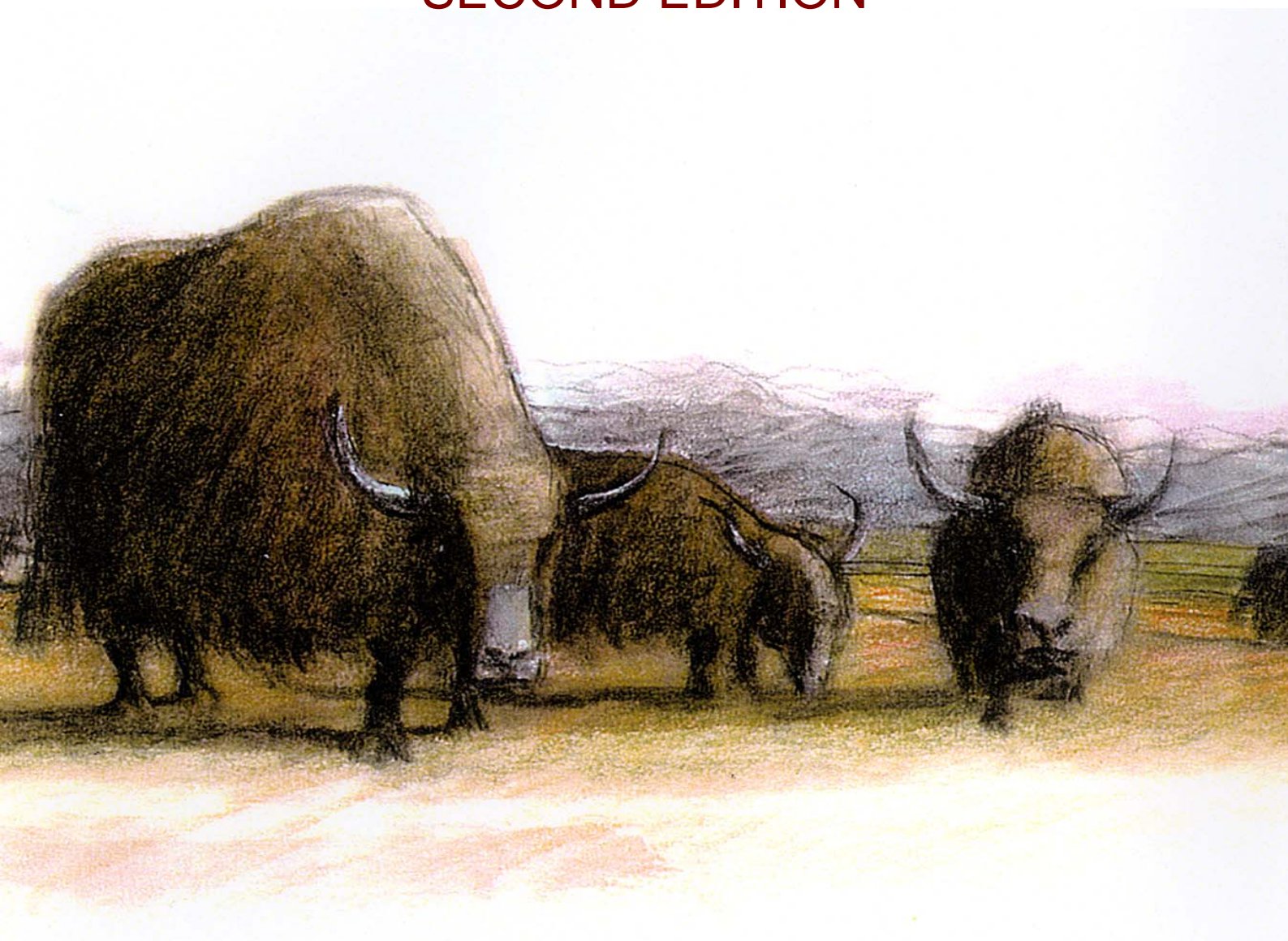


THE YAK

SECOND EDITION



RAP publication 2003/06



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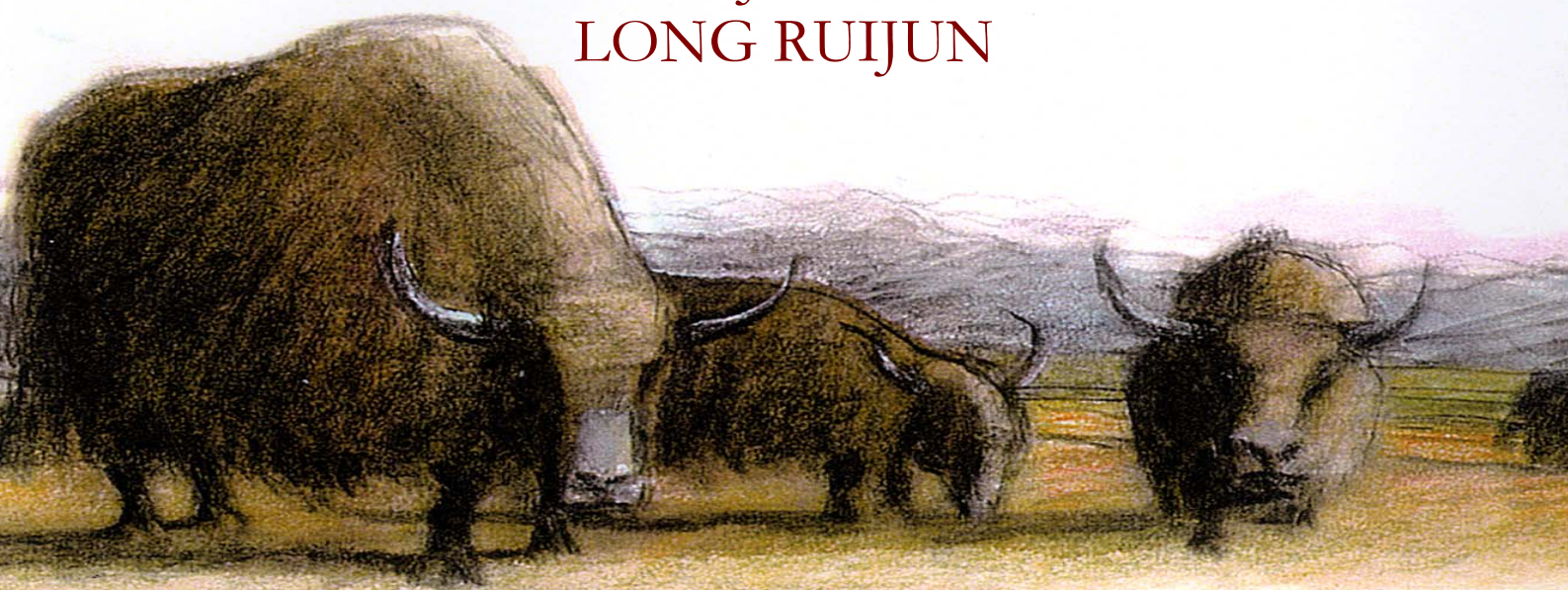
REVISED AND ENLARGED

By

GERALD WIENER

HAN JIANLIN

LONG RUIJUN



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THE YAK

SECOND EDITION

-0-

FIRST EDITION

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PREFACE TO THE SECOND EDITION

Some background to the yak book was provided in the preface to the first edition and this is therefore reprinted below. The second edition represents an extensive revision of the chapters in the first edition and a substantial enlargement through the addition of five new chapters. Sadly, the death of Professor Cai Li in 1997 has meant that his expertise in what he termed “yakology” could not be brought to bear on the revision. Two scientists of a younger generation, eminent in their own specialist subjects but with a major involvement in yak research, have joined this endeavour from Gansu Agricultural University in northwest China – a university that stands in friendly rivalry, in its concern with yak, with the late Professor Cai Li’s Southwest Nationalities College.

Apart from the continuing growth of the scientific literature on yak that has added to this edition, it had become apparent that two matters were insufficiently dealt with previously. One of these is the crucial role that culture and social context play in yak keeping. Although these issues were recognized and alluded to before, the topic has now been expanded into a new chapter. The second matter is the continuing search for the scientific basis underlying yak production. The subjects involved have become increasingly specialized and provide, for the present, perhaps more insights for the scientists than for practitioners of yak keeping – but they are the foundation for future developments. These issues and the understandings derived from them form the basis of three new chapters. The first of these looks in some detail at the alpine rangeland ecosystem and its management. The second deals with fundamental processes in yak nutrition, and the third is concerned with advances in the genetics of yak at the molecular and cytogenetic level.

The discussion of yak in different regions has been greatly enlarged into a chapter divided into three parts. The first part provides information, for the first time in this book, on the special features of yak keeping in six provinces of China – the six that account for most of the yak in that country. The second part, revised and enlarged from an earlier chapter, provides much information on yak keeping and yak research in other countries that have a long history and tradition of yak keeping; this includes a new section that takes a broad sweep over yak in Western High Asia, and includes some of the more remote countries of the region with small but locally important yak populations. The section on Mongolia has been re-written by a new author; some of the others have been re-written or revised by their former authors or with new collaborators. It is a matter of regret that no one could be found willing to write on behalf of the countries of the Russian Federation (with the honourable exception of Buryatia) and that section is therefore based on available literature. The third part of this long chapter has been added to provide a little evidence on yak in countries with environments that are not traditional for yak – principally yak kept commercially in North America, as well as a few in Europe and elsewhere and yak kept in zoos and wild animal parks.

It is hoped, therefore, that the book will continue to appeal to those with an interest in yak but wishing to delve also a little below the surface. It is hoped also that the more esoteric science in the book will provide a review of the subjects treated for those with specialist interests and will be seen by general readers as showing how yak research is being integrated with that on other ruminants. An overview is provided at the start of each chapter for those who do not want the detail. As before, the concluding thoughts in the final chapter are written from my perspective as an outsider to the actual art of keeping yak. An “outsider’s perspective” should at least have the merit of being in tune with one of the important aims of the book, which is to make knowledge of yak more widely accessible to the world outside the yak territories.

Much care has gone into the production of this volume and much help received (see acknowledgements to both editions). Inevitably, some inadequacies may remain. Some will be of our own making and some due to lack of information on certain points. Hopefully, such problems will be few compared to the wealth of information presented.

Gerald Wiener

June 2003

ACKNOWLEDGEMENTS

(second and first editions)

The acknowledgements for help and advice with the second edition of this book should be read in conjunction with the thanks extended in relation to the first edition. These former thanks are clearly still relevant and are also shown below.

Much encouragement and advice was received for the revised and enlarged edition of this book.

From the FAO Regional Office for Asia and the Pacific those involved were principally Denis Hoffmann, a former senior animal health production officer from 1997 to 2002, and David Steane, a freelance livestock consultant.

More specifically, thanks go first to those who have contributed new chapters or sections. The authors concerned are shown at the beginning of each of these chapters or sections and their affiliations as footnotes. Their names will not therefore be listed here, but their collaboration is greatly appreciated. Particularly in relation to countries within the traditional yak zone but outside China, several of the contributors differ from those who participated in the first edition.

Advice and help was sought from and given by many individuals, some on general matters and some in relation to specific chapters. In relation to the more technical new chapters, the help provided in terms of time and expertise is greatly appreciated not only by the compilers of this volume but also by the authors of the relevant chapters. Those to whom profound thanks are due are shown below in alphabetical order (in two cases, they are also authors or co-authors of other sections in the book):

Shikui Dong (formerly, Gansu Agricultural University, China); John Frame (formerly, Scottish Agricultural College, UK); Professor James F. D. Greenhalgh (formerly, Aberdeen University, UK); Chris Haley (Roslin Institute, UK); Professor Corneille Jest (Centre Nationale de la Recherche Scientifique, France); W. Scott Johnston (formerly, Scottish Agricultural College, UK); Professor Hermann Kreutzmann (University Erlangen, Germany); Walter Roder (Advisor, Bhutan); David Steane (formerly FAO).

Appreciation for additional information and help not specifically acknowledged in the text, is also due to the following:

James Delaney (International Yak Association, USA); Nick Lindsay (Senior Curator, Whipsnade Wild Animal Park, UK); Daniel J. Miller (Rangeland consultant, USA); Camille Richard (International centre for integrated mountain development, Nepal);

Dan Wharton and staff (wildlife conservation society, NY, USA); Nyima Tashi and Ji Qiumei (Tibetan academy of agriculture and animal sciences, Tibet, China); Qi Xuebin (Gansu, China); Liu Yingchun (Qinghai, China); Professor Pu Jiabi (Heifer Project International, Sichuan, China); Fu Changxiu (Sichuan, China); Associate Professor Wei Xiaohong (Gansu Agricultural University, China).

Also, other support was provided by Hans-Gerhard Wagner, FAO animal production officer, and by Chanrit Uawongkun, Animal Production and Health Commission for Asia and the Pacific for page layout and page setup.

The editorial assistance of Karen Emmons is appreciated.

The following were the acknowledgements in the first edition of the book:

Help and encouragement has been received by the authors from many sources and these are most happily acknowledged. Our thanks are listed under headings:

FAO Regional Office for Asia and the Pacific

We are very grateful to Obaidullah Khan (Assistant Director-General and Regional representative for Asia and the Pacific) for his support and kindly writing the Foreword for this book. We are particularly indebted to David Steane (Chief technical advisor, conservation and use of animal genetic resources) for actively promoting the publication of this book, for making most of the arrangements for this and also for comments on scientific matters. We are also grateful to Masao Sasaki (FAO regional animal production and health officer) for his support of the project.

Material for book

The authors are indebted to those who personally contributed material for this book, mostly found in chapter 11. Particular thanks are due to Professors M. Tumurjav and M. Olonbayar (Mongolia), E. V. Katzina (Buryatia), R. N. Pal (India), D. D. Joshi (Nepal), Lham Tshering (Bhutan), and A. H. Cheema and A. Ghaffar (Pakistan). Their various and varied contributions have helped greatly to broaden the perspectives of this book. N. Lindsay (Curator) and E. Flack (Veterinarian) kindly provided information on yak at Whipsnade Wild Animal Park (England).

Scientific help

The authors are most grateful for the time and effort given by J. M. M. Cunningham (Emeritus Professor, Glasgow University) and A. J. Smith (Centre for tropical veterinary

medicine, University of Edinburgh). Each read an entire draft of this book. Their comments and questions and the discussions held with them by one of us (G.W.) were most helpful in the development and revision of the manuscript. Professor Crad Roberts (University of Wales) should also be thanked for some initial suggestions on content. Helpful comments on Chapter 5 were also given by R. Webb (Roslin Institute), on Chapter 9 by A. G. Hunter (Centre for tropical veterinary medicine, University of Edinburgh) and on Chapter 4, in relation to haematology, by David Doxey (Veterinary field station, University of Edinburgh).

Translation

An initial translation of the Chinese manuscript of the book by Professor Cai Li, *China yak* (1992) (which provided a basis for the FAO book) was made into English by Ma Li and Zi Xiang-dong (both on the staff of the Southwest Nationalities College). Their time and effort are greatly appreciated. Subsequently, almost the entire burden of translation from Chinese into English and vice versa, during the preparation of this book, fell on Zi Xiang-dong. This was a formidable task owing to the copious correspondence between the authors, neither of whom speak each other's language. The work of translation must have greatly interfered with Zi's academic teaching commitments and with his personal life. We cannot thank him enough.

A relatively small but important amount of translation was done by J. G. Gong (Roslin Institute, Edinburgh) to whom we are also grateful.

Other help

Professor Graham Bulfield (Director, Roslin Institute) is thanked for use (by G.W.) of the facilities of the Roslin Institute. Its three library staff helped, beyond the call of duty, in tracing and obtaining books and reprints of articles needed for reference but often difficult to locate. Frances Anderson undertook the skilled job of preparing camera-ready copy from the material and diskettes supplied by G.W.

Photographs: by Cai Li except where otherwise acknowledged.

FOREWORD TO THE FIRST EDITION

It is fitting that in this year, the 50th anniversary of FAO, the Regional Office for Asia and the Pacific acknowledges, by this publication, the unique and special role of the Yak whose natural environment is almost totally within this region.

The Yak is a relatively insignificant species in global terms, yet it is critical to the livelihood security of the herders in a rather difficult environment.

The Yak's ability to survive in harsh conditions and the peoples' ability to derive sustenance from it are classic examples of adaptation by both the animals and the human beings. The need to ensure the maintenance of domestic animal diversity, therefore, cannot be overstated.

The book is not a purely technical publication but tries, through the use of the scientific and other literature available, to provide a comprehensive document describing all aspects of the Yak and its husbandry. It is, however, unique in providing for the first time such a comprehensive document on the Yak in the English language. It will enable a wide audience to learn and appreciate the contribution the Yak makes both to human survival in an inhospitable environment and to biological diversity.

Obaidullah Khan

Assistant Director-General and
FAO Regional Representative for Asia and the Pacific

PREFACE TO THE FIRST EDITION

A preface should perhaps be in the name of both the authors. That convention is broken here in order to provide me, the "foreign" co-author, with an opportunity to pay particular tribute to Professor Cai Li. He has dedicated an entire lifetime, helped by colleagues, students and co-workers, to observing, recording and trying to understand the yak and its characteristics and attributes and its role in the life, culture and economy of the mountainous regions of central Asia. Some of this study has involved personal hardship, which most young scientists nowadays would find hard to imagine.

The areas of the world in which yak are kept are in many cases, even now, isolated by distance and difficult terrain. Much of yak husbandry is still steeped in tradition and values, which may not be encountered by "animal improvers" elsewhere. It is no mean feat therefore to have gathered the information on which this book is based and it is no discredit to its value that some of the expectations of modern data recording and analysis could not always be observed. Numbers involved in comparisons are often fewer than the observers would have wished, and one of the recurring regrets is that some factors remain confounded – for example, between breeds or types of yak and the location where they are found. It is thus not often possible to say whether a particular type of animal is better, or whether it is the conditions under which it lives which is the deciding factor.

The backbone of this book is the work of Professor Cai Li, particularly in his home province of Sichuan. Much of his work has been quoted by direct reference to specific publications, but other information on yak, when not attributed to a specific source also derives from Professor Cai Li's studies. However, it is hoped that readers will also quickly note that this book is based on a large array of information and a mass of data from many different sources and places. It follows that this book differs in breadth and depth from the many popular and a few review articles on the yak, which represent the bulk of the information published in the English language. (In addition there is a growing number of scientific papers on specific topics concerned with yak, also in the English language - and some in French and German). The more general of these articles mostly set out to say how remarkable an animal the yak is, because it has adapted to life in an extraordinarily hostile environment, and then give just a taste of information on body size, reproductive rate, milk yield, and perhaps little else. Usually, this provides no clue to the wide range of variation in performance and habitat of the yak and to the potential of the yak for change. Such conclusions need to be based on a more detailed assessment of the yak and critical evaluation of the results. Nonetheless, taken together, these articles and specific studies provide an impressive addition to the literature in the traditional languages for yak publications (mostly Chinese, but also many in Russian), and they have been quoted here whenever appropriate.

It is hoped, therefore, that this book will fill a gap in knowledge and understanding, not only among those concerned with the science of animal production, but also those just interested in the yak and wishing to dig a bit deeper. To accommodate especially the more general reader, an overview has been provided at the beginning of each chapter.

In spite of the claim to breadth and depth for this book, it has to be acknowledged that not every possible piece of information published on the yak has been used. Much of the wealth of articles in scientific journals, reports and proceedings of technical meetings (mainly in the Chinese or Russian language) deals with specific detail under specific circumstances. While it is one of the aims of this book to demonstrate the range of variation found in the management and performance of yak in both practical and experimental situations, and to provide a clue to the underlying factors, it was not thought desirable to make the references exhaustive. To do so would also have required some means of interpreting the causes of the plethora of small differences in performance, or characteristics, of the yak that would emerge. Such interpretation is not possible in the absence of a level and scale of experimentation, which has not been undertaken with the yak (or indeed with other types of domestic livestock, if considered over the kind of vast area encompassed by yak territory). The separate chapter on yak husbandry in different countries should go some way towards widening the picture as far as possible.

The publication of this book was requested by the Regional Office for Asia and the Pacific of the Food and Agriculture Organisation of the United Nations to coincide with the 50th anniversary of FAO's foundation. Due to restrictions on time, it has not been possible, in every case, to obtain information for chapter 11, on yak husbandry in different countries, direct from those involved – as was originally hoped. Thus, some of the information for that chapter has had to be compiled from existing, published information.

This preface must end with an apology. The problem of transliterating Chinese, and to a much lesser extent Russian, into the English alphabet may mean that some of the names of authors and the titles of papers and sources given in the list of references may not be totally correct in every detail. Also, it is a matter of regret that some of the references listed will be found difficult to access, even in the form of abstracts, by those wishing to do so. It is hoped that the revolution in communication, in which we find ourselves at the end of the 20th century, will also, in the future, apply to publication across far distant national boundaries for subjects such as the yak.

Gerald Wiener

September 1995

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1 ORIGINS, DOMESTICATION AND DISTRIBUTION OF YAK

OVERVIEW

Fossil remains of the domestic yak and its wild ancestor date back to the Pleistocene period. Over the past 10 000 years or so, the yak developed on the Qinghai-Tibetan Plateau, extending over about 2.5 million sq km and often called the “roof of the world”. Although this is still the centre of the yak’s distribution, yak have spread northward and southward and also, albeit in relatively small numbers, to other parts of the world. Yak are usually found at elevations between 2 000 and 5 000 m (the lower elevations at the more northerly latitudes).

The wild yak may have been tamed and domesticated by the ancient Qiang people. Chinese documents from ancient times (eighth century B.C.) testify to a long-established role of the yak in the culture and life of the people. From the south to the north, the distribution of the domestic yak now extends from the southern slopes of the Himalayas to the Altai and west to east from the Pamir to the Minshan mountains. In relatively recent times the area of distribution has further extended to, for example, the Caucasus and North America. In addition, yak are found in zoos and wild animal parks in many countries.

At the present time, the total yak population is estimated to number around 14.2 million, of which 13.3 million are in Chinese territories, about 0.6 million in Mongolia and the rest in other countries, notably those bordering the Himalayas and countries of the Commonwealth of Independent States (formerly the Soviet Union). Their numbers are said to be increasing in some areas of China. In addition, hybridization of yak with cattle – most usually the local cattle of the area – is widely practised. Hybrids of yak with “improved” European breeds are also produced, though in relatively small numbers.

The wild yak population, as distinct from the domestic yak, is now very restricted in distribution. Numbers are likely to be fewer than 15 000. Although the animals are “protected”, illegal hunting still represents a major problem to their survival. Wild yak are larger in size than the domestic ones. Because the two types readily interbreed, there is interest in the use of wild yak to improve the performance of the domestic type.

The yak is integrally associated with the culture, religion and social life of its herders, their families and communities. However, with outside pressures influencing the life of the people and with technical developments impinging on yak husbandry, it seems likely that the nature of yak keeping has entered a period of change.

Introduction

The yak (*Poephagus grunniens* or *Bos grunniens*) must be regarded as one of the world's most remarkable domestic animals as it thrives in conditions of extreme harshness and deprivation while providing a livelihood for people. A herbivore, the yak lives predominantly on the "roof of the world", as the Qinghai-Tibetan Plateau is often called. The Plateau itself extends over 2.5 million sq km (about 1 million square miles) and was described by Miller (1990) as the most extensive high-elevation region on earth and the best grazing lands in all of Asia. For those more familiar with the western hemisphere, Miller (1990) equated the vast size of this Plateau to the combined areas in the United States of America of Montana, Wyoming, Idaho, Utah, Nevada, Colorado, Arizona and New Mexico. From the central "core" of the yak's habitat, the species has spread to adjacent territories. These areas are, to a large extent, above the tree line where there is virtually no cropping. There is no frost-free period during any part of the year. At its high elevation, the territory overall is characterized by a harsh climate of cool moist summers, severely cold winters and grazing resources restricted by very short growing seasons. More than 13 million yak thus live and provide food, transport, shelter and fuel where few other animals will survive. About 30 million sheep and goats (Miller, 1990) – and the herdsmen's horses – co-exist with yak over large parts of the Plateau. But these are not serious competitors to the yak in much of yak territory, and they do not have the same economic importance. However, yak and sheep are, to some extent, complementary to each other in their grazing habits. In some of the alpine regions, the terrain is also treacherous. Chinese historians have argued that without the yak's capacity to live in such a hostile environment, human civilization might not have established and flourished in these remote areas.

This book traces briefly the development of this remarkable animal and then describes in some detail its characteristics and performance and its products. There is also a discussion of the more recent research and development projects that may provide a basis for improvements in yak performance and in the utilization of the rangelands. The research and development may also lead to a wider distribution for the yak and to a better utilization of yak products. Any marked changes in yak husbandry are also likely to have far-reaching consequences for the social fabric of a society of pastoralists.

Origins

Unequivocal evidence to link the modern yak to its earliest ancestors is not available. Fossil evidence suggests that yak were extensively distributed in north-eastern Eurasia in the late Tertiary period (2.5 million years ago) and that these are the forerunners of wild yak found as Pleistocene fossils in northern China, Inner Mongolia (China), eastern Siberia and northern mid-Asia and on a line roughly connecting these locations (Dyblor, 1957;

Belyar, 1980; Flerow, 1980; Olsen, 1991; but see also Chapter 15, Systematics and phylogeny).

The principal area of distribution for the remaining wild yak of modern times is discussed in the section on wild yak later in this chapter. The Himalayas rose to their present elevation above 4 500 m only in the late Pleistocene epoch. Their rise obstructed the warm and damp airflow from the south and significantly changed the climate of the central area of what is now the Qinghai-Tibetan Plateau. Forest disappeared from the Plateau and was replaced by alpine meadow. Wild yak migrated from northeastern Eurasia and adapted to life on the Plateau and domestication followed.

Domestication and historical distribution

The present domestic yak is descended from wild yak, which may have been caught and tamed by ancient Qiang people in the *Changtang* (a Tibetan term meaning “the empty highland of the north”), an area that covers more than half of Tibet.

This process is thought to have begun in the late Stone Age, about 10 000 years ago, and led to the primary yak industry, beginning in the period of the Longshan Culture of the late New Stone Age (2 800 - 2 300 B.C.) (Qian Yanwen, 1979). The history of China’s yak industry is thus at least 4 500 years old. Chinese historians regard the ancient Qiang people living around 30 000 years ago as the first intelligent humans. They lived and roamed the present Qinghai-Tibetan Plateau, though its average altitude then, at around 3 000 m, was lower than it is now. These people developed quite possibly the earliest animal husbandry culture of excellence in the world – the Qiang Culture. This development is of a different type from that based on agriculture in ancient Mesopotamia, widely regarded as the cradle of civilization. The outstanding achievement of the Qiang Culture was the taming of wild beasts for domestic purposes. Sheep and goats had already been tamed successfully and this led to the taming of yak, horse and other herbivores and the development of a society based on animal husbandry. Domestication of yak in particular led to progress, prosperity and economic advancement for the people because of the value of the yak as a beast of burden and its products of milk, hair, hides and meat – and the availability of its dung as a fuel in the areas above the tree line.

Yak expanded outward from that original area of domestication on the Plateau. To the east, yak migrated from the Bayan Kala mountains into the Songpan grasslands (located in what are now the Aba, Ruoergai and Hongyuan counties of Sichuan province) and into the Danba mountains. To the south, the migration went through passes in the Himalayas to the mountainous grasslands of the southern slopes of the range. To the west, yak entered Kashmir through the western Tibet grasslands. And to the north the migration took the yak over the Kunlun mountains into northern Pamir, northern and southern Tianshan and Altai.

The present-day distribution of the yak developed gradually from these migrations (see Figure 1.1).



Figure 1.1 Principal area (hatched) of the distribution of domestic yak

Nearly all the nationalities that now keep yak are thought to be related to the ancient Qiang people, including, for example, the Suchas and Tibetans. Others such as the Menba, Luoba and the Sherpa people of Nepal were separated from the original Qiang only when they entered the southern slopes of the Himalayan range. The Luoba became the Yi nationality when they migrated to the Yungui Plateau from the east. Similarly, nationalities in central Asia and the Tianshan area are related to the Qiang people, as are the Mongolian and other southern nationalities.

Many old Chinese documents illustrate these links and the associations with the yak. For example, the *Guoyu chuyu* describes events in the late Western Zhou Dynasty (ca. 841 B.C.): “... The Bapu’s rhinoceros and yak cannot be destroyed ...” (Bapu was the northern part of the ancient Ba nation located in the present Daba mountains area of Sichuan province). The old text describes how yak were raised in large numbers.

A geological document, the *Shanhaijing Zhongshanjing*, dating from 400 B.C., states: “In the northeast there is a mountain called Jingshan. Its northern slope abounds with iron and the southern slopes are rich in gold. There are many yak on the mountain ...” The Jingshan is at the extremity of the Daba range in what is now the Xiangyan area of Hubei province.

Many other Chinese documents dating from the fourth to the first century B.C. attest to the abundance of yak on the mountainous slopes. They also describe the migration, often forced by oppression from despotic rulers, of the Qiang people who took their yak with them. The Qiang people thus branched into what became different races living in isolation from each other. One of these was the sixth Mao Niu race – a name synonymous with one of the names for yak (Tong Pingya and Zhao Guopan, 1990).

Another branch of the Qiang people deserves particular attention because of their association with the Jiulong yak, which is now, in terms of its performance, among the most renowned native breeds of China. These people migrated to southern Kangding in what is now the Ganzi Tibetan autonomous prefecture of Sichuan province. They called themselves *muya*, meaning “yak country”. The centre of this territory was in the Mula region of Yajiang county of the prefecture, the original home of the Jiulong breed. The people and therefore the area of distribution of this breed spread, as the yak industry developed, to include several other counties within Sichuan (Kangding, Jiulong, Daofu and Litang) as well as Zhongdian county of Yunnan province.

Thus, the raising of yak was a national characteristic of the ancient Qiang people. Their nomadic lifestyle has carried over into much of yak keeping to this day.

Gradually, the distribution of the yak expanded. But only in relatively modern times did it reach some of the areas where yak are now regarded as important. For example, the raising of yak in the Tianshan mountain area of the Xinjiang Uygur Autonomous Region is only about 100 years old. A century ago, 6 male and 170 female yak were taken from Tibet to Hejing county in the centre of the Tianshan mountain range and the whole of Tianshan (Yu Daxin and Qian Defang, 1983).

Present distribution

In Asia and traditional territories

Yak are found extensively on the plateau of western China in alpine and subalpine regions at altitudes from 2 000 - 5 000 m with a cold, semi-humid climate. The area, as seen in Figure 1.1, extends from the southern slopes of the Himalayas in the south to the Altai in the north and from the Pamir in the west to the Minshan mountains in the east. The centre of the yak’s distribution is the Qinghai-Tibetan Plateau, which is interspersed with several mountain ranges. From the most recently available information (mostly 1997), the number of yak in Chinese territories is estimated to exceed 13 million, of which about 15 percent are hybrids with (mostly) *Bos taurus* cattle of local types. The majority of the yak, as shown in Table 1.1, are concentrated in four of that region’s provinces. The rest of the world accounts for another million or so yak.

The majority of the yak in Mongolia are found in the Hangay and Hovsgol mountains and in the high altitude area of the Mongolian Altai – on the western and northern side of the country (cf. Chapter 11, part 2).

The yak in countries of the Commonwealth of Independent States (CIS, formerly the Soviet Union) are distributed in the narrow mountain area on the borders with China and Mongolia from Pamir in the west to Lake Baikal in the east. Yak were also introduced to

the high alpine areas of the northern Caucasus in 1970, and reintroduced to the Yakutsk valley of Siberia (Yakutia) as recently as 1971 (Verdiev and Erin, 1981), to exploit the potential for meat production from otherwise inhospitable alpine grasslands. The yak of Nepal and Bhutan are on the southern slopes of the Himalayas while those of India are distributed in the high altitude northern provinces and in the small territory of Sikkim. Other pockets of yak populations are in alpine areas of Afghanistan and Pakistan, adjacent to the Qinghai-Tibetan Plateau. These areas of the yak distribution are dealt with in more detail in Chapter 11, part 2.

In the 1970s and 1980s, the yak was introduced to mountainous areas in northern China (but at lower altitudes of 1 500 - 1 800 m) to increase utilization of the grasslands in these cold areas. The results in Weichang county of Hebei province and in the Lingshan area of Beijing suggest a useful role for the yak there (Langjie Zeren *et al.*, 1987; Zhong Guanhui *et al.*, 1986).

Yak in China thus represent about 94 percent of the world's total number of yak but account for only a small proportion of the 140 million bovines in China (numbers in 1996, according to Xu Shangzhon, 1998).

According to Guo Shijian and Chen Weisheng (1996), 1.3 million yak were marketed in China annually. It was also estimated that the annual production from yak was 226 000 tonnes of meat, 13 000 tonnes of fibre and 170 000 pieces of skin (Xu Guifang and Wang Zhigang, 1998). Milk production was quoted as 1.4 million tonnes for 1989 by Li Yifang (1999) and 715 000 tonnes by Xu Guifang and Wang Zhigang (1998) for the year 1997. However, as roughly 40 percent of the meat, 60 percent of the milk and milk products and 80 percent of the fibre produced from yak are used by the herders' families for their own consumption (Guo Shijian and Chen Weisheng, 1996), all these estimates may fall well short of the actual contribution made by yak to the total economy.

Distribution outside Asia in modern times

Export of yak to parts of Europe, North America and other parts of Asia began in the mid-nineteenth century. The purpose was mostly for research and for the possible utilization of cold pastureland. Before that, Samuel Turner, a Briton, sent two yak bulls from Tibet to England in 1783. One died on the way there, and the other, after recovering from the journey, was mated to British cows. Several calves were born, but only one female survived to breed (with an Indian bull) (Turner, 1800).

In 1854, a total of 12 male and female yak were imported into France, also from Tibet. They appeared to acclimatise successfully but performed differently in different areas due to variations in feeding. They did best in the Cantal province of the central French Plateau.

Table 1.1 Distribution of yak and numbers (1997 - 2000 data for China*)

Country	Province or region	Distribution at location	Number ('000)
China			
	Qinghai	All	3 716 (in 2000)
	Tibet	All	3 916 (in 1999)
	Sichuan	Western plateau and alpine area	4 084 (in 2000)
	Gansu	Southern grasslands and	904 (in 1997)
	Xinjiang	Qilian	230 (in 1997)
	Yunnan	mountain area	50 (in 1997)
	Inner	Middle of the Tianshan	0.2 (in 2001)
	Mongolia	mountains	0.9 (in 1983)
	Hebei	Northwestern alpine area	0.1 (in 1983)
	Beijing	Helan mountain area	
Mongolia		Northern mountainous area	610
Countries of CIS		Xishan cold mountainous area	100 (?)
Nepal			20 (+40 hybrid)
Bhutan			38
India			40-51 (?)
Pakistan			11
Afghanistan			2 (?)
North America			2 (?)

*Recent reports suggest that numbers in some areas of China may be higher than those derived from less-recent official statistics shown in the Table. Estimates with question marks attached may be less reliable than others.

Hybrids with cattle were produced in both possible ways – calves from native cows and calves from yak cows - with calves of the latter being reported as the better. However, although the yak disappeared after 1862, local stories lived on about animals at high altitudes that were strong, tolerant of rough conditions and with the tail of a horse (Boulnois, 1976). The horse-like tail, derived from the yak, led to the legend that the original crosses had been between cattle and horses. Clearly, the yak left an impression, but no descendants.

Small herds of yak are found in other parts of Europe, including Switzerland and Austria (Agir, 1997; Michael Goe, personal communication, 2002; Horst Geilhausen, personal communication, 2002). More detail is given in Chapter 11, part 3.

A number of yak were sent to Canada, first in 1909 and again in 1921 for trials, including hybridization with domestic cattle and with American bison in an attempt, later discontinued, to produce an animal capable of meat production in the harsh pastoral conditions of northern Canada. A similar project using only domestic cattle for the hybridizing, was conceived and carried out for some years in Alaska, starting with yak born in Canada (White *et al.*, 1946).

Some yak were present in the late 1980s in the Polar Park of Edmonton, Alberta, Canada. Since then, the yak has expanded in numbers in Canada and the United States for commercial use in meat production. In addition, there are yak in a several zoological and wild animal parks in Europe, North America and elsewhere. More reference to these yak populations, some in environmental conditions thought to be atypical for yak, is included in Chapter 4 in relation to adaptation and in more detail in Chapter 11, part 3.

The name of the yak – a historical note

In the Tibetan language, yak is pronounced as “yag”; although in that form, it usually applies to the yak bull – with *dri* the equivalent Tibetan term for the female yak. Other languages follow this name closely. This use of the same name in numerous languages is considered unusual.

The ancient Chinese people called the animal *Ya Niu*. In the Shang dynasty (before 3 000 B.C.), yak was vividly written as 犛, denoting the yak’s large body, outstretched horns, long hair and big tail. In time, the name was reduced to a word pronounced as “ya”. Later still, this was mispronounced as “mao” – and many homophones began to appear after the Qin and Han dynasties. These words referred not only to the yak but also to yak hair products (because 髦 *mao* means “hair” in Chinese). Some people wrote 毛, pronounced “mao”, as 犛, pronounced “li”, and then called the yak *Li Niu*. The tiny alteration in the script led to a change of name. And this provides an interesting object lesson for good handwriting! A distinction between *Li* and *Mao* to denote yak was first made in the *Compendium of materia medica*, published by Li Shizhen in 1578. *Li Niu* was said to live in the mountains and denoted the wild yak, while *Mao Niu* was used to denote the domestic yak (Li Ruimin, 1986).

Present-day names, in spite of a common thread, vary for the yak from country to country and often from locality to locality within a country. The male and the female are generally known by different names and there is a plethora of different names for the hybrids of yak with other cattle. (For the sake of clarity in this book, the species of either sex will be referred to by its common name of “yak” and the sexes will be distinguished by the prefix “male” and “female”, but with an occasional use of “bull”, “steer” [castrated male] and “cow”).

Some observations on the wild yak

Before the wild yak became known as *Li*, it was called *Zhong* in the Tibetan language and *Zuo* by the ancient Chinese in central China.

Li Shizhen in his *Compendium of materia medica* of 1578, said: “In the southwestern area around yak country, *Li Niu* (the wild yak) lives in the high mountains. Its appearance, hair colour and tail are the same as those of the domestic yak, but its body is larger.” In 1875, N.M. Przewalski, named the wild yak *Bos mutus Prze*, in the belief that the wild yak did not make a sound or “cry”. In fact, although the wild yak does not normally cry, it will let out squeaks and cries during oestrus and the breeding season and if it meets other wild beasts, just as does the domestic yak.

According to Miller and Steane (1996), wild yak once numbered in the millions in the central and eastern border areas of the Qinghai-Tibetan Plateau. Herds of them also existed on the cold pastures of western Sichuan province up to the middle of the twentieth century. Male wild yak could be seen mingling and mating with herds of female domestic yak. A few individuals with hair colour characteristics of wild yak can be seen in domestic herds to the present day – the principal visual difference being grey-white hairs, which are normally absent in the domestic yak, found around the mouth. The domestic yak that do have such grey-white hairs are those that have had, at some stage, an infusion of wild yak blood. This is particularly found among the Plateau breed of yak in Qinghai.

Excessive hunting of wild yak for food drove them from the plateau areas into mountainous areas at even higher altitudes, above 4 500 m and right to the tops of the mountains at 6 000 m. By the 1970s, wild yak were thought to be on the verge of extinction. Some survived in China’s Kunlun mountains and due to protective measures by the Chinese Government, some wild herds are reported to have reappeared at elevations between 4 000 and 4 500 m. Schaller (1998) gives an authoritative account of the distribution and herd dynamics of wild yak. He reports finding few animals, except in the Changtang reserve, in the course of extensive visits to areas of the wild yak’s present and former range. Schaller’s estimate of likely total numbers is around 15 000. However, in view of improved access to much of the territory by road and continuing reports of illegal hunting, survival of the wild yak does not seem assured.

The wild yak is large in body and strong (Figure 1.2). Thick, long hair covers the whole body. The colour of the hair is jet brown or jet black. This is virtually the exclusive colour, but Schaller (1998) reported a golden brown mutation among wild yak seen in the Aru Basin of northwestern Tibet. A colour line down the back of the body and behind the withers is silver grey and there are grey-white hairs around the muzzle. (As referred to earlier, the latter feature is found only in domestic yak that have some wild yak blood.)



Figure 1.2 Wild yak bull of the Kunlun type (Photo courtesy of Lu Zhonglin)

The horns are round and very thick, 15 - 20 cm in diameter. (Some herdsmen used these horns as milking vessels and this can still be found in some remote areas of the country.) The horn arch of the wild yak is open (Figure 1.3), and the head shape has a fierce appearance.



Figure 1.3 Horn arch and part of a wild yak skull (undated) discovered in the middle reaches of the Heihe River in Ruoergai county, Sichuan province

The skull illustrated in Figure 1.3 is the largest of several skulls found in the middle and lower reaches of the Heihe River of Ruoergai county, Sichuan province and presumed to be ancient remains of wild yak. Measurements of the skull are as follows:

Forehead width – highest	34 cm
Forehead width – lowest	28 cm
Distance between base of horns	27 cm
Circumference of base of horns	44 cm
Horn length	99 cm
Largest distance between horns	146 cm
Distance between tips of horns	126 cm

On the basis of these measurements, it was estimated that this yak had been 170 cm high at its withers, had a body length (pin bone to shoulder) of 190 cm, a heart girth of 250 cm and weighed approximately 950 kg, which is 1.5 times the average for domestic yak bulls in the same area (Cai Li, 1989). Schaller (1998) quotes figures based on a number of published studies suggesting a shoulder height for adult wild yak bulls of 175 - 203 cm and of 137-156 cm for adult females. A total body length is given as 358 - 381 cm for bulls. Wild yak bulls are said to be about 35 percent heavier than the cows. The length of 53 horns of wild yak bulls found in the Changtang reserve is reported by Schaller (1998) to have averaged 75.7 ± 10.7 cm along the outside curve.

Wild yak prefer to live in herds of tens or even hundreds of animals. The wild yak has a very acute sense of smell, is highly alert and timid; it tries to escape immediately on sensing or seeing people or other animals. Wild yak stampede readily, but if angered or cornered they are fierce and will attack an intruder. Wild yak dislike heat but are highly tolerant of cold and starvation. Wild yak bulls often wander off individually during the non-breeding season to hill areas away from the high mountains. Such males are known to attack people on remote roads.

In times when wild yak were more prevalent, they were known to come down from the mountains to mate with female domestic yak during the breeding season. The first crossbred generation (F1¹) between the wild and the domestic yak was similar in appearance to the wild yak and had a larger body and fiercer temper than the typical domestic yak. The crosses are difficult to manage, but the herdsman like them because of their apparently better growth and development compared to pure domestic yak. They are also liked because the crossbred males are perceived as protecting the herd better than their domestic counterparts. There is now an attempt, organized by provincial yak breeding centres, to exploit the potential benefits of such crossbreeding through the use of semen from wild yak bulls to inseminate domestic yak cows. Some observations on the body size and performance of such crosses are included in Chapter 3.

Feral yak

Recently, 250 - 300 feral yak were discovered in the Helan mountains of Inner Mongolia at an elevation of 2 500 - 3 000 m (Han Jianlin personal communication, 2002). These animals are thought to be the offspring of yak that lived about 200 years ago that were used at that time by lamas to transport Tibetan religious books from Qinghai to Gansu. The herd contains a high proportion of white animals, which suggests they may be related to Tianzhu White yak. Currently, there is no confirmation of this. Some of the oldest residents in the region contend that these yak are only about half the size that they were 50

¹The F1 in this book denotes the first generation of offspring from a cross of two pure breeds, or a hybrid of yak and cattle. F2 is then the generation produced by mating F1 to F1. Matings of F1 back to one of the parental types is referred to as B - with an appropriate suffix - denoting a backcross.

years ago. This is attributed, with agreement from local technical staff, to inbreeding in the herd. Local farmers also believe the lack of salt in the area may have contributed to what is described as the degeneration of the animals over the years. These yak are said to have shorter and thinner coats than what is normal for other yak and this is attributed to the fact that the area is warmer than typical for yak-producing areas. It would be useful to have more detailed studies of these animals to determine their kinship to other yak and possibly their inbreeding status and to have some record of their performance, reproduction and survival rates.

Yak in the culture of the people

As noted earlier, the yak has a long documented history stretching into ancient times. As the people who kept them migrated, they took their yak with them into wider territory. It is important to stress how closely involved the yak has been, and is, with the culture, religion and social life of the pastoral people of the cold, high-mountainous regions of Asia – at least among those people who can trace their history of yak keeping back over the centuries. This will be given more detailed consideration in Chapter 12 (see also Miller, 2002). The traditions and traditional knowledge of yak keeping provide a suitable counterbalance for the scientific and technological considerations – the main concerns in this book. It is possible, of course, that the cultural and social context of yak herding may diminish in the future in the face of the introduction of market-driven economics and of improved transport and communication. It is also possible that the spread, however slow, of modern concepts of feeding, management and breeding, and the pressures on yak husbandry from those proffering such technological advice, might further erode the force of traditional values. In some areas, such as Nepal, social change in relation to its yak economy, as documented by, for example, Bishop (1989), has led to a great reduction in yak numbers. It would be a pity if the natural resources of the vast territories now purposefully exploited by the yak were to become less productive or deserted through insensitive management of change.

The yak takes its place alongside other animals, both real and mythical, in the history, legends and mythology of the Tibetan region and neighbouring territories, as illustrated with examples by Cayla (1976). The yak and yak emblems are closely associated with many aspects of religious practice of Tibetan Buddhism and depicted widely in temple art, as described succinctly by Olsen (1990). The use of the yak as provider of components for local medicines is but one aspect of their near-mystical importance. Meyer (1976) described some of these medicines and remedies associated with the yak.

As discussed in more detail in Chapter 12, religion, ceremony, social customs and attitudes to wealth and its symbols are all intertwined with each other in the life of the people and with the integral role of the yak in all aspects of that life. This intertwining has counterparts among nomadic people of Africa but is rarely applicable to animal husbandry

in the western part of the world. It is important to bear these points in mind, lest it be assumed that knowledge of the reproductive and productive attributes of the yak and of modern management practices are all that is required to bring about “improvements” in the economy of yak keeping.

The spread of knowledge of the yak outside its "native" area

The relative isolation of both wild and domesticated yak in the mountainous regions of central Asia, around the Qinghai-Tibetan Plateau, is illustrated by the dearth of mention of the yak in the West until relatively modern times. If early travellers to the East had attempted to export yak, they might have been frustrated by a reputedly poor tolerance of the yak to prolonged exposure to heat at lower altitudes - particularly if this involved a relatively rapid transition from cold to hot areas. Although, as already mentioned, yak now exist in zoos and wild animal parks in many parts of the world and commercially in North America. This suggests that the degree of tolerance of the yak to heat and its adaptability to different environments may be better than traditionally thought and that this subject requires reappraisal (see Chapter 11, part 3).

Lydekker (1912) asserted that yak were known by repute in western Europe in the classical Grecian times and given the name of *poiphogoi*, or “eaters of poa grass”, because they were said to feed exclusively on grass. Also, Zeuner (1963) in his *A history of domesticated animals* provided two early references to yak. The first of these dates to the latter part of the first century A.D. when Martial (a Roman poet) alluded to the use, by the ladies of Rome, of the tail of some kind of ox (*Muscarium bubulus*) as a fly-whisk, or clothes brush. Zeuner deduced that the tail was that of the yak and goes on to point out that this, in turn, suggests that overland trading routes to the East must have been fully open then. (The yak-tail fly-whisk has been well-known in India for centuries). Zeuner further referred to accounts of the thirteenth-century travels of Marco Polo, who clearly exaggerated the size of the yak when equating it to an elephant.

Boulnois (1976) provided a much fuller background to the knowledge of the yak made available by Western travellers in early times, especially from the seventeenth century onwards.

It is therefore apparent that factual information on the yak, as distinct from anecdotes, came to Europe rather late, compared to China, as seen from the many references in ancient Chinese literature. Perhaps the first Western account was by Samuel Turner, who was sufficiently impressed by the yak to send two to Europe. His book, *An account of an embassy to the Court of the Teshoo Lama in Tibet*, was published in 1800 and republished in 1971; in it he vividly described the characteristics of the yak and its environs.

In respect to more recent times, there are, apart from much documentation of the yak by Chinese authors and a substantial body of publications in Russian, two substantive accounts in English on the general performance of the yak in China. These reports resulted from visits to various parts of yak country in the 1940s by distinguished American experts in animal husbandry (Phillips *et al.*, 1945, 1946). In the past few decades, relatively brief, general accounts of the yak in English have appeared in textbooks and in FAO publications dealing with the livestock of China and the former USSR. In addition, there are a number of “popular” articles about the yak though they are of the “isn’t-it-wonderful” or “quaint” variety. Fortunately, there are a substantial number of technical papers on specialist research topics regarding the yak and the ecology of its territories published in English, French, German and other languages that are more widely accessible to readers in the West. Many of these are reference sources for this book in addition to the great number from traditional yak-rearing countries. Special mention must be made of the substantial and well-documented study by a team of French scholars (*The yak – its role in the economic and cultural life of its breeders in central Asia*) sponsored by the Société d’Ethnozootechnie au Museum National d’Histoire Naturelle (Paris) (1976).

A recent source of information on the commercial use of yak is the promotional literature and Web site of the International Yak Association, formed by yak breeders in North America.

References

- Agir (1997). Elevages exotiques en Suisse. *Actualités*, 30 Août 1997.
- Belyar, D.K. (1980). *Domestication of yakutsk*. Siberian Publication House.
- Bishop, N.H. (1989). From zomo to yak: Change in a Sherpa village. *Human Ecology*, 17:177-204.
- Boulnois, L. (1976). The yak and the travels of western naturalists. In *Le Yak*. Son rôle dans la vie matérielle et culturelle des éleveurs d’Asie centrale. *Ethnozootechnie*, No.15, France. pp. 7-22.
- Cai Li (1989). *Sichuan yak*. Chengdu, China. Sichuan Nationality Press. 223 pp.
- Cayla, L. (1976). Some mythological aspects of yak in Tibet. In: *Le Yak*. Son rôle dans la vie matérielle et culturelle des éleveurs d’Asie centrale. *Ethnozootechnie*, No.15, France. pp. 23-34.
- Dyblor, E. (1957). The first time to discovery of yak fossils in Yakutsk. *Vertebrate Palasiatica*, 1 (4): 293-300.
- Flerow, C.C. (1980). On the geographic distribution of the genus *Poephagus* during the Pleistocene and Holocene. *Quaternary Paleontol. (East) Berlin*, 4:123-126.
- Guo Shijian & Chen Weisheng (1996). The situation of yaks in China. In: Miller D.G., Craig S.R. and Rana G.M. (ed), *Proceedings of a workshop on conservation and management of yak genetic diversity, at ICIMOD, Kathmandu, 29-31 October 1996*. ICIMOD (International Centre for Integrated Mountain Development), Kathmandu. pp. 25-28.
- Langjie Zeren *et al.* (1987). Supplementary feeding trial for fattening hybrid of Holstein-Friesian and yak in warm season. *Journal of China Yak*, 4: pp. 51-55.

- Li Ruimin (1986). Records of bovine species in ancient Chinese history. In: Zhang Zhongge and Zhu Xianhuang (ed), *Proceedings of papers about history of animal husbandry in China*. Beijing, China Science Press. pp. 146-149.
- Li Shih-Chen (Li Shizhen (1596). *Compendium of materia medica, or The great herbal. (Pen ts'ao kang mu, or Ben cao gang mu)*
- Li Yifang (1999). *Past, present and future of milk industry in China*. Beijing, China Agriculture Press.
- Lydekker, R. (1912). *The ox and its kindred*. London. Methuen & Co. Ltd.
- Meyer, F. (1976). Notes on products from the yak and its crosses used in Tibetan medicine. In *Le Yak. Son role dans la vie materielle et culturelle des eleveurs d' Asie centrale*. Ethnozootechnie, No.15, France. pp. 35-45.
- Miller, D.J. (1990). Grassland of the Tibetan Plateau. *Rangelands*, 12:159-163.
- Miller, D.J. & Steane, D.E. (1996). Conclusions. In: Miller D.G., Craig S.R. and Rana G.M. (ed), *Proceedings of a workshop on conservation and management of yak genetic diversity, at ICIMOD, Kathmandu, 29-31 October 1996*. ICIMOD (International Centre for Integrated Mountain Development), Kathmandu. pp.191-209.
- Miller, D.J. (2002). The importance of China's nomads. *Rangelands*, 24(1): 22-24.
- Olsen, S.J. (1990). Fossil ancestry of the yak, its cultural significance and domestication in Tibet. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 142:73-100.
- Olsen, S.J. (1991). Confused yak taxonomy and evidence of domestication. *Illinois State Museum Scientific Papers*, Vol. 23:387-393.
- Phillips, R.W., Johnson, R.G. & Moyer, R.T. (1945). *The livestock of China*. U.S. State Department Publication, No. 2249.
- Phillips, R.W., Tolstoy, I.A. & Johnson, R.G. (1946). Yaks and yak-cattle hybrids in Asia. *Journal of Heredity*, 37: 163-170, 207-215.
- Prezewalski, N.M. (1883). *From Zaisan Lake through the Kham region of Tibet and the head of the Yellow River*. Second edition (1948). Moscow.
- Qian Yanwen (1979). *The origin of domesticated animal: biohistory*. Beijing, China Science Press.
- Schaller, G.B. (1998). Wild yak. Chapter 7 in *Wildlife of the Tibetan Steppe*. University of Chicago Press. 125-142
- Tong Pingya & Zhao Guopan (1990). *Brief history about livestock and poultry in China*. Beijing, Scientific Books Press. 46-47.
- Turner, Samuel (1800). (1971 reprint of original edition). *An account of an embassy to the Court of the Teshout Lama in Tibet*. Original edition: G. & W. Nicol, Booksellers, London, Reprint: Bibliotheca Himalayica, Series I, vol. 4. New Delhi, Manjusri Publishing House.
- Verdiev, Z. & Erin, I. (1981). Yak farming is milk and meat production. *Molochnoe I miasnoe skotovodstvo*, 2: pp. 16-17.
- White, W.T., Phillips, R.W. & Elting, E.C. (1946). Yaks and yak-cattle hybrids in Alaska. *Journal of Heredity*, 37:355-358.
- Xu Guifang & Wang Zhigang (1998). Present situation and proposal for future development of yak industry in China. *Forage and Livestock*, Supplement: 6-8.
- Xu Shangzhon (1998). Development strategies for the beef industry in China in the twenty-first century. *Forage and Livestock*, Supplement:1-6.
- Yu Daxin & Qian Defang (1983). General situation of Xinjiang yak. *Journal of China Yak*, 1:57-64.

Zeuner, F.E. (1963). *A history of domesticated animals*. London, Hutchinson. pp. 352-353.

Zhong Guanhui *et al.* (1986). Observation on the adaptability of yak introduced into Lingshan area of Beijing. *Journal of Southwest Nationalities College* (Animal Husbandry and Veterinary Sciences Edition), 1:9-14.

2 YAK BREEDS

OVERVIEW

According to the (Chinese) *Provincial annals of livestock breeds*, there are 12 officially recognized breeds of domestic yak in China: the Jiulong yak and Maiwa yak in Sichuan, Tianzhu White yak and Gannan yak in Gansu, Pali yak, Jiali (“Alpine”) yak and Sibü yak in Tibet, Huanhu yak and Plateau yak in Qinghai, Bazhou yak in Xinjiang and Zhongdian yak in Yunnan, and one other, the “Long-hair-forehead yak” in Qinghai – which does not, however, meet all the criteria used to define a yak breed. Among these, the Plateau yak, Maiwa yak, Jiulong yak, Tianzhu White yak and Jiali (“Alpine”) yak are also included in the publication *Bovine breeds in China*.

The yak of the Qinghai-Tibetan Plateau yak (often called Plateau or Grassland yak) and those of the Hengduan mountain Alpine yak (often called Alpine or Valley yak) have long been regarded as “types”. This classification was initially based on the geographic and topographic parameters of their habitats and on the body size of different yak populations in the different environments. Although there are some differences between the main types in appearance and in aspects of their performance – as there are also among the breeds – it is not yet resolved to what extent such differences are genetic and to what extent they derive from varying conditions in the areas in which these yak populations are found.

In this chapter, the main characters of 11 of the principal breeds are reviewed. In addition, information is given on an “improved” strain of yak, named Datong yak, which was started by crossbreeding between Huanhu yak and wild yak (using artificial insemination) and subsequently developed on the Datong Yak Farm in Qinghai. (The Datong yak is not at present classified as a breed because of its limited numbers).

Outside China, most notably in Mongolia and in countries of the CIS (formerly Soviet Union), yak are usually referred to by a name designating the area where they are kept or the area from which they have come. Whether this constitutes different breeds in the genetic sense is a matter for debate and is not generally claimed.

Introduction

The yak was listed by Linnaeus (1766) as *Bos grunniens*, the same genus as other domestic cattle. However, in the middle of the nineteenth century the yak was listed as *Poephagus grunniens* (Gray, 1843) on the grounds of morphological distinctions from both other cattle and from bison. There was a return to *Bos grunniens* following Lydekker (1898), and this form has continued to be used to the present. More recently, however, the *Poephagus* classification has returned and been considered as the most appropriate for reasons discussed by Corbet (1978) and by Olsen (1990, 1991) following a re-examination

of the available fossil evidence. The name *Poephagus grunniens* has been adopted increasingly, over recent years – but is by no means universally accepted. Clearly, this is a matter of considerable interest and concern to taxonomists. Since both the *Bos* and the *Poephagus* genera have their strong adherents in respect to the yak, it will be surprising if this debate ends anytime soon (see also Chapter 15 for new evidence favouring *Poephagus*). Fortunately, both camps agree on the species name of *grunniens* on account of the characteristic grunting noise made by the yak.

The yak has the same number of chromosomes (60) as *Bos taurus* and *Bos indicus* and interbreeds with both; the female hybrids being fertile and the male hybrids sterile. The yak will also interbreed with bison – again, the female hybrids are fertile, but not the males (Deakin *et al.*, 1935). (These authors also report that the yak-bison hybrid showed stamina and speed to a “remarkable degree”.)

Breeds in China

Domestic yak differ from wild yak in being smaller and, not surprisingly, in temperament (see Chapter 1). It is not clear whether these differences have arisen because of differences in the selection pressures on wild and domestic yak or whether and to what extent genetic drift and inbreeding have contributed. However, there are many attributes in common between wild and domestic yak; broadly speaking, they share a similar environment and, as already noted, they will interbreed without difficulty, given the opportunity.

By crossing wild yak bulls with the Huanhu yak on the Datong Yak Farm, using artificial insemination, a “new” strain of yak has been developed (see section, A new strain of Datong yak in Qinghai). Moreover, the semen from the wild yak and semi-wild yak bulls have been extensively used with the intention of improving domestic yak productivity in Qinghai, Tibet, Sichuan, Gansu and Xinjiang (see Chapter 11, part 1). In former times, it was not uncommon for wild yak bulls to wander among domestic yak herds within their territory and mate with them (cf. Chapter 10). Crosses of wild and domestic yak and, consequently, their special qualities have been known for a long time to herdsman in the vicinity of wild yak territory.

Twelve yak breeds were officially recognized by committees of yak experts on the basis of intensive investigations in the six main yak-raising provinces in China. Results of these deliberations published in the provincial annals of livestock breeds in the 1980s and discussed in many other publications (Lei Huanzhang, 1982; Editing Committee [Qinghai], 1983; Department of Animal Husbandry and Veterinary Medicine in Gansu, 1986; Editing Committee [Sichuan], 1987; Liu Zubo *et al.*, 1989; Cai Li, 1989, 1992; Zhang Rongchang, 1989; Zhong Jincheng, 1996; Bhu Chong, 1998; Han Jianlin, 2000; Ji Qiumei, *et al.*, 2002). The recognized breeds are the Jiulong yak and Maiwa yak in Sichuan, Tianzhu White yak and Gannan yak in Gansu, Pali yak, Jiali (Alpine) yak and Sibuyak in Tibet, Huanhu yak, Plateau yak and the “long-hair-forehead” yak in Qinghai, Bazhou yak in Xinjiang and Zhongdian yak in Yunnan. For this book’s present purpose,

the “long-hair-forehead yak” of Qinghai province is not considered further because it does not match the definition of a breed due to its random distribution in herds of both the Huanhu and Plateau yak. The remaining 11 breeds will be described here in some detail. However, all 11 breeds are distinguished only by origin, location and some small differences in productive characteristics (which might be attributable to the locality). There is almost no evidence available of the magnitude of any genetic differences.

The domestic yak of the Qinghai-Tibetan Plateau (known as the Plateau or Grassland yak) and those of the Hengduan mountain range (known as Alpine or Valley yak) in China have been regarded as “types” for a long time. This classification was initially based on the geographic and topographic parameters of their habitats and on the body size of the different yak populations (Cai Li, 1985). In 1982, a number of Chinese experts on the yak agreed to a broad classification of domestic yak into these two principal types (Plateau and Alpine) based on body conformation. The classification also took account of the ecological and social-economic conditions in which the yak were kept and evidence of any selection that had taken place. In general, it was thought that artificial selection applied to the Qinghai-Tibetan Plateau type during its development was less than that applied to the Hengduan Alpine type (Cai Li, 1989).

Other classification suggestions have arisen from time to time but have not been subsequently adopted. Although there are some differences between the main types in appearance and in aspects of their performance – as there are among the breeds – it is not yet resolved to what extent such differences are genetic and to what extent they derive from the different conditions in the areas in which these yak populations are found. Even the once apparently clear distinction between the Qinghai-Tibet Plateau and the Hengduan Alpine types has become blurred or ignored in recent literature.

To resolve the question of the relative contribution of heredity and environment to the apparent differences among the breeds of yak, one would require comparisons of them and of the crosses between them at the same location and at the same time. Better still, such comparisons should be repeated at a number of different locations typical of the different ecological habitats associated with the breeds of yak. If that were done, it might be expected that outward appearance associated with colour, hair and horn types and, to some extent, body conformation would remain largely distinct. However, differences in aspects such as body size and milk production, as well as reproductive performance, might converge in a common environment. But the extent of such effects cannot be predicted. Currently, genetic approaches using chromosomal and protein polymorphisms, mitochondrial DNA RFLP (restricted fragment length polymorphism), mitochondrial DNA sequencing and microsatellite genotyping are being introduced to the study of yak to estimate the genetic distance among breeds and some aspects of breed differentiation (see Chapter 15).

Plateau yak of Qinghai

This yak, now classified as a breed, is found on the cold highland pasture of southern and northern Qinghai province where the wild yak distribution overlapped with it, particularly in former times. Crossing between them is thus assumed to have taken place. Its population numbers around three million (Han Jianlin, 2000). The Plateau yak of Qinghai looks similar to the wild yak in body conformation. Among domestic yak breeds it stands tall, has a relatively large body weight and big head. Both sexes are horned. Similar to wild yak, it has greyish-white hair down its back and around the muzzle and eye sockets. It adapts well to the cold and humid climate at high elevation (see Table 2.1a). The majority of these yak are black-brown in colour (71.8 percent) and the rest are chestnut (7.8 percent), grey (6 percent), spotted (1.7 percent) and white (0.8 percent) (Lei Huanzhang, 1982; Editing Committee [Qinghai], 1983; Liu Zubo *et al.*, 1989). Their productivity is shown in Table 2.1b.

Huanhu yak of Qinghai

This breed is found in the transitional zone around the Qinghai Lake in Qinghai province where the grasslands are predominantly semi-arid and consist of meadow pasture and neighbouring areas consist of dry Gobi and semi-Gobi pastures. It is believed that herds of this strain were domesticated and transferred to this area by the Qiang people, the predecessors of the present Tibetans, and by the Tufan people, beginning 10 000 years ago up through their later migrations. Around 310 A.D., Mongolian immigrants used Mongolian cattle to hybridize with the local yak to improve the relatively low productivity of the animals. Accordingly, the Huanhu yak, numbering about one million (Han Jianlin, 2000), contains some remnants of cattle blood from the time of its origins, and this may account for some of its differences from the Plateau yak (Liu Zubo *et al.*, 1989). Compared to the Plateau yak, the Huanhu has a relatively smaller body size and finer structure, a wedge-shaped head, a narrower and longer nose that is mostly concave in the middle, a smaller but broad mouth, a thinner neck, deeper chest, narrower buttock, longer legs and smaller, but strong solid feet with a hard base to them. Most of the animals are hornless; those with horns have a fine, long and slightly curved set of horns. The colours are varied, but the majority is black-brown (64.3 percent); among the rest, there are grey animals (10.3 percent), white-spotted (10.7 percent) chestnut-brown (4.7 percent), white (3 percent) and other colours (6.9 percent) (Lei Huanzhang, 1982; Editing Committee [Qinghai], 1983; Liu Zubo *et al.*, 1989). Their productivity is shown in Table 2.1b.

Tianzhu White yak of Gansu

The Tianzhu White breed (see Figure 2.1) is found in Tianzhu county of Gansu province, which is located in the eastern end of the Qilian mountains and the northern edge of the Qinghai-Tibetan Plateau (102°02' - 103°29'E; 36°29' - 37°41'N). Its main distribution borders the Menyuan and Huzhu counties of Qinghai where a few white yak are also found. Generally, 2 - 3 percent of all yak populations are white individuals – though these are not regarded as part of the Tianzhu White breed. Because the white yak hair is easily dyed into different colours, it has been highly valued in local markets. On account of this, herdsmen who had migrated from Qinghai started to select and breed pure white herds

about 120 years ago. A more intensive breeding programme started in 1981. Currently, there are around 60 000 of the white individuals (Liang Yulin and Zhang Haimin, 1998; Zhang Haimin and Liang Yulin, 1998). The breed has a medium body size and fine structure, a well-developed forepart but a less-developed rear part and strong but short legs. And there are big differences in size between the two sexes. Compared to the females, the males have larger heads with a wider forehead, longer and coarser horns with a visible contour, a larger mouth and broader muzzle, thinner lips, smaller nose and a coarser neck. The sex dimorphism is greater in the Tianzhu White yak than in other breeds. In the total population of the Tianzhu White breed in Gansu and Qinghai, around half the individuals have only white hair and skin with slightly red eye sockets. They are typical albinos. The rest are white but with coloured spots, mostly around the eye sockets. This colour helps to reduce problems to the eyes from the strong ultraviolet irradiation at high altitudes (Pu Ruitang *et al.*, 1982; Department of Animal Husbandry and Veterinary Medicine in Gansu, 1986; Zhang Rongchang, 1989). Their productivity is shown in Table 2.1b.

Gannan yak of Gansu

Yak raising in the Gannan Tibetan autonomous prefecture of Gansu (100°46' - 104°45'E; 33°06' - 35°43'N), bordering Sichuan and Qinghai, for long has been based on the same yak from the Qinghai-Tibetan Plateau. Frequent exchange of breeding animals continues. There are about 700 000 animals of this breed (Han Jianlin, 2000). It has a strong body conformation and well-developed muscles, a relatively large skull, a short, wide and slightly protruding forehead, a long and concave nose with externally expanded muzzle, a square mouth with thin lips, horned (48 - 97 percent in different herds) or hornless, small ears, round eyes, a well-developed chest and belly and short, strong legs with small feet. Black is the predominant colour (76.8 percent of the animals); among the rest, the colours are white-spotted on black (15.8 percent), grey (6 percent) and yellow and white (1.4 percent). The males have longer and coarser horns with wider distance between the bases and a stronger neck than the females. The females have a small udder with short nipples (Department of Animal Husbandry and Veterinary Medicine in Gansu, 1986; Zhang Rongchang, 1989). Their productivity is shown in Table 2.1b.

Pali yak of Tibet

This breed is mainly found in Yadong county of Shigatse prefecture of the Tibetan Autonomous Region (approximately 88°8'E, 27°5'N), which borders western Bhutan and India. It has a strong and well-developed body conformation that is rectangular, a short skull with a wide forehead, a big round mouth with thin lips, small eyes, broad muzzle, small nose, a short, strong neck, a deep wide chest and large heart girth, a large belly and short, strong legs with small solid feet. Most of the animals have horns with wide bases. Black is the dominant body colour (87 percent); the rest are spotted black (11 percent) and brown (2 percent) (Tang Zhenyu *et al.*, 1981; Liu Zubo *et al.*, 1989). Their productivity is shown in Table 2.1b.

Sibu yak of Tibet

This breed is found in Medrogungkar county (approximately 92°40'E; 29°120'N) in the southeastern Lhasa municipality of Tibet. It has a large head with externally expanded horns, a rectangular-shaped body conformation with a straight back (Dou Yaorong *et al.*, 1984; Liu Zubo *et al.*, 1989). Their productivity is shown in Table 2.1b.

Jiali (Alpine) yak of Tibet

This breed is found in the Jiali (Lhari in Tibetan) county of the Nakchu prefecture (approximately 93°40'E; 31°N) of Tibet at the southern edge of the Nyenchen Thangla mountains. It has a relatively large body shape with a deep and wide chest, and it is mostly horned (83 percent). Compared to the females, males have coarser and stronger horns with a wide distance between the bases. Females have a thinner neck, straighter back, a larger belly and shorter legs than the males. Eighty percent of the animals have a white-spotted head or a completely white head. Half of them are white-spotted black, 41 percent are pure black or with only a white tail and the remaining 9 percent are white, brown or grey (NIAH *et al.*, 1982; Liu Zubo *et al.* 1989). Their productivity is shown in Table 2.1b.

Jiulong yak of Sichuan

This breed (see Figure 2.2) belongs to the Jiulong county of Sichuan province, which is located on the southeastern edge of the Qinghai-Tibetan Plateau (approximately 101°33'E, 28°39'N). It has a long history of development, but today's herds are the descendants of a relatively small population that survived a severe outbreak of Rinderpest some 150 years ago. The population now numbers around 50 000 animals (Zhong Jincheng, 1996; Lin Xiaowei and Zhong Guanghui, 1998). The Jiulong yak has a large body height and body size, with a deep and wide chest and a medium-sized head. The breed is horned. Males, compared to females, have a shorter head but with a wider forehead and wider-based horns, bigger eyes, thinner lips and well-developed teeth, a finer neck, straighter back and shorter legs. Females have a relatively long neck. Black is the predominant colour (61.7 percent); the rest are black-and-white (24.6 percent) and white-spotted on black (13.7 percent) (Editing Committee [Sichuan], 1987; Cai Li, 1989, 1992; Liu Zubo *et al.* 1989). Their productivity is shown in Table 2.1b.

Maiwa yak of Sichuan

This breed (see Figure 2.3), numbering around 600 000 animals (Lin Xiaowei and Zhong Guanghui, 1998), belongs to Hongyuan county of Sichuan province (approximately 102°33'E; 32°48'N), which borders Gansu and Qinghai provinces. The breed originated from almost the same locality as the present-day Jiulong yak. However, it was taken by a migratory tribe to its present habitat, passing through southern Qinghai, in the 1910s. During that migration, matings occurred with other domestic yak on route and with wild yak when it first settled in Hongyuan, when wild yak were still known to come down from Qinghai. The resulting infusions of genes are thought to have improved the original type. The better pasture and ecological environment of the new habitat assisted its development. It has a medium-sized head and a wide flat forehead, straight back, a well-developed belly, a long body with short legs and small solid feet. Most of the animals are horned. Black

accounts for 64.2 percent of the population's colouring; the rest are black with a white-spotted head and tail (16.8 percent), cyan (a very dark blue) (8.1 percent), brown (5.2 percent), black-and-white (4.2 percent) or other colours (1.5 percent) (Cai Bolin, 1981; Editing Committee [Sichuan], 1987; Cai Li, 1989, 1992; Liu Zubo *et al.* 1989). Their productivity is shown in Table 2.1b.

Bazhou yak of Xinjiang

This breed is found mainly in Hejing county (83° - 93°56'E, 36°11' - 43°20'N) in Xinjiang Uyghur Autonomous Region. Their presence dates to 1890 when around 60 animals were brought from Tibet (Zhou Yiqing, 1980); another 176 animals were introduced in 1920 (Dong Baoshen, 1986). In the late 1980s, some breeding bulls were purchased from the Datong Yak Farm in Qinghai to refresh the blood (Dong Baoshen, 1986). There are now about 70 000 Bazhou yak (Fang Guangxin and Liu Wujun, 1998). This breed has a large rectangular body, a heavy head, a short and wide forehead, big round eyes, small ears, a broad muzzle and thin lips, a wide chest, large belly and strong legs with small, solid feet. The majority (77.3 percent) have fine, long horns. Black is the main colour, but some are black and white, brown or grey and white (Gala *et al.*, 1983; Yu Daxin and Qian Defang, 1983; Zhang Rongchang, 1989). Their productivity is shown in Table 2.1b.

Zhongdian yak of Yunnan

This breed is found in the Zhongdian and Deqin counties (99°50' - 100 50'E, 26°85' - 28 40'N) in the very northern part of Yunnan province, at the southern end of the Qinghai-Tibetan Plateau where it borders Tibet and Sichuan. In general, the Zhongdian yak has had frequent exchanges of blood with yak in Sichuan. There are about 20 000 animals of this breed (Zhong Jincheng, 1996; Han Jianlin, 2000). It has a strong body conformation, large round eyes, small ears, a wide forehead, a deep chest, straight back, well-developed legs with large feet and a short tail. Both sexes have horns. There is relatively large variation in body size. The majority of the animals are black (62.4 percent), a black-and-white colouring is found among 27.5 percent of them, while the rest are black with white-spots on the forehead, legs and tail (Liu Guoliang, 1980; Duan Zhongxuan and Huang Fenyin, 1982; Zhang Rongchang, 1989). Their productivity is shown in Table 2.1b.

A new strain of Datong yak in Qinghai

This is the only improved yak population developed deliberately by crossing wild yak bulls with domestic yak females with the intention of creating a new breed of yak. The development is taking place on the Datong Yak Farm in Qinghai (approximately 101°70'E, 32°N and at an altitude of around 3 200 m). For this purpose, one wild yak bull captured in the Kunlun mountains and two in the Qilian mountains (with an altitude of more than 5 000 m) were taken to Datong Yak Farm and trained for semen collection between 1983 and 1986.



Figure 2.1 Tianzhu White yak (Qinghai-Tibetan Plateau type)



a



b

Figure 2.2 Jiulong yak (Henduan Alpine type) a) male; b) female



a



b

Figure 2.3 Maiwa yak (Qinghai-Tibetan Plateau type) a) male; b) female

The semen of these three bulls is used to artificially inseminate the Huanhu yak cows. To date this has produced 1 086 crossbred animals (F1), which formed the foundation generation. Then six F1 breeding bulls were selected from that group. The next generation consisted of 1 700 breeding cows, which were of both the F2 type (from mating F1 females to F1 males) and back-crosses (B1) (from mating F1 males with the domestic yak females). The subsequent generation (designated the second generation in the programme) of 29 breeding bulls and 542 breeding cows was obtained by mating B1 to each other, F1 males with the B1 females and B1 males with the F1 females. That generation, in turn, was used to create a nucleus herd. A third generation was created by intermating the offspring from the second generation. In a similar way, a fourth generation was produced from the third. By the year 2000, there were about 2 000 animals in the nucleus herd at the Datong Yak Farm where most performance records have been taken and where most of the selection was practiced. A further 20 000 animals in multiplier herds were situated at three locations: the Datong Yak Farm in Qinghai and the Shandan and Liqiaru farms in Gansu. The animals in the multiplier herds derived from the third and fourth generations at the Datong Yak Farm. In total, 8 700 breeding animals, from the foundation to the third generation, had their productivity recorded over a 15-year period.

The objective in the nucleus herd was to control inbreeding and to select breeding bulls to improve yak productivity. The average inbreeding coefficient was estimated as 0.094 (0.031 - 0.125). The selection of bulls was made first around the time of birth using their own birth weight (adjusted for the parity of the dam) and the body conformation, birth weights and growth of their parents. Ten percent of the bulls were discarded at this stage. A second selection took place when the bull calves were six months old. Body weight and conformation before winter were considered, and weight was adjusted for parity and month of calving. Between 30 and 50 percent of the bull calves were rejected at that stage. A third selection was conducted at age 18 months. This was regarded as a particularly important time for further selection as the animals were weaned and had had the opportunity to express their performance, in terms of growth and body conformation, under both a harsh winter season and the following summer season with adequate nutrition. Sixty percent of those so evaluated were rejected from further consideration. A final selection was made when the animals were between two and a half and three and half years old. At this time, the bulls were each mated to between 15 and 20 cows to check for their reproductive capacity and the offspring phenotype of potential replacement bulls. Each bull's own growth and body conformation was also reconsidered. Half of the bulls taking part at this stage were discarded. After these four selections, around 11 percent of the original group remained for use as replacement breeding bulls.

The Datong yak looks not dissimilar to the wild yak with its greyish-white mouth, nose, sockets and grey back line. The males are horned and females are either horned or hornless. The body conformation seems to be of a meat type with good body weight, straight back, a wide chest, and long, strong legs. The body colour is typically black, though there may also be a few brown hairs. The body measurements and the selection progress of the Datong yak are shown in Tables 2.2 and 2.3. In addition, the milk and fibre

yields of the Datong yak were recorded and compared with the Huanhu yak and are reported in a number of publications (Bo Jialin *et al.*, 1998a, b; Wang Minqiang *et al.*, 1998).

Postscript on breeds in China

Not surprisingly in view of the relative isolation of different areas from each other, at least in times past, many distinct breeds of yak have developed in China. Five of them are listed as breeds at national level in the *Bovine breeds of China* (Institute of Animal Science [China], 1986). These are the Plateau yak, Maiwa yak, Jiulong yak, Tianzhu White yak and Jiali (Alpine) yak. The Provincial Administration of Standardization in both Gansu and Sichuan also issued breed criteria for the Maiwa yak, the Jiulong yak and the Tianzhu White yak (TAHVS and DAS, 1985; Zhong Guanghui *et al.*, 1995; Wen Yongli *et al.*, 1995).

Some information on the various breeds is shown in Tables 2.1a and 2.1b. Three of the breeds are shown in Figures 2.1, 2.2 and 2.3.

Breeds in countries apart from China

From the available literature, it appears that yak in most countries outside China are not specifically classified as “breeds”. Instead, they are referred to as yak of a particular area in which they are found or from which they have been brought, or they may take their name from the people of the area. For example, Sarbagishev *et al.* (1989) referred in this manner to the yak in various parts of the former USSR: “Yaks bred in Kirgizia are considerably larger than those in Tajikistan.” They are careful to note a management difference between these two populations of yak so as not to draw the conclusion that the differences are necessarily genetic. In the same manner, Zagdsuren (1994) referred to the country of origin when discussing hybridization of yak with cattle of other species. Smirnov *et al.* (1990) referred to yak of “Tuva type” when writing about meat production trials in the northern Caucasus. Verdiev and Erin (1981) referred to Pamir, Altai and Buryatia types, which are the names for the areas or country where the yak are located. In writing about domestic livestock in Nepal, Epstein (1977) also did not separate yak into breeds. It thus appears that differences among “local” populations of yak are recognized, but whether these constitute different breeds, in the genetic sense, is a matter for further investigation. Pal *et al.* (1994) classified the yak of India into a number of types, as described in the section on India in Chapter 11, part 2. For further general information on yak in other countries, see also Chapter 11.

Table 2.1a Main breeds of yak in China and observations on distribution and characteristics

[Source: adapted and revised from Cai Li, 1985]

Location (province or autonomous region)	Breed	Main area	No. (‘000)	Topography	Pasture type	Grass type (predominant type)	Altitude (m)	Average annual temp. (°C)	Rainfall (mm)
Sichuan	Jiulong*	Jiulong county and Shade district of Kangding county in Ganzi Tibetan autonomous prefecture	30	High mountain intersecting valleys	Alpine bush and meadow	Mixed sward	>3 500	2.0	900
	Maiwa*	Hongyuan and Ruergai counties in Aba Tibetan and Qiang autonomous prefecture	200	Hill-shaped plateau	Cold meadow and marsh	Gramineae, cyperaceae	3 400-3 600	1.1	728
Yunnan	Zhongdian	Zhongdian county in Diqing Tibetan autonomous prefecture		Hill-shaped plain among mountains	Alpine bush and meadow	Mixed sward and grass	3 276	5.4	620
Gansu	Tianzhu White*	Tianzhu Tibetan autonomous county	30	Broad plateau and valley	Sub-alpine meadow	Many bush on n. slopes; Gramineae Cyperaceae	[3 000]	0.1	300-416
	Gannan	Gannan Tibetan autonomous prefecture		Hill-shaped plateau	Alpine and sub-alpine	Gramineae, Cyperaceae	3 300-4 400	0.4	664
Qinghai	Plateau*	Northern and southern Qinghai	3 400	Plateau	Alpine meadow	Gramineae, Cyperaceae	3 700-4 700	From -2 to -5.7	282-774
	Huanhu	Mountainous region around the Qinghai Lake		Mountain	Sub-alpine meadow, part forest grassland	Grass	2 000-3 400	From 0.1 to 5.1	269-595
Tibet	Jiali (Alpine)*	Alpine area of Tibet; Jiali county	1 400	Plateau, mountain	Alpine bush and meadow	Mixed sward	>4 000	0	694
	Pali	Yadong county		Plateau, mountain	Alpine meadow	Gramineae, Cyperaceae	4 300	1.7	468
	Sibu	Medrogungkar county		Plateau, mountain	Alpine bush and meadow	Mixed sward	4 000-5 500	0	700
Xinjiang	Bazhou	Centre of Tianshan mountains		Mountain	Sub-alpine meadow	Grass	2 400	-4.7	285

* Listed as national breeds in China. ** Estimated body weight = {(heart girth [m])² x (body length [m]) x 70}.

Table 2.1b Main breeds of yak in China and observations on distribution and characteristics

	Breed	Sex	No.	Body measurements (cm)				Body weight** (kg)	Source
				Height at withers	Body length	Heart girth	Cannon bone circumference		
Sichuan	Jiulong*	M	15	138	178	219	23.6	594	GAAHB and YRO, 1980a, b; Cai Li, 1989
		F	708	117	140	179	18.2	314	
	Maiwa*	M	17	126	157	193	19.8	414	Cai Li, 1989
		F	219	106	131	155	15.6	222	
Yunnan	Zhongdian	M	23	119	127	162	17.6	235	Duan Zhongxuan and Huang Fenyong, 1982
		F	186	105	117	154	16.1	193	
Gansu	Tianzhu	M	17	121	123	164	18.3	264	Pu Ruitang <i>et al.</i> , 1982; Zhang Rongchang, 1989
	White*	F	88	108	114	154	16.8	190	
	Gannan	M	10	126	141	189	22.4	354	Department of Animal Husbandry and Veterinary Medicine in Gansu, 1986; Zhang Rongchang, 1989
		F	159	109	122	157	16.1	210	
Qinghai	Plateau*	M	21	129	151	194	20.1	398	Editing Committee [Qinghai], 1983
		F	208	111	132	157	15.8	228	
	Huanhu	M	14	114	144	169	18.3	287	
Tibet	Jiali	M	8	130	154	197	22.4	421	NIAH <i>et al.</i> , 1982; Liu Zubo <i>et al.</i> , 1989
	(Alpine)*	F	187	107	133	162	16.1	243	
	Pali	M	59	111	123	155	18.3	288	Tang Zhenyu <i>et al.</i> , 1981; Liu Zubo <i>et al.</i> , 1989
		F	321	109	121	152	15.2	217	
Sibu	M	4	132	149	185	21.0	358	Dou Yaozong <i>et al.</i> , 1984; Liu Zubo <i>et al.</i> , 1989	
	F	53	109	127	153	15.9	212		
Xinjiang	Bazhou	M	33	127	140	192	20.7	359	Dong Baoshen, 1986
		F	265	111	124	171	16.3	257	

* Listed as national breeds in China. ** Estimated body weight = {(heart girth [m])² x (body length [m]) x 70}.

Table 2.2 Body measurements and weights of the first generation Datong yak in comparison to the Huanhu yak on the Datong Yak Farm [Source: Bo Jialin *et al.*, 1998b]

Group	No.	Age (month)	Height at withers (cm)	Body length (cm)	Heart girth (cm)	Cannon bone circumf. (cm)	Body weight (kg)
Datong yak	7 ^a	6	88.4 ± 5.6	87.1 ± 5.2	106.8 ± 4.8	12.0 ± 0.7	74.7 ± 10.4
Huanhu yak	7	6	79.4 ± 3.4	52.0 ± 4.6	96.4 ± 5.1	11.3 ± 1.1	58.8 ± 10.2
<i>Difference</i>			5.1*	5.1*	10.4**	0.7	14.88**
Datong yak	7	18	103.1 ± 2.4	108.5 ± 4.7	141.6 ± 4.7	14.6 ± 0.9	150.5 ± 56.1
Huanhu yak	7	18	100.1 ± 3.5	103.2 ± 2.8	131.3 ± 4.5	13.7 ± 0.4	117.7 ± 17.4
<i>Difference</i>			2.7*	5.3*	10.3**	0.9	32.8**

Note: *P<0.05; **P<0.01. a: Pooled data from 4 females and 3 males of both groups.

Table 2.3 Generation progress of body weights of animals in the nucleus herd at the Datong Yak Farm (data from males [M] and females [F] pooled) [Source: Wang Minqiang *et al.*, 1998]

Item	Generation 0	1st generation	2nd generation
Birth weight	11.49 ± 0.98	12.04 ± 0.89	12.42 ± 0.89
No.	10 M and 11 F	12 M and 15 F	14 M and 19 F
Weight at 6 months	71.02 ± 7.80	74.71 ± 10.47	82.19 ± 12.91
No.	10 M and 15 F	4 M and 3 F	12 M and 19 F
Weight at 18 months	135.08 ± 10.18	150.50 ± 6.07	154.40 ± 11.18
No.	8 M and 12 F	9 M and 12 F	8 M and 12 F

References

- Bhu Chong (1998). Present situation of research and production of yak husbandry in Tibet. *Forage and Livestock*, Supplement: 38-40.
- Bo Jialin *et al.* (1998a). Raising of the Datong new yak breed. *Forage and Livestock*, Supplement: 9-13.
- Bo Jialin *et al.* (1998b). Meat production performance from generation Datong yak in China. *Forage and Livestock*, Supplement: 15-18.
- Bo Jialin *et al.* (1998c). Milk production from one generation Datong yak in China. *Forage and Livestock*, Supplement: 19-20.
- Cai Bolin (1981). Introduction to the Maiwa yak. *Journal of China Yak*, 1: 33-36.
- Cai Li (1985). Yak breeds (or populations). In Chen Pieliu (ed), *Domestic animal breeds and their ecological characteristics in China*. Beijing, China Agricultural Press pp. 45-59.
- Cai Li (1989). *Sichuan yak*. Chengdu, China, Sichuan Nationality Press. 223 pp.
- Cai Li (1992). *China yak*. Beijing, China Agriculture Press. 254 pp.
- Corbet, G.B. (1978). *The mammals of the Palaearctic Region: a taxonomic review*. British Museum (Nat. Hist.), Ithaca, New York, Cornell Univ. Press. 314 pp.
- Deakin, A., Muir, G.W. & Smith, A.G. (1935). *Hybridisation of domestic cattle, bison and yak. Report of Wainwright experiment*. Publication 479, Technical Bulletin 2, Dominion of Canada, Department of Agriculture, Ottawa.
- Department of Animal Husbandry and Veterinary Medicine in Gansu (1986). *Annals of livestock and poultry breeds in Gansu*. Lanzhou, China, Gansu People's Press.
- Dong Baoshen (1986). Source, economic traits and development of Hejing yak. *Journal of China Yak*, 2: 33-37.
- Dou Yaozong *et al.* (1984). Tibetan yak. *Journal of Tibetan Animal Husbandry and Veterinary Medicine*, 2: 12-34.
- Duan Zhongxuan & Huang Fenying (1982). Report of survey on the Zhongdian yak. *Journal of China Yak*, 1: 75-82.
- Editing Committee [Qinghai] (1983). *Annals of livestock and poultry breed in Qinghai*. Xining, China.
- Editing Committee [Sichuan] (1987). *Annals of livestock and poultry breeds in Sichuan*. Chengdu, China, Sichuan Scientific and Technology Press.
- Epstein, H. (1977). *Domestic animals of Nepal*. New York, Holmes & Heier. pp. 20-37.
- Fang Guangxin & Liu Wujun (1998). Present situation, constraints and future actions of yak husbandry in Xinjiang. *Forage and Livestock*, Supplement: 50-51.
- GAAHB (Ganzi Agricultural and Animal Husbandry Bureau) and YRO (Yak Research Office of Southwest Nationalities College) (1980a). The good meat-purpose yak – the investigation and study of Jiulong yak. *Journal of China Yak*, 1: 14-33.
- GAAHB (Ganzi Agricultural and Animal Husbandry Bureau) and YRO (Yak Research Office of Southwest Nationalities College) (1980b). The general survey and identification for Jiulong yak. *Journal of China Yak*, 3: 17-24.
- Gala, Mao Guangtong *et al.* (1983). Bazhou yak in Xinjiang. *Journal of China Yak*, 2: 46-50.
- Gray, J.E. (1843). *List of mammals in the British Museum*. London, British Museum.

- Han Jianlin (2000). Conservation of yak genetic diversity in the Hindu Kush Himalayan region and central Asian steppes. In Shrestha, J.N.B. (ed), *Proceedings of the fourth global conference on conservation of domestic animal genetic resources, in Kathmandu, 17-21 August 1998*. pp. 113-116.
- Institute of Animal Science [China] (1986). *Bovine breeds in China*. Shanghai, China, Shanghai Scientific and Technology Press. pp. 117-132.
- Ji Qiumei *et al.* (2002). Resources of yak production in Tibet and reasons for the degeneration of productive performances. *Proceedings of the third international congress on yak, in Lhasa, China, 4-9 September 2002*. Nairobi, International Livestock Research Institute (ILRI). pp 300-307.
- Lei Huanzhang (1982). Discussion of types and utilization of Qinghai yak. *Journal of China Yak*, 2: 1-3.
- Liang Yulin & Zhang Haimin (1998). Conservation and utilization of Tianzhu White yak. *Forage and Livestock*, Supplement: 56-57.
- Linnaeus, C. (1766). *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis synonymis, locis*. Vol 1, Regnum Animale, pt. 1, pp. 1-532.
- Lin Xiaowei & Zhong Guanghui (1998). Present situation and development strategy of yak husbandry in Sichuan. *Forage and Livestock*, Supplement: 26-28.
- Liu Guoliang (1980). Zhongdian yak. *Journal of China Yak*, 2: 75-82.
- Liu Zubo, Wang Chengzhi & Chen Yongning (1989). Yak resources and qualified populations in China. In *Chinese Yakology*. Chengdu, China, Sichuan Scientific and Technology Press. pp. 36-77.
- Lydekker, R. (1898). *Wild Oxen, sheep and goats of all lands*. London, Rowland Ward Ltd. 314 pp.
- NIAH (Nagqu Institute of Animal Husbandry), Jiali Farm and Jiali Veterinary Station (1982). Report of investigation of the Jiali yak. *Journal of China Yak*, 3: 51-56.
- Olsen, S. J. (1990). Fossil ancestry of the yak, its cultural significance and domestication in Tibet. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 142: 73-100.
- Olsen, S.J. (1991). Confused yak taxonomy and evidence of domestication. *Illinois State Museum Scientific Papers*, Vol. 23: 387-393.
- Pal, R.N., Barari, S.K. & Basu, A. (1994). Yak (*Poephagus grunniens* L.), its type – a field study. *Indian Journal of Animal Sciences*, 64: 853-856.
- Pu Ruitang, Zhang Rongchang, Zhao Yiner & Den Shizhang (1982). Introduction to the Tianzhu White yak. *Journal of China Yak*, 1: 64-74.
- Sarbagishev, B.S., Rabochev, V.K. & Terebaev, A.I. (1989). Yaks. In Dmitriev N.G. & Emst, L.K. (ed), *Animal genetic resources of the USSR*. FAO Animal Production and Health Paper, No. 65, Rome. pp. 357-364.
- Smirnov, D.A. *et al.* (1990). Meat yield and meat quality of yaks. *Sel'skokkhozyaistvennykh Nauk Im. V.I. Lenina. (Soviet Agricultural Sciences)*, No. 1: 46-49.
- TAHVS (Tianzhu Animal Husbandry and Veterinary Station) and DAS (Department of Animal Science of Gansu Agricultural University) (1985). *Breed criterion of the Tianzhu White yak in Gansu Province (Gan Q/NM4-85)*. Issued by Provincial Administration of Standardization on 2 January 1985 and effective 1 April 1985.

- Tang Zhenyu *et al.* (1981). Survey of the yak in Pali district of Yadong county in Tibet. *Journal of China Yak*, 2: 46-50.
- Verdiev, Z. & Erin, I. (1981). Yak farming is milk and meat production. *Molochnoe I miasnoe skotovodstvo*, 2: 16-17.
- Wang Minqiang *et al.* (1998). Selection and breeding for bulls and the generation progress of the mass breeding in raising of the Datong new yak breed. *Forage and Livestock*, Supplement: 13-15.
- Wen Yongli *et al.* (1995). *Breed criterion of the Maiwa yak in Sichuan Province (DB51/249-95)*. Issued by Provincial Administration of Standardization on 14 December 1995 and effective 1 January 1996.
- Yang Bohui *et al.* (1998). Study on the fair and underwool production of Datong yak. *Forage and Livestock*, Supplement: 21-23.
- Yu Daxin & Qian Defang (1983). General situation of Xinjiang yak. *Journal of China Yak*, 1: 57-64.
- Zagdsuren, Yo (1994). Heterosis in yak hybrids. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994). pp. 59-62.
- Zhang Haimin & Liang Yulin (1998). Survey on herd structure and management of Tianzhu White yak. *Forage and Livestock*, Supplement: 57-58.
- Zhang Rongchang (1989). *China: the yak*. Lanzhou, China, Gansu Scientific and Technology Press. 386 pp.
- Zhong Guanghui *et al.* (1995). *Breed criterion of the Jiulong yak in Sichuan Province (DB51/250-95)*. Issued by Provincial Administration of Standardization on 14 December 1995 and effective 1 January 1996.
- Zhong Jincheng (1996). *Yak genetics and breeding*. Chengdu, China, Sichuan Scientific and Technology Press. 271 pp.
- Zhou Yiqing (1980). Brief introduction to the Hejing yak in Xinjiang. *Journal of China Yak*, 1: 91.

3 BREEDING, CROSSBREEDING AND HYBRIDIZING OF YAK

OVERVIEW

Pure-breeding is the predominant practice with yak. Apart from a scheme involving selection in crossbreds of wild yak with domestic yak in a process of breed development (see Chapter 2), no information has become available on rigorous selection programmes consistently applied for the improvement of the performance of yak in China. However, some selection schemes appear to be under consideration both in China and other countries. The dearth of organized selection schemes is not surprising with an absence of written records of performance and pedigrees and because of the location of yak in harsh environments and remote regions. Herdsmen in some areas, such as those of the Jiulong yak, have a traditional system of selection for replacement bulls. The Jiulong scheme considers the performances of the sires and maternal performance, as well as the physical appearance of the individual. It has to be remembered that the capacity to survive must be one of the chief attributes in the genetic makeup of the yak. This characteristic is likely to be under constant pressure from natural selection.

There is circumstantial evidence that some inbreeding is likely to have occurred with yak as a result of traditional pure-breeding methods and, in some countries, because of insufficient interchange of breeding stock across national boundaries. This can be expected to have harmful effects on the performance of yak.

Crossbreeding among the different types and breeds of yak does not appear to be systematic, but, on theoretical grounds, should be advantageous. Crossing domestic yak with wild yak is receiving widespread attention and favourable results are reported, with indications of heterosis. Crosses of domestic yak with wild yak are also thought to provide a basis for selection in new breed formation (cf. Chapter 2).

Hybridizing of yak with other species of cattle (mainly *Bos taurus* but also *Bos indicus* in some countries) is widely practised. Bulls of local breeds of cattle are used for natural service. But for hybridizing of yak with relatively high-yielding “exotic” breeds of cattle, the use of AI with frozen semen is normal, as the bulls of these breeds have not, in the past, survived for long in the mountainous regions. Hybridizing of yak with cattle is advocated in several countries as a means of increasing milk and meat output from the mountainous regions. Only the first generation of hybrids (F1) is favoured, as later generations of backcrosses have poorer performance (and hybrid males are sterile). However, the F1 females can usefully be mated to males specially chosen for “meat” production. There are both economic and biological limits on the extent to which interspecies hybridization can be carried out. The biological limit is set by the low reproductive rate of yak and by survival rates. A large proportion of the female yak

population is required simply to replace the pure-bred yak – even if the size of that population were to remain static and not increase, as seems often desired by herders.

Pure-breeding

Ways of improving yak productivity by selection might be of great importance to the people who depend on yak for their livelihood. As discussed earlier, the yak is the dominant domestic animal in the alpine regions and the mountain plateaux of western China and adjacent areas to the south and north – dominant in economic, though not necessarily in numerical, terms. The yak also has great importance in Mongolia and several other countries (see Chapter 11, part 2). It is an integral component of the socio-economic system of people in many remote areas and, often along with sheep and goat, it is the main contributor to the livelihood of the herdsman and their families. And yet, several factors militate against systematic breeding programmes.

The first of these constraints on improvement by genetic selection is that yak are still widely regarded, especially among Tibetan people, as a symbol of wealth. The more yak a family or a village owns, the richer and stronger it is considered to be. To maintain or increase the number of yak can take precedence over improvements in quality, or even overall productivity. Thus, animals are often kept until they die rather than culled for reasons of poor productivity. This can lead to overstocking of pastures and to a potential reduction in the output from the herd as a whole (see Chapters 12 and 13). “Quality” of the herd can become more of a consideration in situations where “competing” families or villages already own similar numbers of animals. Observation also suggests that smaller herds are sometimes of better quality because more pasture resource is available for a given number of animals and greater individual care is given to the animals by the herders.

A second important reason why genetic selection by herdsman, or by extension officers acting on their behalf, is impeded is the absence of the necessary performance and parentage records – although herdsman will often claim to know the parents of yak, especially bulls. It is doubtful if the accuracy of this knowledge is ever tested. In some nucleus breeding herds set up recently on the state farms in Qinghai, Tibet, Gansu and Sichuan, pedigrees but not performance were recorded.

Third, survival of the yak in a harsh, even hostile, environment is of paramount importance, perhaps of higher priority than any other single performance trait (though it is unlikely that this matter has been quantified). In terms of selection for survival under these conditions, natural selection is almost certainly more effective than any current procedure devised by man.

In relation to selection for the main products from the yak – milk, meat and fibre – the only convincing evidence of changes resulting from selection applies to fibre, where selection of a “fibre line” in the Jiulong breed appears to have produced far higher yields than in contemporary animals not selected for this trait (Cai Li *et al.*, 1980). Because fibre traits are quite strongly inherited and much more so (at least in other species) than milk yield or growth traits, selection progress is relatively easier to achieve with fibre production traits.

The milk yield of yak is very low, relative to other cattle, particularly those specializing in milk production. It has been suggested that the amount of milk produced by yak is only the quantity that would normally be needed to rear its calf. Thus, yak calves that receive only some of their dams’ milk, because the rest is taken for human consumption, grow significantly less well (see Chapter 6). An incentive to select for a higher yield in yak is most likely to arise only where there is an expanded market for milk destined for sale.

In respect to meat output from yak, three problems arise that may create conflict with opportunities for selection for growth rate or “size” (meat production), even if these traits were somehow measured. One is the fact that a significant proportion of each year’s growth of the animals during the warm season is lost over the period of nutrient deficiency in winter and early spring. This makes it difficult to see what an appropriate selection strategy should be. If the strategy were to be the increase in the size of the adult animal, say at the end of a growing season, the selection process would be delayed to late in life and hence would make slow progress. A second constraint is that when milk is taken from yak for human consumption and the calf is left short, the precise effect on each individual calf is difficult to estimate (even though an average effect of rearing practice is known). And in any case, there is variation in the quantity of milk produced by the dams. Selection among calves for growth rate therefore would be less accurate than in a totally uniform rearing system. A third problem is the opportunistic nature of the disposal of surplus stock that frequently occurs. The lack of a regular marketing strategy for well-grown animals, combined with the relatively rudimentary nature of the current marketing system, particularly in the remote areas, works against selection for “meat”.

Nonetheless, in the regions where yak products are in great demand in the marketplace, it seems that herdsmen have acquired both the knowledge and skill to improve production traits – even though it may be done unsystematically and perhaps unconsciously. This is a possible reason why some breeds are held in higher esteem than others. But different breeds are rarely compared with each other in the same place and at the same time. So it is difficult to quantify the extent of any genetic differences in performance of the breeds, as distinct from differences in their looks.

Selection objectives for the chief yak breeds in China

In general, there are no clearly defined breeding objectives and no developed breed structure among herdsman. Chinese animal scientists, however, decided towards the end of the 1980s to develop breeding objectives for the principal yak breeds. The intention was to provide technical assistance for a more systematic approach to yak breeding and to aim for earlier maturity, to improve the animal's shape for meat production and to develop strains for either milk or meat, or for meat and hair production. The criteria to be adopted therefore stressed body size, growth rate, dressing and meat percentages, milk yield and fat percentage, as well as the yield of hair – both coarse and down, but with an emphasis on the down.

The criteria proposed were approved in Sichuan and Qinghai for the Jiulong, Maiwa, Plateau and Huanhu breeds of yak (Zhong Guanghui *et al.*, 1995; Wen Yongli *et al.*, 1995) and a corresponding scheme was developed in Gansu for the Tianzhu White breed in 1985 (TAHVS and DAS, 1985). Some information and comments about these schemes appear below, but first though, attention is drawn to a selection procedure used by herdsman. The procedure in the Jiulong breed is regarded as traditional because it occurred before the advent of the recent provincial schemes and also had particular involvement from the late Professor Cai Li and his colleagues (1980; GAAHB and YRO, 1980a, b).

A “traditional” selection procedure used by herdsman in the Jiulong area of Sichuan

Selection of yak by the herdsman in the Jiulong area is relatively systematic. Herdsman pay more attention to choice of yak bulls for breeding than they do to the cows. The guiding principle for the herdsman is to check the ancestors (the parents) first and the bull second. Selection of replacement males starts in the herd with calves from cows that have good conformation and high milk yield over two parities of calving. The herdsman require that the sire of the males being chosen as replacement bulls should have copious hair and a large number of progeny. The bulls being selected should have good conformation. In particular, the herdsman require that the horns of the selected bulls stretch outward from a rough base and that there is a long distance between the horns. The forehead, head, muzzle and mouth have to be broad; the neck thick and the lips thin and long; withers should be high and brisket wide; the back, loin and rump should be wide and flat; the tail hairy; forelimbs straight and hind legs curved; the scrotum should be shrunken. Acceptable coat colours are black or black with some white specks on the forehead and at the extremities of the body (e.g. legs or tail), but not on the body itself.

It is of interest that selection of bulls in the Jiulong area is made in three stages. The first is a pre-selection at the age of one to one and a half years. There is a second selection from among the first group at the age of three years and a final selection at the age of four to five and a half years. (The relative importance given to different traits at each stage is not

specified). Bulls that are culled are castrated and used for meat or draught purposes. After initial mating with cows, bulls that are found to have been defeated in the normal competition for mates, which occurs among the bulls, and males found to have physical defects or bad conformation are then also culled. The herdsmen aim to have two or three successors to an excellent, dominant bull that has been working in the cow herd.

In 1979, in accordance with newly instituted breeding plans, nearly 7 000 reproductive bulls and cows (about a third of the total) were evaluated on physical conformation and body weight (GAAHB and YRO, 1980b). As a result, four adult yak bulls were identified that met or approached the predetermined performance levels. However, by the time the bulls were identified they were too old for use. Clearly, this was an uncertain start to selective breeding and was more akin to a process of population screening (a search for exceptional individuals) than a process of continuous genetic selection. This particular scheme could not be continued, but consideration was subsequently given to selection of yak at various locations and in different counties where the Jiulong yak are kept (Cai Li, 1989). A standardized evaluation scheme for the Jiulong yak was drafted and approved to assist individual evaluation and selection (Zhong Guanghui *et al.*, 1995). Finally, a nucleus herd with 412 breeding animals was established in the centre of the Jiulong yak territory and 106 individuals were maintained on a state farm to implement a breed-improvement programme (Lin Xiaowei and Zhong Guanghui, 1998).

The traditional selection methods for Jiulong yak appear to have produced over a period of many decades, perhaps centuries, an improved breed of yak that is highly regarded. Clearly, the criteria applied contain elements that are related to important aspects of production in the yak. However, a cautionary comment should be added, lest it be thought that these methods have to be unreservedly commended because they have tradition and herdsmen's experience on their side. Geneticists would wish to suggest that there is great scope for improving these procedures, even in the absence of sophisticated indices of breeding value and modern computational procedures. To start with, they would ask how closely related the physical appearance of the yak, so much emphasized by the herdsmen, is to actual performance of the herd – in terms of, say, growth, milk yield or reproductive rate. Usually the relationship is not high. A geneticist would also wish to encourage the herdsmen to pay most attention to those characteristics of the yak that provide the greatest economic return irrespective of whether the products from the yak are for home or commercial use. For that reason, it would also be urged that the number of criteria considered for selection be restricted to an essential minimum. Improvement of the important traits is diluted, or even lost, when a lot of attention is paid to less important, even trivial, matters – as may be the case now.

More recent provincial schemes: the example of the Tianzhu White

The Provincial Administration of Standardization in Gansu adopted criteria in 1985 to standardize the assessment of grading for the Tianzhu White yak and to evaluate breeding value as an aid to selection (TAHVS and DAS, 1985; Zhang Rongchang, 1989). The aim was to improve the breed for meat and hair.

Scores are allocated for aspects of general conformation, the body, testes for males and udder for females, legs, feet and the coat. Calves and adults are graded to somewhat different criteria. Weight and height classes are designed according to age and sex of animal and assigned to four grade classes. The use of selected breeding bulls is recommended, and newborn animals may be assigned a grade on the basis of the grades of their parents. Breeding bulls, in turn, are classified into four grades on the basis of the grades attained by their offspring. There are eight nucleus herds with a total of about 400 breeding animals maintained in the central area of this breed and 40 multiplier herds with approximately 20 000 individuals in surrounding areas (Zhang Haimin and Liang Yulin, 1998).

On the face of it, this scheme, like the “traditional” Jiulong scheme, pays considerable attention to aspects of the animals’ appearance. This may well detract herders from considering more single-mindedly the performance aspects that matter most, namely, in line with the objectives for this breed, meat and hair production and the underlying factors of reproduction and vigour. Also, as has been found elsewhere with breeding schemes, if too many traits are considered there is a likelihood that none are improved (unless combined in highly sophisticated, statistically complex and computerized schemes).

In spite of reservations about the selection schemes, there appears to have been significant progress in the Tianzhu White yak since the 1980s. For example, the body height of adult breeding bulls and cows older than four and a half years increased from 108.1 cm and 104.3 cm (average of 17 males and 88 females) in 1981 to 110.2 cm and 104.7 cm (20 males and 44 females) in 1987 and to 114 cm and 112.9 cm (98 males and 826 females) in 1997. Corresponding body weights changed for males and females from 189.7 kg and 171.4 kg to 199.2 kg and 179.6 kg and to 202.8 kg and 192.7 kg respectively over those same years (Zhang Rongchang, 1989; Wang Yuchang and Wang Yanhong 1994; Zhang Haimin and Liang Yulin, 1998). However, these data were collected in a simple survey on various farms over a period of years. It is not possible, therefore, to distinguish any contributions from genetic improvement from those in management and feeding (or simply from year effects). There is a presumption, though, that management and feeding practices have remained largely unchanged over this period.

Other schemes

Sarbagishev *et al.* (1989) referred to an organized breeding programme in Kyrgyzstan based on specifications for yak males and females that were concerned primarily with conformation, growth rate and body size. Pedigrees were included and breeding values constructed. The improvement scheme was spread over a number of stock-breeding farms.

But the main scientific effort towards genetic improvement of productivity of yak, in many countries, has been directed at hybridization with *Bos taurus* and, to a lesser extent, *Bos indicus* cattle, rather than to selection. Some consideration has also been given to introducing, by crossbreeding, genes from wild yak into the domestic yak population as a means of improving productivity (see the following section). Lei *et al.* (1994) reported a scheme that uses performance criteria of individual yak and the potential benefits of introducing wild yak.

In the late 1980s, the first Wild Yak Frozen Semen Station was established on the Datong Yak Farm in Qinghai with three wild yak bulls (two captured from the Qilian mountains and one from the Kunlun mountains (Lu Zhonglin and Li Kongliang, 1994; Bo Jialin *et al.*, 1998). Another Yak Frozen Semen Station is now in operation at Damxung in Tibet (Zhang Yun, 1994). These are the only A.I. centres in China specific to yak. By 1995, 8 700 crossbred animals of the wild yak with domestic yak had been produced in Qinghai and Gansu that served as the base herds for further selection and breeding of the new improved yak strain of Datong yak (Bo Jialin *et al.*, 1998). The scheme used in this development of a “new” breed is described in Chapter 2.

Zhang Yun (1994) reported that there were ten yak bulls from the Sibü and Jiali yak breeds in Tibet and 28 semi-wild yak (F1, or backcrosses) at the Damxung station, though this number had been reduced to 17 in use. At the time of Zhang’s report, 50 000 doses of semen had been produced and 2 000 yak cows inseminated – as well as a much larger number of yellow cattle to produce hybrids with the yak.

As yet there is no information on progeny records from these A.I. bulls. The full potential of using such information in selection procedures for improved performance of yak has not yet been realized. However, Zhang also suggested that the distribution of yak semen from this station could play a significant role in counteracting adverse effects of inbreeding, which have been thought to occur in yak in some areas. (The need to introduce yak “blood” from outside sources, to counteract inbreeding in the yak population of different areas, is also referred to by Pal in relation to India [see Chapter 11, part 2].)

Group breeding schemes

Because of the potential advantages of group-breeding schemes in promoting genetic improvement, especially when the participating herds are each relatively small,

consideration is being given to setting up such schemes for yak. At present, as far as is known, these remain in the planning stages.

In the early 1990s an “open-nucleus” herd was established at Longri farm in Hongyuan county. This set-up included a small trial to check problems in the recording of accurate pedigrees for purposes of estimating genetic parameters (Zhong Guanghui, 1998). The nucleus herd to promote the improvement of Maiwa yak consists of 12 breeding bulls, tested for their performance, and 180 breeding cows (Lin Xiaowei and Zhong Guanghui, 1998). Records of growth, milk and reproduction have been collected continuously.

Consideration of inbreeding in yak

Inbreeding has harmful effects on nearly all aspects of livestock performance. Inbreeding reduces, for example, reproductive capacity, growth rate, adult size, and milk production and increases mortality, especially among the newborn and young. The amount of harm is usually quite closely related to the degree to which inbreeding occurs. It is a matter that should be considered in relation to yak because the traditional pattern of breeding may encourage inbreeding (cf. Chapter 5). In this system, bulls compete for mates and, in due course, these bulls are often replaced in the hierarchy of the herd by their offspring. This makes it inevitable that some inbreeding occurs. Inbreeding can be much reduced if bulls are exchanged across herds and greater distances – even then the problem may not be avoided but only postponed if two villages, for example, were consistently to exchange breeding stock only with each other. Controlled mating, whereby the herdsman decides on the mates for a particular bull, is similar in that it may reduce or postpone inbreeding, but rarely avoids it for long.

The absence of the pedigrees of animals in yak herds has made it impossible in the past to know the actual extent to which inbreeding has occurred. However, recently, microsatellite markers were used to analyse the genetic structure of different yak breeds/herds in China and other parts of the world and hence to estimate a general inbreeding effect. An assumption is made that the fewer alleles found at any one locus in a breed or herd, the higher will be the degree of inbreeding in that population. These investigations may help clarify the inbreeding issue specific to yak herds or breeds (cf. Chapter 15). However, the actual effects in yak are not known since this requires comparison of the performance of groups differing in their degree of inbreeding. This, in turn, requires performance records linked to pedigrees. For the time being, the probability of harmful consequences of inbreeding in yak is therefore inferred from known, corresponding effects in cattle, sheep and other livestock.

In some countries, such as Bhutan, Nepal and India (see Chapter 11, part 2), concerns about the effects of inbreeding have been expressed by those on the spot. The yak populations in these countries have become relatively closed. This is a consequence of

reduced interchange of breeding stock across national boundaries relative to former times that, in turn, increases the likelihood that related animals are mated to each other. The effects of inbreeding must be suspected whenever the general performance of the stock is known, or thought, to have declined relative to an earlier era, and when other systematic changes in husbandry practices, such as overgrazing, for example, cannot account for it. Thus Kozlovskii (1960) stated that yak in the Gorno-Altai region were becoming closely inbred, which, if true, could well account for the earlier view of Denisov (1935) that the yak of that area were inferior, at that time, to those of other regions. Kozlovskii advocated, by way of remedy, the introduction of unrelated yak males and/or of hybridization with other cattle.

Inbreeding occurs whenever animals that are more closely related to each other than “average” are mated to each other. For example, if a son or sons of a popular bull are used in a herd as his replacement, they, in turn, are liable to mate with some of their half-sisters or cousins. Moreover, such bulls are likely to serve other less closely related females, but related through common ancestors more generations back (grandparents or great-grandparents). Mating of full siblings to each other, or parents to their offspring, which is regarded as close inbreeding, can easily occur if steps are not taken to avoid it. Pal *et al.* (1994), writing in relation to yak in India, stated that farmers may use the same male to serve females of two to three successive generations.

Inbreeding also occurs as a consequence of selection, even though selection is widely and correctly advocated and practised for the genetic improvement of livestock. Selection has the inevitable consequence of bringing about an increase in inbreeding, simply as a consequence of restricting the number of animals that become parents of the next generation. The objective in selection schemes must ensure that the beneficial effects of selecting superior stock outweigh the harmful effects of the consequent inbreeding. This consideration is nowadays a routine part of large-scale and long-term breeding plans, such as cattle improvement programmes involving the widespread use of a few bulls through artificial insemination.

The reason for having dealt with the topic of inbreeding at some length is that experience suggests that the effects of inbreeding are easily ignored because they are not readily recognized in the short term. However, the circumstantial evidence for inbreeding is strong in some yak populations, and the potential for inbreeding should not, therefore, be ignored when yak are allowed to mate.

Crossbreeding within the yak species

No systematic crossbreeding appears to be practised among the different breeds or local populations of yak. This is not surprising considering the relative isolation of different communities and the distances separating them. But it is more surprising that it does not

seem, so far, to have played more than a minor role in investigations to find out whether hybrid vigour would result from such crossbreeding. There is a likelihood that hybrid vigour would result, although the magnitude cannot be predicted. The likelihood of heterosis from breed crossing can be argued from the relative isolation, over a long time, of discrete populations of domestic yak in different localities and from the likelihood that breeding practices within herds have led to inbreeding (although, again, some would dispute this). Crossing under these circumstances could have merits. From past experiments in China where Jiulong yak and Tianzhu White yak were introduced to other localities for crossing with the local yak, the crosses were at least heavier and larger than the local yak (Ren Chen Luoerri *et al.*, 1995; Liang Hongyun *et al.*, 1997). However, in the absence of results from the pure-bred animals of the introduced breed in the same locality, it is difficult to know to what extent this improvement represents the effects of heterosis or the consequence of bringing in “superior” genes from the new breed. Table 3.1 gives some of these results for crosses with the Jiulong yak.

Table 3.1 Improvement of the yak in Luhuo county in Sichuan by crossing with the Jiulong yak [Source: Zhong Jincheng, 1996]

Type	Age (year)	Sex	No.	Average body weight (kg)	Average body measurements (cm)		
					Height	Length	Heart girth
F1 (Jiulong crossed with local)	Birth	M	10	13.8	54.4	48.1	57.6
		F	12	13.2	54.4	49.2	56.8
	0.5	M	8	46.9	71.0	77.4	89.7
		F	10	41.5	68.4	73.6	86.2
	1.0	M	8	85.0	95.7	107.7	127.3
		F	8	80.2	90.3	103.3	122.7
Local Luhuo yak	Birth	M	6	11.9	53.5	46.3	56.2
		F	6	11.0	51.6	46.0	54.0
	0.5	M	6	36.6	66.3	69.3	82.0
		F	4	29.9	63.3	67.8	81.3
	1.0	M	3	81.3	85.0	93.3	109.3
		F	3	77.8	80.3	90.7	106.0

Further support for the potential usefulness of crossbreeding comes from the attention paid more recently to crossing of domestic yak with wild yak and the claims of improved performance from such crossbreeding.

In the results presented from such trials, it is also not possible to differentiate clearly between the additive genetic effects (e.g. the fact that wild yak are larger than domestic yak) and the occurrence and magnitude of heterosis as a result of the crossing; but some

results from such crosses are shown in Table 3.4.

Size of pure wild yak

Measurements were made in the 1960s on five adult male wild yak by the Agriculture and Animal Husbandry Department of Tibetan government (Study Group [Qiangtang], 1978). These animals had been caught in the Qiangtang area of northern Tibet. Their measurements are shown in Table 3.2.

Table 3.2 Body dimensions and weight of five male wild yak from Tibet

Body dimensions (cm), weight (kg)	Average	Range
Head length	61.1	(55 - 67)
Forehead width	27.3	(26 - 32)
Circumference of base of horn		(30 - 40)
Body length	179.3	(171 - 193)
Height at withers	158.8	(152 - 163)
Heart girth	240.6	(218 - 264)
Chest depth	91.1	(90 - 92)
Chest width	61.6	(53 - 78)
Cannon bone circumference		(22 - 24)
Estimated body weight	1 000.0	

Some wild yak calves caught by staff of the Animal Husbandry Institute of the Yushu Tibetan autonomous prefecture of Qinghai province were compared with domestic yak calves under the same conditions of feeding and management (Xu Guilin, 1985). Table 3.3 shows the weights and weight gains of the two groups. It can be seen from these results that the wild yak calves were 86 percent heavier than the domestic yak calves at three months of age but, relative to their weight, grew more slowly (though not necessarily less in absolute terms) so that by the age of 16 months the wild yak were only 63 percent heavier than the domestic ones.

Table 3.3 A comparison of the body weights and weight gains at various ages of five wild yak and 19 domestic yak kept under the same conditions of feeding and management [Source: Xu Guilin, 1985]

Age (months)		3	4	5	6	12	16
Domestic yak	Weight	33.6	39.2	48.2	51.5	59.1	67.4
	gain (kg)	5.6	9.0	3.3	7.6	8.3	
Wild yak	Weight	62.5	71.9	77.3	81.5	92.5	110.1
	gain (kg)	9.4	5.4	4.2	11.0	17.6	

Crossbreeding of wild yak with domestic yak

Some results from the crossing of wild yak with domestic yak are available. Provided the progeny from such crosses of domestic with wild yak have not been given preferential treatment over the domestic yak alongside them (and that may be a matter in question), the results suggest that the crosses have an advantage. Lu Hongji *et al.* (1987), for example, showed that the birth weight of crosses between domestic and wild yak were more than 30 percent heavier at birth than domestic yak calves. By age six months, the advantage in favour of the cross had increased to more than 50 percent. Calves with only one quarter wild-yak blood were 16 percent and 35 percent heavier at birth and six months of age, respectively.

Staff at the Lanzhou Institute of Animal Husbandry and Veterinary Science of the Chinese Academy of Sciences used some frozen wild yak semen to inseminate female domestic yak on the Datong Yak Farm of Qinghai province (Lu Hongji *et al.*, 1987). They also produced some backcrosses of the F1 to local domestic yak (to produce 0.25 percent wild yak) and mated some local domestic yak to males of the Jiulong (domestic) breed of yak (cf. Chapter 2, Datong breed). The results are shown in Table 3.4 and suggest that crossing to the wild yak increased body weights and weight gains over the first six months of life. These weight gains were greater, relative to the birth weights, in the crosses with wild yak than in crosses with the Jiulong. The local domestic yak showed the lowest relative weight gains to six months old. There were no measurements beyond that age. Some of the wild-domestic crossbred yak at the Datong farm are illustrated in Figure 3.1.

Table 3.4 Body weights (kg \pm SD) of local domestic yak and crosses with Jiulong yak and wild yak [Source: Lu Hongji *et al.*, 1987]

	Type of calf			
	Local yak	Local x Jiulong (F1)	Local x F1 (wild) (25% wild)	Local x wild yak (F1)
Birth weight	13.2 \pm 2.3 (n = 25)	14.0 (n = 2)	15.3 \pm 1.9 (n = 76)	17.3 \pm 2.3 (n = 77)
6-month weight	65.2 \pm 10.5 (n = 64)	73.7 \pm 6.9 (n = 9)	86.1 \pm 4.6 (n=21)	101.3 \pm 9.4 (n = 33)

In the 1990s, there was intensive use in Qinghai of the wild yak semen by A.I., or the use of semi-wild yak bulls with natural mating, to try to improve the domestic yak productivity and “rejuvenate” the yak population. Some comparable data from observations of the F1 (half wild yak blood), B1 (one quarter wild yak blood) and local yak under the same feeding and management system in southern Qinghai are shown in Table 3.5

(Yan Shoudong, 1998). It was found that the body measurements and weights of the semi-(F1) and quarter-wild yak (B1) were higher than those of domestic yak within the same age groups. As seen from Table 3.5, birth weight, height, length and heart girth of the F1 were greater than of the domestic yak calves and particularly at 18 months old, the measurements of both the F1 and the B1 were greater than of domestic yak.

Interest in the use of the wild yak to improve production of domestic yak was exemplified by the presentation of a number of papers on this topic at the first, second and third international congresses on yak, held in China in 1994, 1997 and 2000 (Zhang Rongchang *et al.*, 1994; Yang Rongzhen *et al.*, 1997a; Han Jianlin *et al.*, 2002; Zhao Bingyao and Zhang Jianwen, 1994). It was noted in those papers that, historically, herdsmen in the Gannan area of Gansu drove their domestic yak females into regions where wild yak lived, in order to allow natural mating with wild yak bulls. The crossbred progeny would later be selected to improve the domestic yak population. Based on this popular experience, more systematic studies using frozen semen from wild yak bulls are in progress. Substantial numbers of first-cross and backcross (25 percent wild yak) offspring have been born and are reported to grow significantly larger than the local domestic yak. The benefits of wild yak blood, as noted in these studies, have also carried over into crossing with the local yellow cattle. When yak bulls that had 50 percent wild yak blood were mated to yellow cattle, the resulting F1 hybrids were of the order of 20 percent larger at six months old than comparable F1 hybrids of yellow cattle with domestic yak. Yang *et al.* (1997b), Lu and Zhao (1997), Yan Shoudong (2002) and Amarsanaa *et al.* (2002) presented similar findings using wild yak to increase the growth and the related meat production of the domestic yak.

It is not known, from any of the studies previously referred to, what is the relative importance of the role of heterosis and of the additive genetic contribution from the wild yak to its cross with the domestic yak, as discussed earlier in relation to crosses among domestic breeds of yak.

Results of studies in another area of Gansu (Lu Zhonglin and Li Kongliang, 1994) suggested that substantial increases in body size, hair production and meat output were achieved in first crosses of wild with domestic yak, relative to the latter. Milk yield was found to have increased by more than 10 percent. Yan Ping *et al.* (1994) reported, more specifically, that the fleece weight of adult females was 1.76 kg, 1.65 kg and 1.47 kg for half-wild, quarter-wild and domestic yak, respectively. These authors also found that, importantly, the proportion of the undercoat was increased substantially with the introduction of wild yak blood – but the strength of the fibres was not affected. The use of wild yak to improve domestic yak performance through a process of crossing and selection was also reported to be under investigation in Qinghai (Lei Huanzhang *et al.*, 1994).

But clearly, only the additive genetic contribution from the wild yak genes will be useful in the actual process of subsequent selection (though the cross will retain some of the advantages from the initial heterosis). It is the perceived advantages of the introduction of wild yak blood into domestic yak populations that led to a project to develop a new breed from such a crossbred foundation (see Chapter 2).

Breed conservation

Taking into account the size of the present domestic yak population as a whole, it would be difficult to argue that conservation measures are a matter of urgency at this time. This might change if social or economic pressures were to reduce the extent of yak keeping – as is already evident in some areas, such as Nepal – or if predicted changes in global climate (over decades and centuries) have the effect of restricting the future distribution and size of the yak population.

Preservation of some of the remarkable traits of the yak in terms of its adaptation to a harsh environment and to long periods of severe deprivation should, nonetheless, be of interest to animal breeders worldwide. There are parts of the world where these characteristics could assist in establishing animal production and other parts where such resilience, on the part of the animal, could lead to better utilization of natural resources. Currently, however, the gene pool of the domestic yak as a whole is not endangered.

A different situation seems to exist for some of the more localized, and to an extent differentiated, populations or breeds of yak. The total numbers in some of these breeds is not large and hybridization with *Bos taurus* and *Bos indicus* cattle further reduces the proportion of the yak population available for its replacement.

For example, the Jiulong yak, possibly the best producer among the yak breeds, numbers 50 000 animals (Zhong Jincheng, 1996; Lin Xiaowei and Zhong Guanghui, 1998). The total numbers, however, tell only a small part of the story. Starting from a small herd, the Jiulong breed of yak has been a closed population for hundreds of years. Throughout the breed's history, herdsman are said to have avoided introducing outside blood. Moreover, the system of selection practised by the herdsman (previously described), and the natural competition among bulls for dominance makes it virtually certain that the effective size of the population is small and that inbreeding occurs (though the extent of this is a matter for debate). Thus, if the particular properties of the Jiulong are worth preserving and are not to be lost through genetic drift, special measures may be required. This was recognized by Chinese experts some years ago and led to the setting up of a random-breeding herd of 100 yak females and 20 males maintained per generation (Zhong Jincheng, 1996).

Table 3.5 Body weight and measurements of F1 and B1 of wild yak crossed with domestic yak in southern Qinghai [Source: Yan Shoudong, 1998]

Group	Sex	Age (month)	No.	Height (cm)	Length (cm)	Heart girth (cm)	Cannon bone Circumference (cm)	Body Weight (kg)
F1	m	At birth	21	56.1 ± 3.4	52.3 ± 4.6	59.6 ± 4.6	8.10 ± 0.38	14.9 ± 1.8
	m	6	19	80.8 ± 6.0	81.8 ± 7.5	94.3 ± 7.3	9.74 ± 0.42	49.6 ± 6.7
	m	12	11	80.7 ± 4.4	82.6 ± 6.7	92.5 ± 7.3	10.23 ± 0.61	45.9 ± 7.2
	m	18	13	91.8 ± 6.4	96.5 ± 8.7	117.5 ± 9.4	11.85 ± 0.83	98.9 ± 27.8
	f	At birth	31	56.2 ± 3.7	52.5 ± 5.2	59.6 ± 3.8	8.10 ± 0.57	14.6 ± 2.3
	f	6	30	79.3 ± 5.7	80.8 ± 9.0	93.1 ± 8.3	9.62 ± 0.68	45.8 ± 9.0
	f	12	20	81.6 ± 6.3	81.7 ± 8.6	97.6 ± 8.0	10.30 ± 0.64	49.4 ± 8.9
	f	18	19	90.0 ± 3.9	94.6 ± 11.6	114.6 ± 6.2	11.84 ± 0.67	90.9 ± 22.5
B1	m	At birth	41	55.2 ± 4.3	51.2 ± 4.4	59.8 ± 7.2	8.27 ± 0.39	14.8 ± 2.5
	m	6	39	78.1 ± 7.5	78.5 ± 7.3	94.2 ± 10.4	10.18 ± 1.33	50.7 ± 13.7
	m	12	20	83.5 ± 7.8	85.0 ± 8.7	98.6 ± 8.8	10.30 ± 1.49	54.5 ± 13.5
	m	18	23	92.8 ± 7.3	97.3 ± 10.0	115.9 ± 7.7	11.48 ± 0.72	95.7 ± 23.2
	f	At birth	64	54.6 ± 3.4	51.5 ± 4.4	58.7 ± 4.5	7.89 ± 0.66	14.7 ± 2.6
	f	6	64	77.3 ± 7.4	77.2 ± 7.9	92.7 ± 9.6	9.86 ± 0.97	47.9 ± 13.0
	f	12	37	82.2 ± 5.3	83.7 ± 7.3	99.3 ± 8.2	10.49 ± 0.80	54.7 ± 10.1
	f	18	37	91.4 ± 6.0	96.3 ± 7.9	116.3 ± 6.8	11.62 ± 0.87	94.3 ± 15.4
Domestic yak	m	At birth	81	53.1 ± 4.1	48.8 ± 4.0	57.5 ± 3.9	7.83 ± 0.63	13.6 ± 2.3
	m	6	76	77.4 ± 5.2	79.5 ± 8.1	92.8 ± 7.1	9.18 ± 0.71	48.1 ± 9.4
	m	12	50	80.9 ± 5.0	81.8 ± 5.9	97.8 ± 7.8	10.34 ± 0.73	53.6 ± 10.0
	m	18	49	89.7 ± 5.4	94.3 ± 8.0	113.6 ± 7.8	11.44 ± 0.90	88.7 ± 19.6
	f	At birth	92	52.8 ± 3.8	47.9 ± 4.0	56.8 ± 4.0	7.58 ± 0.54	12.9 ± 2.1
	f	6	88	76.6 ± 6.3	79.7 ± 6.5	93.6 ± 7.2	9.62 ± 0.78	48.1 ± 9.5
	f	12	66	81.2 ± 6.0	82.1 ± 6.4	97.9 ± 6.9	10.20 ± 0.86	51.5 ± 9.5
	f	18	62	89.6 ± 5.6	94.4 ± 8.1	114.8 ± 8.2	11.47 ± 0.96	93.2 ± 21.0

This was managed in the Hongba area of Jiulong county and was the responsibility of the Animal Husbandry Station there. Income from the sale of milk and culled animals met some of the costs. There was also a subsidy from local government to assist the project. This type of approach is clearly commendable as one way forward in terms of breed conservation. A random-breeding herd has, however, a further potential advantage in that it can also serve as a yardstick against which to measure progress from any genetic selection in other parts of the breed population.

Other yak breeds may be in a similar situation to the Jiulong, with total numbers not large and the size of the “effective” breeding population possibly quite small. The Tianzhu White breed, in an area of Gansu province, could be one and its conservation is being considered (Wang Yuchang and Wang Yanhong, 1994). Zhang Haimin and Liang Yulin (1998) indicated that the number and proportion of the pure white yak in Tianzhu have increased as a result of the protection programs; for example, in 1952, the proportion of pure white animals was 20.3 percent and in 1981 it was 31.5 percent. It increased to 44 percent in 1998. Interestingly, the price of a white tail was double that of a black one in 1998 (120 yuan per kg compared to 60 yuan per kg).

Local breeds may have special merits or special characteristics that could be lost in the absence of positive action to maintain such breeds. Investigation of the need for conservation in the yak should therefore receive some attention even if local rather than general action may be called for. A useful start might be an up-to-date census of the yak population, its various types and breeds and current breeding practices. In combination, such information would help to indicate the (genetically) effective size of the different breeding populations, both in China and elsewhere. A census of numbers alone, as regularly practised in some countries such as Mongolia, though helpful, is not enough for this particular purpose.

Too often in matters of conservation, action has been delayed until damage to the breed, or even extinction of the species, has become imminent. This must not be allowed to happen with the yak.

The genetic approaches using chromosomal and protein polymorphisms, mitochondrial DNA RFLP and sequencing, and microsatellite genotyping (referred to in Chapter 2) to estimate genetic distances among breeds should go some way towards determining priorities for breed conservation (Han Jianlin, 1996, 2000). (The technology is discussed in more detail in Chapter 15).

For the wild yak, it is widely accepted that conservation is a matter of importance and urgency. Accounts, from as recently as the nineteenth century, testified to vast herds of wild yak in the Kunlun mountains of Tibet and Qinghai. These are no longer seen. Miller *et al.* (1994) estimated that wild yak of all ages and both sexes may still have numbered

around 15 000 in the early 1990s, and this is also the number quoted more recently by Schaller (1998). Miller and Schaller (1996) claimed an estimated 7 000 - 7 500 wild yak remained in the Chang Tang Wildlife Reserve in Tibet at the time of their survey. But this number does not necessarily give an accurate picture of the threat confronting this wild species. Wild yak in China are included in the country's wildlife-protection legislation, but, according to Miller *et al.* (1994), the Departments concerned have inadequate resources for enforcement. The factors that have led to a dramatic decline in wild yak numbers over the past century still operate, even if to a lesser extent. These factors include excessive hunting, partly for food, the encroachment of the infrastructure of modern society, such as roads, and the increasing competition for grazing land from domestic livestock (Miller *et al.*, 1994).

Hybridization of yak with cattle of other species

Ancient documents show that yak have been hybridized with ordinary cattle (*Bos taurus*) for at least 3 000 years. Documents from the eleventh century China, in the Zhou dynasty, suggest that hybridization of yak with cattle by the Qiang people gave benefits that nowadays would be called heterosis (or hybrid vigour). The name *Pian Niu* and variants of it have been used for these hybrids from earliest times (Ceng Wenqiong and Chen Yishi, 1980; Xie Chenxia, 1985; Cai Li, 1989). However, many other names exist (see section on local names). In some areas, such as northern India, Nepal and Bhutan, hybridizing with *Bos indicus* cattle also occurs.

Systematic hybridization of yak with other cattle has been recommended and practised for many years – and certainly as long as hybridization by plant breeders has been in fashion. The hybrids find a special niche with herdsmen in providing extra milk and as draught animals, usually at somewhat lower altitudes than the typical yak country. Hybridization is carried out primarily with yak females mated to bulls of local cattle.

This is regarded as the normal hybridization and, in China the F1 is called “true *Pian Niu*” (or simply *Pian Niu*). The reciprocal hybridization of female cattle to yak bulls is also practised and regarded as “counter-hybridization” with the progeny called “false *Pian Niu*” (see Figure 3.2) and many other local names.

The hybrids are always mated back to either yak or cattle males. There is no alternative to this as the F1 males are sterile. The herdsmen use, for the most part, the cattle available to them in their area; in China, for example, they are the local, so-called “yellow cattle”. The hybrid progeny of the F1 generation are then called “local *Pian Niu*”. However, much investigation has gone into the use of “improved” breeds of cattle of dairy, beef and dual-purpose types. Results of hybridizing with both local and “improved” cattle breeds are given in Chapter 7. The name that is given to the first hybridizing of yak with “improved” cattle breeds is “improved *Pian Niu*” – in order to distinguish it from the “local *Pian Niu*”.

Information on the production of hybrids between yak and cattle will also be found in Chapter 11 in relation to individual countries.

In the course of experiments in the 1920s and 1930s at Buffalo Park, Wainwright, Canada, aimed at developing a meat animal for the cold northern regions, including Alaska, a small number of hybrids were also successfully produced between yak (male) and female American bison and half-bison (bison crossed with a cattle cross) (Deakin *et al.*, 1935).



Figure 3.1 *Pian Niu* female
(F1 from yak dam and local,
yellow cattle sire)



Figure 3.2 “False” *Pian Niu* female
(F1 from local, yellow cattle
dam and yak sire)

Local names for hybrids

Names for the first generation hybrids of yak and cattle include the name *dzo* in Tibetan areas, variants of which extend into Mongolia and other countries, and *chauri*, the name used in Nepal. The various types of backcross hybrid, both to cattle and to yak, have an especially rich variety of names that differ in different parts of China and elsewhere. Descriptions of these names have been given by, among others, Zhao Zhengrong (1957), Hu Angang *et al.* (1960), Cai Li (1980), Joshi (1982), Zhang Rongchang (1989) and Pal (1993). The uninitiated traveller may find himself confused by the fact that the local people in China are said to call the hybrids of yak with cattle “improved cattle” – this usage is avoided here.

Distribution of hybrids

In the areas of the Hengduan Alpine type of pasture, hybridizing of yak females with cattle males is not widely practised, nor is interspecies hybridization common in the pastoral regions at high elevation to which cattle cannot adapt. Such hybridization is, however, widespread in areas of mixed pastoral and agricultural production at lower altitudes. Table 3.6 shows, by way of example, the relative proportions of pure yak to hybrids and yellow cattle in two such areas in Sichuan. In the main yak-producing areas, hybridization with cattle is normally restricted to only a small proportion of the yak herd (see section, Limits to hybridization).

Nomenclature

Because of the diversity of local names for different stages of hybridizing and in order to avoid confusion in the presentation of results in this and later chapters, the scientifically more formal nomenclature of F1 (first-generation hybrids), and B1 (backcrosses), etc. will be used. It should be noted that in publications from China and some other countries, the backcross-hybrid generations are often denoted as F2, F3, F4, etc. This nomenclature will not be used here as it also could lead to confusion among readers, geneticists in particular, who will be accustomed to these notations denoting successive generations of crosses (or hybrids) mated among themselves. Backcross hybrids will be described here by the letter B, with a number denoting the generation and a letter to show whether the last male used was cattle or yak – when that has been specified. (Thus, B1(C) would denote a backcross-hybrid animal produced from the mating of a F1 female to a cattle bull, etc.). In the same way, in cases where doubt could arise, the F1 generation will indicate whether the sire was a cattle breed or a yak.

Table 3.6 Proportions of yak, *Bos taurus* cattle and hybrids in Ganzi county of Sichuan

Type	Pastoral area (%)	Agricultural area (%)
Yak	91.4	16.8
F1	7.8	55.8
B1(C)	0.7	3.7
Cattle	<0.1	21.9
Total No.	41 541	25 560

The hybrid females are an important source of milk and milk products, for home consumption or for sale, and the males, since they cannot be used for breeding, are used for draught purposes, or are slaughtered for meat (see Chapter 7).

In China, the reciprocal hybridization procedure between yak bulls and yellow cattle females is carried out mainly in the cattle-producing areas of the cold Minshan mountains, especially in the Min county of Gansu province and Pingwu county in Sichuan province. These hybrids do not give much milk and are used mainly for draught purposes.

Hybridization policy

The first generation of hybrids of yak and “ordinary” cattle adapt well to the conditions in which they are used. They have some of the good characteristics of both parental types: resistance to a harsh environment from the yak and extra productivity, milk in particular (but with a lower fat percentage), from the cattle. Backcross hybrids to cattle, however, are less well adapted to the environment, and their productivity is often little better than that of yak – most probably through loss of heterosis (although there is no strict quantification of this). Backcross hybrids to cattle are not therefore favoured – one practice being to dispose of these hybrid calves immediately after birth, in order to have all the milk from the dam available for use or sale by the herders.

The alternative of backcrossing to the yak does, however, provide a particularly good source of animals for meat production. This system is encouraged and practised in China and elsewhere.

Cai Li *et al.* (YRO and XLF, 1983; YRO and GISP, 1984) showed, from a comparison of two neighbouring and otherwise similar grassland farms in Sichuan, that the output per head of animal, per unit of land and per unit of labour can be seriously reduced if the proportion of B1 hybrids is allowed to become too high. On the Xiangdong Livestock Farm, the proportion of B1 hybrids was not allowed to exceed 5 percent of the total herd and some selection was practised of those retained. On the other farm, Axi Livestock farm, the backcross progeny of the F1 hybrid generation were retained in full. The results of the comparison are shown in Table 3.7.

The use of “improved” breeds.

In China, starting at Datong in Qinghai province around 1939 and in the area now known as the Ganzi Tibetan autonomous prefecture in Sichuan from 1941, some yak were crossed with Dutch Holstein-Friesian bulls. Such hybridization did not become systematic until the mid-1950s when 200 bulls of various breeds were introduced to the yak-producing areas of China (Zhang Rongchang, 1989). The breeds included the Holstein-Friesian, Shorthorn, Simmental; Latvia, Ala-Tau, Kostrome cattle, the Mongolian, Binzhou, Sanhe, Qinchuan, Yinging and others. More recently, Charolais, Hereford, Limousine and others have been added to those available for hybridizing with yak. Mating was tried initially by natural mating, but artificial insemination was also used and continues as the predominant practice (Cai Li, 1989; Zhang Rongchang, 1989). From 1979 to 1985, a yak research team coordinated the hybridizing with such exotic breeds in the five principal provinces with yak in China, and some 32 000 hybrids were produced. As so often happens with fieldwork, relatively little of this work has provided comparative performance results – those available are quoted in Chapter 7.

Table 3.7 Comparison of output of animal products from two neighbouring and similar farms in pastoral areas of Sichuan province (1977 - 1981)

	Xiangdong	Axi
Total stock	2721	4346
Yak (%)	69.7	31.5
F1 (%)	25.4	21.1
B1 hybrids* (%)	4.7	47.1
Ordinary cattle (%)	0.2	0.3
Output value** of:		
Milk	49 673	64 565
Cheese	2 405	2 931
Hide	1 753	1 789
Hair and down	1 914	1 258
Market animals	38 760	54 825
Total value	94 505	125 368
Average output per:		
Head of stock	34.7	28.9
Head of staff	716	412.4
6.7 ha grassland	92.8	53.5

*B1 hybrids here are mostly backcrosses to cattle bulls – very few to yak.

**Output value (yuan; US\$1=1.7 yuan) as the mean of 1979 - 1981 calculated according to fixed prices in 1980 as follows: milk 0.33 yuan/kg; cheese 0.56 yuan/kg; hide 8.9 yuan each; hair and down 1.74 yuan/kg; market cattle 85 yuan/head.

To better exploit the advantages of hybridization while avoiding the reproductive problems caused by using large “exotic” bulls, an alternative has been devised in parts of China whereby crossbred cattle, instead of large exotic breeds, are hybridized with the yak. For example, the Holstein Friesian or Simmental breed was used to produce F1 breeding bulls by crossing them first, by A.I., with the local cattle. The F1 crossbred bulls, with their relatively smaller body size, were then used on the yak to produce a hybrid F1 through natural mating.

Although the growth and performance of the hybrids for both milk and meat production was highly regarded (see Chapter 7, for performance results) the bulls of these various “improved” breeds (and 75 percent grade bulls of these breeds with yellow cattle) did not adapt to the local conditions and high altitudes in China. Most of the bulls died of mountain sickness or for other reasons within two years of introduction, and many died within the first few months. The bulls introduced in the mid- and late 1950s left fewer than 1 000 F1 and B1 hybrid progeny over a more than 20-year period.

Hybridization of yak with these “improved” breeds of cattle is now carried out by A.I. with frozen semen. This procedure inevitably restricts the utilization of these breeds to the more

accessible and well-organized yak herds. In practice in many areas, therefore, the *Bos taurus* (and *Bos indicus*) cattle used for hybridizing with the yak will continue to be the local types of cattle.

Hybridization of yak with “exotic” breeds of cattle has also been practised in other countries for a long time (see Chapter 11, part 2), such as in as, some countries of the former USSR. Thus, Denisov (1938) reported on hybrids of yak and Schwyz (Brown Swiss) cattle, and more recently Katzina *et al.* (1994) added the Jersey and the Galloway and a continuing use of the Schwyz (now of American origin, hence probably the American Brown Swiss) to the list of exotic breeds referred to previously. Several of the breeds referred to are also used in Mongolia (Zagdsuren, 1994).

Limits to hybridization

The relatively low reproductive rate of the yak sets severe limits on the proportion of the female yak population that can be used for hybridizing with cattle if the numbers of the pure yak population are to be maintained, or possibly increased. In practice, it has been found best to restrict production of hybrids to the F1 generation only (whose offspring, in turn, are then slaughtered for meat). The male sterility of the hybrids prevents *inter-se* crossing systems and allows only the mating of the F1 hybrid back to yak or cattle bulls. Reduced productivity, relative to the F1, makes the B1 and later backcross generations unattractive commercially.

The actual proportion of the female yak population that can be hybridized with cattle depends on the reproductive rate, the replacement rate for cows (depending on the rate of death and disposal of the cows) and the loss of female calves before they reach reproductive age. These factors will vary from region to region and from year to year.

If it were assumed that:

- the yak population remained static in numbers,
- an average reproductive rate for the yak cow is around of 0.5 (equivalent to a live calf every second year),
- 10 percent of cows are eliminated annually and
- 10 percent of calves are lost before breeding age,

then 50 percent of the yak cow population could be available for hybridization. (These assumptions are equivalent, on average, to a yak cow producing, in her lifetime, two female progeny that survive to breeding age.) Any intention to expand the yak population would reduce the proportion that could be hybridized. If an increase of 10 percent in population numbers were required (and, as indicated earlier, herdsmen like to increase the number of animals they own), then only 10 percent of the yak cows could be hybridized with cattle – when the other assumptions remain the same.

Other assumptions would be entirely reasonable. Thus, higher replacement rates for cows and poorer survival of calves would reduce the proportion of yak females available for hybridization. For example, if replacement rates for cows and mortality among calves were both as high as 20 percent, as happens in some situations and some years, no yak cows would be available for hybridization if the reproductive rate of the yak did not exceed 50 percent – even with a static yak population. Matters would be even worse if snow disasters strike in particular years and localities and the rebuilding of the pure yak population becomes the top priority. On the other hand, in some regions and countries, where reproductive rate over a lifetime of the yak may be higher than in the examples given, the proportion of the yak female population available for hybridization can be increased.

The precise proportions of the yak population available for hybridization thus depend on the circumstances in any particular herd or group of herds. The point has been made often (see also Chapter 7) that the production of yak-cattle hybrids can play a useful role in improving the economics of animal production in the mountainous regions and particularly at the lower elevations of the yak territory and in the proximity to markets where the extra produce can be sold. But it also needs to be said that such hybridization is not a panacea. The pure yak must, perforce, remain the major proportion of the total bovine population in the mountainous regions. The attractions of hybridizing yak with cattle should not be allowed to detract from the need to consider genetic and husbandry improvements for the yak itself. In fact, improvements in the productivity and reproductive rate of the yak would also in turn increase the opportunities for hybridizing of yak with cattle, as already apparent in some areas.

There is clearly an opportunity to produce additional hybrids from the reverse process, that of mating cows of other local, domestic cattle species to yak bulls or using the semen of yak for insemination – although it appears that this hybrid (the “false *Pian Niu*”) is traditionally used mainly for ploughing (see Chapter 7). This process also depends on having available a reproductive surplus in the cattle population.

Recently, Professor Jack Rutledge (personal communication, 2002) made a technology-based proposal for trials to produce hybrids from “improved” (e.g. Holstein) cattle and yak by *in vitro* production of embryos – using oocytes from slaughter cattle and yak semen. The resulting embryos then need recipient dams for their further development to birth. This proposal was conceived in the context of a situation (in a part of the Andes) where such hybrids might become a suitable dairy animal in the absence of either the yak or of a sufficiently productive cattle population or alternative milk producer. Although these procedures may have little immediate relevance to traditional yak-rearing areas, the idea is intriguing (see also Chapter 16)

References

- Amarsanaa, B., *et al.* (2002). Growth patterns of F₁ calves of wild × domestic yak. *Proceedings of the third international congress on yak, in Lhasa, China, 4-9 September 2000*. International Livestock Research Institute (ILRI), Nairobi. pp 420-422.
- Bo Jialin *et al.* (1998). Raising of the Datong new yak breed. *Forage and Livestock*, Supplement: 9-13.
- Cai Li (1980). Nomenclature of the hybrids between yak and cattle. *Journal of China Yak*.
- Cai Li (1980). Selection and breeding of yak – suggestions to pure-breeding of Jiulong yak. *Journal of China Yak*, 1: 58-65.
- Cai Li (1989). *Sichuan yak*. Chengdu, China, Sichuan Nationality Press. 223 pp.
- Ceng Wenqiong & Chen Yishi (1980). Yak in ancient China. *Journal of China Yak*, 1: 71-74.
- Deakin, A., Muir, G.W. & Smith, A.G. (1935). *Hybridization of domestic cattle, bison and yak. Report of Wainwright experiment*. Publication 479, Technical Bulletin 2, Dominion of Canada, Department of Agriculture, Ottawa.
- Denisov, V.F. (1935). Some data on the yak and its hybrids in Kirghizstan. *Trud. Kirgiz. Kompl. Eksp.*, 4: 115-171. (Cited from *CAB Animal Breeding Abstracts*, 4: 298-300.)
- Denisov, V.F. (1938). Hybridization of the yak with Kirghiz cattle and the Schwyz. *Izv. Acad. Nauk. USSR (Otd. mat. est., Ser. boil)*, 863-878. (Cited from *CAB Animal Breeding Abstracts*, 7: 116-117.)
- GAAHB (Ganzi Agricultural and Animal Husbandry Bureau) and YRO (Yak Research Office of Southwest Nationalities College) (1980a). The good meat-purpose yak – the investigation and study of Jiulong yak. *Journal of China Yak*, 1: 14-33.
- GAAHB (Ganzi Agricultural and Animal Husbandry Bureau) and YRO (Yak Research Office of Southwest Nationalities College) (1980b). Phenotypic characterization of Jiulong yak. *Journal of China Yak*, 3: 17-24.
- GISP (Grassland Institute of Sichuan Province) and LF (Longri Farm) (1993). Summary of the project titled “Study on the selection and breeding to improve production performances of Maiwa yak”. *Journal of China Yak*, 3: 2-10.
- Han Jianlin (1996). Yak genetic resources in China: evaluation of chromosome, protein and mtDNA polymorphism. In: Miller D.G., Craig S.R. and Rana G.M. (ed), *Proceedings of a workshop on conservation and management of yak genetic diversity, at ICIMOD, Kathmandu, Nepal, 29-31 October 1996*. ICIMOD (International Centre for Integrated Mountain Development), Kathmandu. pp. 175-183.
- Han Jianlin (2000). Conservation of yak genetic diversity in the Hindu Kush Himalayan region and central Asian steppes. In Shrestha, J.N.B. (ed), *Proceedings of the fourth global conference on conservation of domestic animal genetic resources, in Kathmandu, 17-21 August 1998*. pp. 113-116.
- Han Jianlin *et al.* (2002). *Yak production in Central Asian highland*. *Proceedings of the third international congress on yak, in Lhasa, China, 4-9 September 2000*. ILRI (International Livestock Research Institute), Nairobi. 572 pp.
- Hu Angang, Cai Li & Du Shaodeng (1960). An investigation on yak in Ganzi County. *Journal of Southwest Nationalities College (Animal Husbandry and Veterinary Sciences Edition)*, 4: 46-50.

- Joshi, D.D. (1982). *Yak and chauri husbandry in Nepal*. Kathmandu, H.M. Government Press, Singha Durbar. 145 pp.
- Katzina, E.V., Davydov, V.N. & Baldanov, N.D. (1994). Elaboration of the scheme of production and usage of industrial hybrids of yak and meat cattle. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994). pp. 44-48.
- Kozlovskii, B. (1960). The greater use of commercial crossing in yak breeding. *Molochnoe I Myasnoe Skotovodstvo*, 5 (11): 32-26. (Cited from *CAB Animal Breeding Abstracts*, 29: 270.)
- Lei Huanzhang *et al.* (1994). Studies on yak selection (1982-1986). Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue, June 1994) pp. 139-143.
- Liang, Hongyun *et al.* (1997). Analysis on crossbreeding and improving results for introduced Tianzhu White yak. Proceedings of the second international congress on yak held in Xining, China, 1-6 September 1997. Xining, China, Qinghai People's Publishing House. pp. 76-78.
- Lin Xiaowei & Zhong Guanghui (1998). Present situation and development strategy of yak husbandry in Sichuan. *Forage and Livestock*, Supplement: 26-28.
- Lu Hongji *et al.* (1987). A test on improving yak's productive performances by introducing wild yak blood. *Journal of China Yak*, 2: 8-12.
- Lu Zhonglin & Li Kongliang (1994). Distribution, types and utilisation of wild yak in China. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 23-26.
- Lu, Zhonglin & Zhao, L.Q. (1997). Great change in production system of yak. Proceedings of the second international congress on yak, in Xining, China, 1-6 September 1997. Xining, China, Qinghai People's Publishing House. pp. 26-28.
- Miller, D.J. & Schaller, G.B. (1996). Threats to the Chang Tang Wildlife Reserve, Tibet. *Rangelands* 18 (3): 91-96.
- Miller, D.J., Harris, R.B. & Cui-Quan Cai (1994). Wild yak and their conservation in the Tibetan Plateau. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 27-35.
- Pal, R.N. (1993). Domestic yak (*Poephagus grunniens* L.): a research review. *Indian Journal of Animal Sciences*, 63: 743-753.
- Pal, R.N., Barari, S.K. & Biswas, D. (1994). Yak (*Poephagus grunniens* L.) husbandry in India. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 16-21.
- Ren Chen Luoerri, Wu Zhengning & Zhou Juli (1995). Analysis of the usefulness by crossing the Jiulong yak bulls with the local Li County in Sichuan. *Journal of China Yak*, 2: 32-35.
- Sarbagishev, B.S., Rabochev, V.K. & Terebaev, A.I. (1989). Yaks. In: Dmitriev N.G. and Emst, L.K. (ed), *Animal genetic resources of the USSR*. FAO Animal Production and Health Paper, No. 65, Rome. pp. 357-364.
- Schaller, G.B. (1998). *Wildlife of the Tibetan Steppe*. University of Chicago Press.

- Study group (Qiangtang) of Agriculture and Animal Husbandry Department of the Tibetan Autonomous Region (1978). The observation on wild animals on the Qiangtang grassland. *Scientific Research Materials Collection*, pp. 60-66.
- TAHVS (Tianzhu Animal Husbandry and Veterinary Station) and DAS (Department of Animal Science of Gansu Agricultural University) (1985). *Breed criterion of the Tianzhu White yak in Gansu Province (Gan Q/NM4-85)*. Issued by Provincial Administration for Standardization on 2 January 1985 and effective 1 April 1985.
- Wang Yuchang & Wang Yanhong (1994). Conservation and improvement of the Tianzhu White yak. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 80-85.
- Wen Yongli *et al.*, (1995). *Breed criterion of the Maiwa yak in Sichuan province (DB51/249-95)*.
- Xie Chenxia (1985). *History of sheep and cattle husbandry (including deer) in China*. Beijing; China Agriculture Press. pp. 31-32.
- Xu Guilin (1985). The differentiation of wild yak and domestic yak and the economic value of wild yak in breeding. *Journal of China Yak*, 1: 21-25.
- Yan Ping, Lu Zhonglin & Lu Hongji (1994). Study on production and quality of hair for wild yak with domestic yak. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 154-156.
- Yan Shoudong (1998). Observation on the growth and development of crossbred wild yak. *Forage and Livestock*, Supplement: 46-47.
- Yan Shoudong (2002). *A study on the improvement of yak reproductive performance by introducing wild yak blood*. Proceedings of the third international congress on yak, in Lhasa, China, 4-9 September 2000. ILRI (International Livestock Research Institute), Nairobi. Pp 324-327.
- Yang, Rongzhen *et al.* (1997). *Report on growth and development of domestic yak progenies rejuvenated by wild yak*. Proceedings of the second international congress on yak, in Xining, China, 1-6 September 1997. Xining, China, Qinghai People's Publishing House. pp. 21-25.
- Yang Rongzhen, Han Xingtai and Luo Xiaolin (1997a). *Yak production in the Central Asian highlands*. Proceedings of the second international congress on yak, in Xining, China, 1-6 September 1997. Xining, China. Qinghai People's Publishing House. 298 pp.
- YRO (Yak Research Office) of Southwest Nationalities College and XLF (Xiangdong Livestock Farm of Sichuan Province) (1983). Experiment and its result analysis on improving productive performance of yak by using frozen semen of ordinary cattle for AI. *Journal of Southwest Nationalities College* (Animal Husbandry and Veterinary Sciences Edition), 2: 17.
- YRO (Yak Research Office) of Southwest Nationalities College and GISP (Grassland Institute of Sichuan Province) (1984). The research on the interspecific cross combination between female yak and cattle bull. *In The research on the utilization and exploitation of grassland in the northwestern part of Sichuan province*. Chengdu, China, Sichuan Nationalities Press. pp. 107-103.
- Zagdsuren, Yo (1994). *Some possibilities to increase meat and milk production of yak husbandry*. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 113-118.

- Zhang Haimin & Liang Yulin (1998). Survey on herd structure and management of Tianzhu White yak. *Forage and Livestock*, Supplement: 57-58.
- Zhang Rongchang (1989). *China: the yak*. Gansu Scientific and Technology Press, Lanzhou, China. 386 pp.
- Zhang Rongchang, Han Jianlin and Wu Jianping (1994). *Yak production in the Central Asian highlands*. Proceedings of the first international congress on yak, in Lanzhou, China. *Journal of Gansu Agricultural University* (Special issue June 1994). 345 pp.
- Zhang Yun (1994). The relationship between season and age of stud yak bull in Damxung. Proceedings of the first international congress on yak. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 303-307.
- Zhao Bingyao & Zhang Jianwen (1994). Present situation, problems and prospects of wild yak utilization in Gansu. *Journal of Gansu Agricultural University* (Special issue June 1994) pp. 137-139.
- Zhao Zhengrong (1957). *Animal husbandry in the middle part of Gansu province*. Beijing, Scientific Publishing House.
- Zhong Guanghui (1998). Brief introduction to the research activities of the Department of Animal and Technology of the Southwest Nationalities College. *Forage and Livestock*, Supplement: 60-61.
- Zhong Guanghui *et al.* (1995). *Breed criterion of the Jiulong yak in Sichuan Province (DB51/250-95)*.
- Zhong Jincheng (1996). *Yak genetics and breeding*. Chengdu, China, Sichuan Scientific and Technology Press. 271 pp.