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TRANSITIONS AMONG TREPONEMATOSES IN ANCIENT MEXICO

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The frequency pattern through time for periostitis in the long bones of three ancient Mexican populations was carried out to understand the distinct treponematosis and the particular signature each leaves on the bone (Bejel, Yaws and Syphilis). From the results gained from the patterns from each population three sequencial phenomenon were established, each different from the previous and different from each other. The initial sickness has all the characteristics of Bejel and is present since 3100 b.C. in Tlatilco. This same pattern we found in the population of Marismas Nacionales in Nayarit (Pacific Coast) with dates after A.D. 1150-1300. It is after the last cultural period (Post Classic, 1300-1521) that we find a change, the population of the metro line excavations has two manifestations, on one side the skeletons of route II show a pattern that corresponds to a new sickness, Yaws. And the samples obtained from routes I and III reflect a pattern of syphilis. The change between the treponematosis in ancient Mexico is found in the epoch above the Mexicas of the Central Highlands of Mexico. The Mexicas came from northern Mexico, an area where it has been reported that Yaws was endemic. Therefore the possibility exists that the Mexicas shared this sickness before their migration and in this way arrived in Central Mexico. Another possibility is that during the period between 3100 b.C. to A.D. 1300 the drastic bicultural event caused large transformations and did not permit the continuation of the transmission of Bejel. The simultaneous presence of Yaws and Syphilis found in the skeletal samples from the Metro lines from Mexico City may be caused by the lack of precision in the chronology of the finds and for this reason we may have skeletons of individuals from Lines I and III that had contact with European populations and the new sickness, Syphilis. Therefore we have the presence of two dramatic changes in these populations, involving two invasions, the Mexica and the Spanish, each could be the decisive factors in the yield and or transformation of treponematosis in ancient Mexico.

Key Words: Periostisis, yaws, syphilis.

Se analiza a través del tiempo el patrón de frecuencia de periostitis en la diáfisis de los huesos largos de tres poblaciones del México antiguo con el fin de reconocer las distintas treponematosis (Bejel, Yaws y Sífilis) que dejan su huella en el hueso. Por los resultados de los patrones de cada población se establecen tres fenómenos secuenciales, cada uno diferente del anterior y entre sí. La enfermedad inicial tiene todas las características propias de Bejel y está presente desde 3100 a.C. en Tlatilco, Estado de México. Este mismo patrón lo encontramos en la población de Marismas Nacionales en Nayarit (costa del Pacífico) con fechas posteriores 1150-1300 d.C. Es hasta el último período cultural (Postclásico, 1300-1521) que encontramos un cambio, la población del Metro presenta dos manifestaciones, por un lado los esqueletos de la ruta II muestran un patrón que corresponde a una nueva enfermedad, Yaws, y la muestra obtenida de las rutas I y III que reflejan el patrón de Sífilis. El cambio entre las treponematosis en el México antiguo se ubica en la época del arribo de los mexicas al Altiplano Central de México. Los mexicas provienen del norte de México, área en donde se ha reportado la presencia de Yaws de forma endémica, así puede existir la probabilidad de que también los mexicas compartieran esta enfermedad antes de su migración y así llegará al centro de México. Otra posibilidad es que durante el lapso de 3100 A.C. a 1300 d.C. los drásticos acontecimientos bioculturales de las poblaciones del centro de México dieran lugar a las grandes transformaciones y no hayan permitido la continuidad de transmisión del Bejel. La presencia simultánea de Yaws y Sífilis en las muestras esqueléticas encontradas en las líneas del metro de la ciudad de México puede deberse a la falta de precisión en la cronología de estos hallazgos y por lo tanto podemos encontrarnos ante la presencia de esqueletos de individuos que hayan tenido contacto con población europea en las líneas I y III y por lo tanto ante una nueva enfermedad, la Sífilis. En esta problemática tenemos la presencia de dos cambios dramáticos en estas poblaciones, se trata de dos invasiones, la mexicana y la española, que pueden ser los factores decisivos en la conformación y/ o transformación de las treponematosis en el México antiguo.

***Palabras claves**: Periostitis, yaws, sífilis.*

Evidence from paleopathology indicates the presence of treponemal disease in the Americas (Baker and Armelagos 1988). Existence of treponematosis-induced periostitis in ancient Mexico was documented in several studies (Mansilla and Pijoan 1995; Mansilla and Pijoan 1998a and 1998b). The time course of events in the central Mexican plateau appears pivotal in clarification of the nature of treponemal disease. Influx of new population groups had a dramatic effect on society and its health (Mansilla and Pijoan 1998a).

The application of the criteria established and used by Rothschild and Rothschild (1994; 1995a; 1995b, and Rothschild et al. 1995), is based on

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population approach (Roberts 1965; Rothschild and Rothschild 1993; Rothschild and Woods 1990, 1991). This method allowed the separation of three Mexican site treponematoses into varieties, provided insights to the change of the pattern of this disease and independent verification to the written history of the region.

Although controversy has raged as to whether treponematoses are simply manifestations (e.g., climate-induced) of a single disease or actually separate diseases (Hackett 1963; Hudson 1958), animal studies appear to resolve the issue. Differential sensitivity of different hamster strains (to Bejel, Yaws and Syphilis) (Schell et al. 1981) indicates that they are truly separate diseases. Rabbit studies (Larsen et al. 1995) confirm those in hamsters.

Just as examination of isolated bones is generally inadequate for recognition of disease (Rothschild and Martin 1993), examination of isolated skeletons (Lagier et al. 1995; Skinner 1995) does not allow confident recognition of a specific treponematosis. The diseases are, however, distinguishable on the basis of population analysis. The criteria applied are predicated, not on isolated bony or even single skeleton impact, but rather on the full spectrum of the disease (in its manifestations as a populations phenomenon) (Rothschild and Rothschild 1995b).

Syphilis produces periosteal reaction in 2-12% of adults (rarely subadults) in affected populations, but with a limited osteologic distribution (Freedman and Meschan 1943; Jostes and Roche 1939; Rothschild and Rothschild 1994, 1995a, 1995b; Rothschild et al. 1995). Several aspects of bone involvement in syphilis appear unique for that treponematosis. The periosteal layer in sabre shin tibiae is usually remodeled to the extant that all surface signs of periosteal reaction are effaced (Rothschild and Rothschild 1994, 1995a, 1995b; Rothschild et al. 1995). Tibial involvement may be unilateral in syphilis. While a single individual may have poly-ostotic disease, the average number of bone groups [e.g., femora (e) is/are one bone group, fibula(e) another] affected is less than 3 (pauci-ostotic pattern) (Rothschild and Rothschild 1994; 1995a; 1995b and Rothschild et al. 1995). Involvement of the radius and ulna is infrequent and hand or foot involvement, quite rare.

Involvement in syphilis contrasts with yaws, in which a typically poly-ostotic periosteal reaction has been found in 20-40% of affected populations (Hackett 1963; Rothschild and Heathcote 1993; Rothschild and Rothschild 1994, 1995a, 1995b, and Rothschild et al. 1995). As Yaws is of childhood onset, it is not surprising that the osseous impact is recognizable early. Twenty percent of subadults are affected. The mean number of bone groups affected is always 3 or greater and tibial involvement is invariably bilateral. Long bones of the upper extremities and hand and foot bones are commonly affected.

Surface evidence of periosteal reaction is never effaced in Yaws (Heathcote and Rothschild 1993; Rothschild and Rothschild 1994, 1995a, 1995 b; Rothschild et al. 1995). Distribution of bone involvement is more poly-ostotic than in syphilis.

A third pattern, hitherto unreported in North America is that of bejel. It produces periosteal reaction as frequently as yaws, but in a pauci-ostotic patterns (Hershkovitz et al. 1995; Rothschild and Rothschild 1995b). Disease acquisition in early childhood results in frequent (at times exceeding 20%) affliction of subadult skeletons. Although a few individuals may have polyostotic disease, the average number of affected bone groups in this disease is two. Tibial involvement is invariably bilateral.

Three Mexican populations were examined to determine the nature of periosteal reaction in each, define which treponematosis was present, and identify the time course of transition among those identified.

Methods

Three sites were chosen to assess the population frequency, nature, extent, and character of periosteal and other osseous reaction. These included Tlatilco IV, a pre-Classic site of the Central Plateau, dated at 3100 years before present (ybp), Marismas Nacionales with two sites (Tecualilla and Chalpa in Nayarit, on the Pacific coast), dated at 1150-1300 C.E., and excavations of three subway tunnels of Mexico City, dated at 1300-1521 C.E.

Skeletal remains were subjected to visual examination of all articular and cortical surfaces to identify all occurrences of articular and peri-articular bony alterations throughout each skeleton, specify the types of bony alterations at each occurrence, and map the distribution of occurrences in each skeleton. Metaphyseal and diaphyseal cortical and periosteal alterations were also assessed.

All variation from normal smooth cortical surfaces was noted. Treponemal disease was specifically recognized on the basis of periosteal reaction and osteitis (Freedman and Meschan 1943; Gann 1901; Goff 1967; Hunt and Johnson 1923; Jostes and Roche 1939; Moss and Bigelow 1922; Rothschild and Heathcote 1993; Rothschild and Rothschild 1994 1995a. 1995b; Rothschild and Turnbull 1987; Rothschild et al. 1995).

Comparisons of population and (bony) element affliction frequencies was by Chi square analysis or Fisher Exact Test. Test was performed to assess significance of variance of number of bone groups affected in the populations studied.

Results

One hundred twenty five adult and 28 subadults skeletons were examined from the Tlatilco IV site (Table 1). Forty-four individuals had periosteal reaction. Four had sabre shin deformity, with prominent surface periosteal reaction. Tibial involvement was invariably bilateral. Disease was predominantly pauci-ostotic (bone groups affected). Hand and foot involvement was extremely rare. Fourteen percent of juveniles were affected.

Thirty-seven individuals from Tecualilla and 27 from Chalpa Nay (representing 57 adults and 7 subadults) were examined (Table 1). Twenty-nine individuals had periosteal reaction. Eight had sabre shin deformity, with prominent surface periosteal reaction. Tibial involvement was invariably bilateral. Manifestations were predominantly pauci-ostotic, with no hand or foot involvement.

Forty percent of subadults from the Tecualilla site were affected. Presence of only two subadults in the Chalpan Nay population precludes fulfillment of the criteria for subadult affliction.

One hundred individuals (including 36 subadults) from subway tunnel # 2 were examined (Table 1). Twenty-two individuals had periosteal reaction. Tibial involvement was bilateral in all affected skeletons. Sabre shin deformity was present in 1 individual, with prominent surface periosteal reaction. Manifestations were polyostotic, frequently involving hands and feet.

One hundred forty individuals from subway tunnel # 1 and 68 individuals from subway tunnel # 3 were examined. Seventeen adult individuals had periosteal reaction. Periosteal reaction was present in only one of 62 subadults. As sabre shin deformity was not present, criteria related to tibial remodeling could not be applied. Hands and feet were spared in this pauci-ostotic affliction, which manifest unilateral tibial involvement in 35%.

Discussion

The study confirms that by Goodman et al. (1988) that periosteal reaction is very common in such pre-Columbian skeletal populations. Their interpretation (that this is simply an indicator of stress) is clearly rebutted by comparisons with first millennium and post-Columbian English population which lack evidence of significant periostitis. This (periosteal reaction) is clearly a treponemal phenomenon, indistinguishable from popultions documented as afflicted with treponemal disease

Table 1. Skeletal Manifestations of Treponemal Disease in Early Mexican Populations

	Marismas			Subway		
Population	Tlatilco	Tecualilla	Chalpa Nay	Tunnel #2	Tunnel #1	Tunnel #3
Provenience	1100 BCE	1150-1300 CE		1300 — — — — — —		1521 CE
Population #	125	32	25	64	96	50
Percent afflicted	32	47	48	27	10	12
Subadult #	28	5	2	36	44	18
Percent afflicted	14	40	*	14	0	6
Tibial						
-Unilateral	No	No	No	No	Yes	Yes
-Sabre without periostitis	No	No	No	No	*	*
Hand/foot affected	1%	0	0	16%	0	0
Average number of affected bones	2.4	2.1	2.6	4.5	1.7	1.5
Diagnosis**	Bejel	Bejel	Bejel	Yaws	Syphilis	Syphilis

* Inadequate number present to assess.

** Derived according to criteria documented in Rothschild and Rothschild (1995a,b, 1998).

(Rothschild and Heathcote 1993; Rothschild and Rothschild 1995b; Rothschild et al. 1995).

Documentation of Presence of a Variety of Periosteal Reaction Patterns

The population patterns of periosteal disease in the samples clearly demostrate the presence of three sequential phenomenon (Table 1), each quite different from the preceding phenomenon and from each other. As the phenomenon in Tlatilco and Marismas were identical, they were combined for further analysis (Table 2).

Skeletal populations from tunnels # 1 and # 3 were indistinguishable and therefore also combined for subsequent comparisons (Table 2).

Differential Diagnosis from Non-treponemal Disorders

Other disorders associated with periosteal reaction do not occur with sufficient population frequency (Resnick and Niwayama 1988; Rothschild 1982) to merit serious consideration. Further, they do not cause sabre shin reaction and have very different patterns of skeletal affliction. Hypertrophic osteoarthropathy (Resnick and Niwayama 1988; Rothschild 1982; Rothschild and Martin 1993), thyroid acropachy (Resnick and Niwayama 1988; Rothschild 1982; Rothschild and Yoon 1982), infantiles cortical Hyperostosis (Resnick and Niwayama 1988), hypervitaminosis A, and fluorosis (Resnick and Niwayama 1988; Rothschild and Martin 1993; Seawright and English 1967) can not be the manisfestations of the periostitis found in this study due to the differences in the typical characteristics of each disease.

Table 2. Periosteal Reaction Patterns in Early Mexican Populations

Groups*	Group I	Group II	Group III
Frequency			
-Adult	69/187	17/47	11/85
	|- -(Chi sq = 2.26- -| |- -(Chi sq = 6.068)- -|		
		(non-significant)	(p < 0.01)
	|- - - -Chi sq = 20.25, p < 0.0001)- - - -|		
-Subadult	6/29	5/31	1/61
	|- -(Chi sq = 0.14)- -| |- -Fisher exact test- -|		
	(non-significant)		(p = 0.008)
Average number of bones affected	2.4	4.5	1.6
	|-(t test = 4.398, 85 df, p <0.0005)-|		|-(t test = 2.634, 30 df, p < 0.005)-|
Hand/foot affliction	1/95	12/72	0/140
	|- -Chi sq = 13.91- -|		|- -Fisher exact test- -|
	(p < 0.001)		(l<0.00001)

* Group I = Tlatilco, Tecualilla and Chalpa Nay skeletal populations;
Group II = Skeletal population from Tunnel #2;
Group III = Skeletal populations from Tunnels #1 and #3.

Bejel

The character of periosteal reaction clearly was uniformly represented in Tlatilco and Marismas sites, spanning 2000 years. It is only with the much more recent sites that significant changes is noted, clearly reflecting the appearance of one, then another new disease. While all three disorders were recognized as treponemal in nature, there clearly was a transition among three diseases. The initial disease had all the characteristics of Bejel (Hershkovitz et al. 1995; Rothschild and Rothschild 1995b). Recognition of bone involvement in 32% to 48% of the Tlatilco and Marismas skeletal populations suggests that essentially the entire population was afflicted, a phenemenon typical for Bejel (Hershkovitz 1995; Spirov 1991).

This disease is easily distinguished from the low population penetrance characteristic of Syphilis (Chi square = 20.25, p – 0.0001). Subadult involvement was significantly greater than that noted in Syphilis (Fisher exact test, p = 0.008). Absence of unilateral tibial involvement or of complete sabre shin remodeling also distinguishes the Tlatilco and Marismas populations from those with Syphilis. Their disease is also easily distinguished from the polyostotic disease Yaws, which frequently affects the hands and feet (Chi square = 13.91, p – 0.001).

Yaws

The time period characterized by subway, tunnel # 2 witnessed replacement of the initial disease bejel with a new disease (Table 1), with all the findings previously documented as characteristic of yaws (Rothschild and Heathcote 1993; Rothschild and Rothschild 1995b; Mansilla and Pijoan 1998b). This disease is easily distinguished from the more pauce-ostotic

syphilis (Chi square = 3.973. p-0.05), in which hand and foot and subadult affliction are so rarely observed in skeletal populations (Rothschild and Rothschild 1994, 1995a, 1995b); Rothschild et al. 1995). Other evidence for syphilis (in form of complete sabre shin surface remodeling and unilateral tibial disease) was also lacking. Disease in this tunnel # 2 population was also easily distinguished from the more pauci-ostotic bejel, which infrequently affects hands and feet (Chi square = 13.91, p – 0.001) (Hershkovitz et al. 1995; Rothschild and Rothschild 1995b).

Syphilis

Another transition clearly occurred between the tunnel # 2 and tunnels # 1 and # 3 sites. The polyostotic patterns became pauci-ostotic (Chi square = 6.088, p – 0.01), with infrequent involvement of hands and feet, but with new observation of unilateral tibial affliction. The patterns had changed from that of yaws to that of syphilis (Rothschild and Rothschild 1994, 1995a, 1995b; Rothschild et al. 1995).

Bejel was easily ruled out, on the basis of low population frequency (Chi square = 20.246, p – 0.0001), infrequency of subadult affliction (Fisher exact test, p = 0.008), and recognition of unilateral tibial involvement (Hershkovitz et al. 1995; Rothschild and Rothschild 1995a, 1995b).

Transitions

If the assumption of representativeness of cementery populations (documented for other diseases by Rothschild and Rothschild 1993; Rothschild and Woods 1990, 1991; Rothschild et al. 1988, 1990, 1992; Woods and Rothschild 1988) is accepted, we can suggest that ancient Mexican populations were afflicted with bejel at least 3100 ybp. The latter had apparently been replaced by 1150CE with a new disease, yaws, which was itself replaced by syphilis.

As change in climate cannot be invoked for this phenomenon, the effect of "cultures in conflict" (Crosby) is suggested. Such might lead to alteration in living conditions (Cockburn 1963a; Hackett 1963; O'Neill 1993; Powell 1995). Were the transition among treponemal diseases in Mexico associated with a major change in living condition and habits?

The area of periosteal reaction –treponemal disease transition investigated in this study represents a time of great "sturm und drang" in the history of the Mexican plateau. This area of transition from hunter-gatherers to stable population by 3100 ybp contained a pattern of periosteal reaction quite distinct. It was identical in character to that previously described in 19th century Bedouin and in 4000 ybp Iraq (Kish site) and in Meriotic Sudanese (Rothschild and Rothschild 1996).

It seems possible that the character of treponemal disease remained stable for over 2000 years, until the advent of the Mexicas migrating from Northern Mexico. They apparently populated the area below the Mogollan Plateau in which yaws was endemically represented (Mansilla and Pijoan 1998b) the juxtaposition of timing of documentation of yaws in the capital of the Mexica civilization, and the advent of Mexica conquest of the region, suggest the culpability of the Mexica invaders. If Mexicas were infected with yaws in their original northern Mexico habitat, it would not be surprising that the disease was transported to the central Mexican plateau. As the Mexica culture permeated the area, displacing the endogenous populations, the one disease (bejel) was replaced by a second disease (yaws), already endemic in Mexicas.

A second scenario is that bejel actually disappeared, to be replaced by yaws. The period of conflict (culminating in the Mexica victory) may have been associated with dramatic culture changes which could have altered continued (bejel) transmission (Powell 1995).

The subway project excavation revealed two patterns of disease segregated by tunnel. The susposition is that tunnels # 1 and # 3 represent an area synchronically utilized. The burials in tunnel #2 are quite different in character. Given the reproducibility of findings in archeological sites for other diseases (Rothschild and Rothschild 1993; Rothschild and Woods 1990, 1991; Rothschild et al. 1988, 1990, 1992; Woods and Rothschild 1988) and the internal consistence within the Tlatilco-Marismas and the tunnel # 1 and # 3 groups, it is assumed that the individuals form tunnel # 2 had a disease different from that affliction those in tunnels # 1 and # 3 and also from that found in earlier sites.

Dating of skeletons from the subway excavations is insufficiently precise to allow definitive sequencing. Since the initial timing corresponds to Mexica invasion, yaws was likely the treponematosis that superceded bejel. If it is assumed that the Mexicas were responsible for the introduction of

yaws, perhaps tunnels # 1 and 3 represent victims of another contacting culture, that of Spain. If Spanish mainland contamination by syphilis was as epidemic as suggested (Quetedl, 1990), it would not be surphising that Spanish sailors transmitted it back to sites of Spanish conquest in the New World.

Thus, two options are considered. Did Mexica invasion replace bejel with yaws and Spanish invasion, yaws with syphilis? Did Yaws infest west/central Mexico, while yaws migrated down Mexico's east coast and Mexicas upset the "equilibrium" by introducing syphilis?

Denouement

Documentation that population skeletal manifestations of the treponemal diseases are sufficiently (and reproducibly) distinct (Rothschild and Rothschild 1994; 1995a, 1995b; Rothschild et al. 1995) should allow meaningful assessment of the course of invasion of the various treponemal disorders throughout the world. Application of these criteria to ancient Mexico documents the presence of treponemal disease in the form of Bejel and its subsequent replacement of Yaws and then by Syphilis in these three populations.

Mexica and Spanish invasion clearly represented periods of change. Was the timing of onset of Syphilis in ancient Mexico simply coincident to other changes? Was it related to direct introduction of a new contagious disease? –or were the voyages of Columbus a major contribution factor to social change in ancient Mexico?

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