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The History and Composition of the Raymond A. Dart Collection of Human Skeletons at the University of the Witwatersrand, Johannesburg, South Africa

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ABSTRACT The Raymond A. Dart Collection of Human Skeletons (Dart Collection) is housed in the School of Anatomical Sciences at the University of the Witwatersrand, Johannesburg, South Africa, and comprises one of the largest documented cadaver-derived human skeletal assemblages in the world. This collection originated in the early 1920s as a result of the efforts of Raymond Dart and continues to grow. The skeletons included represent varied indigenous and immigrant populations from southern Africa, Europe and Asia. This contribution documents the history of the collection and provides an updated inventory and demographic assessment of this valuable research collection. According to a recent inventory the Dart Collection currently comprises 2,605 skeletons representing individuals from regional SA African (76%), White (15%), Coloured (4%) and Indian (0.3%) populations. A large proportion of the skeletons (71%) represent males. The recorded ages at death range from the first year to over 100 years of age, but the majority of individuals died between the ages of 20 and 70. The Dart Collection has been affected by collection procedures based on availability. All of the cadavers collected before 1958, and large proportions subsequently, were derived from unclaimed bodies in regional South African hospitals. Some details of documentation (age at death, population group) are estimates and some aspects of the collection demographics (sex ratios) do not closely reflect any living South African population. Our inventory and analysis of the Dart Collection is aimed to assist researchers planning research on the materials from this collection. Am J Phys Anthropol 140:324–335, 2009.

The School of Anatomical Sciences at the University of the Witwatersrand (Wits), Johannesburg, South Africa (formerly known as the Department of Anatomy and Human Biology, and before that, the Department of Anatomy) houses many valuable research collections. These were established mainly due to the efforts of Raymond Arthur Dart and Phillip Vallentine Tobias, two prominent physical anthropologists who spent their careers at Wits and transformed a fledgling department of Anatomy into a center of teaching and research excellence.

Perhaps the most recognized of these collections is that of the fossil hominids presently stored in the (recently named) Phillip Tobias Fossil Primate and Hominid Laboratory. The other important collection associated with the School of Anatomical Sciences is the Raymond A. Dart Collection of Human Skeletons (commonly referred to as 'the Dart Collection'), which contains a documented sample of over 2,500 modern human skeletons of cadaver-derived origin.

Since its inception in the early 1920s, numerous research projects as well as undergraduate, graduate and postgraduate theses and dissertations have been completed utilizing the skeletons comprising this collection. These projects have covered a wide variety of fields including forensic anthropology, population biology, human variation, dentistry, medicine and clinical anatomy (Tal and Tau, 1983; Tobias, 1987, 1991). Moreover, the Dart Collection continues to provide an invaluable resource for research in skeletal biology, paleoanthropology and related disciplines. In South Africa, there is a recognized need (Steyn and İşcan, 1997, 1998) for the development and application of local forensic and osteological standards for human identification, attributed to changes in the nature and incidence of violent crime since the transformation of the country's government in the mid-1990s (Steyn and İşcan, 1997; L'Abbé et al., 2005; Dayal et al., 2008).

There are a number of other human skeletal collections recently publicized and available for research, both in South Africa (L'Abbé et al., 2005; Morris, 2005) and

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elsewhere (Giraudi et al., 1984; Hunt and Albanese, 2005; Eliopoulos et al., 2007; Komar and Grivas, 2008) but the Dart Collection is one of the few human skeletal collections worldwide that are both documented, and whose catalogue numbers in the thousands (see Table 3.1 in Usher, 2002)—perhaps the two best known are the Hamman-Todd Collection (http://www.cmnh.org/site/ResearchandCollections/PhysicalAnthropology/Collections/Hamann-ToddCollection.aspx) and the Terry Collection (Hunt and Albanese, 2005) in the United States.

The objectives of this paper thus are: a) to draw attention to the presence and value of the Dart Collection in the research community; b) to present a comprehensive account of the collection's history (see also (Tal and Tau, 1983; Tobias, 1987, 1991)) and c) to document the composition of the collection in its present state. We anticipate that the information presented here will be of assistance to any researcher working in the Raymond Dart Collection of Human Skeletons.

BACKGROUND

History of the Dart Collection

In January 1923, Australian born anatomist Raymond Dart took over the Headship of the Anatomy Department at the recently established University of the Witwatersrand, Johannesburg. Although the position might have looked very appealing for a young scientist (Dart was only 32 when he arrived in South Africa) the truth was altogether a different matter. Before coming to South Africa, Dart had been working under the famous neuroanatomist and anthropologist Sir Grafton Elliot Smith at the University College, London, one of the leading research institutions in the field of anatomy. Going to a little known provincial university was not much of a prospect for a young, ambitious scientist. Even the headship did not mean much—when he arrived Dart was the only academic staff member, and had only one technician working under him. Dart's arrival in Johannesburg was not voluntary (Dart and Craig, 1959; Wheelhouse and Smithford, 2001). He was, in fact, advised by Smith to apply for the position. Initially, Dart did not comply but was then strongly urged by Smith to do so and later to accept the position when offered (only two candidates applied; the other one was chosen only to refuse the offer and leave it to Dart). The reason for Smith's 'recommendation' was probably due to Dart's personality. Dart was known as a gifted anatomist but also as a maverick scientist who tended too easily to heterodoxy and was prone to make statements which were seen to be inadequately substantiated (Keith, 1950). This reputation would follow Dart until the end of his career.

Dart's first impression of the Anatomy Department at Wits was less than enthusiastic as there were virtually no resources for scientific research (Dart and Craig, 1959). Rather than give in to dissolution, the energetic Dart decided to take on the task of building his newly acquired department from nothing. He was soon engaged in organizing an anatomy museum, library, laboratories and collections necessary for teaching and research. Although new acquisitions were often paid for from Dart's own pocket, he managed to keep his enthusiasm for improving the department's facilities. Subsequently, the interest seems to have spread to students and new staff members alike. Indeed, one such enthusiastic student—Josephine Salmons brought Dart a fossilized baboon skull from the Buxton Lime Quarry next to the small town of Taung. This was the first in the chain of events which would lead to one of the most important discoveries in the history of paleoanthropology—that of the Taung skull (Dart, 1925; Tobias, 1984, 1990c; Gundling, 2005; Kuykendall and Štrkalj, 2007).

The collection that Dart found particularly important was that of human skeletons. The idea of such a collection came from an intellectual legacy going back to Sir William Turner of the University of Edinburgh and George S. Huntington of the College of Physicians and Surgeons in New York (Tobias, 1985, 1987; Hunt and Albanese, 2005). There has been an amazing continuation of scientific tradition backwards and forwards between the continents: Europe, America, Africa and Australia (Tobias, 1984, 1987; Hunt and Albanese, 2005; Tobias, 2005). Dart was introduced to it in the Anatomy Department of Washington University, St. Louis which he visited as a Rockefeller Fellow in 1921 (Tobias, 1984, 1987, 2005). There, Robert James Terry, professor of anatomy and a former student of both Turner and Huntington (in 1890s) started the collection of cadaver-derived skeletons of known age and sex from both African- and European-American populations (Trotter, 1981; Hunt and Albanese, 2005). Dart also visited the anatomy Department at Case Western Reserve University in Cleveland. The department was headed by Thomas Wingate Todd, who continued the tradition of building the collection of human skeletons (now known as the Hamann–Todd Collection), which was established by his predecessor Carl August Hamann. Like Terry and Todd, Dart realized the value of such collections and made it a priority to assemble one at Wits which would match those housed in St. Louis and Cleveland. Later Dart's staff and that of his successors, who continued their careers at other anatomy departments, continued this tradition of establishing human skeletal collections: Alexander Galloway in the Makarere College, Kampala, Uganda, David Allbrook and Leonard Freedman in the University of Western Australia in Perth.

Dart was known as an inventive anatomy teacher, with a knack for introducing new approaches to dissection of the human body. One of the imperatives of Dart's dissecting technique was to induce minimum damage to the bones (e.g. cutting only a few ribs and the calotte) to produce a skeletal collection of essentially intact specimens. Dart's dissection techniques were further improved by his students Phillip Vallentine Tobias and Maurice Arnold (1963–1964) and later John Cameron Allan, and described in the highly successful dissection manual *Man's Anatomy* which has endured numerous editions. It is still in use in some South African universities in its abridged version *Practical Anatomy*, authored by Jules Kieser and John C. Allan (1999).

The skeletal collection established by Dart was growing annually, increasing with the number of students in various medical and science courses. In 1958, after 32 years of service in Wits' Anatomy Department, Dart retired from active academic service. The skeletal collection at that time consisted of more than a thousand skeletons (Tobias P. 1995. Anatomia Witwatersrandensis: a brief history of the Wits anatomy department. Unpublished typescript). The headship of the department was taken over by Dart's young protégé Phillip Tobias (Štrkalj and Pather, 2005). Tobias also realized the importance of the skeletal collection and continued Dart's programme to further increase its numbers (Tobias, 1991).

Upon Dart's retirement, and to honour the great scientist's contribution, the collection was named, at Tobias's

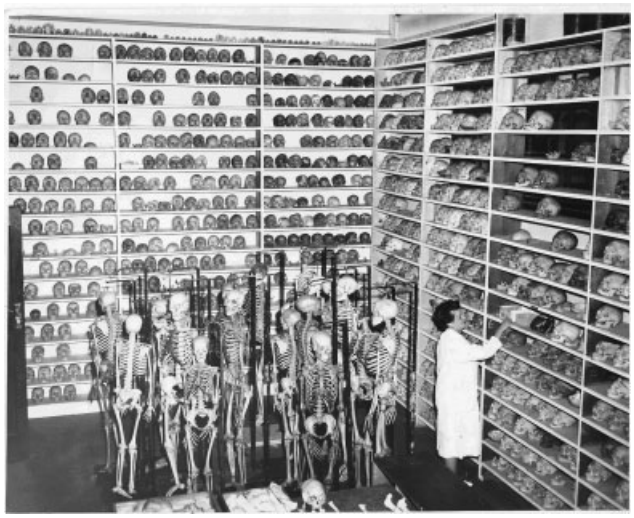

Fig. 1. The RA Dart Collection in the 1950s.

instigation, the Raymond Dart Collection of Human Skeletons (Tobias, 1987). However, in 1959, the year when Tobias took over the department from Dart, disaster struck the Raymond Dart Collection (Tobias P. 2005. Personal communication, interview with G. Štrkalj). At that time, the collection was kept in the basement of the Wits Medical School, into which water flooded from burst pipes in the Hospital Street, where the Medical School was situated, and spread to submerge much of the collection. Many of the skeletons came out of the boxes and were floating freely. The staff at the Anatomy Department collected them all and took them to the roof to dry out. Once they dried completely they were returned to the boxes. However, in the process some of them were mixed and as a consequence many boxes contained remains of more than one individual. There were two instances when the mixing occurred—in the basement during the flood and on the roof when all the bones were removed from their boxes. Unfortunately, at that time individual bones were not marked with accession numbers and bone marking started only as a consequence of this accident (Tobias, 2005). This mixing of the bones was never rectified and a number of researchers working in the collection have noted the problem with the pre-1959 specimens (Tal and Tau, 1983; Tobias, 2005). It is not possible to document exactly how many of the skeletons were mixed in this incident, but the records show that 1,265 cadaver-derived skeletons have recorded dates of death prior to the end of 1959, suggesting that a substantial number of skeletons were potentially affected.

The positive effect of the incident was the construction of a new storage facility next to the Anatomy Department for the collection (Tobias, 2005). New shelves were made and skulls were stored separately from the postcranial material (see Fig. 1), due to the fact that a proportionally larger number of researchers had been interested in the study of skulls only. When the Medical School moved from the suburb of Hillbrow to new premises in Parktown, much larger and better-equipped storage and study rooms were allocated to the collection.

The main focus of improving the collection in Tobias's time was to achieve a more 'equal representation' of all South African populations and both sexes—a similar problem was faced in the Terry Collection as reported by Trotter (1981). This task in the Dart Collection seemed to be generally improved in the early 1980s when the total number of skeletons was approximately 3,000. Consequently, the skeletonisation activities were modified and reduced during this time, and only skeletons of the groups that were not well represented or those of the individuals considered to be of research interest (e.g. anatomical variation, unusual pathology, etc.) were subsequently added to the collection.

Over time, additions to the collection included unprovenanced skeletal remains derived from a variety of sources including archaeological collections and donations. These specimens largely constitute the deaccessioned material discussed below, and together they represent the most sensitive and ethically challenging component of the collection (Legassick and Rassool, 2000) and are generally not used (or useful) for research purposes. In time, they may require special consideration under the South African Heritage Resources Act (SAHRA, 1999).

According to notes accompanying the original collection catalogue, the exchange of skeletal material with other institutions was not unusual in the early years (in the 1920s and 1930s). The record-keeping was not as meticulous at that time, and the precise information about these exchanges is unfortunately missing. For example, according to the catalogue records two skeletons were sent to Italy in 1925, and four more in 1926—but the exact destination in Italy was not recorded. Six skulls (three without mandibles) were received from Italian anthropologist Fabio Frassetto, Chair of Anthropology at the University of Bologna. Six skeletons were sent to the United States and one to Australia during this period. Again, details are missing, but it would appear that at least five of the skeletons that went to the United States were sent to Terry for his collection in Washington University (Hunt and Albanese, 2005). In 1930, five skeletons of Native Americans (members of the Arikara nation of Northern Dakota) were received from Terry. Finally, two skeletons were donated from Australia while a single skull was received from Paris, France. Records for these specimens are now also deaccessioned as the material itself is no longer present in the collection.

As the collection grew a number of damaged skeletons were designated for use in teaching anatomy and osteology, and also constitute part of the deaccessioned material. Currently, this separately-curated 'Teaching Collection' consists of approximately 350 skeletons that are annually distributed (a whole or a half skeleton depending on the course) to students in medicine and the allied medical disciplines for use during their academic year in the School. Although the Teaching Collection is not officially part of the Raymond Dart Collection, it is historically derived from it and has occasionally been used in specific research projects when bone modification or sampling (i.e., for possible DNA extraction) is required.

Upon Tobias's retirement in 1990 Maciej Henneberg took over the Headship of the Department. To enlarge the size of the collection it was decided that the process should be reactivated. After his departure in the beginning of late 1990s, however, a considerable number of skeletons were deaccessioned in a maintenance exercise for the collection—as mentioned above, 'deaccessioning' of skeletons only applied to material that was without provenance, such as isolated archeological material and other 'donated' finds, or that was missing due to long

term loan (i.e., for decades). Such fragmentary and undocumented material, if actually present, was not considered useful for research; in any event the original documentation was preserved as an historical archive and all available specimens were also retained. Thus, the Dart Collection skeletons, following the deaccessioning exercise, now consist wholly of cadaver-derived specimens accompanied by some degree of documentation and once utilized in the anatomy teaching programme.

The skeletonisation programme is ongoing and generally adds to the Dart Collection annually, but the number of skeletons available has dropped because of changes in the medical curriculum and the demand for prosected specimens in the new anatomy teaching programme.

Acquisition procedures for Dart Collection

The cadaver-derived skeletons that comprise the Raymond Dart Collection have always been collected under the provision of South Africa's Human Tissues Act (No. 65 of 1983, and by previous Acts, e.g. the Anatomy Act No. 20 of 1959), to supply materials for medical research and teaching. For many years, the Dart Collection specimens represented unclaimed bodies from Gauteng (and previously from Transvaal) Provincial hospitals, but since 1958 a bequeathment programme has increasingly contributed to the collection, providing cadavers to the School of Anatomical Sciences for teaching and research in medical sciences. The collection records document that the number of bequeathed cadavers increased yearly and finally exceeded that of unclaimed cadavers in 1992, but currently is in decline.

It is common for documented human skeletal collections to include a mix of unclaimed and bequeathed remains (Hunt and Albanese, 2005; L'Abbé et al., 2005; Komar and Grivas, 2008). These acquisition practices each bring different potential biases to the collection regarding the age, sex, health and socioeconomic representation of the sample (Usher, 2002; Komar and Grivas, 2008), all of which must be given due consideration in determining the suitability of a research sample to a particular research problem.

Skeletonisation process

The preparation and cleaning of the skeletons for the Dart Collection generally follows procedures used for similar collections elsewhere (Stephens, 1979; Nawrocki, 1997; Fenton et al., 2003; Hunt and Albanese, 2005; Eliopoulos et al., 2007), and involves several phases. After cadavers have been utilized for dissection in the anatomy programme, the remaining soft tissue is removed as completely as possible using scalpels and other dissection equipment. The bones and the remaining (minimal) soft tissue are placed in wire-screen mesh or cloth bags to avoid loss of small elements, and heated continuously in water to the boiling point for 5 days without interruption—water must be added to cover the bones throughout this process. Following this procedure, any remaining soft tissue is removed manually and the bones are cleaned thoroughly with soft brushes. The bones are then chemically cleaned and degreased in a special degreasing unit using trichloroethylene. The bones are then kept in the degreasing unit for 5 days at simmering point. The bones are removed from the degreasing unit and allowed to cool and dry (Legodi P. 2005. Personal communication, interview with G. Štrkalj).

Finally, the bones are soaked for 5 days in a 50-l tank containing 200 ml of hydrogen peroxide diluted in water at room temperature. At the end of this procedure, the bones are allowed to dry for a final time. When dry, the bones are labeled and catalogued, boxed and transported to the collection storage area.

Documentation of the collection

In mid-1980s Jeffrey McKee (then a lecturer in the Department of Anatomy and Human Biology) compiled an electronic database of all material in the Dart Collection. This database was subsequently expanded and developed further through the efforts of Mike Raath under the direction of the departmental Collections Committee as part of the deaccessioning exercise mentioned above. This database remains in use and is updated as new skeletons are added to the Dart Collection.

During the deaccessioning exercise Mike Raath, assisted by Elijah Mofokeng and Portia Mamiane and a number of student assistants, completed a physical check of each box/skeleton number on the catalogue list. A complete inventory of materials present in the collection was produced, resolving many discrepancies in the records, deaccessioning the missing materials as mentioned, recoding many of the variables in the database such as population affinity and age (see below), and adding to the records existing supplementary information about individual skeletons from the original hand-written accession list and other available documentation.

Population affinity. The documentation of population affinity is an important demographic aspect of any skeletal collection, but is not straightforward. In the southern African region, population migrations during prehistoric and historic periods have involved populations throughout the African continent as well as from Europe and Asia (Nurse et al., 1984; Soodyal, 2006). Thus, the South African populations from which the Dart Collection is derived are extremely diverse in their culture, linguistics, biology and genetics. The complex and conflicting nature of such concepts as 'race' and 'tribe' have been widely discussed (Cartmill, 1998; Kaszycka and Štrkalj, 2002; Wang et al., 2003; Lieberman et al., 2004), and is particularly acute given the socio-political context of South Africa (Morris, 1988; Ellison and de Wett, 1997; Štrkalj et al., 2004). Biological variation of local South African populations has been vigorously studied from the nineteenth century onwards (Nurse et al., 1984; Tobias, 1985; Dubow, 1995; Legassick and Rassool, 2000; Štrkalj, 2000; Morris, 2005), including both typological and more fluid concepts of 'race'. In the South African context (and elsewhere), there is added confusion stemming from a separation of 'ethnic' and 'biological' identity (MacEachern, 2000; Morris, 2000), so that individuals may not self-identify consistently with either a particular 'tribe' or 'race'.

In this context, it is not surprising that the population classifications for local 'tribes' used in the Dart collection records over the years have been problematic. The indigenous South African populations experienced extensive detribalisation before and during the period of collection (De Villiers, 1968), and many individuals represented by skeletons in the collection were migrant workers whose origin was either not known or not accurately recorded on their death certificate (from which some Dart Collection data are derived). In at least some cases, it is reported that 'tribe' was determined from an individual's surname or other contextual information (Tal and Tau,

TABLE 1. List of abbreviations used in the catalogue of the Raymond Dart Collection of Human Skeletons. (Reprinted with permission from the School of Anatomical Sciences, University of the Witwatersrand.)

RAYMOND DART COLLECTION OF HUMAN SKELETONS
Department of Anatomical Sciences
Faculty of Health Sciences
University of the Witwatersrand, Johannesburg

KEY TO HEADINGS, ABBREVIATIONS AND CONVENTIONS USED IN THE CATALOGUE

COLUMN HEADINGS

A No	Raymond Dart Collection catalogue number
AD No	cadaver catalogue number (cadaver-derived specimens only)
IA No	'Inspector of Anatomy Register' number (cadaver-derived specimens only)
Pop Gp	population group ('Tribe') (see Table of Abbreviations in far right column)
Sex	self explanatory
Age	in years, or assessed category
Death Date ..	date of death as recorded in AD and IA registers
Skel	post-cranial skeleton
Calv	calvaria or calotte
Mndb	mandible
Notes	self explanatory
Source/Status	derivation and/or current status of individual specimens (see adjacent column for conventions)

ABBREVIATIONS / CONVENTIONS USED IN COLUMNS

A No :
Numbers run serially, and are unique (in a few early cases A Numbers were inadvertently duplicated; where it was impossible to resolve, the specimens concerned have been de-accessioned and transferred to other collections or discarded, and the entry annotated accordingly; where they could be resolved, they have been differentiated by suffixes - e.g. 130A, 130B).

AD No :
Applies only to specimens derived from hospital cadavers, not to 'ex situ' specimens (= donated or archaeological material).

IA No :
Register number for Government Inspector of Anatomy records (details in this register include Death Certificate details, etc; *not accessible except with special prior permission of the Head of Department*).

Pop Gp :
See Table of Abbreviations adjacent.

Sex :
F = female; M = male; ? = not stated; blank = unknown.

Age :
As assessed or recorded in Death Certificate by attending doctor (for cadavers), or as assessed by researcher / excavator (for 'ex situ' specimens):
ADU = adult;
JUV = juvenile;
IMM = immature;
N/S = not stated;
S/B = still-born.
Infant ages recorded as 'y:m', e.g. 0:8 = eight months old; 1:5 = one year and five months.

Death Dt:
Date of death as recorded in Death Certificate, in the format 'mm/dd/yy'.

Skel, Calv, Mndb :
F = fragmentary, N = absent,
P = partial, Y = present

Source / Status :
CADAVER = cadaver derived specimen;
DEACC = specimen de-accessioned and transferred elsewhere or disposed of. *Entries for de-accessioned specimens are shaded grey.* Where de-accessioned material has been transferred to another departmental collection, that fact is recorded; this material is therefore available for study on request;
EX SITU = specimen from an external source (i.e. not from a cadaver), incl. material from archaeological excavations or donated by external donors;
AR = archaeological 'ex situ' material;
DN = donated 'ex situ' material;
LB = transferred to 'Loose Bones' Collection, and available for special study (possibly including destructive procedures);
NO PROV / NP = no provenance available;
T1, T2, T3 = transferred to components of departmental Teaching Collections (therefore available for study on request).

TABLE OF ABBREVIATIONS FOR POPULATION GROUPS
*(Note: since the 1990s, details of Population Group have not been recorded)**

?	Unknown or not stated
AMAZ ...	Amazizi (South Africa)
AMIN	Native American
AMNE ...	African American
AUAB ...	Australian Aboriginal
AZTE	Native South American ('Aztec')
BACA ...	Amabaca (South Africa)
BUSH	San ('Bushman') (South Africa)
CAUC ...	'Caucasian' (?White)
CHIN	Chinese
COAN ...	Coana (South Africa)
DAMA ...	Damara (Namibia)
ESKI	Inuit ('Eskimo') (North America)
EURO ...	'European' (White South African)
FING	Amafingu (South Africa)
GONI	Ngoni (?Nguni) (South Africa)
GRIQ	'Griqua' (?Khoi-Khoi) (South Africa)
HERE	Herero (Namibia)
HLUB ...	Hlubi (South Africa)
HOTT ...	'Hottentot' (?Khoi-Khoi) (South Africa)
HYBR ...	Mixed-race
INDI	Indian
KALA ...	Kalanga (Karanga) (Zimbabwe)
KUND ...	Kunda (South Africa)
MALA ...	Malawian
MCHO ...	Mchopi (South Africa)
MIXE	Mixed-race ('Coloured') (South Africa)
MLAY ...	Malay (South Africa)
MOCA ...	Mocanana (South Africa)
MOQU ...	Moquoi (South Africa)
MOZA ...	Mocambican
N/S	Not Stated (Black South African, of unstipulated population group)
NDEB ...	Ndebele (South Africa)
NYAM ...	Nyambaan (South Africa)
NYIK	Manyika (Zimbabwe)
OVAM ...	Ovambo (Namibia)
PEDI	Pedi (South Africa)
POND ...	Pondo (South Africa)
ROLO ...	Rolong (Botswana)
ROTS	Barotse (Zambia)
SAKI	Sakia (South Africa)
SHAN ...	Shangaan (South Africa)
SHIN	Shinga (South Africa)
SHON ...	Mashona (Zimbabwe)
SOTO	Sotho (South Africa)
SWAZ ...	Swazi (South Africa / Swaziland)
TEMB ...	Tembu (South Africa)
TSON	Tsonga (South Africa)
TSWA ...	Tswana (South Africa / Botswana)
VEND ...	Venda (South Africa)
XOSA	Xhosa (South Africa)
ZULU	Zulu (South Africa)

**The 'Population Group' is as recorded on the Death Certificate (for cadavers) or as assessed by the excavator / researcher (for 'ex situ' material). From the 1990s, this information was no longer recorded other than as 'White' or 'S.A.N. / Black'.*

1983) and not from a confirmed source. In addition, South Africa's changing national and academic policies regarding racial classification (Morris, 1988) also caused ambiguities—for example, some skeletons were designated in the original catalogue as a member of a specific tribal group such as 'Zulu', and others more generally as 'South African Negro' (S.A.N.) or 'N/S' ('not specified', which also applied to 'donated' archeological finds). Further ambiguities include the category designating members of the South African 'Coloured' population—a formal population designation in South Africa for those of mixed (African, European, Asian) ancestry; recorded at different times as 'Coloured', 'Mixed' or 'Hybrid'. Similarly, skeletons representing individuals of European ancestry were recorded as either 'White', 'Euro' or 'Caucasian'. Table 1 is a list of the abbreviations as used in the original catalogue.

The South African 'tribal' populations represented in the collection have been shown to be homogeneous morphologically in both cranial (De Villiers, 1968) and post-

TABLE 2. Summary of the Dart Collection deaccessioning exercise (1997)

Source code	Subcategory	*N*	Totals	Comments
CADAVER		2,567	2567	Total number of cadaver-derived specimens from bequeathed and unclaimed bodies; used in teaching anatomy
DEACC		1,447		Total number of deaccessioned skeletons due to various circumstances (see below)
	DEACC	506		Deaccessioned material due to long-term loan, material once on loan to Wits but since returned to original source, or specimens absent (records exist, but not box could be located). This material no longer physically exists in the collection
	DEACC (FH)	2		Border Cave specimens now accessioned in the Fossil hominid collection
	DEACC (LB)	6		Fragmentary and/or damaged isolated specimens now in the Loose Bones collection; can be made available for destructive research samples
	DEACC (T)	186	700	Material now accessioned in one of the Teaching Collections of the School of Anatomical Sciences; including specimens long used in teaching, once articulated, and incomplete or damaged specimens which were not deemed useful in research; however, these specimens may be made available for research (including destructive methods) by arrangement
	EX SITU (AR)	282		*Ex situ* material includes skeletons from an external source (i.e., not cadaver-derived); this category includes all material derived from known archaeological sites or context (included donations from amateur collectors)
	EX SITU (DN)	344		*Ex situ* skeletal material from donated sources, including fragmentary isolated finds from presumed recent context, isolated skulls and bones from other collections, and some material from known sites such as the Historic Cave at Makapansgat
	EX SITU (NP)	110	736	Donated *ex situ* material with no known provenance or accompanying information
	NO PROV	11	11	Isolated skulls from unknown sources

The original documentation consisted of records for 4,014 specimens, many of which were not present on the collection shelves. See Table 1 for an explanation of the Source Code and Subcategory labels.

cranial measures (Lundy, 1983). The new database coding system has combined different population group categories to eliminated ambiguities and dual categories, though the terminology used is still anachronistic. The South African census utilizes the population categories African, White, Coloured and Asian/Indian (Statistics South Africa, 2006). For this database, to highlight the South African origin of these skeletons, we reflect the census categories by using the groups South African (or SA) African, SA White, SA Coloured and SA Asian/Indian.

Sex and Age. The classification of individual sex and age for the Dart Collection skeletons is more straightforward, but not without issue. Although sex was (presumably accurately) recorded from medical records and soft tissue inspection for all but a small number of specimens (see results), stated ages at death data are more difficult to confirm for accuracy. Given the high proportion of unclaimed bodies that are represented in the collection, and the fact that they often represent migrant laborers from outside the Gauteng (Johannesburg) region, the accuracy of this age data is known to be questionable (Tal and Tau, 1983). However, the available documentation includes the recorded age (in years) for 2,559 skeletons in the collection (the age distribution for the collection is discussed below).

In addition, the only age at death recorded for some individuals ($N = 46$) was a general age category such as 'Infant', 'Juvenile' or 'Adult'. However, the specific criteria employed for such age determinations at different time periods of data collection are not known.

The definition and use of age categories in skeletal biology varies among studies (Steele and Bramblett, 1988; Morris, 1992; Saunders, 1992) without agreement on any universal standards. There is also the issue of comparing physiological or maturity ages (Demirjian, 1986; Saunders, 1992) to recorded chronological ages, causing further difficulty in the use and comparison of reference collections.

In acknowledging these difficulties in recording useful age estimates, the original age at death data in the Dart Collection database have been retained, but they have also been recorded into a categorical maturity 'age' variable (see Table 3) and a 10-year categorical age variable (see Table 5) to facilitate comparison with other published studies, and to allow construction of aged samples using different criteria.

CURRENT COMPOSITION OF THE COLLECTION

An analysis of the skeletal composition of the Dart Collection follows, to reflect the organizational changes to the Dart Collection database resulting from the recent inventory and deaccessioning exercise, and to assist future researchers in planning projects utilizing this collection. Except in Table 2, the deaccessioned skeletal materials are not included in the following analyses. Tables, figures and statistics presented were produced in Microsoft Excel 2002 and SPSS v. 14.

The deaccessioning process dramatically altered the original composition of the Dart Collection and the result of this process is summarized in Table 2. In 1997, the Dart Collection records documented 4,014 skeletons that had been, at one time or another, accessioned into the Dart Collection. These came from a variety of sources, including cadavers used in teaching anatomy, archaeological sites, donations from amateur collectors, police cases and loans or acquisitions from other collections around the world. As indicated above, some of these skeletons were used for teaching osteology, provided on 'long term' loan to other institutions, and some were apparently lost or damaged without record. In total, 1,447 skeletons were deaccessioned during this process, but the material on long-term loan (DEACC), that used in the teaching collections, DEACC (T), and some from *ex situ* contexts (see Table 2) were not actually present on the shelves. In addition, the Dart Collection records included two Border Cave skeletons now housed in the Fossil Hominid collection and a wide variety of fragmen-

TABLE 3. Demographic composition of the Dart Collection, reporting the population group categories (see Table 1) as originally recorded in the collection records

Population group	Males				Females				Total
	0–5 y	6–19 y	20–59 y	60+ y	0–5 y	6–19 y	20–59 y	60+ y	
AMNE				1					1
BACA			11	4					15
BUSH			1						1
CHIN				1					1
COAN			1	1					2
DAMA			1						1
EURO		3	68	192	1	1	39	168	472
FING			10	7		1	9	2	29
GONI			1	1					2
GRIQ			16	1			5		22
HLUB	1		4	3			3		11
HOTT			4	4			1	2	11
INDI			2	3					5
KALA		1	10	2					13
MALA		1	31	7	1				40
MCHO				1					1
MIXE	1	1	42	29	1	1	32	8	115
MLAY				1					1
MOCA							1		1
MOZA			2	4					6
N/S	4	4	117	42	3	3	47	19	239
NDEB			32	3		1	4	2	42
NYAM			2	2					4
NYIK			2						2
PEDI			12	4			3		19
POND		1	20	3			1		25
ROLO		2	4	3		1	7	1	18
ROTS			2						2
S.A.N.		1	48	7		2	20	4	82
SAKI							1		1
SHAN	1	1	61	18	1	1	4		87
SHIN			2						2
SHON			2						2
SOTO	4	11	184	61	6	6	85	21	378
SWAZ	2	4	41	14		1	16	5	83
TEMB				1			1		2
TSON			11	3					14
TSWA	1	3	36	18	0	2	25	7	92
VEND		1	39	5			3	1	49
XOSA	2	8	119	34		1	43	15	222
ZULU	2	8	226	100	4	5	74	25	444
Total	**18**	**50**	**1,164**	**580**	**17**	**26**	**424**	**280**	**2,559**

Indigenous South African population groups are indicated in boldface. Specimens without recorded age at death (N = 46, bringing the total to 2,605) are not included.

tary, isolated, and largely undocumented archaeological and donated material, including for example, a number of skeletons from the Historic Cave (or Gwaŝa) at Makapansgat. Following the deaccessioning exercise, there were a total of 3,039 skeletons, primarily from cadaveric sources (N = 2,605), but including some remaining *ex situ* material (archaeological and donations; N = 434). Henceforth, only the 2,605 cadaver-derived skeletons are considered to comprise the Dart Collection.

Table 3 represents the current cadaver-derived Dart Collection composition as recorded by categories used in the original database, including population groups, sex and age at death using maturity categories. The SA population groups represented by the largest skeletal samples in the collection are the Zulu (444), Sotho (378) and Xhosa (222); the 'S.A.N.' and 'N/S' groups are also large, and represent SA African population groups recorded as 'South African Negro' and 'Not Specified' from the 1990s. The European group (EURO, sometimes also recorded as 'Caucasian') is also well represented (N = 472) compared with most other population groups.

Table 4 summarizes the sex and population group demography of these cadaver-derived skeletons in the Dart Collection. Note that the collection is comprised of approximately 72% SA African, 18% SA White and considerably smaller proportions of other groups. In addition, there are 756 female skeletons (29%) and 1,840 males (71%).

A summary of the recorded age-at-death categories in 10-year intervals of the cadaver-derived skeletons in the Dart Collection, subdivided by population group can be viewed in Table 5. Only the SA African population group (the largest population sample in the collection) includes individuals representing all age and sex categories; other than the SA Whites, other population groups are extremely depleted when subdivided by age and sex categories. However, when the complete collection is considered, both males and females are represented in all age

TABLE 4. Sex and population group demography of the cadaver-derived skeletons in the Dart Collection

Population Group	Males		Females		Unknown	
	N	%	*N*	%	*N*	%
SA African	1390	75.5	486	64.3	4	44.4
SA Whites	268	14.6	210	27.8	1	11.1
SA Coloured	74	4.0	42	5.6	1	11.1
SA Indians	5	0.3				
Other SA	26	1.4	8	1.1	2	22.2
Other African	74	4.0	10	1.3		
Other (Worldwide)	2	0.1				
Unknown	1	0.1			1	11.1
Total (2,605)	**1,840**		**756**		**9**	

categories, and most of the individuals represented in the Dart Collection were adults who died between the ages of 20 and 70 years.

A frequency distribution of the documented age at death for all cadaver-derived skeletons in the Dart Collection is illustrated in Figure 2. Notably, this figure demonstrates major age 'spikes' at 10-year intervals and lesser 'spikes' at intervening 5-year intervals (a similar pattern was observed for both males and females). This pattern suggests that the recorded age-at-death for many individuals represents an estimate to the nearest 5- or 10-year interval, rather than actual reported (known) ages, but that ages in between are likely to be accurately recorded.

As can be observed from Figure 2, it is difficult to describe the age distribution as 'normal'. However, of the 2,560 skeletons accompanied by age-at-death records, 1,034 fall on 5- or 10-year age intervals (e.g., 20 or 25 years, etc). As demonstrated in Figure 2, the frequency for some age values (e.g., 50 years) is more than three times that of either adjacent age value (i.e., 49 or 51). Thus, good practice would insure that these age categories are not over-represented (but can be included) in any study sample drawn from this collection.

The general shape of the age distribution, and the skewness and kurtosis values obtained, suggest that the age data for the entire sample, and for males and females overall (not shown) are roughly normal. However, when the age data are subdivided by population group, and by sex within population groups, the resulting distribution curves are skewed. For the SA Coloured and SA Indian samples, this is a factor of small available sample sizes; for the SA White sample, it seems to relate to a sampling bias for older-aged individuals. Figure 3 illustrates a box-and-whisker plot of age at death for the three most numerous SA population groups in the Dart Collection. Although the age at death ranges for males and females within population groups largely overlap, a nonparametric test of medians for *K* independent samples in SPSS produced significant results between median ages for males and females in the SA African sample ($\chi^2 = 25.38$, $P < 0.001$), but not for the SA White or SA Coloured samples (the SA Indian sample was too small to produce a result). There is a clear discrepancy in the ages at death between population groups; the median values for the SA White sample are older by roughly 20 years in males and 30 years in females compared to the SA African and Coloured samples (with both sexes included, the median age for the SA White sample is 70 years, compared with that of 45 and 49 years for the SA African and SA Coloured samples, respectively). In addition, whereas the distribution of

TABLE 5. Age at death categories (10-year) for skeletons in the Dart Collection by population group and sex

Population Group	Males										Females									
	0–10 y	10–19 y	20–29 y	30–39 y	40–49 y	50–59 y	60–69 y	70–79 y	80–89 y	90+ y	0–10 y	10–19 y	20–29 y	30–39 y	40–49 y	50–59 y	60–69 y	70–79 y	80–89 y	90+ y
SA African	21	38	135	242	311	289	212	80	33	8	15	22	80	105	88	67	60	27	11	3
SA Whites	2	1	1	6	26	35	64	73	50	5	1	1	3	1	9	26	56	51	55	6
SA Coloured	1	1	6	9	15	12	10	8	8	3	1	1	7	10	7	8	5	2	1	
SA Indians					1	1	2	1												
Other SA			3	3	6	9	2	2	1					1	3	2	1		1	
Other African		4	16	19	12	7	10	2	1	3	1	1	4	1	2		1			
Other (Worldwide)								2												
Unknown			1																	
Total	24	44	162	279	371	353	300	168	93	19	18	25	94	118	109	103	123	80	68	9

Note that this table includes only 2,560 of the 2,605 cadaver-derived specimens, as the age at death for some was recorded only as a categorical value (e.g., 'infant' or 'adult').

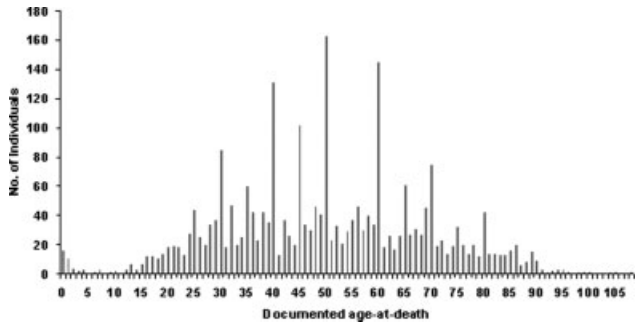

Fig. 2. Age at death distribution of cadaver-derived skeletons in the Dart Collection.

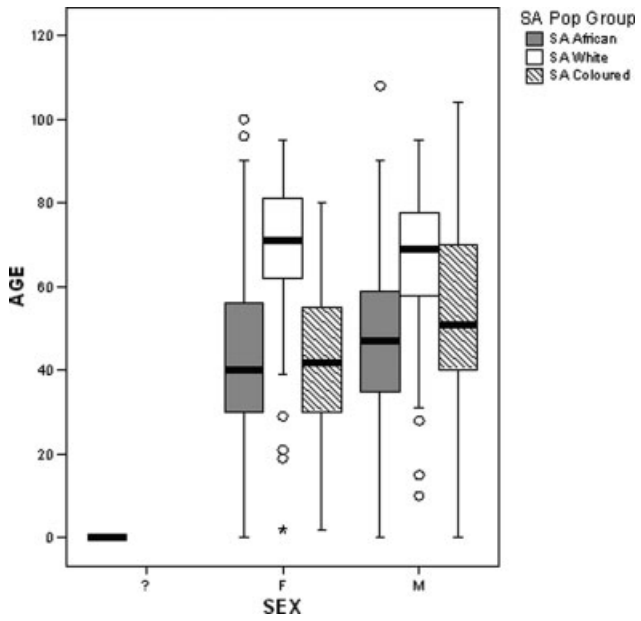

Fig. 3. Age at death for SA African, White and Coloured samples in the Dart Collection cadaver-derived sample. Box-and-whisker plots show median age, interquartile range and outliers.

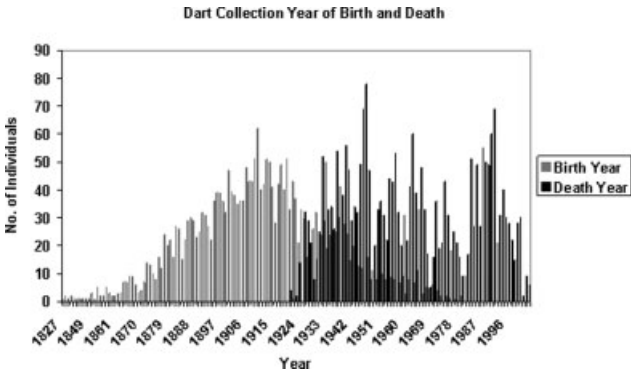

Fig. 4. Frequency distributions for calculated year of birth and year of death for cadaver-derived skeletons in the Dart Collection.

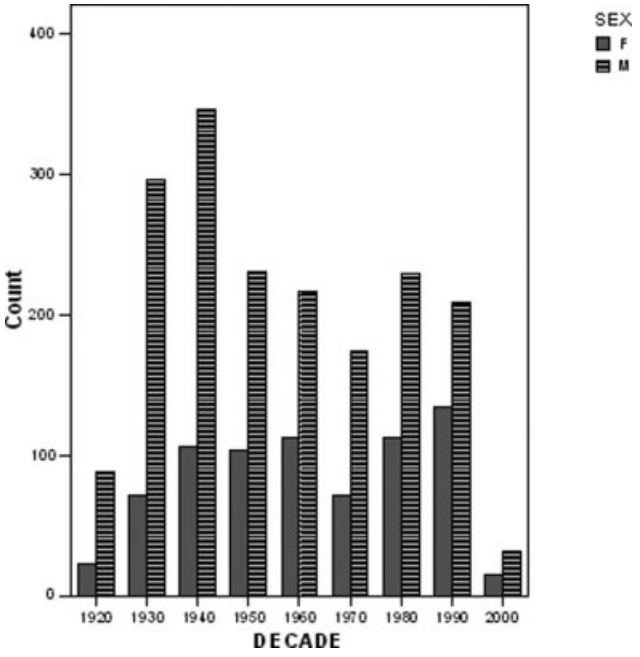

Fig. 5. Year of death by decade for males and females in the cadaver-derived Dart Collection.

ages for the latter two population groups includes both older and younger extremes, there are very few white individuals represented at ages younger than approximately 40 years. The difference in median age between population samples (sexes combined) again obtained a significant result using the nonparametric median test ($\chi^2 = 416.43$, $P < 0.001$).

Figure 4 portrays the frequency distributions for calculated year of birth (year of death minus recorded age) and year of death (which is equivalent to the year of entry into the collection) for cadaver-derived skeletons in the Dart Collection. It is interesting to note that the distribution of year of death (i.e., of entry into the collection) is extremely irregular, while that for the calculated year of birth is approximately normal. This may simply be due to the large sample size involved (resulting in normality of the calculated year of birth distribution), and the 'randomness' of selection of skeletons (leading to irregularity in the year of death distribution), which was based on availability during any given interval.

In addition, the birth years span a period of approximately one and one-half centuries (1827–1980), encompassing dramatic changes in the country's sociopolitical development, technology and lifestyle. It is impossible to say exactly how such phenomena may have affected individuals living at different times during this period, but it is unlikely that any identifiable groupings can be regarded as biosocially 'homogeneous populations'.

Figure 5 presents the frequency distribution of the year of death by decade for males and females in the cadaver-derived Dart Collection sample. In any decade, a larger sample of males was incorporated into the collection compared to females (as indicated by the totals from Table 3), but both males and females have been continually included at roughly similar proportions throughout the collection period.

Figure 6 presents the frequency distribution of the year of death by decade for the Dart Collection (presented as the four SA census population groups). The

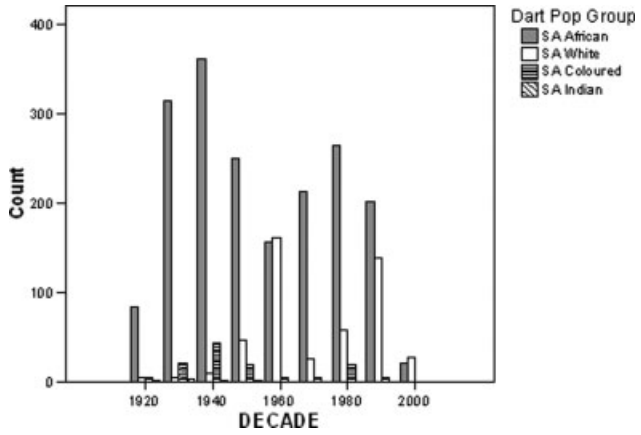

Fig. 6. Year of death by decade for population groups in the cadaver-derived Dart Collection.

majority of skeletons overwhelmingly represent the SA

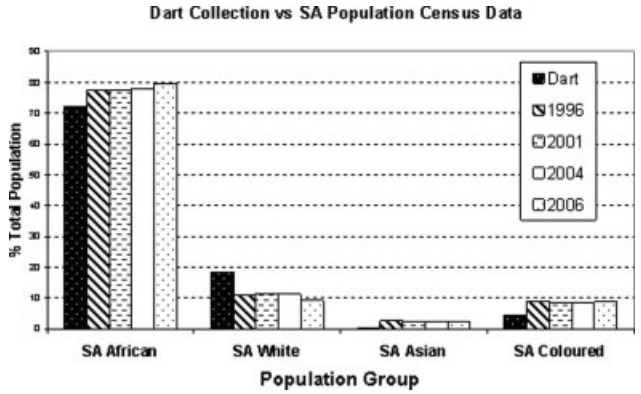

Fig. 7. Comparison of the Dart Collection cadaver-derived sample (in % of total) with South African census data for population groups.

African population, but in some decades (1960, 1990, 2000) the sample of SA Whites is nearly or at least as large.

A comparison of the percentage composition of the Dart Collection with data taken from the South African census between 1996 and 2006 (Statistics South Africa, 2006) is demonstrated in Figure 7. The percentage composition of the four major population groups in the Dart Collection generally reflects the percentages documented in the general population of South Africa, though the White population is somewhat over-represented, and the Asian/Indian population extremely under-represented ($N = 5$; Table 3).

The Dart Collection database also shows the status of the completeness of skeletons and their associated crania and mandibles (Table 6). The top half (6a) presents counts of the complete (Y) and partial (P) crania and mandibles for male and female skeletons. Thus, of the 2,605 accessioned skeletons, 2,466 include a partial or complete cranium, and 2,346 include either a partial or complete mandible. No data are available for the completeness of the various postcranial elements of the skeletons.

The bottom half of Table (6b) presents data on the presence of associated crania and mandibles with a particular postcranial skeleton. The first row (titled 'Skeletons') is derived as the totals for each column in Table 6a, and indicates the number of crania and mandibles that are not present (N), partial (P) and present (Y). The shaded area is the cross tabulated data for associated crania and mandibles, indicating that there are 2,226 crania present with an associated mandible, one with a partial mandible, and 28 with the mandible missing.

TABLE 6. Counts of partial and complete crania and mandibles in the Dart Collection

		Crania			Mandibles		
	SEX	N	P	Y	N	P	Y
(a)							
	?	3	0	5	4	0	4
	F	26	52	679	61	1	695
	M	110	159	1,571	194	4	1,642
(b)							
Skeletons Crania	$N = 2{,}605$	139	211	2,255	259	5	2,341
	N				105	4	30
	P				126	0	85
	Y				28	1	2,226
				2,466			2,346

(a) Tabulations of the numbers of crania and mandibles by sex. Each column sums to the first row of part (b). (b) Cross tabulations of the number of postcranial skeletons, crania and mandibles to indicate the overall completeness of individual specimens in the collection. The shaded area details the numbers of crania with associated mandibles (see details in text).
N, not present; P, partial; Y, present.

FURTHER CONSIDERATIONS

Any study of past populations must rely on a basic assumption of uniformitarianism. In paleodemographic, bioarcheological or even forensic research, we work under the assumption that modern skeletal samples are representative of past populations in whatever parameters of interest. In this context, a number of publications have discussed biases and limitations relating to the use of skeletal reference collections, and provided various guidelines for researchers (Ericksen, 1982; Rose et al., 1991; Usher, 2002; Hunt and Albanese, 2005; Komar and Grivas, 2008). The essential question is whether contemporary skeletal collections (including cemetery assemblages) can be used as a valid comparative reference for reconstructing different aspects of the biology of living populations in the past. It is generally acknowledged that biases exist, but that they cannot be specifically identified or quantified for a specific skeleton or sample (Komar and Grivas, 2008).

These issues have been the focus of a great deal of research in the fields of paleodemography and bioarchaeology since the publication of methodological critiques by Wood et al. (1992) and Bocquet-Apel and Masset (1996), producing numerous responses to these issues (see discussions in Buikstra and Konigswald, 1985; Meindl and Russel, 1998; Wright and Yoder, 2003). Although any discussion of paleodemographic methods is well beyond the scope of this contribution, the basic issues stem from various biases in estimating demographic parameters (age, sex, population affinity) for skeletal populations used as reference standards in skeletal biology research. These same issues are relevant to planning research using the Dart Collection.

Usher (2002) identified three characteristics for the composition of an 'ideal' skeletal reference collection, including a) known ages-at-death of the skeletons; b)

adequate representation of the living population from which skeletons were derived with respect to variation in socioeconomic status, race and health and c) representation of all ages and both sexes. Although we do not claim that the Dart Collection (or any other skeletal collection) is 'ideal', our database analysis indicates that the Dart Collection arguably addresses these three criteria with certain caveats.

The potential inaccuracy in stated age-at-death for many skeletons in the collection may be problematic for studies requiring an accurately age-documented sample, but specimens aged between 5- and 10-year intervals are thought to be accurate, and a variety of alternate age categories can be constructed from the available age data. The collection includes large (but extremely unequal) samples for the three major South African population groups, suggesting that considerable population variation is represented. The skeletons derive from both unclaimed and bequeathed cadavers representing different socioeconomic histories, but this information is not easily accessible as part of the collection documentation. In addition, accompanying death certificates record the cause of death but these data has not been integrated as part of the database, and in any event is not thought to be consistently or reliably recorded. All ages and both sexes are represented in the collection overall, but females are generally under-represented, and sub-adult and infant individuals are poorly represented or absent for some population groups.

CONCLUSIONS

The Dart Collection consists of 2,605 modern human skeletons representing the major population groups of South Africa, collected between 1921 and the present and including documentation of sex, age and population affinity.

This analysis of the collection database suggests that its demographic characteristics are fairly representative of the contemporary South African population in terms of population affinity, but that females are relatively under-represented and the recorded age data is not reliable for all skeletons. In addition, sampling biases are likely to have affected the composition of the collection due to the extremely long period of time represented by the skeletons, the country's particular sociopolitical history, and other details of the acquisition procedures.

These issues are not unique to the Dart Collection, and similar concerns are reported for other collections in South Africa (L'Abbé et al., 2005) and elsewhere (Usher, 2002; Hunt and Albanese, 2005; Komar and Grivas, 2008). The Dart Collection is unique compared with other collections because of the combination of large sample size, extensive duration of the collection period, demographic documentation and population diversity represented by its skeletons. As long as the existing biases are acknowledged and accounted for by the use of appropriate methods, the Dart Collection retains a great potential to contribute to a wealth of future research projects in skeletal biology, bioarchaeology and related fields.

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