of Virginia), Michael Peletz (Colgate University), Rayna Rapp (New School for Social Research), Daniel Segal (Pitzer College), Martine Segalen (University of Paris X, Nanterre), Sydel Silverman (Wenner-Gren Foundation), Verena Stolcke (Universidad Autónoma, Barcelona), Marilyn Strathern (University of Cambridge), Pauline Turner Strong (University of Texas, Austin), Melbourne Tapper (University of Texas, Austin), Kath Weston (Arizona State University), and Yunxiang Yan (University of California, Los Angeles).

In looking back to past configurations of kinship study within anthropology, the symposium offered an opportunity to reappraise analytic concepts and contrast different national traditions (primarily American, British, and French). Two panels explicitly addressed these concerns. One provided critical readings of key texts (including those of Morgan, Lévi-Strauss, Schneider, Wagner, and Strathern) to reexamine analytic concepts such as consanguinity and affinity, maternity and paternity, substance, genealogy, and property (Feeley-Harnik, Carsten, McKinnon). The other assessed the limitations of older French and British frameworks of kinship analysis in the context of historically changing patterns of kin relations in France, China, Malaysia, and the United States (Segalen, Yan, Peletz).

In looking at emerging reconfigurations of kinship and kinship studies, the symposium focused on the transformations of analytic concepts as they are refracted through a range of novel sites of kinship production. Five panels explored the changing definitions of what might count as kinship studies by surveying a diversity of new uses and sites of kinship production. The first panel investigated the "border-crossing" practices and meanings entailed in transracial, transnational, and transcultural adoptions (Gailey, Strong, Howell). The second, on the new reproductive technologies, examined not only the changing meanings of biology—as "natural facts" come to be created in the lab—but also the complex negotiations of kinship in the context of surrogacy, egg donation, assisted conception, and cloning (Franklin, Cussins, Stolcke). The third took up the old theme of genealogies but considered their newer uses in the context of genetic counseling, the Human Genome Diversity Project, and biomedicine (Rapp, Tapper, Marks). A fourth, on kinship as knowledge, information, and property, examined the creation of kinship through photography, computerized artificial-life modeling, and claims to knowledge as intellectual property (Bouquet, Helmreich, Strathern). And a fifth examined the historical and contemporary entanglements of the cultural meanings of blood, seed, lineage, and evolutionary inheritance—and the ways in which these are mobilized to create the inclusions and exclusions definitive of kinship—in contexts ranging from biblical texts to blood transfusions to the arguments of the new evolutionary psychology (Delaney, Weston, Silverman). Finally, two sessions traced some of the crosscutting themes that emerged during the symposium. In one, discussants considered the themes of "substance," "genealogy," "property," and "agency"; in the other, Daniel Segal, as an invited discussant, addressed the relation between culture and science in kinship studies.

One way to describe what happened in the symposium

 We thank the Wenner-Gren Foundation for the opportunity to hold this symposium and the participants for their tremendous energy and enthusiasm, their keen and provocative papers, and their good humor, graciousness, and warm congeniality. For comments on earlier drafts of this conference report we thank Mary Bouquet, Janet Carsten, Charis Thompson Cussins, Carol Delaney, Jonathan Marks, Martine Segalen, Verena Stolcke, Marilyn Strathern, and Kath Weston.

is to map out the implications of these new directions in kinship study for our understanding of what the concept of kinship makes visible and why we find "kinship" useful for analyzing certain kinds of phenomena. The symposium's inquiries might best be described in terms of two general trajectories of investigation, one asking what comes to signify kinship and the other what kinship comes to signify.

WHAT SIGNIFIES KINSHIP

An important achievement of the symposium was the exploration and complication of analytic and ethnographic understandings of the symbolic density of the substances that come to signify kinship and their relation to the formation of kin ties. In considering a range of analytical and cultural understandings of the substance-codes of kinship (to use a formulation provoked by Carsten's paper), participants found that they are as thick and dense with meanings as their negotiations are delicate and subtle.

From blood to hypertext. In a detailed historical exegesis of the connection between Morgan's work on kinship and his studies of the American beaver, Feeley-Harnik documented how he relied not on modern understandings of biology but rather upon a thick layering of connections among linguistic, zoological, geological, and hydrological flows and formations that linked together ideas about land, animals, water, railroads, indigenous peoples, their languages, and the afterlife. Moving from the late 19th to the late 20th century, Carsten and Franklin probed what we mean analytically and ethnographically by the terms "substance" and "biology," respectively. Carsten demonstrated not only the ambiguity and multivocality of the term "substance" as it is used analytically but also the ways in which other cultures' understandings of the flows of substance make visible the specificity of Euro-American ideas about the relation between nature and culture, substance and code. Franklin traced the changing understandings of what is meant by biological "facts" in the context of the geneticization of biology and, in particular, the commodification of genetic information as intellectual property. Similarly, Stolcke argued that cloning demonstrates the extent to which biological facts can change. The fact that Dolly's conception was not, until recently, assumed to have been a biological possibility illuminates the historical nature not only of scientific understanding but also of ontology.

Following the threads of Euro-American kinship analogies—from biology to blood to genes to code to information—revealed that, in the late-20th-century Euro-American cultures, the substance-codes that might signify kinship include a diverse range of phenomena from genetic disease syndromes to the "informatics" of computer programming to family photography. Thus Rapp's paper showed how a shared gene—for Down's syndrome, Marfan's syndrome, or achondrodysplasia and other forms of dwarfism—becomes the basis for new forms of kinship biosociality emerging out of genetic-disease support groups. Providing a striking example of the analogic unfolding of what signifies kinship, Helmreich explored how artificial-life scientists read genes as "information" and "code," which, in turn, allows them to read the "information" and "coding" of computer programs as equivalent to "life itself" and the running of computer programs as equivalent to the evolutionary unfolding of kinship relations over time. In a similar fashion, Bouquet's paper invited participants to reflect on the ways in which the generic conventions of family photography have become one of the primary substance-codings of kinship relations in Euro-American cultures and in ethnographic representations. In the end, it is clear not only that what we mean by terms such as "substance" and "biology" is much richer and more diverse than we thought but also that what count as the substance-codes of kinship have undergone significant historical transformation.

Kinship negotiations: What's biology not/got to do with it? In navigating the multiplication, division, and recombinatory logic of kinship productions in late-20th-century Euro-American cultures, the symposium participants made significant contributions to our understanding of the mechanisms by which possible lines of relation are made visible or invisible by foregrounding and backgrounding various substantial connections and cultural codings. Papers achieved an analytic sensitivity to the multiplicity of potential "kin" connections by tracing the deliberate and self-conscious lines of connection and disconnection produced by social actors and groups as they negotiated the specific parameters of what might count as kinship. While agency, "choice," and negotiation become foci of analysis, participants were careful to frame their use of such terms by an analysis of the complex historical and sociocultural forces that produce the possibility (or negation) of agency and "choice."

In considering the decisions made in the context of the unprecedented combinatory practices of the new reproductive technologies, Cussins provided an account of the techniques employed to decide which of several possible mothers of a child—genetic, gestational, social—would be recognized as the "real" one. Arguments that foreground one possible line of relationality simultaneously background and erase other possible avenues to the creation of kinship ties. For instance, the shared tie through genetic substance might be foregrounded to connect a mother to her child through her daughter's egg but effaced when such close physical connections threaten conjugal integrity or look too much like incest. Similarly, Weston's paper showed how a range of shifting solidarities are established by foregrounding the same shared bodily substance—blood—in different contexts to create lines of "transfusion" across racial or class divisions. However, in other contexts—for instance, blood banks—the disembodiment, standardization, and commodification of blood both obscure tensions and close down possibilities for solidarities across race and class lines. In her paper on transnational adoption, Howell offered a different perspective on the tension between foregrounding and backgrounding different possible ar-

guments for the creation of kinship ties by showing how Norwegians move between three contradictory explanatory frames: one that naturalizes adoptive relations in biological terms, one that stresses social nurturance, and one that biologizes culture as a form of heredity.

Novel recombinatory possibilities are conspicuous not only in what are most evidently the "new" contexts of kinship—such as transnational adoption or new reproductive technologies—and not only in Western or Euro-American contexts. As Yunxiang Yan argued in his account of new "privatized" family formations in rural northern China, changes in both customary exchange relations (*guanxi*) and the wider commercial economy in China have introduced new forms of "practical kinship" that foreground links through friends and affines and background traditional patrilineal relations. Examining changing kinship patterns in France—in particular, the "recomposed families" resulting from multiple divorces and remarriages—Segalen described the mechanisms by which "third age" grandparents foreground or background their relation to their children and grandchildren and thereby alter the intergenerational flow of resources (inheritance, property), sociality, and assistance in caring for children within newly flexible urban families.

WHAT KINSHIP SIGNIFIES

Kinship systems have often been theorized as classification systems and even as grammars. In turn, such social technologies of naming and classifying, or of sorting and dividing, are seen to be generative of the kinds of material, relational, and cultural worlds that are possible or livable, and for whom. As a classificatory technology, kinship can be mobilized to signify not only specific kinds of connection and inclusion but also specific kinds of disconnection and exclusion, as well as the boundary-crossing trickster movements that confound such classificatory moves. Since relations of power are central to the articulation of such classificatory moves, kinship also speaks to the possibilities for equality, hierarchy, and violence. Moreover, kinship's classificatory maneuvers can be mobilized to bring into being the inclusions and exclusions, the relations of equality and hierarchy, and the boundary fixing and boundary crossing that together define and defy *other* categories of relation, including genders, sexualities, races, species, machines, nature, and culture.

Nature, culture, and the properties of kinship. Because, in Euro-American cultures, kinship is a medium through which relations are naturalized and naturalized relations are transformed into cultural form, kinship articulations bring into being what will count as the difference between nature and culture—between what is considered given in the nature of things and what must be created (Strathern 1992*a*, *b*). And, because Euro-American culture is configured as "after nature" (Strathern 1992*a*)—as "something more" added to and transformative of nature—property, enterprise, and paternity (which all depend on the idea of adding "something more" to nature) become central to the narratives of kinship that articulate the origins of culture and the significance of scientific invention.

In her depiction of disputes in Melanesia over compensation payments and intellectual property rights, Strathern made visible the cultural logic of Euro-American links between ideas about property and the power of knowledge to make kinship relations evident, and she contrasted these with Melanesian ideas about valuables and the productivity of exchange to differentiate kinship relations. Building upon Strathern's arguments, McKinnon's and Franklin's papers explored the relationship between kinship, property, and paternity in anthropological stories of the origin of culture and in contemporary stories of scientific progress, respectively. Examining two contrasting "origin stories" in the work of Morgan and Lévi-Strauss, McKinnon explored how both theorists imagine the development of culture as the transformation of naturalized forms of kinship (maternal, female, consanguineal) into transcendent cultural forms marked by the simultaneous discovery and coalescence of paternity and property (whether conceptualized in terms of inheritance or exchange). Similarly, in responding to Haraway's description of a "shift from kind to brand" (1997), Franklin showed how naturalized "kinds" (species, lineages, genealogies) are both affirmed and exceeded in the creation of transgenic animals that can be corporately owned, bought and sold as commodities, and reproduced through patented means of recombinant nuclear transfer. "Authored" or "created" by scientists, such animals literally become a new species of product and thus a novel form of reproductive biowealth. The use of kinship as a signifier of the origins of culture (as well as the relation between paternity and enterprise) was reiterated by Helmreich in his study of artificial-life scientists' efforts to create new communities of life forms in the virtual environment of the Internet.

Genes, genetics, and genealogies. The uses of the concepts of blood, genes, genetics, and genealogy to produce social classifications and definitions of the "family of man" are not a recent phenomenon. However, symposium papers took critical steps in advancing our understanding of how the acceleration of scientific and medical research into human phylogeny and disease constitutes a powerful force in society in relation to which kinship definitions are actively reconstructed in a range of contexts. Papers provided a contrastive frame for theorizing the multiple uses of genealogy as it is mobilized in the service of discrimination and subordination and as the basis for new communities of shared concern.

Several papers addressed the scientific-political uses of kinship in the production of "naturalized" or "racialized" types and discriminations. Marks traced the naturalization of the idea of "isolated" and "pure" human populations—which draw clear lines of exclusion and inclusion—through various scientific studies of genes and race up to and including the Human Genome Diversity Project. In the process, he warned of the pitfalls and consequences of the unexamined classificatory maneuver of the HGDP—especially in the light of those of

an earlier era, which distinguished populations subject to eugenic interventions and were a means for establishing hierarchical control over genetic resources. Similarly, Tapper's historical reading of the scientific construction of sickle-cell anemia in Africa demonstrated how colonial scientists and administrators used sickling rates to naturalize tribal relations as biogenetic categories. Again, mapping racial categories "in the blood" reshaped not only the practice of medicine but also, through it, the structures of government by means of which African people became racialized "tribes" subject to colonial subordination and control.

By contrast, other papers in the symposium demonstrated the innovative uses of the analogies of kinship to create new forms of inclusiveness and egalitarian community. For instance, Rapp showed how the scientific identification of genetic mutations through screening has enabled the renegotiation of disease and disability within genetic-disease support groups and provided the basis for the creation of genetic genealogies and kinship communities based on equality rather than hierarchy, inclusion rather than exclusion.

From amity to the ambivalence and violence of kinship. One of the purposes of the symposium was to explore the ways in which ideologies of kinship become embedded in and signifiers of relations of power that draw lines of hierarchy and exclusion, produce dominance and subordination, and generate violence in the heart of kinship. While these relations are as central to kinship as amity or diffuse enduring solidarity, they have heretofore been theoretically sidelined.

Going back to the story of Abraham—a foundational narrative of three world religions—Delaney traced the ways in which ideas about paternity entail ideas about ownership and inheritance that have multiple consequences for who is included and excluded in the genealogy of Abraham: priority is given to fathers over mothers, to children of married over those of unmarried mothers, and to male over female children. Moreover, the entailments of religious ideas about paternity in the Abraham story place an act of violence (the willingness to sacrifice one's child) at the heart of both kinship and religious faith.

Once the focus of inquiry includes both inclusions and exclusions, both the amity and the violence at the heart of kinship, both the egalitarian and the hierarchical lines of relation, ambivalence emerges as an important avenue for understanding the complexities of kinship relations. Peletz argued that a focus on ambivalence yields insights into the nature of kinship as it is shaped by the tensions and contradictions between differential relations of power and resistance, individual agency and desire, and diverse rights, demands, and obligations.

Cultures of inclusion and exclusion: Fixing and crossing boundaries. If, as has been argued, kinship has long been used to conceptualize ideas about the bounded integrity of nations (Schneider 1969, Heng and Devan 1992, Das 1995, Delaney 1995), of race and caste (Williams 1995), of species (Haraway 1997), of bodies and machines (Haraway 1991, 1997; Helmreich 1998), it has also been and, especially now, has increasingly become a medium through which both the fixing and the crossing of boundaries between these categories is signified. The symposium explored various ways in which kinship is mobilized to articulate these kinds of bounding and boundary-crossing effects.

With regard to ideas about race, Tapper's paper demonstrated how discourses concerning blood (specifically sickling) could be used in the colonial context to bring into effect rigid distinctions between "races" and "tribes," while Weston's paper explored how discourses concerning blood transfusions could bring into relief both racial fears of miscegenation and narratives of the cross-racial kinship solidarity of common blood. With regard to ideas about both race and class, Gailey noted how transnational adoptions simultaneously bridge, erase, and reinforce racial and class lines: the politics of race include some and exclude other children from the international adoption market, and the ideology of upper-middle-class Euro-American kinship requires the erasure and exclusion of birth parents from what will count as "family" and the strict bounding of the adoptive family.

With regard to ideas about culture and nation, Strong's paper demonstrated how adoptions of Native American children by Euro-American couples take place in a context of differential power and operate under a hegemonic definition of what constitutes a "family"—thereby working to exclude and erase nondominant forms of family relation. In the process, distinct lines between two cultures (and nations) are drawn by reference to different understandings of what counts as family. In a contrary fashion, Howell examined the ways in which Norwegian adoptions of Korean children effect a bridging between the two cultures and nations as Norwegians travel to Korea to find their children's "roots," the Korean government recognizes its children in Norwegian families, and Norwegians attempt to create Korean culture in Norwegian meeting halls.

With regard to species, Rapp noted how parents can sometimes conceptualize their own children with genetic diseases as distinct and separate species, while Franklin investigated the emerging terrain of transgenic species boundary-crossing. In all these examples, kinship becomes a medium through which to think about and negotiate the shape and consequences of such boundary-crossings and boundary enforcement, as well as their respective embodiments.

In contemplating the contemporary transformations of kinship—which often appear to involve explicit and self-conscious cultural innovation and negotiation—participants were faced with multiple tasks. As much as they were concerned to trace the new lines of combinatory logic which produce kinship in the conjunctures of biotechnology, biosociality, patented life forms, transspecies hybrids, cyborgs, and global-local compressions, they were determined not only to avoid overestimating the novelty of such phenomena but also to map out the points where such combinations and fusions are prohibited, suppressed, or unacknowledged. As much as

they were intrigued by the ways in which boundaries—of nations, cultures, species, races, persons, bodies, cells—have been breached, they were interested in the points at which new boundaries are being established and patrolled. As much as they focused on the destabilization of older foundational certainties, they highlighted the ways in which new understandings are made to seem certain, essential, and given in the nature of things. As much as their attention turned to the role of process, negotiation, and choice, they were attentive to the cultural understandings that shape these processes and make them possible for some people in some contexts but not for others.

CONCLUSION

The trajectory of kinship studies described by the papers in this symposium differs from those outlined in recent books on kinship by Parkin (1997) and Stone (1997), in which the distinction between biological and social facts is defended, a return to more traditional approaches to kinship is advocated (Parkin 1997:137–38), and the challenge to the concept of kinship offered by Collier and Yanagisako (1987) is rejected (Stone 1997:4). In the midst of ongoing debates within anthropology concerning the scientific authority of the discipline, the relationship of anthropology to cultural studies, and other sources of discontent, it is likely that the study of kinship will continue to register broader currents of the discipline, much as it has always done.

For the participants in the Mallorca symposium, Holy's observation in his astute review of anthropological perspectives on kinship is apt: "New insights into kinship have been gained, as they are always gained, through shift[s] in contextualization" (1996:6). Indeed, the symposium amply demonstrated that a number of shifts in contextualization, both theoretical and ethnographic, have produced new insights into what signifies kinship and what kinship signifies. These insights open kinship study to a richly diverse range of interrelated phenomena of markedly different scale, from the gene to the body, the species, the family, the nation, the globe, and beyond. One of the challenges of the new kinship studies will be to trace the connections and conceptual crossovers between phenomena at these vastly different scales of embodiment.

References Cited

COLLIER, JANE, AND SYLVIA YANAGISAKO. Editors. 1987. *Gender and kinship: Essays toward a unified analysis*. Stanford: Stanford University Press.

DAS, VEENA. 1995. "National honor and practical kinship: Unwanted women and children," in *Conceiving the new world order: The global politics of reproduction*. Edited by Faye Ginsburg and Rayna Rapp, pp. 212–33. Berkeley: University of California Press.

DELANEY, CAROL. 1995. "Father state, motherland, and the birth of modern Turkey," in *Naturalizing power: Essays in feminist cultural analysis*. Edited by Sylvia Yanagisako and Carol Delaney, pp. 177–99. New York: Routledge.

HARAWAY, DONNA. 1991. *Simians, cyborgs and women: The reinvention of nature*. New York: Routledge.

———. 1997. *Modest_Witness@Second_Millennium.FemaleMan©_Meets_OncoMouse™*. New York: Routledge.

HELMREICH, STEFAN. 1998. *Silicon second nature: Culturing artificial life in a digital world*. Berkeley: University of California Press.

HENG, GERALDINE, AND JANADAS DEVAN. 1992. "State fatherhood: The politics of nationalism, sexuality, and race in Singapore," in *Nationalisms and sexualities*. Edited by Andrew Parker, Mary Russo, Doris Sommer, and Patricia Yaeger, pp. 343–64. New York: Routledge.

HOLY, LADISLAV. 1996. *Anthropological perspectives on kinship*. London: Pluto Press.

PARKIN, ROBERT. 1997. *Kinship: An introduction to basic concepts*. Oxford: Blackwell.

SCHNEIDER, DAVID M. 1969. "Kinship, nationality, and religion in American culture: Toward a definition of kinship," in *Forms of symbolic action: Proceedings of the 1969 annual spring meeting of the American Ethnological Society*. Edited by Robert F. Spencer, pp. 116–25. Seattle: University of Washington Press.

STONE, LINDA. 1997. *Kinship and gender: An introduction*. Boulder: Westview Press.

STRATHERN, MARILYN. 1992*a*. *After nature: English kinship in the late twentieth century*. Cambridge: Cambridge University Press.

———. 1992*b*. *Reproducing the future: Anthropology, kinship, and the new reproductive technologies*. New York: Routledge.

WILLIAMS, BRACKETTE F. 1995. "Classification systems revisited: Kinship, caste, race, and nationality as the flow of blood and the spread of rights," in *Naturalizing power: Essays in feminist cultural analysis*. Edited by Sylvia Yanagisako and Carol Delaney, pp. 201–36. New York: Routledge.

Modification of Vicuña Carcasses in High-Altitude Deserts[1]

ATILIO NASTI

Venezuela 306, 1704, Ramos Mejia, Buenos Aires, Argentina. 18 VI 99

Information obtained in recent years on the modification of bones in certain modern ungulates has contributed to the development of interesting taphonomic models linked to zooarcheological and paleoecological questions (Behrensmeyer and Dechant Boaz 1980, Binford 1981, Blumenschine and Madrigal 1993, Brain 1981, Hill 1979, Hill and Behrensmeyer 1984, Lyman 1994, Tappen 1995, Vrba 1980). It is apparent that understanding the nature of contemporary bone modification will help us to evaluate and interpret the interactions of past environments and to construct unambiguous models of the processes of formation of the archeological record (Behrensmeyer 1983, Marean 1991, Palmqvist, Martínez Navarro, and Arribas 1996, Walker 1980). To this end, I shall present

 Translated by David Thompson.

some of the results of a study of modern vicuña (*Lama vicugna*) carcasses in an effort to identify the principal agents of alteration (Mondini 1995; Nasti 1995, 1996, 1998; Olivera and Nasti 1991; Olivera and Barandica 1996).

The data come from observation of contemporary environments as part of a taphonomic program on postdepositional bone accumulation and modification with regard to modern ungulates (camelids) in the Department of Antofagasta de la Sierra, Province of Catamarca, Argentina (Nasti 1998). The study area is geographically part of the southern Argentine puna, a high-desert (3,450 m above sea level) continuation of the Peruvian-Bolivian high plateau, which extends westward to northern Chile. Vegetation is sparse and scattered, being concentrated only in the most humid sectors (the fertile plains) and at the edges of watering holes. Its climate is arid with a wide range of temperatures from 25°C and prevailing winds from the east that average 80 km per hour (Olivera 1991). As in other areas of the south-central Andes, much of the archeological information on the region is based on the zooarcheological record (Yacobaccio 1991, Olivera 1992, Olivera and Elkin 1996), and therefore understanding the processes of formation of bone accumulations and the modifications that they undergo in extreme environments is a priority (Olivera and Nasti 1991).

In this extremely arid ecosystem, there are many environmental factors that can affect bones, among them weathering, selective burial in different environments, and fluvial transport, a common phenomenon in the high plains (Fernández 1994, Nasti 1998). Among these phenomena, alteration by carnivores is one of the most attractive objects of study (Binford 1981, Blumenschine and Marean 1993, Haynes 1988, Hill 1989, Marean and Spencer 1991). Various animals that can alter bones exist in the region, including the rodents *Lagidium* sp. and *Ctenomys* sp., but it is the carnivores, because of their size, that may be most important in the modification of carcasses. Among the principal carnivores found in this part of the southern puna are the puma (*Felis concolor*) and the fox (*Pseudalopex* sp.), represented by two local species, the red fox (*P. culpaeus*) and the grey fox (*P. griseus*) (Olivera 1992, Mondini 1995). For the purpose of assessing the degree of exploitation of carcasses and comparing the alteration by these agents, five vicuña skeletons, two modified by pumas and three by foxes, were examined. All of the carcasses were those of young individuals (Wheeler 1982). The first two were located and monitored within a week of their having been killed and consumed by pumas.

The puma, the first link in the local food chain, is an essentially solitary animal of nocturnal habits, spending the greater part of the day sleeping. Its favorite prey are the weakest animals, especially the young, the old, or the sick (Yepes 1938). Outside of the mating season and, for females, the period of caring for the young, the puma lives alone. It can travel a circuit more than 18 days long, covering distances of up to 40 km in a single night. It is essentially carnivorous, although it is eventually able to digest certain plant foods along with other small mammals and birds. The number of adults in an area does not vary much. Two to four cubs are born per female per year (El puma 1984). The size of the territory is the principal regulator of the number of pumas, and thus few of them are expected to be found in a small area, implying little intraspecific competition.

Generally the puma stalks its prey and takes it by surprise, this being the key strategy for successful predation. In the majority of cases it does not consume all of its prey, devouring it completely only when resources are scarce or it is old. In contrast to other felines, the puma eats where it hunts, and when its hunger is satisfied it may hide the remains for consumption when prey is scarce (Yepes 1938). In most instances its access to prey is planned according to the sequence locate→select→stalk→attack. After surprising its victim, it suffocates it by squeezing its trachea. Next it frequently devours part of the chest, neck, stomach, and thoracic cavity. Thus the damage is concentrated primarily on the spinal column and the ribs. In the vertebrae, damage is detected on the spinal processes (transverse and dorsal apophyses) of the thoracic and lumbar sections of the spinal column, where small punctures are observed (Binford 1981). It is apparent that, as do other felines, they consume the ventral and thoracic cavity first, causing fractures at the distal ends of the ribs.

In contrast to the puma, the fox frequently obtains its prey via an unplanned strategy, playing the role of scavenger with regard to an ungulate the size of a vicuña (40–50 kg). In this context the scavenger gains access to a partially consumed carcass whose thoracic cavity has been opened. Therefore, vicuña carcasses devoured by foxes display many marks on the spinal column, especially the spinal processes of the thoracic and lumbar vertebrae, and on the ribs. The iliac crest of the pelvis reveals furrowing (Binford 1981). At the same time, small punctures may be observed on the nasal bone.

Except for the cranium and the pelvis, then, there do not seem to be substantial differences with regard to bone modification between the two species. When the bones selected by the two agents are compared with regard to the occurrence of different anatomical elements, there seem to be no significant differences (table 1). In fact, a more detailed analysis reveals that the most important differences are due more to the morphology of the marks than to their extent or location.

In the carcasses consumed by the puma the damage is mostly punctures and furrows (Binford 1981), leaving marks 3–5 mm in diameter (Borrero and Martin 1993). Although no fractures were observed, the pressure of the feline's mandibles was apparent in small fissures that collapsed the periosteum and converged radially toward punctures more than 5 mm in diameter. Whereas guanaco (*Lama guanicoe*) skeletons studied in Patagonia show puma damage to the head and other parts of the skeleton, including fractures in long bones (Borrero 1990, Borrero and Martín 1993), no such damage is evident here. The fox, in contrast, leaves primarily scoring (Binford 1981) and punctures less than 2 mm in diameter. Fissures produced by the pressure of the mandibles were

TABLE 1
Number and Frequency of Carnivore Traces on Selected Elements of Vicuña Carcasses

	Puma			Fox		
Anatomical Element	NER[a]	*n*	%	NER[a]	*n*	%
Cranium	2	0	.00	3	2	.66
Mandible	4	0	.00	0	0	.00
Atlas/axis	2	2	1.00	2	0	.00
Cervical	14	4	.28	13	0	.00
Thoracic	24	24	1.00	18	14	.77
Lumbar	14	14	1.00	12	6	.50
Caudal	20	0	.00	0	0	.00
Sacral	2	2	1.00	1	1	1.00
Rib	14	6	.42	37	12	.32
Scapula	2	0	.00	2	1	.50
Humerus (proximal)	4	2	.50	4	0	.00
Humerus (distal)	4	0	.00	3	0	.00
Radio-ulna (proximal)	4	0	.00	3	0	.00
Radio-ulna (distal)	4	0	.00	3	0	.00
Carpal	20	0	.00	10	0	.00
Pelvis	2	0	.00	2	1	0.5
Femur (proximal)	4	0	.00	4	0	.00
Femur (distal)	4	0	.00	4	0	.00
Tibia (proximal)	4	0	.00	4	0	.00
Tibia (distal)	4	0	.00	4	0	.00
Tarsal	20	0	.00	15	0	.00
Metapodial (proximal)	8	0	.00	5	0	.00
Metapodial (distal)	8	0	.00	5	0	.00
Phalange	48	0	.00	24	0	.00

NOTE: $Z = 0.27$, $p > .05$.
[a]Number of elements recovered.

not observed. The marks found on the cranium and the pelvis are consistent with the consumption of the carcasses by scavengers.

Although access by these two agents does not seem to damage the carcasses significantly, we may ask to what degree the skeleton might be modified as to spatial distribution and with what frequency the different anatomical parts might be transported and/or accumulated by these agents. The presence of the majority of the bones, both in the puma kills and in the situations in which the carcasses were eaten by foxes, would seem to indicate that the carcasses are not substantially altered. Analysis of the differential survival of various anatomical elements (fig. 1) shows, however, that in carcasses consumed by the puma the survival frequency is high for all elements except ribs (58%), while the survival index for carcasses consumed by the fox shows an important reduction in frequency (except for the cranium) particularly for vertebrae (caudal), phalanges, and the distal ends of the metacarpals. This suggests that primary access by the puma affects the integrity of carcasses less than secondary access by the fox, with the modification by scavengers being due more to the transport of parts to their dens than to consumption at the site of encounter (Mondini 1995). With regard to the modifications produced by the fox, our observations are consistent with other research results (Mondini 1995) in that transport to dens of parts of the appendicular skeleton, primarily the ends of the feet (metapodials, phalanges) and caudal vertebrae, shows that the fox is capable of modifying to some extent an ungulate carcass the size of a young vicuña.

In summary, we can hypothesize that in the absence of factors of biological instability such as nutritional stress (that is, in reference to the predator/prey balance), carcasses will not be totally exploited and consequently damage and dispersion by these carnivores will be limited. This argument does not in itself guarantee that the limited exploitation of carcasses and the modifications implied are based entirely on the predator/prey balance, and it cannot, of course, be applied to the ecosystem of the past. However, factors linking the behavior of prey in times of environmental stress with the degree and extent of damage done to carcasses have already been identified in other ecosystems (Blumenschine, Cavallo, and Capaldo 1994; Borrero and Martín 1993; Domínguez Rodrigo 1994*a*, *b*), and I do not see any reason at the moment to exclude certain ethological principles, in the form of a hypothesis, from this ecosystem. In this connection, we know that to overcome the selective criteria

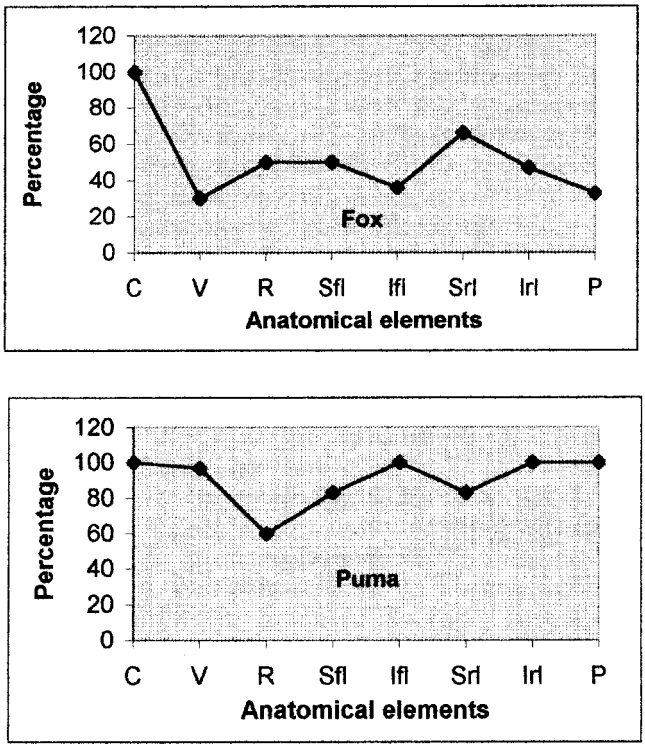

FIG. 1. *Percentage of survival for vicuña anatomical elements devoured by foxes and pumas.* C, *cranium;* V, *vertebrae;* R, *rib;* Sfl, *superior front leg* (*scapula, humerus, radio-ulna*); Ifl, *inferior front leg* (*carpal, metacarpal*); Srl, *superior rear leg* (*pelvis, femur, tibia*); Irl, *inferior rear leg* (*tarsal, metatarsal*); P, *phalange.*

of nutritional pressures predators can either defend their prey and devour it where it was obtained or leave it, which necessitates moving it to a safer place (Domínguez Rodrigo 1994*a*).

In contrast to what happens in other contexts of predation by felines (Domínguez Rodrigo 1998, Capaldo and Blumenschine 1994, Haynes 1982, Selvaggio 1994, Hill 1989), vicuña carcasses are not dismembered and dispersed in the process of consumption by the puma, while the fox, as a secondary agent, scatters the extremities as it feeds (Mondini 1995). In other depositional contexts, generally far from watercourses, the mummification of the tissues of carcasses by dehydration may hamper the disarticulation of certain segments of the appendicular skeleton by scavengers like the fox, and here the degree and extent of damage to the bones will be greater. As a matter of fact, 25% more punctures and furrows were found on the ends of the metapodials, distal femora, humeri, and ulna/radius fragments of mummified carcasses (Nasti 1998).

Although we cannot rule out the occurrence of bones or parts of carcasses in caves or rock shelters as a result of puma activity, the transport of parts of a carcass by pumas will be almost entirely confined to the feeding of the young (Hornocker 1970). In contrast, bone accumulations attributable to the fox are common (Mondini 1995).[2] Here the most frequent elements are the distal extremities of the metapodials of juveniles and adults (Mondini 1995). The difference in the representation of various anatomical elements is linked more to ease of transport than to availability.

The incidence of carnivore damage to camelid carcasses may be very important for evaluating situations of environmental stress, given that access time and degree of exploitation of carcasses are vital parts of the cycle of competition (Blumenschine, Cavallo, and Capaldo 1994; Nasti 1996, 1998). For both the puma as predator and the fox as scavenger, the lack of both intraspecific and interspecific competition would allow access for an unlimited time, accounting for the degree of damage and the relative integrity of the carcasses (Cavallo and Blumenschine 1989, Domínguez Rodrigo 1998). In this habitat, in which the number and variety of carnivores are limited, the pressure of competition is low and consequently the moving of carcasses is expected to be uncommon (Domínguez Rodrigo 1994*b*, Marean and Bertino 1994, Blumenschine, Cavallo, and Capaldo 1994, Nasti 1998, Scott 1985).

The strategy with regard to modification of carcasses will depend on the carnivore's position in the food chain; a carnivore at the highest point of the pyramid does not usually move its prey because it has no serious competitors. Whereas the wild dogs of the African savannah can defend their prey from competitors like the leopard because they are gregarious (Domínguez Rodrigo 1994*a*), the fox is neither physically nor socially strong enough to do so. It is true that only the systematic moving of remains can generate a significant accumulation of bones. Some canines, such as the coyote and the wolf, systematically carry bones back to their dens. In contrast to the fox, they are gregarious, and thus their social behaviour will in principle determine their strategies for consumption and transport (Bekoff 1978, Binford 1981).

This kind of information is important for interpreting the paleoecological conditions under which human societies developed. If we wish to identify and understand the behavioural context of bone accumulations we must consider the factors that condition the selection of different anatomical parts (Binford 1981). In principle and in terms of the behavior of these agents, we cannot rule out the possibility of finding bone accumulations in caves or shelters in the puna ecosystem, and given the results reported here and those of similar studies elsewhere it may be possible to attribute them to the activities of puma or fox on the basis of the elements represented and the size and character of the marks on them. Distinguishing the effects of various biological factors on the formation of bone accumulations is of prime importance, because in this region of extreme conditions it is bone accumulations that constitute much of the basis for our inferences about the environments and the societies of the past.

2. In this connection, overrepresentation of the appendicular skeleton, especially the distal extremities, at the expense of the axial skeleton due to the activities of the fox has been observed not only in camelids but also in ovicaprids.

References Cited

BEHRENSMEYER, A. 1983. "Patterns of natural bone distribution on recent land surfaces: Implications for archaeological site formation," in *Animals and archaeology*, vol. 1, *Hunters and their prey*. Edited by J. Clutton-Brock and C. Grigson, pp. 87–92. British Archaeological Reports International Series 163.

BEHRENSMEYER, A. K., AND D. DECHANT-BOAZ. 1980. "The recent bones of Amboseli National Park, Kenya, in relation to East African paleoecology," in *Fossils in the making*. Edited by A. K. Behrensmeyer and A. Hill, pp. 72–93. Chicago: University of Chicago Press.

BEKOFF, M. 1978. *Coyotes: Biology, behavior, and management*. New York: Academic Press.

BINFORD, L. 1981. *Bones: Ancient men and modern myths*. New York: Academic Press.

BLUMENSCHINE, R. J., A. CAVALLO, AND S. CAPALDO. 1994. Competition from carcasses and early hominid behavioral ecology: A case study and conceptual framework. *Journal of Human Evolution* 27:197–213.

BLUMENSCHINE, R. J., AND T. C. MADRIGAL. 1993. Long bone marrow yields of some African ungulates. *Journal of Archaeological Science* 20:555–87.

BLUMENSCHINE, R. J., AND C. MAREAN. 1993. "A carnivore's view of archaeological bone assemblages," in *From bones to behavior: Ethnoarchaeological and experimental contributions to the interpretation of faunal remains*. Edited by J. Hudson, pp. 273–300. Carbondale: Southern Illinois University.

BORRERO, L. A. 1990. Taphonomy of guanaco bones in Tierra del Fuego. *Quaternary Research* 34:361–71.

BORRERO, L. A., AND F. MARTÍN. 1993. "Tafonomía de carnívoros: Un enfoque regional," *Actas de la II Jornada de Arqueología de la Patagonia*. Edited by Gomez Otero, pp. 2–25. Puerto Madryn.

BRAIN, C. K. 1981. *The hunters or the hunted? An introduction to African cave taphonomy*. Chicago: University of Chicago Press.

CAPALDO, S. D., AND R. J. BLUMENSCHINE. 1994. A quantitative diagnosis of notches made by hammerstone percussion and carnivore gnawing on bovid long bones. *American Antiquity* 59:724–48.
CAVALLO, A., AND R. BLUMENSCHINE. 1989. Tree-stored leopard kills: Expanding the hominid scavenging niche. *Journal of Human Evolution* 18:393–99.
DOMÍNGUEZ RODRIGO, MANUEL. 1994*a*. Las razones adaptativas del comportamiento subsistencial de los animales carnivoros y sus estrategias iniciales de consumo de presas: Relevancia en el proceder tafonómico. *Quaderns de Prehistoria y Arqueología de Castelló*, no. 16, pp. 9–17.
———. 1994*b*. Dinámica trófica, estrategias de consumo y alteraciones óseas en la sabana africana: Resumen de un proyecto de investigación etoarqueológico (1991–1993). *Trabajos de Prehistoria* 51(1):15–37.
———. 1998. La formación de las acumulaciones óseas de macrofauna: Revisión de los criterios de discernimiento de los agentes biológicos no antrópicos desde un enfoque ecológico. *Zephyrus* no. 46, pp. 103–122.
El puma. 1984. *Fauna Argentina* 31.
FERNÁNDEZ, J. 1994. "Portrero del Caballo Muerto: Aspectos arqueológicos, cronológicos y paleoambientales del Precerámico tardio en el ecosistema hidrófilo de las vegas puneñas." *Actas del XI Congreso Nacional de Arqueología Argentina*, vol. 2, pp. 22–26. San Rafael, Mendoza, Argentina.
HAYNES, G. 1982. Utilization and skeletal disturbance of North American prey carcasses. *Arctic* 35:266–81.
———. 1988. Longitudinal studies of African elephant death and bone deposits. *Journal of Archaeological Science* 15:131–57.
HILL, A. 1979. Disarticulation and scattering of animal skeleton. *Paleobiology* 5:261–74.
———. 1989. "Bone modification by modern spotted hyenas," in *Bone modification*. Edited by R. Bonnichsen and M. Sorg, pp. 169–78. Orono: Center for the Study of the First Americans.
HILL, A., AND A. K. BEHRENSMEYER. 1984. Disarticulation patterns of some modern East African mammals. *Paleobiology* 10:366–76.
HORNOCKER, M. 1970. Winter territoriality in mountain lions. *Journal of Wildlife Management* 33:457–64.
LYMAN, R. 1994. *Vertebrate taphonomy*. New York: Academic Press.
MAREAN, C. 1991. Measuring the post-depositional destruction of bone in archaeological assemblages. *Journal of Archaeological Science* 18:677–94.
MAREAN, C., AND L. BERTINO. 1994. Intrasite spatial analysis of bone: Subtracting the effect of secondary carnivore consumers. *American Antiquity* 54:748–68.
MAREAN, C., AND L. SPENSER. 1991. Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity* 56:645–58.
MONDINI, M. 1995. Artiodactyl prey transport by foxes in puna rock shelters. CURRENT ANTHROPOLOGY 36:520–22.
NASTI, A. 1995. Observaciones tafonómicas sobre la desarticulación natural y supervivencia de partes anatómicas de vertebrados modernos en medioambientes puneños. *Palimsesto* 3: 12–27.
———. 1996. "Predadores carroñeros y huesos: La acción del puma y el zorro como agentes modificadores de esqueletos de ungulados en la puna meridional." *II Reunión de Tafonomía y Fosilización*. Edited by F. Heiva and M. F. Blasco Sancho, pp. 122–26. Zaragoza.
———. 1998. Tafonomía y etnoarqueología en la puna austral: Criterios integrativos sobre las modificaciones óseas y procesos de formación del regístro arqueológico. Ph.D. diss., Universidad de Buenos Aires, Buenos Aires, Argentina.
OLIVERA, D. 1991. "El Formativo de Antofagasta de la Sierra (Puna Meridional Argentina): Análisis de sus posibles relaciones con contextos arqueológicos agro-alfareros tempranos del noroeste argentino y norte de Chile." *Actas del XI Congreso Nacional de Arqueología Chilena*, pp. 34–51. Santiago: Sociedad Chilena de Arqueología.
———. 1992. Tecnología y estrategias de adaptación en el Formativo (Agro-Alfarero Temprano) de la puna meridional argentina, un caso de estudio: Antofagasta de la Sierra (Provincia de Catamarca, Argentina). Ph.D. diss., Universidad Nacional de La Plata, La Plata, Argentina.
OLIVERA, D., AND M. BARANDICA. 1996. "Procesos de formación del registro arqueológico en vegas de altura de la Puna de Atacama: Aportaciones tafonómicas y geomorfológicas." *II Reunión de Tafonomía y Fosilización*. Edited by F. Heiva and M. F. Blasco Sancho, pp. 271–79. Zaragoza.
OLIVERA, D., AND D. ELKIN. 1996. De cazadores y pastores: El proceso de domesticación de camélidos en la puna meridional argentina. *Zooarqueología de Camélidos*, no. 2, pp. 95–125.
OLIVERA, D., AND A. NASTI. 1991. Introducción al Simposio de Estudios Actualísticos en Arqueología: Tafonomía, etnoarqueología y arqueología experimental. *Shincal* 3(1):28–32.
PALMQVIST, P., B. MARTÍNEZ-NAVARRO, AND A. ARRIBAS. 1996. Prey selection by terrestrial carnivores in a Lower Pleistocene paleocommunity. *Paleobiology* 22:514–34.
SCOTT, J. 1985. *The leopard's tale*. London: Elm Tree Books.
SELVAGGIO, M. 1994. Carnivore tooth marks and stone tool butchery narks on scavenged bones: Archaeological implications. *Journal of Human Evolution* 27:215–28.
TAPPEN, N. 1995. Savanna ecology and natural bone deposition. CURRENT ANTHROPOLOGY 36:223–60.
VRBA, E. 1980. "The significance of bovid remains as indicators of environmental and predation patterns," in *Fossils in the making*. Edited by A. Behrensmeyer and A. Hill, pp. 247–72. Chicago: University of Chicago Press.
WALKER, A. 1980. "Functional anatomy and taphonomy," in *Fossils in the making*. Edited by A. Behrensmeyer and A. Hill, pp. 182–97. Chicago: University of Chicago Press.
WHEELER, J. 1982. Aging llamas and alpacas by their teeth. *Llama Word* 1(2):12–17.
YACOBACCIO, H. 1991. Sistemas de asentamiento de los cazadores-recolectores tempranos de los Andes Centro-Sur. Ph.D. diss., Universidad de Buenos Aires, Buenos Aires, Argentina.
YEPES, C. 1938. Capacidad defensiva de la fauna. *Revista Argentina de Zoogeografía* 2(2):15–32.

The Postclassic Mesoamerican World System[1]

MICHAEL E. SMITH AND FRANCES F. BERDAN
Department of Anthropology, University at Albany, SUNY, Albany, N.Y. 12222, U.S.A. (*Mesmith@csc.albany.edu*)/*Department of Anthropology, California State University, San Bernardino, Calif. 97415, U.S.A.* (*fberdan@wiley.csusb.edu*). 18 v 99

In April 1999, 12 scholars met by invitation at Michigan State University for a weeklong research conference on Postclassic Mesoamerica. The purpose of the conference was to bring together current data on Postclassic Mesoamerica and to construct a new synthesis of the economic, political, and cultural dynamics of the time period. The past two decades have seen an explosion of research on Postclassic societies, and a number of scholars had felt that it was time for a comprehensive and

interdisciplinary synthesis of new data and ideas. The participants, representing the approaches of archaeology, ethnohistory, art history, and epigraphy, were Frances Berdan, Elizabeth Boone, Geoffrey Braswell, Janine Gasco, Nikolai Grube, Dorothy Hosler, Susan Kepecs, Philip Kohl, Marilyn Masson, John Pohl, Helen Pollard, and Michael Smith. This group includes specialists in many regions of Postclassic Mesoamerica, from western Mexico to Yucatan and the southwestern Maya highlands. Papers were circulated in advance, and discussion focused on key issues and themes. The conference was funded by the Wenner-Gren Foundation for Anthropological Research, with additional support from the University at Albany, SUNY, and California State University, San Bernardino.

Mesoamerican societies of the Postclassic period stood out from earlier societies in a number of ways, and participants' first task was to identify the major changes that produced the Postclassic social, political, economic, and ideological patterns. Compared with earlier time periods, Postclassic Mesoamerican societies were characterized by larger regional populations, smaller polities, a higher volume of long-distance exchange, a greater diversity of trade goods, a more highly commercialized economy, new standardized forms of pictorial writing and iconography, and new patterns of macroregional stylistic interaction. Participants agreed that these developments came about in two broad cycles of change. The first was a series of transitions from the major Classic-period civilizations to new Epiclassic/Early Postclassic patterns. These transitions, often labeled "collapses," occurred at varying times and rates in different areas. The second cycle of change was notable for its occurrence at roughly the same time throughout Mesoamerica—the 12th century—and for the similarity of economic and cultural changes across much of Mesoamerica. In areas with refined Postclassic chronologies, this transition occurred between the Early and Middle Postclassic periods; in areas with rougher chronologies, the transition marked the change from the Early to the Late Postclassic periods. Discussion at the conference focused more on the second of these cycles of change and on the resulting dynamics of the Middle-to-Late Postclassic period. The Epiclassic and Early Postclassic periods are far less well known and require a separate effort at analysis and synthesis. In the remainder of this report, the term "Postclassic" is used for convenience to refer to the post-12th-century, Middle-to-Late Postclassic time period.

WORLD-SYSTEMS THEORY AND POSTCLASSIC MESOAMERICA

One of the goals of the conference was to evaluate the usefulness of world-systems theory for understanding Postclassic Mesoamerica. Participants agreed that none of the published versions of archaeological world-systems theory (e.g., Algaze 1993, Peregrine 1996) provides an adequate model for the social and cultural dynamics under discussion. Wallerstein's original model of the modern capitalist world system is generally viewed by archaeologists as too restricted and of limited relevance to ancient societies. Participants agreed that many later adaptations of the world-systems approach, such as that of Chase-Dunn and Hall (1997), relax the model beyond usefulness by identifying world systems among all types of societies, including hunter-gatherers. Many considered the most relevant example of world-systems analysis to be Abu-Lughod's (1989) historical analysis, applying a generalized world-systems approach to empirical data.

In spite of their dissatisfaction with existing world-systems models, participants found concepts from the world-systems literature crucial for understanding Post classic Mesoamerica. All were comfortable in labeling Postclassic Mesoamerica a world system, defined as a widespread system of interaction that cuts across political boundaries. The basic division of labor in Mesoamerica extended far beyond the borders of any single state or empire, and actions and processes in one area affected societies in distant areas. Chase-Dunn and Hall's view of world systems as composed of four spatially distinct interaction networks (bulk-goods, political-military, prestige-goods, and information) was considered particularly useful. One benefit of this approach is that it encourages consideration of stylistic and cultural factors in addition to the economic phenomena that typically dominate discussion of world systems.

Most participants agreed that the spatial extent of the Postclassic world system, as defined by exchanges of goods and information, corresponds to the traditional culture area of Mesoamerica as defined long ago by Paul Kirchhoff and others in terms of a list of traits. Postclassic Mesoamerican societies interacted with peoples to the north and south, obtaining turquoise from the American Southwest and bronze technology and perhaps other items from South America and lower Central America. Although this might suggest that the relevant world system included these distant areas, the intensity of economic and stylistic interaction was far higher within Mesoamerica than between Mesoamerican societies and other groups, leading participants to agree that Mesoamerica is indeed a useful scale of analysis during the Postclassic period.

Following the lead of Abu-Lughod (1989), participants identified several geographical subsystems or interaction zones within the Postclassic world system within which exchanges were particularly intensive. These subsystems include western Mexico (Michoacan and Jalisco), the Aztec empire, the Maya realm, and a southern Pacific coastal zone. Participants were dissatisfied with the concepts of core and periphery for Postclassic Mesoamerica. Within empires (e.g., the Aztec and Tarascan cases), cores dominated peripheries both politically and economically, but the terms "core" and "periphery" do not advance our understanding beyond normal considerations of capitals extracting tribute from provinces. Apart from empires, however, the concepts of core and periphery have less meaning for ancient societies. In current archaeological world-systems theory (e.g., Peregrine 1996), ancient world systems exhibited "core-periphery differ-

entiation" (in which cores and peripheries have different levels of political and economic activity) but not "core-periphery hierarchy" (in which cores dominate peripheries economically as in the modern capitalist world system). If cores did not dominate peripheries in ancient systems, then perhaps these concepts are unnecessary. Participants in the conference noted that some areas did have higher levels of political and economic activity than others and agreed that these could be termed "core zones" for lack of another term. A working definition of such zones focused on areas of high population where economic, political, and ideological power were highly concentrated, leading to a high level of economic and intellectual production.

The list of core zones included the areas around Chichen Itza, El Tajin, Cholula, and Tula in the Early Postclassic period, Mayapan and Cholula/Tlaxcala in the Middle Postclassic, and the Basin of Mexico, Central Michoacan, and Cholula/Tlaxcala in the Late Postclassic. Although other areas were differentiated from these zones, participants felt that "periphery" was not an appropriate term for them, since nearly all areas of Mesoamerica were involved in intensive production activities and long-distance exchange networks and these did not necessarily focus on core zones. Thus their view of the Mesoamerican world system had cores but not peripheries. Although some world-systems theorists may find this formulation objectionable, participants were more interested in producing a better understanding of the Mesoamerican data than in achieving theoretical purity.

Some areas were more heavily involved in production for exchange than others, however. The term "affluent production zone" was suggested for areas with dense populations whose economic activities were intimately tied in to international exchange networks. For example, in Middle Postclassic central Mexico, Morelos and the Basin of Mexico were affluent production zones and the Cholula/Tlaxcala area was a core zone. In the Late Postclassic period, the Cholula/Tlaxcala area remained a core zone, the Basin of Mexico became one, and Morelos remained an affluent production zone. One new development in Postclassic Mesoamerica was an expansion of these affluent production zones far beyond their extent in earlier periods. A number of "resource extraction zones," where important raw materials such as obsidian, metal, and salt were obtained, were also identified.

POLITICAL AND ECONOMIC NETWORKS

One of the characteristic patterns of Postclassic Mesoamerica was the prevalence of city-states or small polities. In most areas, the regional systems of small interacting polities documented in the 16th-century ethnohistorical record had their beginnings in the 12th century. Exceptions to this pattern were the powerful Middle Postclassic Mayapan state in Yucatan (where the transition to small polities occurred later) and the Late Postclassic Tarascan empire of central Michoacan. Although the territorially extensive Aztec empire receives much discussion in the literature, it can be viewed as a weak imperial veneer over a foundation of city-states in both its core region (the Basin of Mexico) and its provinces. The Tarascan empire of western Mexico employed more direct strategies of control than the Aztec empire, and its processes of political centralization showed a trend opposite to that in many areas.

The small size of the polities of Postclassic Mesoamerica was conducive to the expansion of commercial exchange. The archaeological record reveals larger quantities of imported goods in Postclassic contexts, and ethnohistoric accounts describe marketplaces, professional merchants, and the use of money throughout Mesoamerica at the time of Spanish conquest. The Polanyi/Chapman concept of "port of trade" for long-distance commerce (Chapman 1957) was examined and found inadequate. Instead the Late Postclassic had a number of international trade centers. Whereas traditional "ports of trade" were described as occurring between hostile polities, most international trade centers were located either near the boundaries of the major exchange subsystems or between them, particularly in coastal settings along the Gulf and Pacific coasts.

Much discussion at the conference focused on key commodities in the Postclassic world system. These were goods whose production and exchange had major impacts within city-states. Prestige goods such as feathers and exotic jewelry of greenstone, turquoise, rock crystal, and metal were widely traded and had important economic and social roles. Archaeological and ethnohistoric evidence does not suggest that the production, exchange, and consumption of prestige goods were controlled by or limited to elites in the Postclassic period, as in the "prestige-goods economy" model. The high level of commercialization in the Postclassic economy, particularly the prevalence of marketplace exchange, rules out this model. Excavation data from several areas show that both elites and commoners had access to imported prestige goods, probably because of the operation of regional marketing systems.

Bulk luxuries such as salt, cacao, and textiles played particularly important roles in the Postclassic economy. The production of obsidian reached new heights in the Postclassic period, with shaft mines used at a number of extraction zones. The volume of obsidian in circulation increased greatly. New research on copper-bronze metallurgy helps document technological and exchange processes and shows the importance of Michoacan and Jalisco within the overall world system.

INFORMATION NETWORKS

Stylistic and iconographic evidence of information exchange between regions was a major topic of discussion, and new understandings were reached with regard to the "Mixteca-Puebla" phenomenon that has confused Mesoamericanists for decades. Participants identified a broad class of widely distributed international styles. The term "Mixteca-Puebla style" was considered best used to denote the distinctive polychrome painting style

of the Mixteca-Puebla region proper in the Middle and Late Postclassic periods. This style includes the Mixtec and Borgia-group codices, Mixtec and Puebla-Tlaxcala polychrome ceramics, and murals at Mitla, Tizatlan, and other sites in the Puebla-Tlaxcala area. Objects and manuscripts painted in the Mixteca-Puebla style helped cement interpolity alliances and confederations among "peer-polity" city-states in the Mixteca-Puebla region, where there was an intimate relationship between public ritual and political process.

Another international style is the related but distinct Aztec style, found primarily in Nahua historical and ritual codices, murals at Malinalco and other sites, and imperial Mexica sculpture. This Late Postclassic style spread by emulation throughout much of the Aztec empire in the form of manuscripts used by diverse local elites to track their dynastic histories. Aztec-style histories did not penetrate the Mixteca-Puebla region (part of which was conquered by the empire), probably because the Mixtec had their own ancient historical codices. A third related but poorly understood international style is present in fragmentary murals at the southwestern (highland) Maya cities of Utatlan and Iximche.

Polychrome murals at Tulum, Santa Rita, and several other Maya sites had been previously characterized by Donald Robertson and others as sharing a "Postclassic International Style" with murals in the Mixteca-Puebla region, but participants considered this assessment incorrect. The Maya murals in question were painted in a local Maya style that incorporated a small number of standardized international religious symbols probably derived from the Mixteca-Puebla and/or Aztec styles. The label "Postclassic International Symbol Set" was proposed for these elements. Although their meaning is difficult to reconstruct, they do provide clear evidence for artistic interaction between Yucatan and highland Mexico that probably accompanied commercial exchange. There are numerous examples of central Mexican (Mixteca-Puebla and Aztec) styles and traits in southern Mesoamerica during Postclassic times but few Maya traits in central Mexico. This pattern contrasts with that of earlier periods, when styles and traits spread more evenly in both directions. The conference did not produce a clear explanation of this pattern, but participants agreed that Postclassic styles and symbols were distributed through a vast information network that carried no connotations of political or economic domination. Although more research is needed, the world-systems approach was considered to provide a more satisfactory framework for understanding these patterns than recourse to migrations, conquests, and vague processes of "influence" radiating out of central Mexico.

CONCLUSIONS

Participants agreed that they had made significant progress in advancing knowledge and understanding of the economic and social dynamics of Postclassic Mesoamerica. Bringing together scholars employing a diversity of approaches (archaeology, ethnohistory, art history, and epigraphy) contributed greatly to the comprehensive and integrative character of the discussions. Work has begun on an edited volume to be titled *The Postclassic Mesoamerican World*. Rather than simply publish revisions of the original papers, it was decided to construct a volume from scratch to address the important data and issues identified at the conference. This book will have chapters by various combinations of the 12 participants, grouped into six sections: An Ancient World System, Polities, Economic Networks, Information Networks, Regional Case Studies, and World-System Integration. In Peregrine's (1996) terms, the book will adopt a "world-system perspective" without embracing any single "world-systems theory."

A number of topics were identified as needing research in the future, including analysis of variation in exchange and production between and within regions, the relationship between population size and economic activity, the variable nature of borders and borderlands, more precise identification of commercial networks through archaeometric sourcing of artifacts, and a more comprehensive analysis of the distribution and significance of Postclassic styles and iconography. The refinement of archaeological chronologies is particularly important for the documentation of changes through time and the reconstruction of relationships among regions. It is difficult to examine Postclassic processes in areas like the Valley of Oaxaca, where a single 600-year archaeological phase covers the entire Postclassic epoch. Many of these topics can be approached through problem-oriented archaeological fieldwork that addresses the impact of macroregional processes on local conditions at the household, community, and regional levels. This kind of fieldwork is currently being done in several parts of Mesoamerica by the participants and others, and our understanding of Postclassic economic and social dynamics will only continue to improve in the years to come.

References Cited

ABU-LUGHOD, J. L. 1989. *Before European hegemony: The world system, A.D. 1250– 1350*. New York: Oxford University Press.

ALGAZE, G. 1993. *The Uruk world system: The dynamics of expansion of early Mesopotamian civilization*. Chicago: University of Chicago Press.

CHAPMAN, A. C. 1957. "Port of trade enclaves in the Aztec and Maya civilizations," in *Trade and market in the early empires*. Edited by K. Polanyi, C. M. Arensberg, and H. W. Pearson, pp. 114–53. Chicago: Henry Regnery.

CHASE-DUNN, C., AND T. D. HALL. 1997. *Rise and demise: Comparing world-systems*. Boulder: Westview Press.

PEREGRINE, P. N. 1996. "Introduction: World-systems theory and archaeology," in *Pre-Columbian world systems*. Edited by P. N. Peregrine and G. M. Feinman, pp. 1–10. Madison, Wis.: Prehistory Press.

Internal Working Models, Trust, and Sharing among Foragers[1]

BARRY S. HEWLETT, MICHAEL E. LAMB, BIRGIT LEYENDECKER, AND AXEL SCHÖLMERICH
Department of Anthropology, Washington State University, Vancouver, Wash. 98686, U.S.A. (hewlett@vancouver.wsu.edu)/Section on Social and Emotional Development, National Institute of Child Health and Human Development, Washington, D.C., U.S.A./Martin-Luther University of Halle, Germany/ Ruhr University of Bochum, Germany. 17 V 99

Examining forager economic and social behavior, Bird-David has hypothesized (1990:194) that "gatherer-hunters share the characteristic that their members' views of the environment are centered around metaphors that commonly draw on primary kin relations, though not necessarily just on the 'parent' relation. These metaphors entail a common view of the environment as giving, though in varied ways." She has suggested that many aspects of forager economic behavior—demand sharing (Barnard and Woodburn 1988), lack of food storage, and minimal time spent in subsistence activity—are linked to culture-specific metaphors (cognitive models) that contribute to a trusting, giving, and generous view of the environment. Among some forager groups (Nayaka, Mbuti, and Batek in her study) the parent-child relationship is the primary metaphor ("forest as parent")—people view the environment as an ever-providing, loving, and unconditionally supportive parent—whereas in other forager groups the metaphors are linked to sexual relatedness (Canadian Cree) or procreational relatedness (Australian Aborigines) (Bird-David 1993). Although there is diversity in the metaphors cultures utilize to integrate views of the natural and social environments, Bird-David indicates that there are metametaphors common to most if not all foragers that convey "giving" or trusting views of the environment, and this view of foragers is widely accepted by those who study foragers. Thus, for example, Richard Lee (1998) listed "the giving environment" as one of the distinguishing features of foragers in his keynote address at the recent International Conference on Hunting and Gathering Societies in Osaka.

Bird-David's analysis is important because it identifies and gives priority to cultural models of how foragers themselves view their environment and because it offers a viable supplement to ecological explanations of forager subsistence. We agree with many of her observations and characterizations of foragers and believe that an understanding of foragers' schemas may provide insights into their economic and social relations. Unfortunately, her approach (like that of Ingold [1990] and Woodburn [1982]) does not identify the mechanisms by which local (i.e., culture-specific) or pan-forager metaphors, schemes, or cognitive models develop. What is the process of intergenerational cultural transmission? How do foragers in diverse physical and social contexts acquire pan-forager schemas? This paper identifies a mechanism that partially explains how and why foragers might become trustful of others and of the natural environment—the internal working model.

The internal working model is a dynamic, affectively charged model based upon an infant's experiences with caregivers (Verschueren, Marcoen, and Schoefs 1996). Bowlby developed the concept as part of his theory of infant-caregiver attachment (1969, 1973). He was interested in explaining the intense distress, anxiety, and despair infants exhibited when separated from their primary caregivers. He hypothesized that the infants' fussing, crying, crawling, or reaching functioned to maintain proximity to caregivers and that this strategy was designed by natural selection to promote the safety and survival of infants. Research in several cultures supports the universality of the attachment system, as infants in all cultures demonstrate attachment behaviors towards specific others by late infancy (Main 1990). Babysitters and parents usually learn that very young infants can be transferred to several individuals without the infant's fussing or crying much, but by eight months the infant will cry for particular others and often does not want to be held by strangers (e.g., a new babysitter).

As their memories and information-processing capacities mature and there are repeated infant-caregiver interactions, infants develop schemas—cognitive knowledge structures or internal working models. Infants with primary caregivers who are warm, attentive, take their perspective, perceive their signals and interpret them correctly, and react promptly and contingently develop "secure" and trusting internal working models of others and self (Lamb 1981, Lamb et al. 1984). Infants whose primary caregivers misread and either do not or inconsistently respond to their cues develop "insecure" and mistrustful internal working models of others and self. Infants with a secure sense of self and others are more likely to explore their environments and become more autonomous. Insecure infants develop feelings of anxiety, fear, or grief and tend to have low expectations about self-with-others (Main 1990); their fear and distrust can lead to assertiveness, aggression, and violence.

Internal working models emerge in infancy, but several recent longitudinal studies and meta-analyses indicate that they are relatively stable from the early years through adolescence and adulthood (e.g., Fraley 1998, Waters et al. 1995). They help individuals predict and

 We are grateful to the Aka, Ngandu, and Euro-American families for so graciously allowing impersonal behavioral observations by strange anthropologists and psychologists and to Patricia Evans, Hope Hallock, Nan Hannon, Nancy Kimmerly, Christina Larson, Laura Scaramella, and Donald Shannon for assistance in data collection and analysis. We acknowledge and thank the government of the Central African Republic for authorizing the research. We also thank James Woodburn and Nurit Bird-David for their comments on earlier drafts. The National Institute of Child Health and Human Development and the Swan Fund supported the research.

interpret others' behavior and plan their own courses of action. They provide the basis for understanding and reading the intentions of others. They are rather conservative in that children who have been consistently rebuffed by their primary caregivers are not likely to seek or accept comfort if a temporary caregiver is more sensitive. However, they are not fixed. Threatening or distressing events (e.g., early death of family members, unexpected divorce, life-threatening illness, regular but unpredictable natural disasters) can alter them. It is important to view internal working models from a life-course perspective because particular cultural institutions and ecologies, such as formal education (which ranks children on a near-daily basis), immediate and strict patrilocal residence (i.e., visits to wife's family limited), or living in ecologies with regular but unpredictable disasters (e.g., typhoons, earthquakes) can contribute to an insecure sense of self, others, and the environment even when early experiences foster security. It is also important to remember that the organization of an individual's attachment behaviors is based not only upon internal working models but also upon such factors as the availability of attachment figures (whether a parent or a spouse), the duration of the attachment relationships, and the frequency with which separations occur (Fraley 1998).

Several components of the theory of internal working models are useful additions to anthropological approaches that emphasize mental representations:

1. Internal working models develop in a context of multisensory communication. The tone, sensitivity, and appropriateness of caregiver-infant vocalizations, eye and body movements, sounds, and smells all contribute to the development of a model. These models develop in a prelinguistic context. By contrast, most cognitive approaches emphasize verbal and linguistic communication.

2. Internal working models are affectively charged in that they pattern how an individual feels about others and self. They are basic emotional/visceral reactions and do not require conscious mediation for their acquisition or use. By contrast, existing symbolic approaches seldom discuss emotional dimensions of culture and cognition.

3. Internal working models emphasize what individuals actually experience rather than semantic information or knowledge (i.e., episodic versus semantic schemas [D'Andrade 1996]).

4. Internal working models are dynamic and generalized. They are modified during the life course and aid the individual in perceiving and interpreting events.

5. Internal working models contribute to the conservation and persistence of culture over space and time because they are emotionally based representations of self and others (Freedman and Gorman 1993).

6. The development of internal working models involves biologically and agent-based processes that are an integral part of human nature. Infants actively try to negotiate and manipulate their caregiving environments in order to enhance their own survival and fitness. By contrast, most cognitive approaches in anthropology seldom mention biology and assume that the children are relatively passive recipients of culture.

The concept of internal working models is powerful and useful because it links experience, emotions, cognition, and biology. It is an integrated and holistic approach to understanding a key mechanism that shapes and transmits culture.

Cultural and critical anthropologists will, however, be quick to point out that the terms "secure" and "insecure" are culturally biased constructions. Securely attached children are said to be well-adjusted while insecurely attached children are seen as deviant or problematic, even though recent research (Lamb et al. 1984, Main 1990, Chisholm 1996, Belsky 1997) suggests that children classified as insecure are responding to their social and caregiving environments in ways that enhance their survival and fitness. Caregivers who do not respond empathetically to their infants may be experiencing social (e.g., divorce, death, serious illness, moving to unfamiliar environment) or economic stress or may have other reproductive priorities. Main (1990) indicates that "aloof and detached" children (often called "avoidant/insecure" by attachment theorists) are trying to avoid provoking their parents or withdrawing in order to begin establishing a high degree of self-sufficiency, while "clingy and dependent" children (called "resistant/insecure") are trying to elicit care and attention from rejecting and insensitive parents. An interactional style that lacks much empathy or sensitivity might also prepare a child to mistrust others in a volatile environment.

METHODS

Attachment theory indicates that early experiences contribute to the development of a child's internal working model of others and self (Lamb et al. 1984). As does Bird-David, we suggest that foragers are, in general, more likely than peoples with other modes of production to develop trusting and confident views of others, the self, and the environment. In order to determine whether foragers might have distinctive internal working models, we examined the daily experiences of three-to-four-month-old infants in three cultures with contrasting modes of production: Aka foragers and Ngandu farmers from central Africa and upper-middle-class urban Euro-Americans from the Washington, D.C., area. More extensive but less precise cross-cultural ethnographic data were utilized to examine the potential for a pan-forager pattern.

We focused on three-to-four-month-olds because this is when the various neural components of specific states (e.g., distress, sleep) become intercoordinated as infants clearly begin to recognize and behave differently towards specific individuals sometime after the second month of life (Ainsworth 1973). Our analyses emphasize three types of caregiver-infant interaction—holding/touching, feeding, and fussing/crying. These experiences provide clues regarding caregivers' predictability, reliability, and sensitivity to their infants.

Twenty Aka, 21 Ngandu, and 21 Euro-American fam-

ilies with three-to-four-month-old infants participated in the study. Families were observed for 3 hours on each of four different days in and around their homes for a total of 12 hours per family. Observations were infant-focused. Families were asked to pursue their everyday activities while ignoring the presence of the observer. Aka and Ngandu were observed from 6 A.M. to 6 P.M. every day of the week, whereas the Euro-Americans were observed from 8 A.M. to 8 P.M. on weekdays. Evening observations were conducted with the Euro-Americans so that fathers would be available at least part of the observation time. Some Euro-American fathers are staying home part of the day to help out or spend time with their infants.

Observers noted on a checklist the occurrence of 25 caregiver or infant behaviors as well as the location, position of infant, and presence of others (see Hewlett et al. 1998 for methodological details). The observer watched for 20 seconds and recorded for 10 seconds for a 45-minute period, then took a 15-minute break before starting the next 45 minutes of observation. Qualitative methods such as participant observation, informal interviews, and key-informant interviews were also employed to place the quantitative behavioral data in cultural context. (Structured interviews with parents will be reported elsewhere.)

A few distinguishing features of the three cultures may be briefly mentioned: Aka live in camps of 25–35 related people and move camp several times a year for various reasons (e.g., better hunting, a death in camp). Aka rely primarily upon cooperative net hunts that involve men, women, and children. Aka houses, dome-shaped, are built by women and have just enough room for a 4-foot-long log bed and a fire. Houses are very close to each other (1–2 feet), so all camp members live in an area about the size of a large living and dining room in the United States (see Hewlett 1991). The frequency and scope of sharing are greatest among the Aka, who share food and material items with many individuals in different households on a daily basis. Egalitarianism is emphasized at the individual level; although there is a clear sexual division of labor, men and women of all ages are respected for their abilities and contributions.

Ngandu women are the primary providers for their families. Ngandu men clear and burn the plantations, while women plant, weed, harvest, and prepare all subsistence food items (manioc, corn, peanuts, plantains). Ngandu live in sedentary communities of about 100–400 people alongside roads. Ngandu men built the mud-and-thatch houses, which are about 40 feet by 20 feet and have one to three rooms. Polygyny is common among the Ngandu (one-third of men have more than one wife), and each wife has her own room or house. Houses are about 40 feet from each other, but there are no walls or fences between them. The Ngandu focus on maintaining egalitarianism and sharing between households; households that accumulate more than others and do not share with neighboring family members are prime targets of sorcery, which is believed to cause illness and even death. Sharing between households is not frequent (i.e., not daily), however, and there is marked inequality within Ngandu households—men and older individuals receive more deference, respect, and resources than others. Men and women participate in very few activities together, and men eat separately and receive bigger portions of meat. Ngandu often note the extensive nature of Aka sharing and intergenerational equality. One Ngandu man noted that you can give an Aka man a cigarette and he will share it with everyone in camp, including children. Ngandu also note that Aka children call their parents by their first names, which from an Ngandu vantage point demonstrates disrespect.

Although Aka are primarily foragers and Ngandu farmers, all Aka today farm at least part of the year, and most Ngandu, men in particular, spend part of the year in the forest hunting or gathering forest products. Aka fields are deep in the forest, and Ngandu-style houses are built near them.

The Euro-Americans in the study lived in apartments, townhouses, or single-family homes in the more affluent suburbs of Washington, D.C. Both men and women worked outside of the home. All of the fathers were employed full-time, while none of the mothers was working outside of the home during the observation period. All but one of the mothers had been employed full-time before their infants' birth but had taken leave from their jobs to care for them. Most had returned to work by the time the infants reached 12 months of age. Mean family income was over $80,000 per year in 1991. The Euro-Americans had many of the features of so-called yuppies—well-educated middle-to-upper-middle-class families with one infant. By comparison with Aka and Ngandu, they were the least likely to share (i.e., in scope and frequency), and accumulation by individuals and households is encouraged and highly valued. Gender egalitarianism was somewhere between that of Aka and that of Ngandu. Euro-American husbands and wives ate, slept, and performed many activities together, as do the Aka, but there was more violence directed against spouses and children among them. For instance, Hewlett has worked with Aka for over 25 years and has yet to see a husband hit a wife. Hitting a child is also rare and is cause for divorce.

RESULTS

Holding, feeding, and fussing/crying experiences of Aka, Ngandu, and Euro-American three-to-four-month-olds were examined in detail. Konner's (1976, 1977) data on !Kung infants were included where possible because these are probably the best-known forager infants in anthropology, but Konner's data collection methods were different from those utilized in this study and therefore the !Kung data were not included in the statistical analyses.

Holding/touching. Figure 1 portrays the proportion of time the infants were held/touched during daylight hours and over a 24-hour period. The 24-hour data are estimates and assume that the Aka, Ngandu, and !Kung infants slept next to caregivers during evening hours while the Euro-American infants slept in cribs. The

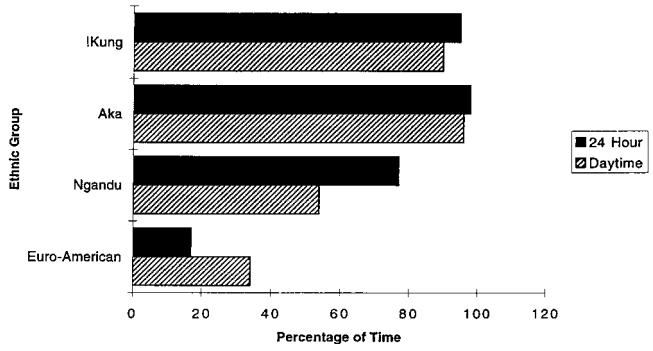

FIG. 1. *Mean percentage of time infants in four cultures are held/touched during daylight hours and over a 24-hour period.*

!Kung holding data are based upon spot observations of infants in the camp throughout the day.

Aka and !Kung forager holding/touching were remarkably similar, whereas highly significant differences existed among the three study groups (analysis of variance $F = 109.0$, 2 d.f., $p = .000$). The differences between Aka and the other two groups occurred, in part, because the others put their infants down when they fell asleep whereas the foragers continued to hold/touch their infants while they slept. Ngandu held their infants 44% of the time when they slept and 60% of the time while they were awake, while Aka held their infants 94% of the time while they slept and 98% of the time while they were awake. The Euro-American infants were held 22% of the time while sleeping and 44% of the time while they were awake. The asleep-versus-awake holding differences are highly significant for the Ngandu and Euro-Americans ($p < .001$ in both cases) but not for the Aka.

Researchers have previously described dramatic differences in the amount of holding/touching between foraging and urban industrial societies (e.g., Konner 1976), but this is the first study to suggest significant differences between foragers and farmers. Observers of farmer-infant interactions have emphasized frequent bodily contact, but a careful reading of these studies indicates that infants were less likely to be held while they were asleep during the day. Kipsigis caregivers held/touched their five-month-old infants 80% of the time the infants were awake but only 30% of the time while they were asleep (Super and Harkness 1982). LeVine et al's. classic study of the Gusii also draws attention to the regular proximate caregiving but states that at three months "the baby sleeps a great deal and is put down on a mat" (1994:157).

Feeding. Table 1 summarizes the frequency and duration of infant feeding. There were no statistical differences among the three groups in the percentage of intervals in which infant feeding occurred, but there were significant differences between Aka and Ngandu ($t = -4.90$, 33.01 d.f., $p < .001$ [two-tailed] and Aka and Euro-Americans ($t = 2.31$, 37.39 d.f., $p < .05$ [two-tailed]) in the frequency of feeding/nursing bouts. Aka caregivers fed their infants about twice as frequently as did Ngandu or Euro-American caregivers. Aka and !Kung foragers, however, were remarkably similar in the frequency of feeding bouts—about four times an hour. It is important to note, however, that the Aka, Ngandu, and Euro-American data are limited to 3–4-month-olds in several contexts while the !Kung data encompass 3–40-month-olds in camp settings only. The observational methods employed with the !Kung were similar to ours in that feeding was coded every 30 seconds and bouts were defined as sequences of intervals separated by at least one interval.

TABLE 1
The Feeding of Three-Month-Old Infants among Aka Foragers, Ngandu Farmers, and Euro-Americans

	Aka	Ngandu	Euro-Americans
Number of infants	20	21	21
Percentage of daylight hours spent feeding	15.2	12.6	12.5
Mean number of feeding bouts per hour	4.0	2.2	1.6
Mean number of minutes spent feeding per hour	9.1	7.7	7.5
Mean number of minutes per feeding bout	2.4	3.4	4.7
Percentage of infants receiving nonmaternal breast-feeding	55.0 (11/20)	9.5 (2/21)	0.0 (0/21)
Mean percentage of intervals in which infants received nonmaternal breast-feeding (with range)	8.4 (0–49)	1.6 (0–27)	0.0
Percentage of infants receiving nonmaternal feeding (including breast-feeding)	75.0 (15/20)	19.0 (4/21)	33.3 (7/21)
Mean percentage of intervals in which infants received nonmaternal feeding (with range)	8.6 (0–49)	4.4 (0–44)	0.3 (0–4)
Percentage of infants receiving water or (for Euro-Americans) bottle as part of feeding	20.0 (4/20)	47.6 (10/21)	52.4 (11/21)
Percentage of infants receiving some solid foods	10.0 (2/20)	33.3 (7/21)	n.d.

NOTE: The 17 !Kung infants (3–40 months old) studied by Konner and Worthman (1980) were fed for 13% of daylight hours; mean number of feeding bouts per hour was 4.1, mean number of minutes spent feeding per hour 7.8, and mean number of minutes per feeding bout 1.9.

Ngandu and Euro-American feeding patterns were similar in that infants were fed about twice an hour. These feeding rates are similar to those of horticulturalists such as the Gainj of New Guinea, where young infants nurse about twice an hour for about 3.5 minutes per session (Wood et al. 1985). The Euro-Americans in this study were quite distinct from those in other studies because more mothers breast-fed and took time off from work to care for their infants. Barr et al. (1989) reported that Euro-American caregivers fed their infants 5 to 7 times in a 24-hour period with a median of 3-hour intervals, whereas the parents in this study fed their infants 14 times on average during 9 hours of observation. Most mothers had returned to work by the time the infants were six months old, so presumably there was a dramatic drop in feeding frequency over time. Both bottle- and breast-feeding were utilized by several families.

The Aka were distinct in the frequency with which women other than mothers breast-fed infants. This is the only study to use the same observational methods to compare forager and farmer nonmaternal breast-feeding, and the data indicated significant differences in the number of infants who experienced nonmaternal feeding ($\chi^2 = 9.8$, 1 d.f., $p < .005$) and the amount of time infants were fed nonmaternally ($t = 2.06$, 26.2 d.f., $p < .05$). Nonmaternal feeding is known in several societies (56 of the 65 cultures studied by Raphael [1973] "permitted" women other than mothers to breast-feed infants), but, as the data in this study suggest, it may be more pervasive in foraging societies. Two societies widely recognized in the anthropological literature for the high frequency of nonmaternal breast-feeding are both foraging communities—the Efe of the Ituri Forest (Tronick, Morelli, and Winn 1987) and the Andaman Islanders (Radcliffe-Brown 1964).

Fussing and crying. Table 2 summarizes the duration and frequency of fussing and crying in the three groups. Duration is represented by the percentage of 30-second units in which either fussing or crying were observed. Infants often do not cry/fuss during the complete 30-second interval, so the actual duration of fussing and crying is somewhat less than that reported. Ngandu infants fussed and cried significantly longer and more frequently than infants in the other two groups, Euro-American infants were intermediate in fussing but cried about the same percentage of time as Aka infants. They were similar to Ngandu infants in frequency of fussing. Aka infants cried or fussed the least (4.7% total, 3.38 times per hour) and Ngandu infants the most (13.24% total, 6.27 times per hour).

It is important to remember that the internal working model is influenced by the baby's conclusions about the probability that its distress signals will elicit predictable responses. If a caregiver never responds, then there is no information, and if the caregiver responds randomly whether or not the infant is crying, there is no predictable response. Most behaviors, of course, happen both when it is crying and when it is not, so the clarity of the response depends on how much more/less likely the behavior is to occur given fussing/crying.

TABLE 2
Mean Percentage of Time and Frequency of Fussing or Crying among Aka Foragers, Ngandu Farmers, and Euro-Americans

	Aka	Ngandu	Euro-Americans
Mean percentage of time fussing	3.06	9.45	6.33
Mean percentage of time crying	1.66	3.79	1.80
Mean frequency of fussing per hour	2.59	4.69	4.38
Mean frequency of crying per hour	0.89	1.58	1.02

Given the importance of predictable response, table 3 lists base rates (percentage of intervals in which the behavior occurs when infant is not fussing or crying), co-occurrence rates (percentage of intervals in which the behavior occurs when the infant is fussing or crying), and difference scores for eight possible caregiver responses (physical soothing, nonphysical soothing, feeding, holding, vocalizing, stimulating/arousing, caregiving, and no response). Two such scores are listed: (1) the difference between the base rate and the co-occurrence rate and (2) a proportional rate which is the log of the ratio between the co-occurrence and base rates. The scores show the magnitude of the difference between base rates and co-occurrence rates. The ratio of the nonbehavior rates with and without fussing/crying estimates the reliability with which caregivers responded to their babies. Overall, the responsiveness signal was much clearer for Aka infants than for infants in the other groups and least clear for the Ngandu.

Because the Aka infants were almost always held, fussing and crying had little effect on that behavior. By contrast, Euro-American infants were more likely to be held when either fussing or crying, while crying had minimal association with holding among the Ngandu. In all groups, caregivers were more likely to be observed soothing infants when the latter were crying or fussing, although this was proportionately less common among the Ngandu. Aka caregivers were more likely to soothe physically (e.g., by walking or rocking the infant) their fussing or crying infants than were caregivers in the other groups. Aka caregivers spent slightly more time feeding infants than did caregivers in the other groups and, in contrast to both, were more likely to feed them when they fussed than when they did not.

Stimulating/arousing was not common among the Aka and Ngandu; it was more common among the Euro-Americans, who tended to stimulate/arouse more as a means of distracting fussy infants. Like caregivers in the other groups, however, they seldom stimulated/aroused infants who were crying. They also vocalized much more than did Aka and Ngandu caregivers, although caregivers in all groups vocalized more when their infants fussed or cried. In most instances, however, this vocalizing co-

TABLE 3
Behaviors That Co-occur with Fussing and Crying in Three Cultures

	Aka				Ngandu				Euro-Americans			
Behavior	Base Rate[a]	Co-occurrence Rate[b]	Difference	Proportional Difference[c]	Base Rate[a]	Co-occurrence Rate[b]	Difference	Proportional Difference[c]	Base Rate[a]	Co-occurrence Rate[b]	Difference	Proportional Difference[c]
Fussing												
Physical soothing	2.2	41.2	39.0	1.27	1.7	28.1	26.4	1.22	1.0	20.3	19.3	1.31
Nonphysical soothing	1.5	26.0	24.5	1.24	1.8	25.6	23.8	1.15	1.0	29.6	28.6	1.47
Soothing overall	2.8	48.2	45.4	1.24	2.4	31.9	29.5	1.12	1.4	37.7	36.3	1.43
Feeding	15.0	22.5	7.5	0.18	12.7	12.1	−0.5	−0.02	12.9	7.5	−5.4	−0.23
Vocalizing	3.2	25.8	22.6	0.91	2.4	7.1	4.7	0.47	32.5	51.0	18.5	0.20
Vocalizing only	1.4	1.1	−0.3	−0.10	1.4	2.0	0.6	0.15	16.6	18.3	1.7	0.04
Caregiving	5.0	7.3	2.3	0.16	6.3	8.0	1.7	0.10	8.3	13.8	5.5	0.22
Stimulating/arousing	0.6	0.5	−0.1	−0.08	1.7	1.9	0.2	0.05	8.0	10.3	2.3	0.11
None of the above	76.2	27.8	−48.4	−0.45	77.2	51.1	−26.1	−0.18	54.4	27.5	−26.9	−0.30
Holding	95.9	99.9	4.0	0.01	54.2	52.0	−2.2	−0.02	34.6	45.0	10.4	0.11
Crying												
Physical soothing	2.6	48.9	46.3	1.27	3.2	29.9	26.7	0.97	1.5	38.1	36.6	1.40
Nonphysical soothing	1.6	40.3	38.7	1.40	2.9	34.0	31.1	1.07	2.0	46.7	44.7	1.37
Soothing overall	3.2	59.2	56.0	1.27	3.8	40.0	36.2	1.02	2.7	57.2	54.5	1.33
Feeding	15.2	15.0	−0.2	−0.01	12.6	14.3	1.7	1.13	12.6	9.6	−3.0	−0.12
Vocalizing	3.3	39.7	36.4	1.08	2.7	6.4	3.7	0.38	33.5	43.7	10.2	0.11
Vocalizing only	0.2	0.3	0.1	0.18	1.8	0.8	−1.0	−0.35	16.8	12.8	−4.0	−0.12
Caregiving	4.9	14.4	9.2	0.47	6.0	17.8	11.8	0.47	8.5	17.9	9.4	0.32
Stimulating/arousing	0.6	0.0	−0.6	0.00	0.8	0.3	−0.5	−0.43	8.2	2.5	−5.7	−0.51
None of the above	75.6	18.9	−56.7	−0.60	75.9	41.8	−34.1	−0.26	53.3	16.2	−37.1	−0.52
Holding	95.8	99.7	3.9	0.02	54.0	59.0	5.0	0.04	34.2	57.7	23.5	0.23

[a]Percentage of intervals in which behavior occurs when infant is not fussing/crying.
[b]Percentage of intervals in which behavior occurs when infant is fussing/crying.
[c]Log of co-occurrence rate divided by base rate.

occurred with other soothing behaviors; Table 3 shows that vocalizing only was extremely rare among Aka and Ngandu and occurred about as frequently when infants were not fussing or crying.

The table also shows that the probability that caregivers were engaged in none of the target behaviors dropped dramatically when the infants either fussed or cried. The change was particularly marked among the Aka, who were as likely as the Ngandu not to be engaged with their infants when they were quiescent but as likely as the Euro-Americans to be attending to their infants using one of the target behaviors when they were crying or fussing.

In order to obtain a clearer picture of the frequency of no response to fussing/crying, we examined fussing/crying "events"—a continuous sequence of 30-second intervals in which some fussing/crying occurred separated by at least one interval without fussing/crying. We also examined the interval following the last fussing or crying event to see if there was a response, with the thought that fussing or crying might have occurred at the end of an interval with the response being recorded in the following one. Figure 2 summarizes four types of responses that took place during at least one interval of a fussing/crying event. Physical and nonphysical soothing were combined, and vocalizing was dropped because it usually occurred with soothing; vocalizing only and stimulating/arousing were omitted because their base rates were similar to rates when the infant was fussing or crying. Caregiving was omitted because it was not clear whether it actually increased the frequency of fussing and crying.

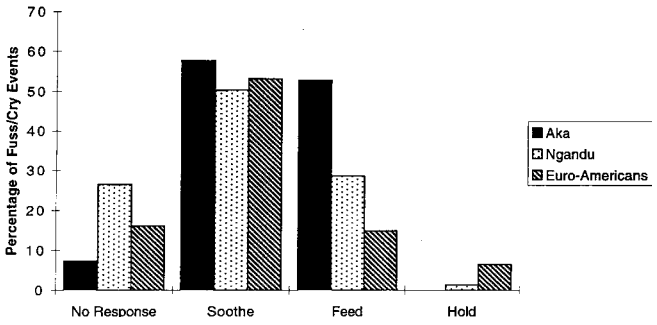

FIG. 2. *Types of responses to fussing/crying events.*

Holding was considered a response only if the infant was not being held before the fussing/crying event.

Figure 2 shows that lack of response to a fussing/crying event was substantially less frequent than is suggested by the interval data in table 3 (i.e., no response 20–50% of the time). The three groups were statistically distinct from each other, with the Ngandu having the highest frequency of no response and the Aka the lowest. The fussing/crying event data were consistent with the interval data in that soothing was a common response in all groups, feeding was especially common among the Aka, and holding was more common among the Euro-Americans.

The Ngandu infant fussing/crying data may seem unusual because it is often assumed that caregivers in non-Western cultures are much more responsive to infant fussing or crying than are caregivers in urban-industrial cultures and that as a result infants in these cultures cry less overall. But, in fact, few data exist on responses to fussing/crying events in small-scale cultures. LeVine has written the most about how responsive agricultural caregivers are by comparison with urban-industrial caregivers, but his Gusii and Boston fussing/crying data are based upon one hour of observation per infant at each age point. LeVine et al. reported that Gusii fuss/cry less (1994:201) than Boston Euro-Americans, but no statistical support was provided. The tables and figures indicate that Gusii three-to-four-month-olds cry more in more than 30% of the observations and that crying is the most frequent behavior at this age; infant vocalization, looking, physical contact, and exploring are all less frequent than crying (1994:207–8). By comparison, crying was the third most frequent behavior in a sample of infants in Boston (Richman, Miller, and LeVine 1992). Other studies of infants in East Africa suggest that farmers may not be especially responsive to infants' crying: Munroe and Munroe (1984) indicated that Logoli caregivers did not respond to 25% of infant crying episodes, and Borgerhoff Mulder and Milton (1985) stated that Kipsigis caregivers did not respond to 15–20% of infants' cries. It is also possible that the non-Western caregivers are described as so responsive in these studies because they are being contrasted with Euro-American parents in the 1960s and 1970s, when parents had more children and often relied upon Dr. Benjamin Spock, who at the time recommended letting children cry so that they could learn independence. For instance, Bell and Ainsworth's 1972 study of U.S. infants indicated deliberate nonresponse to 46% of crying episodes during the first three months. It is again important to consider the relatively high socioeconomic status and specific circumstances (i.e., mothers with a firstborn staying home specifically to be with the infant) of the Euro-American parents in this study.

The results of Barr et al.'s study (1991) of !Kung crying are consistent with this study in that forager infants cried less and caregivers were more responsive than Euro-American infants and caregivers. At three months !Kung infants cried 3.7 minutes per waking hour while Dutch infants cried 7.2 minutes. If we assume that infants sleep about 30% of the time and do not cry during that time, the Aka would cry 3.4 minutes per waking hour while the Euro-American infants would cry 6.8 minutes per waking hour. But it is important to be cautious in making comparisons with !Kung infants because the data collection methods were so different—three-month-old !Kung infants were observed for a total of 90 minutes in the camp, and the observations took place only when the infants were awake, not in the sling at the mother's side, not nursing, and within 15 feet of their mothers.

Cross-cultural data. A less precise but more comprehensive comparative analysis of infants' experiences in two very broad categories of cultures—tropical foragers and other nonindustrial peoples—is summarized in table 4. The table is a modified version of one created by Lozoff and Brittenham (1979) using data from Barry and Paxson's cross-cultural infancy codes (1971) for the 186 cultures in the Standard Cross-Cultural Sample (Murdock and White 1969). Lozoff and Brittenham distinguished tropical hunter-gatherers from other nonindustrial cultures (some of which were foragers) because this was thought to be the environment of evolutionary adaptation. The cross-cultural data tend to support the patterns described in this paper in that forager infants are held more frequently and are somewhat more responsive than infants in other nonindustrial cultures.

Rohner (1986) also conducted a study of parental warmth and affection versus rejection towards two-to-six-year-olds in 101 cultures and found rejection of children absent in forager societies and significantly more common in agricultural and pastoral societies.

DISCUSSION

Attachment theory posits that social-emotional experiences with caregivers contribute to the development of internal working models of self and others which become a social-emotional baseline for predicting and understanding feelings towards and interactions with others. We examined infant-caregiver experiences among three-to-four-month-olds in three groups with different modes of production in an attempt to determine whether there were distinctive features in the development of internal working models among foragers. In general, our data sup-

TABLE 4
Infant Care Practices (Percentage) among Foragers and Other Nonindustrial Cultures, Farmers, and Urban Industrial Cultures (Modified from Lozoff and Brittenham 1979)

Infant Care Practices	Tropical Foragers[a]	Other Nonindustrial Cultures[b]
Infant carried or held more than 50% of the time until age of crawling	100	56
Infant carried with sling or no carrying device (vs. cradle board, basket, or infant seat)	90	76
Generally affectionate care in infancy (expressions of affection, permissiveness, immediate response to demands)	100	72
Immediate, nurturant response to crying	100	74

[a]Foragers living between 22°30′ N and 22°30′ S; includes !Kung, Hadza, Mbuti, Semang, Vedda, Tiwi, Siriono, Botocudo, Shavante, and Chenchu.
[b]The remaining 176 cultures of the Standard Cross-Cultural Sample (Murdock and White 1969).

port Bird-David's suggestion that pan-forager meta-metaphors (schemas) exist and that foragers are more likely than individuals in cultures with other modes of production to have trusting and giving views of others and the environment. Infants in foraging cultures are more likely than infants in horticultural or urban-industrial cultures to be held, breast-fed on demand, breast-fed by women other than their mothers, and responded to sensitively when fussing or crying. These cultural experiences contribute to the development of trusting, accepting, and giving internal working models, mechanisms important to the survival and fitness of the child (e.g., ability to read and predict the intentions of others) as well as to the persistence of culture. Our approach supplements Bird-David's work in that it identifies a specific mechanism by which pan-forager schemas develop and are culturally transmitted and conserved.

Internal working models help to explain why African forest foragers ("pygmies") with diverse subsistence techniques (e.g., net, bow or gun hunters, gatherers, trappers, etc.), kinship systems (e.g., Hawaiian or Iroquois), relations with farmers (e.g., close or distant), and levels of acculturation (e.g., spend most of the year in village or forest) have similar social relations. Social relations are influenced by how one views self and others. For instance, Hewlett has traveled extensively in central Africa and has observed enormous diversity in forest foragers' ways of life, but within this diversity he has experienced a style of social interaction that is common to foragers and quite distinct from that of neighboring farmers. We suggest that early interactional experiences and the consequent development of internal working models explain, in part, the commonalities in forager (or farmer) social relations. The implication is that internal working models and consequent style of social relations can generate a diversity of cultural institutions, kinship systems, social roles, and sharing patterns (Fiske 1991). The distinguishing feature of forager or farmer lifeways may be the nature of social relations rather than subsistence techniques or kinship and descent patterns.

Suggesting that there is a pan-forager pattern of any sort is not popular in anthropology today; many anthropologists question whether the term "forager" is even useful. We agree with Kelly (1995) and others that foragers have/had a diversity of social systems, subsistence systems, and mating patterns, but we suggest that within this diversity there are patterns of social relations that are distinct from those of most agriculturalists. Without a doubt, there are or were foragers or farmers who do not fit the patterns described here. The Hadza, for instance, may not; Blurton Jones (1993) indicates that Hadza caregivers let their infants cry for long periods and are not very indulgent. While we do not expect forager groups or individuals to fit the pattern, we do feel that most ($>90\%$) immediate-return or mobile foragers will fit at least several aspects of the pattern.

It is important to note that what happens in early infancy does not in and of itself determine adult feelings and perceptions about self, others, and the environment. Furthermore, children in each of the three cultures in this study experience childhood and adolescence in very different contexts—involving different physical and social settings, cultural expectations of children, cultural practices with regard to children, and general cultural institutions and schemas—and each stage of development influences their internal working models. It is not possible to review the typical life course in each of the three cultures, but a few brief examples will illustrate the importance of viewing internal working models from a life-course perspective.

Aka children grow up in a cultural system that minimizes ranking, whereas Euro-American children move into a system that ranks individuals on a nearly daily basis. Even when they have sensitive caregivers and initial trusting internal working models, the ranking institutions point out differences between individuals which may in turn influence views of self and others. Aka and Ngandu children grow up among the same familiar individuals throughout their lives, whereas Euro-American children frequently change schools, classrooms, teams, and neighborhoods. Aka and Ngandu children's friends know them very well and are in a better position than Euro-American children's friends to interact or respond in sensitive and multisensory ways.

Attachment theory is not explicitly concerned with the development of feelings and views towards the natural environment, but several ethnographers (Bird-David 1993, Ingold 1987, Milton 1996, Mithen 1996) have described the links between social and natural ecologies. Early infant experiences and the hypothesized internal working models described in this paper reflect the Aka and Ngandu views of the environment. The Aka have a trusting or giving view of the environment and view the landscape as an integral part of their social world—they engage with the natural environment as trusting sharing partners. They trust that, under normal conditions, the forest will provide food. As Ichikawa (1992) points out, this does not mean that foragers have a completely positive, romantic view of the environment; food shortages, accidents, and malevolent spirits cause problems on a regular basis, but these are consistent with the ups and downs of any social relationship. As early experiences and internal working models would predict, Ngandu are generally suspicious and fearful of both the natural and social environment even though they know both the forest and "others" in their social environment quite well. A number of malevolent spirits—ancestral to generalized spirits—can cause harm at any time, and sorcery accusations are a topic of daily conversation and concern. Our analysis of Ngandu infant care practices provides an explanation for these distrustful views.

The link between the early experiences of Euro-American infants and Euro-American views of the natural environment (e.g., the human-nature dichotomy) is less clear, in part because Euro-Americans do not live in a forest or other "natural" environment. Their environment is the suburb, and children are constantly cautioned not to trust everyone. Euro-Americans' views of their social environment, therefore, are at least somewhat consistent with the infancy data presented here.

There are several limitations to this study. First, we do not directly examine internal working models as a developmental psychologist might, by administering standardized tests. Instead, we assume that certain infant experiences shape the development of such models. Also, attachment theory has seldom been used to explain intercultural variability. Second, while we provide cross-cultural evidence to support Bird-David's hypothesis regarding forager schemas, we present few descriptive data to test her hypothesis that these schemas impact economic behavior. Intracultural data linking early experiences and economic behavior are needed.

Third, we examine the development of internal working models at a single age point. Data on Aka and Ngandu at nine-to-ten months of age suggest that the patterns observed at three-to-four months continue—Ngandu infants fuss/cry significantly more than Aka, and Aka continue to hold infants twice as much as Ngandu—but we do not know much about changes later in life. Fourth, the cross-cultural data on infancy have an African bias.

A fifth limitation is that the views of "others" considered here are Aka, Ngandu, and Euro-American views of members of their own ethnic group (and, for the U.S. sample, socioeconomic stratum). Aka generally trust other Aka, but they often distrust the Ngandu. Other biocultural mechanisms and processes (e.g., other marker traits, repeated negative experiences, kin selection) may influence these behaviors.

Finally, it is important not to draw conclusions about these cultures on the basis of this limited description. Ngandu children, for instance, are very self-assured, and Ngandu parents are in fact more interactive (i.e., providing more verbal and physical stimulation) with their infants than are Aka in late infancy. Euro-American parents are more interactive and stimulating than both Aka and Ngandu.

CONCLUSION

We have examined Bird-David's (1992) hypothesis that foragers are more likely than peoples with other modes of production to have "giving" metaphors/views of the natural environment. We were interested in explaining why the cognitive models or schemas that she describes existed among many foragers in diverse natural and social ecologies and how they were transmitted from generation to generation. We identified a holistic emotionally based mechanism, the development of internal working models, which partially explained the intergenerational transmission and social reproduction of the trusting view of others and the environment that is common to many foragers. The social-emotional experiences of Aka forager infants were compared with the early experiences of Ngandu farmers and urban Euro-Americans. Aka infants were held/touched substantially more, breast-fed more frequently by more people, and responded to more regularly and contingently than infants in the other two groups. Descriptive cross-cultural data supported the quantitative case-study data. Early experiences provide a social-emotional baseline for viewing, interpreting, and predicting the actions of others. The internal-working-model approach explains, in part, why trust and giving are common in forager social-emotional-economic relations despite the enormous diversity in their natural ecologies, subsistence techniques, kinship systems, and levels of acculturation.

We have also described a pattern of infant care distinct from that of farmers. Prior to this study, infancy was thought to be similar in foraging and farming cultures with respect to the measures discussed here (bodily contact, nursing, attention to fussing/crying) because both foragers and farmers have high infant mortality. Bird-David also suggested that these giving metaphors/schemas for viewing the environment explain the extensive sharing, minimal time spent in subsistence activities, and lack of storage among foragers. While our data are consistent with her predictions, we have been unable to test this aspect of her hypothesis directly.

References Cited

AINSWORTH, M. 1973. "The development of infant-mother attachment," in *Review of child development research*, vol. 3. Edited by B. M. Caldwell and H. N. Riciuti. Chicago: University of Chicago Press.

BARNARD, A., AND J. WOODBURN. 1988. "Introduction," in *Hunters and gatherers*, vol. 2, *Property, power, and ideology*. Edited by T. Ingold, D. Riches, and J. Woodburn. Oxford: Berg.

BARR, R. G., M. KONNER, R. BAKEMAN, AND L. ADAMSON. 1991. Crying in !Kung infants: A test of the cultural specificity hypothesis. *Developmental Medicine and Child Neurology* 33:601–10.

BARR, R. G., M. KRAMER, I. B. PLESS, C. BIOSJOLY, AND D. DEDUC. 1989. Feeding and temperament as determinants of early infant cry/fuss behavior. *Pediatrics* 84:514–21.

BARRY, H., AND L. M. PAXSON. 1971. Infancy and early childhood: Cross-cultural codes. *Ethnology* 10:466–508.

BELL, S. M. M., AND M. D. S. AINSWORTH. 1972. Infant crying and maternal responsiveness. *Child Development* 43: 1171–90.

BELSKY, J. 1997. Attachment, mating, and parenting: An evolutionary interpretation. *Human Nature* 8:361–81.

BIRD-DAVID, NURIT. 1990. The giving environment: Another perspective on the economic system of gatherer-hunters. CURRENT ANTHROPOLOGY 31:183–96.

———. 1992. Beyond "The original affluent society": A culturalist reformulation. CURRENT ANTHROPOLOGY 33:25–46.

———. 1993. "Tribal metaphorization of human-nature relatedness: A comparative analysis," in *Environmentalism: A view from anthropology*. Edited by Kay Milton. New York: Routledge.

BLURTON JONES, N. 1993. "The lives of hunter-gatherer children: Effects of parental behavior and parental reproductive strategy," in *Juvenile primates*. Edited by M. E. Pereira and L. A. Fairbanks, pp. 309–26. New York: Oxford University Press.

BORGERHOFF MULDER, M., AND M. MILTON. 1985. Factors affecting infant care in the Kipsigis. *Journal of Anthropological Research* 41:231–62.

BOWLBY, J. 1969. *Attachment and loss*. Vol. 1. *Attachment*. New York: Basic Books.

———. 1973. *Attachment and loss*. Vol. 2. *Separation*. New York: Basic Books.

CHISHOLM, J. 1996. The evolutionary ecology of attachment organization. *Human Nature* 7:1–38.

D'ANDRADE, R. 1995. *The development of cognitive anthropology*. Cambridge: Cambridge University Press.

FISKE, A. P. 1991. *Structures of social life*. New York: Free Press.

FRALEY, R. C. 1998. Attachment continuity from infancy to adulthood: Meta-analysis and dynamic modeling of developmental mechanisms. Paper presented at the annual meetings of the Human Behavior and Evolution Society, Davis, Calif.

FREEDMAN, D. G., AND J. GORMAN. 1993. Attachment and the transmission of culture: An evolutionary perspective. *Journal of Social and Evolutionary Systems* 16:297–329.

HEWLETT, B. S. 1991. *Intimate fathers*. Ann Arbor: University of Michigan Press.

———. 1996. *Diverse contexts of human infancy*. Englewood Cliffs: Prentice-Hall.

HEWLETT, B. S., M. E. LAMB, B. LEYENDECKER, AND A. SCHÖLMERICH. n.d. "Parental investment strategies among Aka foragers, Ngandu farmers, and Euro-American urban industrialists," in *Evolutionary biology and human social behavior*. Edited by L. Cronk, N. Chagnon, and W. Irons. New York: Aldine de Gruyter. In press.

HEWLETT, B. S., M. E. LAMB, D. SHANNON, B. LEYENDECKER AND A. SCHÖLMERICH. 1998. Culture and early infancy among Central African foragers and farmers. *Developmental Psychology* 34:653–61.

ICHIKAWA, M. Comment on: Beyond "the original affluent society," by N. Bird-David. CURRENT ANTHROPOLOGY 33:40–41.

INGOLD, T. 1990. *Hunters, pastoralists, and ranchers*. Cambridge: Cambridge University Press.

———. 1987. *The appropriation of nature: Essays on human ecology and social relations*. Des Moines, Iowa: University of Iowa Press.

KELLY, R. L. 1995. *The foraging spectrum*. Washington, D.C.: Smithsonian Institution Press.

KONNER, M. J. 1976. "Maternal care, infant behavior, and development among the !Kung," in *Kalahari hunter-gatherers*. Edited by R. B. Lee and I. DeVore. Cambridge: Harvard University Press.

———. 1977. "Infancy among Kalahari Desert San," in *Culture and infancy: Variations in the human experience*. Edited by P. H. Leiderman, S. T. Tulkin, and A. Rosenfeld, pp. 287–328. New York: Academic Press.

KONNER, M., AND C. WORTHMAN. 1980. Nursing frequency, gonadal function, and birth spacing among !Kung hunter-gatherers. *Science* 207:788–91.

LAMB, M. E. 1981. "The development of social expectations in the first year of life," in *Infant social cognition: Empirical and theoretical considerations*. Edited by M. E. Lamb and L. R. Sherrod. Hillsdale, N.J.: Erlbaum.

LAMB, M. E., R. A. THOMPSON, W.P. GARDNER, E. L. CHARNOV, AND D. ESTES. 1984. Security of infantile attachment as assessed in the "strange situation": Its study and biological interpretation. *Behavioral and Brain Sciences* 7: 127–71.

LEE, R. B. 1998. Hunter-gatherer studies and the millennium: A look forward (and back). Paper presented at the International Conference on Hunting and Gathering Societies, Osaka, Japan.

LE VINE, R. A., S. DIXSON, S. LE VINE, A. DIXSON, P. H. LEIDERMAN, C. H. KEEFER, AND T. B. BRAZELTON. 1994. *Child care and culture: Lessons from Africa*. Cambridge: Cambridge University Press.

LOZOFF, B., AND G. BRITTENHAM. 1979. Infant care: Cache or carry. *Journal of Pediatrics* 95:478–83.

MAIN, M. 1990. Cross-cultural studies of attachment organization: Recent studies, changing methodologies, and the concept of conditional strategies. *Human Development* 33:48–61.

MILTON, K. 1996. *Environmentalism and cultural theory: Exploring the role of anthropology in environmental discourse*. New York: Routledge.

MITHEN, S. 1996. *The prehistory of the mind: The cognitive origins of art, religion, and science*. London: Thames and Hudson.

MUNROE, R. H., AND R. L. MUNROE. 1984. Infant experience and childhood cognition. *Ethos* 12:291–306.

MURDOCK, G. P., AND D. R. WHITE. 1969. Standard cross-cultural sample. *Ethnology* 8:329–69.

RADCLIFFE-BROWN, A. R. 1964. *The Andaman Islanders*. New York: Free Press.

RAPHAEL, D. 1973. *The tender gift*. New York: Schocken Books.

RICHMAN, A. L., P. M. MILLER, AND R. A. LE VINE. 1992. Cultural and educational variations in maternal responsiveness. *Development Psychology* 28:614–21.

ROHNER, R. P. 1986. *The warmth dimension: Foundations of parental acceptance-rejection theory*. Beverly Hills: Sage.

SUPER, C. M., AND S. A. HARKNESS. 1982. "The infant's niche in rural Kenya and metropolitan America," in *Cross-cultural research at issue*. Edited by L. L. Adler, pp. 247–55. New York: Academic Press.

TRONICK, E. Z., G. A. MORELLI, AND S. WINN. 1987. Multiple caretaking of Efe (Pygmy) infants. *American Anthropologist* 89:96–106.

VERSCHUEREN, KARINE, ALFONS MARCOEN, AND VEERLE SCHOEFS. 1996. The internal working model of self, attachment, and competence in five-year-olds. *Child Development* 67:2495–503.

WATERS, E., S. MERRICK, L. ALBERSHEIM, AND D. TREBOUX. 1995. Attachment security from infancy to early adulthood: A 20-year longitudinal study. Paper presented at the

meetings of the Society for Research in Child Development, Indianapolis, Ind.
WOOD, J. W., D. LAI, P. L. JOHNSON, K. L. CAMPBELL, AND I. A. MASLAR. 1985. Lactation and birth spacing in Highland New Guinea. *Journal of Biosocial Science* 9:159–73.
WOODBURN, J. 1982. Egalitarian societies. *Man*, n.s., 17:431–51.

First Known Tibia of an Early Javanese Hominid[1]

SHUJI MATSU'URA, MEGUMI KONDO, FACHROEL AZIZ, SUDIJONO, SHUICHIRO NARASAKI, AND NAOTUNE WATANABE
Department of Human Biological Studies, Faculty of Human Life and Environmental Science, Ochanomizu University, Tokyo 112- 8610, Japan (Matsu'ura and Kondo)/*Geological Research and Development Centre, Bandung 40122, Indonesia* (Aziz and Sudijono)/ *Department of Anthropology, Gunma Museum of Natural History, Gunma 370- 2345, Japan* (Narasaki) / *University of Tokyo, Tokyo 113- 0033, Japan* (Watanabe). 15 IV 99

The Solo River drainage on the island of Jawa (Java), Indonesia (fig. 1), has yielded many fossil remains of early Asian hominids since E. Dubois's initial discoveries in the 1890s. Most of these remains have, however, been assigned to skulls and teeth, while little has been definitely known of the rest of the skeleton. Relative dating by element analyses of bone, as we show here, attributes great antiquity, probably late Early Pleistocene, to the modern-shaped hominid tibia recovered in 1977 from Sambungmacan, Central Jawa, the first tibia in the inventory of the Javanese hominids. The antiquity of the tibia may have a significant bearing on the ongoing controversy surrounding the geological age of the hominid femora from Trinil which caused the species to be named *Pithecanthropus* (now *Homo*) *erectus*.

At Sambungmacan an adult hominid braincase similar to the Ngandong skulls (considered as advanced and the latest *H. erectus* or as archaic *H. sapiens*) was encountered in 1973 in the course of canal-digging operations at a meander site of the Solo River (see Jacob et al. 1978). In September 1977 a field survey was carried out at the site by the Indonesia-Japan joint research team in the framework of the Cooperation Technical Assistance Project 41 (Watanabe and Kadar 1985) to map the sediments exposed along the short-cut canal. Vertebrate bone remains were also collected during this fieldwork, and in the Sambungmacan collection was later found a well-fossilized hominid tibial fragment (Matsu'ura et al. 1990) about 10 cm long and referable to the lower part of right tibial shaft (Baba, Aziz, and Watanabe 1990).

This specimen had been inscribed "SB210977," meaning "Sambungmacan, 21st September in 1977," but sufficient context for determination of provenance is lacking because it was a surface find. Locating its original source horizon by some geochemical approach is, therefore, fundamental to the construction of the chronology, relative or absolute. At Sambungmacan, the calcareous gravelly bed of the Kabuh Formation and the sandy facies of the Setri Formation have yielded vertebrate fossils (Susanto et al. 1995). The Kabuh Formation and its correlatives, the richest source of *H. erectus* remains in Jawa (Matsu'ura 1982, Pope and Cronin 1984), are assigned to the Lower-to-Middle Pleistocene (Sudijono, Mano, and Wikarno 1995, Mano 1997). The Setri Formation of Sambungmacan was formerly reported as a Kabuh-equivalent bed at the north-wall exposure of the canal (Shibasaki et al. 1985, Matsu'ura et al. 1990) but is now assigned to the lower-to-middle Upper Pleistocene (Sudijono, Mano, and Wikarno 1995).[2]

Our previous work (Matsu'ura et al. 1990) using a relative-dating technique based on the analysis of fluorine, which is diagenetically taken up by buried bone at the expense of hydroxyl ions in apatite crystals, has shown that the fluorine content of the Sambungmacan tibia (2.37%) corresponds to that of fossil bones collected by the project team *in situ* from the Kabuh and Setri formations at Sambungmacan, indicating that the tibia dates well back into the Pleistocene. However, we could not settle its stratigraphic provenance (Kabuh or Setri) because the bone fluorine content for the two formations overlaps considerably and the tibia's falls within the overlapping range. Thus the clarification of its antiquity has awaited further research.

Recent studies (Kondo et al. 1994, 1995; Kondo et al. in preparation; Matsu'ura, Kondo, and Aziz 1994, 1995; Matsu'ura et al. in preparation) have shown that a new geochemical approach by multielement analyses of bone using inductively coupled plasma (ICP) spectrometry, accompanied by fluorine assay (see Matsu'ura 1982), is very effective for provenance discrimination of fossil bones from the Sangiran area of Central Jawa (Kondo et al. 1994, 1995; Kondo et al. in preparation) and has assisted in the geochronological placement of the Sangiran hominids (Matsu'ura, Kondo, and Aziz 1994, 1995; Matsu'ura et al. in preparation). Here we report the results of applying the multielement approach to the Sambungmacan tibia, using for comparison 18 *in situ* bone samples that had earlier been subjected to fluorine determination (by the

 The progress of this work was facilitated by a Grant-in-Aid for Scientific Research (No. 09440283) to SM and MK from the Japanese Ministry of Education, Science, and Culture.

2. Electron spin resonance (ESR) dating of a bovid tooth from Sambungmacan has produced ages of 32,400 ± 2,400 years ago and 53,300 ± 4,000 years ago for two uranium-uptake models, the early and the linear (Swisher et al. 1996). However, the stratigraphic context of the tooth sample is not clear.

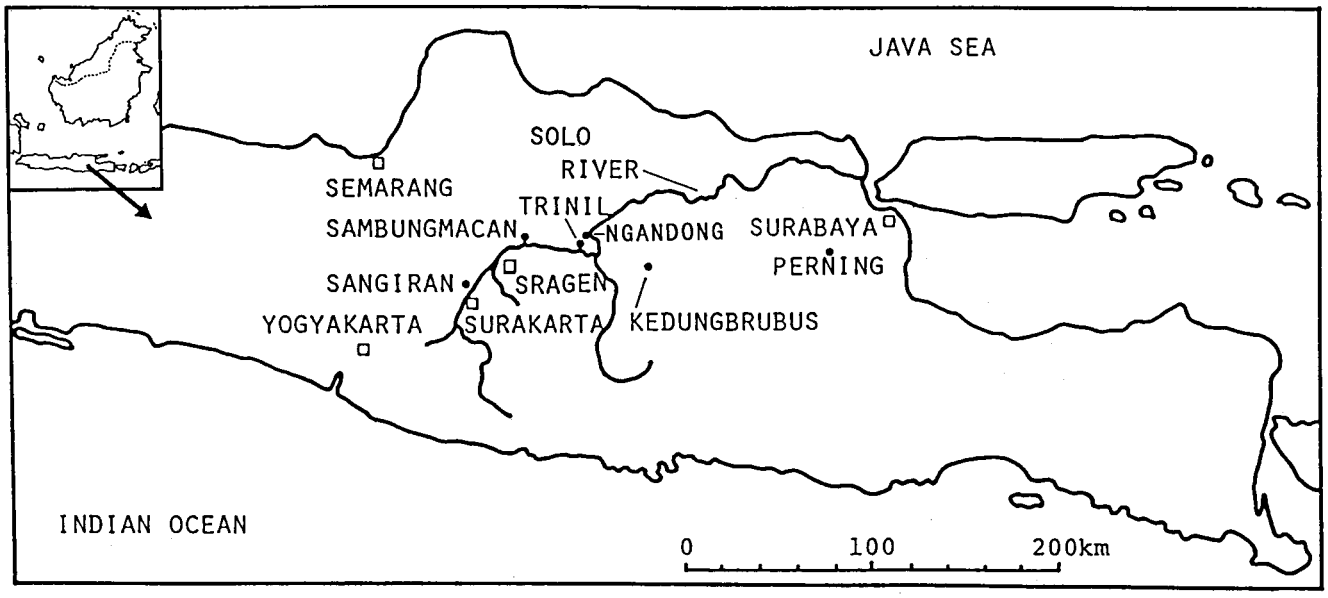

FIG. 1. *Central and East Jawa, showing some fossil hominid sites* (dots).

ion-sensitive electrode method [Matsu'ura et al. 1990]) as mentioned above.

About 5 to 10 mg of powdered compact bone tissue prepared as described previously (Matsu'ura et al. 1990) was weighed and dissolved in 15 ml of 0.6N HCl and then passed through a 0.2 μm Advantec Toyo Dismic-25 filter. Dilutions were done when necessary. Main chemical constituents (phosphorus and calcium) and seven minor and trace constituents (sodium, magnesium, manganese, zinc, strontium, yttrium, and barium) of the mineral phase of bone were measured by ICP atomic emission on a Seiko Instruments SPS7700 spectrometer.

Examination of the analytical data reveals that sodium, strontium, and barium are more or less useful for identifying the source layers of bones from Sambungmacan. These elements, adsorbed (Na) or structurally substituted (Sr and Ba) in apatite crystals, show virtually homogeneous distributions within the compact bone (Kondo et al. 1994, 1995; Kondo et al. in preparation); this is usually one of the important requirements in comparing measured values of hominid fossils and nonhominid fauna (Oakley 1980; Matsu'ura 1982; Matsu'ura, Kondo, and Aziz 1994, 1995). Biogenic levels of strontium and barium in bone are diet-dependent and sometimes used as paleodietary indicators. Pleistocene bone remains from the Solo River basin, however, have undergone appreciable postmortem chemical changes such as introduction or leaching of various elements (Matsu'ura 1982, 1986; Matsu'ura et al. 1990; Kondo et al. 1994, 1995; Kondo et al. in preparation; Matsu'ura, Kondo, and Aziz 1994, 1995; see Jacob 1975; Swisher et al. 1996). The levels of strontium and barium, 1,030 ppm and 610 ppm on average respectively, in bones from Sambungmacan may be significantly elevated because of diagenesis from the biogenic levels (usually at most 500 ppm for Sr and 250 ppm for Ba) and should mainly reflect the varying geochemical environments of the burial media.

From figure 2, a bivariate scattergram, and figure 3, a plot of the discriminant scores based on the ratios of

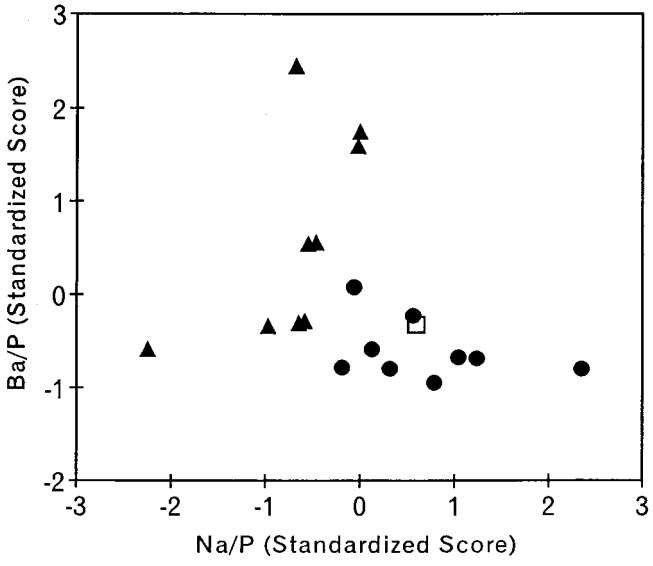

FIG. 2. *Scatter diagram of concentration ratios of sodium/phosphorus and barium/phosphorus in bone of vertebrate fossils from Sambungmacan.* Solid triangles, *Setri Formation;* solid circles, *Kabuh Formation;* open square, *human tibia.*

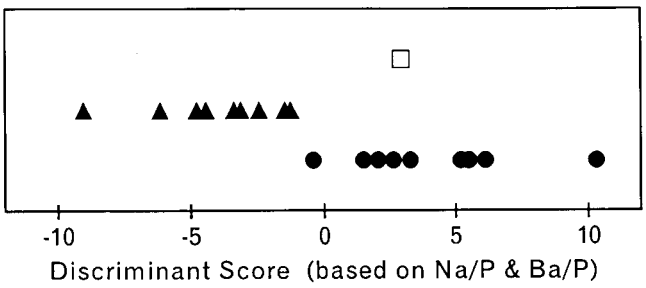

FIG. 3. *A result of discriminant analysis using the concentration ratios of sodium/phosphorus and barium/phosphorus for provenance discrimination of fossil bones from Sambungmacan. The score for the human tibia* (open square) *lies 3.0 standard deviations from the mean score for the Setri bones* (solid triangles) *and close to 0.37 standard deviations distant from the mean score for the Kabuh bones* (solid circles).

sodium to phosphorus (phosphorus content being a convenient measure of the apatite present in the bone sample) and barium to phosphorus, we can infer that the hominid tibia in question has its origin in the Kabuh Formation. This conclusion is also supported by a discriminant analysis based on the ratios to phosphorus of fluorine, sodium, strontium, and barium (fig. 4).

The bone-bearing bed of the Kabuh Formation at Sambungmacan is thought to be correlated with a lower part of the Bapang (Kabuh) Formation in the Sangiran area (Sudijono, Mano, and Wilkarno 1995, Mano 1997). This correlation accordingly assigns to the tibia a probable age of late Early Pleistocene (Watanabe and Kadar 1985, Sudijono, Mano, and Wikarno 1995) or a very late phase of the Matuyama geomagnetic polarity chron (Hyodo et al. 1993) and argues for a provisional linkage of the specimen with the Trinil H.K. fauna (de Vos et al. 1994). In any case, it is the first known tibia of an early Javanese hominid.

The present approach would also be promising for the clarification of the stratigraphic provenance of the hominid braincase from Sambungmacan.

It should be remarked that the geologically old tibia from Sambungmacan looks more like modern specimens, while is has the thickened cortex and narrowed medullary cavity which is also present in the *H. erectus* tibia from Zhoukoudian (Choukoutien), China. As Baba, Aziz, and Watanabe (1990) have reported, the typically triangular cross-section and transversely somewhat flattened shape of the Sambungmacan tibia at mid-shaft show an external morphological pattern close to that of East Asian Neolithic males, in contrast to the Ngandong tibiae and the Zhoukoudian tibia.

The "advanced" modern form of the famous thigh bones from Trinil, although they share some morphological features (particularly in the distal shaft), such as thickened cortex, with other *H. erectus* femora (Kennedy 1983), has raised doubts about their association with the Trinil *H. erectus* holotype skullcap from both anatomical (Weidenreich 1941, Day and Molleson 1973, Kennedy 1983) and geological (Bartstra 1982) viewpoints. These doubts are, however, not supported by biostratigraphic reinvestigations (Sondaar, de Vos, and Leinders 1983, de Vos et al. 1994), and the results of bone chemical analyses have not yet resolved the question (Day and Molleson 1973, Day 1984, Matsu'ura 1986). Thus the relationship of the Trinil femora to the Trinil skullcap (presumably from around the basal Kabuh Formation) remains to be proved by further geochemical study such as that reported here. Provided that the femora also derive from the Kabuh Formation, the modern-shaped but more robust leg bones represented by the Trinil femora and the Sambungmacan tibia would imply the acquisition of some endemic mode of postcranial adaptation by the early Javanese hominids, possibly in a fairly isolated and insular environment.

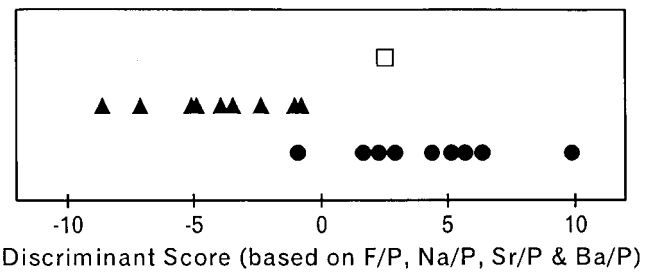

FIG. 4. *A result of discriminant analysis using the concentration ratios of fluorine/phosphorus, sodium/phosphorus, strontium/phosphorus, and barium/phosphorus for provenance discrimination of fossil bones from Sambungmacan. The score for the human tibia* (open square) *lies about 0.55 standard deviations distant from the mean score for the Kabuh bones* (solid circles) *and 2.7 standard deviations from the mean score for the Setri bones* (solid triangles).

References Cited

BABA, H., F. AZIZ, AND N. WATANABE. 1990. Morphology of the fossil hominid tibia from Sambungmacan, Java. *Bulletin of the National Science Museum, Tokyo, Series D* (*Anthropology*) 16:9–18.

BARTSTRA, G.-J. 1982. The river-laid strata near Trinil, site of *Homo erectus erectus*, Java, Indonesia. *Modern Quaternary Research in Southeast Asia* 7:97–130.

DAY, M. H. 1984. The postcranial remains of *Homo erectus* from Africa, Asia, and possibly Europe. *Courier Forschungs-Institut Senckenberg* 69:113–21.

DAY, M. H., AND T. I. MOLLESON. 1973. "The Trinil femora," in *Human evolution*. Edited by M. H. Day, pp. 127–54. Symposia of the Society for the Study of Human Biology 11.

DE VOS, J., P. Y. SONDAAR, G. D. VAN DEN BERGH, AND F. AZIZ. 1994. The *Homo*-bearing deposits of Java and their ecological context. *Courier Forschungs-Institut Senckenberg* 171:129–40.

HYODO, M., N. WATANABE, W. SUNATA, E. E. SUSANTO, AND H. WAHYONO. 1993. Magnetostratigraphy of hominid fossil-bearing formations in Sangiran and Mojokerto, Java. *Anthropological Science* 101:157–86.

JACOB, T. 1975. "Indonesia," in *Catalogue of fossil hominids,* pt. 3, *Americas, Asia, Australia*. Edited by K. P. Oakley, B. G. Campbell, and T. I. Molleson, pp. 103–16. London: British Museum (Natural History).

JACOB, T., R. P. SOEJONO, L. G. FREEMAN, AND F. H. BROWN. 1978. Stone tools from mid-Pleistocene sediments in Java. *Science* 202:885–87.

KENNEDY, G. E. 1983. Some aspects of femoral morphology in *Homo erectus*. *Journal of Human Evolution* 12:587–616.

KONDO, M., S. MATSU'URA, E. FUJIMORI, H. SAWATARI, AND H. HARAGUCHI. 1994. A multielement approach to the relative dating of Java Man fossils from Sangiran. Paper presented at the 48th joint meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology, Kagoshima City, Japan, October 7–9. (Abstract in *Anthropological Science* 103[1995]:161.)

———. 1995. Multielement dating of hominid fossils from Sangiran. Paper presented at the 49th joint meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology, Chiba City, Japan, October 13–15. (Abstract in *Anthropological Science* 104[1996]:171.)

MANO, K. 1997. Some aspects of the age of the Kabuh Formation, Early-Middle Pleistocene in Jawa Island, Indonesia. *Odontology* [Matsudo, Japan] 1:6–17.

MATSU'URA, S. 1982. A chronological framing for the Sangiran hominids: Fundamental study by the fluorine dating method. *Bulletin of the National Science Museum, Tokyo, Series D* (*Anthropology*) 8:1–53.

———. 1986. Fluorine and phosphate analysis of fossil bones from the Kabuh Formation of Trinil. *Bulletin of the National Science Museum, Tokyo, Series D* (*Anthropology*) 12:1–9.

MATSU'URA, S., M. KONDO, AND F. AZIZ. 1994. A preliminary report on stratigraphic allocation of Sangiran hominid remains by multielement analyses of bone. Paper presented at the 48th joint meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology, Kagoshima City, Japan, October 7–9. (Abstract in *Anthropological Science* 103[1995]:161.)

———. 1995. Stratigraphic positions of hominid remains from Sangiran and their possible palaeoanthropological implications. Paper presented at the 49th joint meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology, Chiba City, Japan, October 13–15. (Abstract in *Anthropological Science* 104[1996]:172.)

MATSU'URA, S., N. WATANABE, F. AZIZ, T. SHIBASAKI, AND M. KONDO. 1990. Preliminary dating of a hominid fossil tibia from Sambungmacan by fluorine analysis. *Bulletin of the National Science Museum, Tokyo, Series D* (*Anthropology*) 16:19–29.

OAKLEY, K. P. 1980. Relative dating of the fossil hominids of Europe. *Bulletin of the British Museum* (*Natural History*), *Geology* 34:1–63.

POPE, G. G., AND J. E. CRONIN. 1984. The Asian Hominidae. *Journal of Human Evolution* 13:377–96.

SHIBASAKI, T., D. KADAR, SUDIJONO, M. ITIHARA, T. SURADI, H. KUMAI, S. YOSHIKAWA, A. P. KADAR, F. AZIZ, F. HASIBUAN, K. FURUYAMA, M. FURUTANI, AND T. HAYASHI. 1985. "Geology and stratigraphy of the Sambungmacan area," in *Quaternary geology of the hominid fossil bearing formations in Java*. Edited by N. Watanabe and D. Kadar, pp. 45–47. Geological Research and Development Centre, Bandung, Indonesia, Special Publication 4.

SONDAAR, P. Y., J. DE VOS, AND J. J. M. LEINDERS. 1983. Reply: Facts and fiction around the fossil mammals of Java. *Geologie en Mijnbouw* 62:339–43.

SUDIJONO, K. MANO, AND R. WIKARNO. Editors. 1995. *Geology of the Quaternary environment of the Solo-Madiun area, Central-East Jawa.* Geological Research and Development Centre, Bandung, Indonesia, Special Publication 17.

SUSANTO, E. E., K. MANO, SUDIJONO, T. SIHOMBING, AND F. AZIZ. 1995. "Geology of the middle course of the Solo River between Sambungmacan and Ngawi," in *Geology of the Quaternary environment of the Solo-Madiun area, Central-East Jawa.* Edited by Sudijono, K. Mano, and R. Wikarno, pp. 39–44. Geological Research and Development Centre, Bandung, Indonesia, Special Publication 17.

SWISHER, C. C., III, W. J. RINK, S. C. ANTÓN, H. P. SCHWARCZ, G. H. CURTIS, A. SUPRIJO, AND WIDIASMORO. 1996. Latest *Homo erectus* of Java: Potential contemporaneity with *Homo sapiens* in Southeast Asia. *Science* 274: 1870–74.

WATANABE, N., AND D. KADAR. Editors. 1985. *Quaternary geology of the hominid fossil bearing formations in Java*. Geological Research and Development Centre, Bandung, Indonesia, Special Publication 4.

WEIDENREICH, F. 1941. The extremity bones of *Sinanthropus pekinensis*. *Palaeontologia Sinica,* n.s., *D* 5:1–150.