

WEEDS OF BHUTAN

CHRIS PARKER



**NATIONAL PLANT PROTECTION CENTRE SIMTOKHA
ROYAL GOVERNMENT OF BHUTAN**

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WEEDS OF BHUTAN

CHRIS PARKER

NATIONAL PLANT PROTECTION CENTRE SIMTOKHA

ROYAL GOVERNMENT OF BHUTAN

1992

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Introduction

A major objective of the Royal Government of Bhutan's Seventh Five Year Plan is to strengthen agricultural research, increase agricultural production and improve the degree of food self-sufficiency in the country. Among the constraints to increased crop production are the losses caused by pests, diseases and weeds. As a first step in reducing losses caused by weeds most regions of the country have been surveyed to determine the identity of the weed species involved so that the nature of the problems are known and the best techniques can be applied to their control. If chemical herbicides are to be used, it is especially important for the weeds to be correctly identified, otherwise expensive treatments may prove quite ineffective.

This book is based on the surveys conducted during three consultancies: in March 1991; from July to September 1991; and from May to July 1992. Specimens were collected, photographs taken and the occurrence and importance of each species recorded into a database. Sets of herbarium samples were placed with the National Herbarium, Thapa and at the National Plant Protection Centre, Simtokha.

Bhutan has an exceptionally rich flora, thanks to its wide range of altitudes and ecological conditions and this has been augmented by the introduction of many cosmopolitan weeds, some of them recorded for the first time during these visits. The scope of the surveys was incomplete and coverage of the highlands was much better than that of the southern lowlands. Nevertheless it is hoped that most of the important and more common species have been noted and included. Certainly, many more species occur occasionally in annual crops and especially in perennial crops and pastures, contributing to the weed problem but rarely important as individual species. The most frequent of these were included as 'marginal' weeds in *A First Manual of Bhutan Weeds* based on photocopies of weed specimens and distributed to the main agricultural centres in December 1991. Such marginal species have largely been excluded from this volume, and the *First Manual* should be referred to as necessary. Some of the photocopies of weeds, obtained directly from the dried specimens, have been used here when no suitable photographs were available or in order to clarify leaf shapes.

There are illustrations of 187 species, many at the seedling as well as the mature stages. These are predominantly weeds of annual and perennial crops but some parasitic weeds of forestry and some wild plants likely to be poisonous to livestock are also included. Their inclusion as weeds is on the basis of their being undesirable or 'out of place' in certain situations, even though some of them may be beneficial

in other places. Local names are given for many species but the list of these is far from complete. Where local names have not so far been obtained, space has been left for the reader to write them in whenever the information becomes available. Use of local names, however, can be confusing as many different names are sometimes used for a single species, even within the same language, while the same name is often used for a number of quite different plants. Latin names are therefore important and should be used whenever possible. The Latin names and arrangement of families are, with few exceptions, according to the *Flora of Bhutan*. Characteristics by which they may be recognised are described. Their distribution and importance is noted and, where appropriate, some suggestions are given on control measures. There are also some introductory chapters on general methods of weed control and, in particular, on control in certain selected crops. This volume is not, however, intended as a weed control manual. It is primarily addressing the essential first step in the development of any control method, namely, the accurate identification of the problem species. Little work has so far been done in Bhutan on weed control measures and any recommendations made now will rapidly become outdated as new information is acquired. Control measures will therefore be covered separately in extension literature in due course.

I wish to acknowledge the help of a great many individuals and institutions in the preparation of this book. Firstly, the many staff of the Ministry of Agriculture who have guided and assisted me in the field surveys, especially the Project Manager of the National Plant Protection Centre and his staff at Simtokha and at the Regional Plant Protection Centres at Wangdi and Khangma; the officers-in-charge and staff of the research centres at Wangdi and Khangma; the Project Manager and staff of the Bhutan National Potato Project at Yusipang and Bumthang; the officer-in-charge and staff of the Animal Husbandry Research Institute at Serbitang. I also thank the officer-in-charge of the Forestry Research Division and staff of the National Herbarium at Taba for their cooperation and assistance; the Botany Department of Sherubtse College, Kanglung, for provision of local names; Long Ashton Research Station, University of Bristol, U.K. for the loan of slides to illustrate *Mikania*, *Striga* and *Orobanche* species; and the administrative staff in the office of the European Community/Development of Agricultural Support Activities (DASA) in the Thimphu office for their support and assistance at all times.

Finally my thanks to the staff of the Flora of Bhutan Project at the Royal Botanic Garden, Edinburgh, U.K. who have provided invaluable assistance in the identification of many of the plants, access to their library and herbarium with its extensive Himalayan collections, and in providing free access to unpublished taxonomic accounts to be published in forthcoming parts of the Flora.

The importance of weeds

Most, if not all, farmers recognise the importance of weeds and the need to control them at least to some degree. They recognise that vigorous weed growth, causing shading of the crop, will reduce yield and, under dry conditions, weeds will exaggerate the effects of drought. They will also recognise that there is competition for nutrients in the soil and that weeds will have the opposite effect to manures, causing yellowing and reduced yields. For two main reasons, however, farmers do not always prevent serious loss due to weeds. Firstly, they fail to realise that loss is occurring even when the crop is not obviously damaged. Unlike the damage done by insect pests and diseases, weeds can cause up to 25% yield loss in a crop without any apparent symptoms. These losses can only be detected and demonstrated to the farmers by suitably designed on-farm trials. Secondly, farmers do not always have the time or resources to weed at the optimum time.

The weeds causing the greatest harm to crops are those which germinate with, or even before the crop. These will inevitably compete for plant nutrients and for water. Later they may shade the crop and compete for light, reducing its photosynthetic capacity. But even if the weeds remain shorter than the crop they will continue to compete for nutrients and water.

Weeds can be damaging in several other ways. Some are known to be 'allelopathic' — i.e. they produce toxic chemicals which poison the crop, causing still further damage. e.g. *Cynodon dactylon* and *Imperata cylindrica*. Climbing weeds, in addition to competing for light and nutrients, may also cause the crop to fall over ('lodge') thereby exposing the grain or fruit to damage on the ground or making it difficult to harvest the crop (e.g. *Convolvulus* and *Ipomoea* species). Other weeds may have toxic seeds or foliage which will result in dangerous crop produce or poisoning of livestock. Crop produce can be damaged in other ways, e.g. potatoes can be pierced by the rhizomes of perennial grass weeds.

Another indirect but important effect of weeds is on the incidence of pests and diseases. Generally, weedy crops may encourage rats and certain insect pests such as grasshoppers, or may cause disease as a result of increased humidity in the crop canopy. Particular weeds can also be alternate hosts to specific insects such as aphids, or disease organisms such as rusts. Occasionally the converse may be true — weeds may help to reduce the incidence of other pests or diseases (e.g. by harbouring the natural enemy of an insect pest) but such instances are rare and it is generally unlikely that the benefits will outweigh the loss due to the weed.

Two other potential advantages of weeds deserve more serious consideration. Firstly, they may have value as forage for cattle, or even as human food. Farmers may deliberately delay weeding so that 'weeds' are large enough to be of value as fodder or food. In this case the economic benefit can outweigh any loss in the main crop. In the pasture situation also, it is particularly difficult to decide what should be regarded as a 'weed' when most naturally occurring plants have at least some nutritional value. Secondly, weeds can play an important role in preventing soil erosion. There could be serious disadvantages in very early weeding (especially by mechanical means) on many of the steeply sloping fields of Bhutan when heavy rains are expected.

The percentage of the crop that is lost because of weeds varies tremendously — it can range from zero to 100%. Even in the absence of weeding, losses in some crops in Bhutan appear to be negligible. Wheat, mustard and buckwheat are quite often not weeded at all, yet the numbers of weeds may be small and of little consequence. The reasons for this lack of weed growth have not been confirmed but may be several. They could be the result of exact timing of planting or of tillage in relation to rainfall or irrigation; the rotational pattern; or the efficiency of weeding in previous crops etc. In any event, it would be of great interest to discover the reasons for this sparseness of weeds. In other situations, dense weed growth occurs immediately the crop has been planted. Without weeding, the crop is swamped, resulting in losses of 30-100%. But even when the farmer does his normal weeding a few weeks after sowing, losses may still amount to 20-25%. Maize, especially, is very sensitive to weed competition during the vegetative stage. Experiments have shown that there is a 'critical period' during which weeds must be controlled if loss is not to occur. This period varies from field to field and year to year but it sometimes begins as early as 2 weeks after sowing and can last up to 6 weeks after sowing. Few experiments have yet been done in Bhutan to determine such losses but they can be expected to show similar results.

The biology of weeds

The life-form of weeds can vary from the very small, short-lived and (apparently) insignificant, to large perennial plants such as shrubs and trees. While the two extremes can perhaps be ignored, there is still a great variation or division in the weeds covered in this book. The first and most important division is not so much as regards size but in the ability of the plants to persist from year to year. **Annual** weeds grow from seed each year while **perennial** weeds continue growing from one year to the next, or regenerate each year from the same rootstock. An intermediate class includes the **biennial** weeds which establish from seed at the end of one season and mature and die the next. Another important division is between the normal free-living weeds and those that are **parasitic** on the crop.

Annual weeds establish from seed each year, hence their **germination** behaviour is critical to their success. Prevention of seed production should be all that is required for their control. However, even complete prevention of seeding for several years may not result in their elimination because of the phenomenon of seed **dormancy** which ensures that only a proportion of the seeds in the soil germinate in any one season. Dormancy may simply be the result of a tough seed coat which has to be damaged mechanically or by soil organisms before the seed will germinate. Other seeds have specialised physiological dormancy which can only be overcome by special environmental conditions involving combinations of temperature, wetting, drying, light etc. Environmental conditions therefore dictate whether germination will occur and from what depth in the soil (often it will be only in the upper few centimetres). If these conditions are at all critical for a particular species, there will be a distinct **periodicity** of germination. Some weeds may germinate relatively freely throughout the year while others germinate only over a very short period. This can provide an opportunity for their control by pre-planting tillage but, in general, the most successful weeds are those that germinate naturally over the main period of crop planting. Other characteristics of annual weeds which affect their importance in damaging the crop include the speed with which they grow and their leafiness. Their success will also depend on the ease with which they can be controlled. Weeds with fleshy, succulent shoots such as *Portulaca oleracea* will regrow after uprooting whilst weeds which can be very easily killed by hoeing may be totally resistant to certain selective herbicides.

Biennial weeds germinate late in the monsoon and form a rosette of foliage which persists over the winter. Only after they are chilled in the winter and/or as a result of the increasing daylength in the spring do they flower and mature. They are normally

killed by tillage before spring crops are sown but can be important in over-wintered crops such as buckwheat.

Perennial weeds all persist for more than one year but have varying form. Some (especially at low altitudes) simply keep growing and spreading from one year to the next without having any specialised resting stage, such as *Paspalum conjugatum* or *Mikania micrantha*. Others (especially at cooler high altitudes) die down each winter but regenerate from special resting organs such as tubers, roots or rhizomes. Some of the most important and difficult to control have a combination of the spreading character with resting stages deep in the soil. Examples include *Potamogeton distinctus* with rhizomes and overwintering turions, *Cyperus rotundus* with rhizomes and tubers, *Arisaema* with corms, and *Fagopyrum dibotrys* and *Cynodon dactylon* with simple rhizomes. *Persicaria runcinata* persists by forming tubers which are quite shallow in the soil but these still make it much more difficult to control than the closely related annual *P. nepalensis*.

Parasitic weeds are generally unable to live independently and are physically attached to the crop, either to the shoots as in dodders (*Cuscuta* species) and mistletoes (Loranthaceae and Viscaceae), or to the roots as in broomrapes (*Orobanche* species) or witchweeds (*Striga* species). They depend on the crop for part or all of their water and nutrients and can consequently do vastly more damage than other weeds. Fortunately the root parasites *Striga* and *Orobanche* are not yet of any importance in Bhutan but they are serious in India and Nepal and are illustrated and described in this book so that they can be recognised and dealt with should they be introduced.

General methods of weed control

This section is not intended to provide detailed recommendations for weed control in Bhutan but to outline the main methods available and their relevance to Bhutanese agriculture.

Prevention

If crop seed is contaminated with weed seeds, extra weeds will be sown with the crop under conditions ideal for their growth. They may be similar to those already in the field and merely increase the amount of weeding needed, but if the seed has been brought in from elsewhere, there is the danger of introducing new weed problems. The parasitic dodders (*Cuscuta* species) are often introduced in this way, especially in seed of fodder legumes, vegetables and niger seed. The annual grass weeds *Avena fatua* and *Phalaris minor* are also commonly spread in seed of wheat and barley. Crop seed should always be inspected thoroughly and cleaned by sieving if necessary.

Tree seedling transplants can sometimes be contaminated with perennial weeds. Shake off soil and weeds if necessary before planting.

Farmyard manure can also be seriously contaminated with weed seeds and should be very well rotted before use.

Invasion of weeds into the crop from field edges can be prevented by suitable hygiene. This may include the control of parasitic mistletoes in the trees surrounding orchards.

Physical methods

Ploughing and harrowing Ploughing is the standard method by which weeds are destroyed before planting. Initial ploughing may need to be quite deep (15 cm) to uproot and/or bury well-established annuals, and perennials with rhizomes. Consequently many are not well controlled by the traditional plough which goes little deeper than 10 cm. A dry period is also needed to ensure the tougher weeds and rhizomes are killed. Under very wet conditions, cultivation may do little more than transplant the weeds. But, provided conditions are suitable, established weeds

are either destroyed or are loosened and can be collected and removed by hand. If it then rains before planting, a further shallow ploughing or harrowing should be enough to destroy seedling weeds. It may even be worth delaying planting for a few days to allow weeds to be killed before the crop is planted. This is referred to as a 'stale seedbed technique'. In the absence of rain, a deliberate irrigation may be applied in order to trigger the germination of a flush of weeds for the same purpose. In the very early stages after crop emergence, light harrowing can also be used to kill young weeds but, if this is done, some crop damage is inevitable.

Hoeing Various tools are used for shallow cultivation after crop sowing, Hoes are used between the crop plants and are used most effectively if the crop has been planted in rows. Row-planting also allows the use of hand-pushed wheel-hoes in rice and various types of inter-row cultivators in dryland crops.

Hand-weeding This, combined with hoeing, is the most widely used method in Bhutan once the crop has been planted and is often a completely adequate and efficient method, provided it is done early enough. In rice, small weeds are scraped with the fingers (and also trodden in with the feet) whilst larger weeds are later removed by hoes or by hand-pulling. A disadvantage of hand-pulling is that it tends to be left until the weeds are large enough to be easily grasped, and this may be too late to avoid weed competition. The use of hoes may need to be encouraged as an alternative.

Cutting and mowing This is hardly suitable in annual crops but is used in orchards to reduce weed growth without disturbing the soil and damaging tree root systems.

Fire A method already used in Bhutan is to spread a mulch of dry plant material over seedbeds (especially of chilli) and to set fire to it just as weeds are emerging, but before the crop appears. Burning stubble and weed growth after harvest can reduce carry-over of weed seed. Fire is also used elsewhere in the world in the form of flame guns but these are less relevant to Bhutan.

Cultural methods

There are many less direct ways in which weeds can be suppressed or discouraged.

Flooding This is by far the most important of all weed control methods in rice. Although rice growth is directly favoured by flooding, it is much more important for weed control than directly for the health of the crop. Most of the commoner dryland weeds are prevented from germinating or are killed by the water. Many of the typical

weeds of rice can survive flooding once they are established but they too are unable to germinate under water. Therefore, it is essential to keep the water level at a constant depth of a few centimetres, in order to suppress as many weeds as possible. Some truly aquatic plants can both germinate and persist under water. They have to be physically removed or controlled by herbicide.

Irrigation Pre-planting irrigation can be used to stimulate a flush of weeds which can then be destroyed mechanically before the crop is sown.

Planting The **time** of planting can be critical for the success or failure of weeds which themselves have a critical time of germination. A small delay in the time of planting can allow the main flush of a particular weed to be destroyed before the crop is sown. The **method** of planting can also be important. Row-planting allows for more efficient weeding in almost all crops. Relatively deep sowing of crop seed when the surface soil is drying out may allow the crop to be established with moisture which lies a few centimetres deep in the soil, while the surface is too dry to allow weed germination.

Smothering Weeds need light and can be suppressed by smothering. In fruit orchards, they can be controlled either by dead mulch material spread under the trees or by the shading effect of a ground-cover legume. In high value vegetable crops, black plastic can be highly effective but mulches of straw or other plant material are more appropriate. In annual crops, some smothering may be achieved by the crop itself, provided it is densely planted, well-grown and manured.

Crop variety Maximum smothering can be achieved by selecting the appropriate crop variety. In the case of the parasitic weeds, *Striga* and *Orobanche*, there may be varieties which are resistant to the parasites.

Crop rotation When a weed is particularly difficult to control in a crop, it may build up over the years to be a severe problem. It might be possible to overcome this by changing to a crop in which the weed is more easily controlled.

Biological control methods

Certain insects and fungal pathogens are used elsewhere in the world for the control of weeds and some of these might be applicable in Bhutan in due course. Weeds for which these methods have been, or are being, developed include *Mikania*, *Parthenium*, *Cassia*, *Lantana* and *Eupatorium* species.

Chemical methods

Selective herbicides kill weeds (but not necessarily all) without damaging the crop, even when the crop is exposed to them (e.g. butachlor in rice).

N. B. Selective herbicides are only selective when used in the correct way, i.e. with the right dose, at the right time, against the right weeds in the right crop.

Non-selective herbicides kill or damage most plants but can be used selectively by avoiding contact with the crop (e.g. glyphosate under fruit crops).

Pre-emergence — before emergence. Pre-emergence herbicides function in the soil and are used before the emergence of weeds, though sometimes after the emergence of the crop. For example, butachlor is a pre-emergence herbicide in terms of its activity but its application in rice is post-emergence.

Post-emergence — after emergence. Post-emergence herbicides function through the shoots and foliage of weeds (e.g. glyphosate).

Some herbicides have both pre- and post-emergence activity (e.g. metribuzin in potato).

Contact herbicides are those post-emergence herbicides which kill the leaves that are wetted but are not moved inside the plant and so do not kill other parts of it. An example is paraquat but this herbicide is too toxic to be recommended.

Translocated or systemic herbicides are conveyed inside the weed and can kill underground parts of perennial weeds (e.g. glyphosate).

Formulation of herbicides may be as granules, liquids or powders.

Application of granular herbicides can be directly by hand (with gloves) but granules are generally reliable only in flooded rice. Other formulations have to be diluted accurately in water for spraying, or for wiping onto weeds by rope-wick applicators or other simpler devices.

Some advantages of herbicide use are:

- Pre-emergence herbicides can increase yields by preventing weed growth at the earliest, most critical stage of crop growth, hence eliminating weed competition more completely than any traditional method, especially where hand-weeding is delayed by wet weather or shortage of labour.

- Herbicides require very little labour for their application and can provide effective weed control earlier and at less cost of labour than traditional methods.
- Herbicides can substitute for cultivations before or after crop planting and hence reduce the risk of soil erosion. Less disturbance of the soil also reduces damage to the roots of trees.

Some disadvantages of herbicides are:

- The risk of damage to the treated crop resulting from incorrect dose, timing or choice of product.
- The risk to a neighbouring crop if the wind causes 'drift' on to one which is susceptible.
- The risk of failure due to resistant weeds or unsuitable conditions (e.g. dry soil) and resulting in economic loss for the farmer.
- The costs of the chemical and of suitable application equipment and protective clothing. (The herbicides for most crops other than flooded rice need to be sprayed as liquids.)
- The need for an efficient distribution system so that herbicides are available at short notice when required.
- The problems of educating farmers in the correct use of herbicide, especially those that require dilution and application at a precise spray volume.
- The risk of controlling only the easier weeds and encouraging those which are more resistant. After some years the weed complex will tend to 'shift' towards perennial weeds.
- The potential risk to the environment if herbicides are used on a large scale.

The list of disadvantages above emphasises the difficulties of exploiting herbicides in a country such as Bhutan, and progress in dryland crops will depend on thorough research, and the development of good extension methods. The success of butachlor in rice, however, shows that the farmers are eager to use this technology.

Integrated control

Farmers have always used an integrated system of weed control involving many different combinations of mechanical, manual and cultural control. Now that

herbicides are available they should not be seen as a replacement for traditional methods but as a highly effective additional component in the integrated system. It is especially important that herbicides should not be expected to provide complete weed control. They may at first appear to be doing so, but there are almost inevitably some species which will not be controlled and if these are allowed to grow unchecked they may soon make both the herbicide **and** traditional methods ineffective. Hence, even where herbicides are being used they should be supplemented by at least some hand-weeding to eliminate surviving weeds.

General rules of good weed control

- 1 Prepare a clean seedbed
- 2 Plant clean seed
- 3 Weed early
- 4 Prevent weeds from seeding

Weed control in selected crops

Maize

The damage caused by weeds in maize

Maize is one of the crops most seriously affected by weed competition. Crop loss studies show that there is a 'critical' period from as soon as 2 weeks after sowing to about 6 weeks, during which weeds must be removed if full crop yield is to be obtained. Although symptoms are obvious (yellowing and stunting) when weeds are not controlled at all, there can still be quite serious reduction in yield, without obvious symptoms, when weeds are not controlled early enough.

The main weed problems

A very wide range of weeds can occur in maize (see p. 223), but the commonest in Tashigang and other eastern districts include the following (with local names in Dzongkha, Nepali or Shachopa):

<i>Digitaria ciliaris</i>	tampula (Dzo.); chittrey (Nep.)
<i>Persicaria runcinata</i> (P)	.chuchum (Dzo.); ratnaulo (Nep.); gangchuma (Sha.)
<i>Persicaria nepalensis</i>	helepsi (Dzo.); ratnaulo (Nep.); metoshim (Sha.)
<i>Fagopyrum dibotrys</i> (P)	titi phapar (Nep.); themnang (Sha.)
<i>Commelina maculata</i> (P)	pishamphi (Sha.)
<i>Galinsoga parviflora</i>	jagyouma (Dzo.); udasoy (Nep.); yurungpa (Sha.)

Those marked (P) are perennials and create special difficulties, often re-growing from underground parts very quickly after weeding. A special weed problem which could affect maize in Bhutan is the parasitic weed *Striga* — see p. 206.

Weed control methods in maize

Mechanical tillage or cultivation is the main means of clearing land prior to planting and is especially important for the destruction of perennial weeds with tough crowns or rhizome systems. The depth of tillage may need to be varied according to the

depth of the root or rhizome systems of the weeds. Some manual collection of perennial weed material may also be needed to prevent it re-establishing itself. The final tillage before planting is often a more shallow harrowing, to destroy newly germinated annual weeds. After crop emergence, the plough is sometimes used to create crude rows in broadcast crops. It is preferable, however, to plant in rows and then to use inter-row A-blades or other implements, either hand-pushed or pulled by oxen, to disturb the soil between the crop rows. This, of course, is not feasible in the absence of row-planting.

Manual control of weeds, by hand-pulling or by hoeing is by far the most common method used in Bhutan. Hoeing is ideal as it can be done efficiently from the earliest stage, preferably from 2 weeks after sowing. Weeds in or close to the row, are the most damaging while those in the inter-row can be left a little later. Hand-pulling is usually done only when weeds are larger. This is suitable for mid- and late-season weeding, but the first one or two weeding should normally be by hoe. Any manual weeding is simpler and more efficient in a row-planted crop.

Chemical weed control by herbicide offers potential for the more efficient control of weeds in maize and a saving in labour costs. However, there are problems of finding herbicides which will control the commonly occurring perennial weed species, especially in mixed cropping with soyabean or other legume. Briefly, **atrazine** is a pre-emergence herbicide controlling most annual weeds but it is sometimes weak on grasses. It **cannot** be used in mixed crops. To improve control of grass weeds, **alachlor** or **metolachlor** are often used in a mixture with atrazine. In mixed crops of maize with soyabean or other legume, these could be used safely on their own (without atrazine) but would probably not control the full range of annual weeds, let alone perennials. It is especially important in that situation to combine herbicide use with supplementary hand-weeding to remove resistant weeds and prevent them from building up. Separate leaflets on the use of herbicides in maize will be issued when sufficient research has been conducted in Bhutan.

Integrated control of weeds in maize

- i) Follow traditional cultural methods which help to suppress weeds, and create the cleanest possible seedbed
- ii) Plant in rows
- iii) Use hoes for first weeding between 2 and 3 weeks after sowing, no later, and repeat as necessary after about 5-6 weeks
- iv) Use inter-row cultivation equipment to reduce labour
- v) Use herbicide when available but continue to use supplementary hand-weeding to remove surviving weeds in mid-season

Rice

The damage done by weeds in rice

In flooded rice, weeds do not compete for water but they do rob the crop of nutrient and larger species may also compete for light. With good water control the impact of weeds is reduced but considerable labour has still to be invested in removing the aquatic species which would otherwise cause damage. Thus it is perhaps the cost of weeding rather than the reduction in yield which is of greatest concern with this crop.

The main weed problems

The most serious weeds of rice in Bhutan (see p. 222) are those which are best adapted to the flooded conditions. These aquatic species can sprout or germinate even under standing water and include not only the notorious 'shochum' (*Potamogeton distinctus*) at higher altitudes but also more extensively the following weeds:

<i>Monochoria vaginalis</i>	damperu (Dzo.) or piralay (Nep.)
<i>Cyperus difformis</i>	guchen (Dzo.) or mothey (Nep.)
<i>Schœnoplectus juncooides</i>	inchodum (Dzo.) or swirey (Nep.)
<i>Echinochloa crus-galli</i>	jama (Dzo.) or sama (Nep.) (some forms)

Many other more minor species can also occur, even with good flooding. Others can survive flooding once they are established but can only germinate and thrive when allowed to do so as a result of temporary drainage. These include *Cyperus iria* (having the same local names as *C. difformis*) and most types of *Echinochloa*.

Weed control methods in rice

Mechanical weeding includes the initial land preparation, usually a dry ploughing some time ahead of transplanting, then flooding and wet-ploughing immediately before transplanting. Mechanical weeding is also possible for post-planting weed control provided the crop has been planted in rows. Then rotary weeders can be pushed between the rows, greatly reducing the total labour required for weeding. This practice is especially recommended on less sloping land where terraces are large.

Flooding is by far the most important means of weed control in rice. Most of the important weeds of dryland crops are completely suppressed by submergence — their seeds require oxygen for germination. This greatly reduces the range of weeds occurring and leaves only the truly aquatic species. In order to achieve the greatest reliability from flooding, it is essential that rice paddies are kept continuously flooded (or drained only for very short intervals otherwise non-aquatic species may establish themselves and survive later flooding) and are as level as possible so that the whole area is submerged, without some areas being too deeply flooded for the rice. Any high spots will immediately allow the establishment of the semi-aquatics which will then persist even if the water level is raised. While flooding usefully controls the non-aquatic weeds, it does of course encourage the aquatics of which 'shochum' is the worst. It is hoped that some systems of deeper tillage, with or without manipulation of the flooding regime, may be found to control this weed but research is still in progress.

Manual control of weeds is the predominant method in Bhutan and is largely effective in preventing any serious yield loss. In most cases, a first weeding should be done within 3 weeks of transplanting, when larger weeds are uprooted and small weeds are stirred into the mud by fingers and feet. A second weeding later involves mainly hand-pulling and removal of the weeds onto the paddy bunds.

Chemical control of weeds has been practised in Bhutan for some years with a very high degree of success and without any known side-effects. The granular herbicide, butachlor ('Punch'), is spread by hand within 2-3 days of transplanting, at a dose of 20-25 kg of 5% granules per hectare (1-1.25 kg active ingredient per ha). This controls virtually all the main annual weeds but fails to suppress 'shochum'. New herbicides have been tested which do control 'shochum'. These are likely to become available in the near future but are extremely expensive and other methods may still be needed for control of this particular problem.

Integrated control of weeds in rice

- i) Use dry tillage to create a clean seedbed before flooding
- ii) Flood and wet-plough to create a level terrace
- iii) Maintain a uniform depth of water
- iv) Hand-weed 2 to 3 weeks after transplanting and again at 5 to 6 weeks
- v) In larger terraces, plant in rows and use rotary weeder
- vi) Use butachlor, but follow with hand-weeding if necessary

Potato

The damage caused by weeds in potato

Potatoes are slow to emerge and weeds can become dominant if not removed early. Yield reductions of 50-60% have been recorded in trials in Bhutan where weeds have been left, or have been inefficiently removed. Apart from competing for water, light and nutrients, some perennial weeds can cause additional damage to potatoes by piercing the tubers with their sharply-pointed rhizomes tips.

The main weeds

Virtually all the weeds of dryland in Bhutan can occur in potato (see p. 223) but the most abundant and troublesome are generally the same as those in maize:

<i>Digitaria ciliaris</i>	tampula (Dzo.); chittrey (Nep.)
<i>Persicaria runcinata</i> (P)	chuchum (Dzo.); ratnaulo (Nep.); gangchuma (Sha.)
<i>Persicaria nepalensis</i>	helepsi (Dzo.) ratnaulo (Nep.); metoshim (Sha.)
<i>Fagopyrum dibotrys</i> (P)	titi phapar (Nep.); themnang (Sha.)
<i>Commelina maculata</i> (P)	pishamphi (Sha.)
<i>Galinsoga parviflora</i>	jagyouma (Dzo.); udasoy (Nep.); yurungpa (Sha.)

(P) indicates perennial species.

Others, associated with the high fertility of potato growing include:

<i>Amaranthus</i> species	moth (Dzo.); ludey jhar (Nep.); lasomo (Sha.)
<i>Chenopodium</i> species	hethu (Dzo.); bethe, bathu (Nep.); bethu (Sha.)

Weed control methods in potato

Mechanical tillage by plough or other implement is especially important for potato, not only to control established annual and perennial weeds prior to planting, but also to create a suitable tilth in which the potato tubers can develop. After crop emergence ridging is usually done manually but can be achieved by a suitable ridging implement pulled by oxen. Although potatoes are sometimes still planted on a broadcast basis, most growers follow the recommended practice of planting in rows.

Manual methods are usually used for the combined and inter-related operations of ridging and weed control. A standard practice is to wait until the crop has emerged to a height of 10-15 cm before hoeing weeds and simultaneously piling soil onto the rows to create a ridge. This timing is almost certainly too late under all but the driest conditions, and a first weeding/ridging should normally be done as soon as the potatoes emerge (at 4 weeks), or even sooner if weed growth is heavy.

Chemical control of weeds in potato is possible with a number of herbicides and one of these has been well tested in Bhutan. Metribuzin ('Sencor') has both pre-emergence and post-emergence action on young weeds and is applied immediately after the first weeding/ridging. As noted above, this should ideally be at or before potato emergence. Although emerged potatoes are not readily damaged by the herbicide, considerable weed competition can have occurred if treatment is delayed. The recommended dose of 0.7 kg a.i. per hectare is generally safe to potato but damage can occur on some new varieties even at this dosage, and on any variety if the dose is much exceeded. Hence no general recommendation has been released yet and any use by farmers in the future will need to be supported by very effective advice. Its performance on all the important weeds has not yet been checked. It is believed to control *Panicum runcinata* but it may be less effective on many other perennials, and supplementary weeding will be important for control of these.

Integrated control of weeds in potato

- i) Primary tillage should be as deep and thorough as possible
- ii) Roots and rhizomes of perennial weeds should be cleared by hand
- iii) Plant in rows, in shallow ridges
- iv) Use hoes to weed and ridge at 3-4 weeks and again after emergence
- v) When herbicide is available use with extreme caution and supplement with hand weeding

Vegetables

The damage caused by weeds in vegetables

Vegetable crops often suffer extremely heavy weed growth, due to combinations of irrigation, high soil fertility, and short-cycle cropping which gives weeds regular opportunities for germination. Yields are correspondingly very much reduced

wherever there is failure to weed sufficiently early and effectively. Few yield data are available from local experiments but from experience elsewhere it is certain that yields may be reduced by 50% under some conditions.

The main weeds

The most important weeds are very much the same as in other dryland crops such as maize and potato, and include the same species, especially:

<i>Digitaria ciliaris</i>	tampula (Dzo.); chittrey (Nep.)
<i>Persicaria runcinata</i> (P)	chuchum (Dzo.); ratnaulo (Nep.); gangchuma (Sha.)
<i>Persicaria nepalensis</i>	helepsi (Dzo.); ratnaulo (Nep.); metoshim (Sha.)
<i>Galinsoga parviflora</i>	jagyouma (Dzo.); udasoy (Nep.); yurungpa (Sha.)
<i>Amaranthus</i> species	moth (Dzo.); ludey jhar (Nep.); lasomo (Sha.)
<i>Chenopodium</i> species	hethu (Dzo.); bethe, bathu (Nep.); bethu (Sha.)

but also:

<i>Cynodon dactylon</i> (P)	rampa (Dzo.); dubo (Nep.); saram (Sha.)
<i>Cyperus rotundus</i> (P)	guchen (Dzo.); mothey (Nep.)

(P) indicates perennial species.

Weed control methods

Land preparation is important, as in other crops, and is perhaps sometimes neglected in intensive vegetable growing because of pressure to make maximum use of good land. For perennial weeds such as *Cynodon* and *Cyperus*, however, thorough, deep, dry season tillage may be the only effective method.

Mulching should be feasible on small areas of high-value vegetable crops and is already practised in the cultivation of chillies, partly for insect control as well as for weed control. The practice could be used more widely.

Manual methods are inevitably the mainstay of weed control in vegetables. The same principles that apply to maize, apply to vegetables, namely, the necessity of starting weeding early i.e. within 2 to 3 weeks of sowing. Also, the greater efficiency obtained by planting in rows when growing maize, applies equally to vegetable growing.

Chemical methods are unlikely to be available for vegetables in Bhutan for many years owing to the difficulty of finding herbicides sufficiently selective and safe to use in these generally sensitive crops.

Integrated control of weeds in vegetables

- i) Use thorough, deep, land preparation, especially for control of perennial weeds
- ii) Use mulching with *Artemisia* or other available material to suppress weeds and insect pests
- iii) Plant in rows
- iv) Start hoeing no later than between 2 and 3 weeks after sowing, and repeat as necessary

Orchards

The damage caused by weeds in orchards

Weeds are likely to be most damaging to tree crops such as apple and citrus during the first few years after planting out. This is the period before they cast any significant shade and there is severe competition for nutrients and water, especially from perennial grasses. Traditional methods of weed control involve quite deep disturbance of soil around the trees. This damages tree roots without being fully effective in overcoming the problem. The combination of weed competition and root damage may often delay economic fruit production by one to two years. Later in the life of an orchard the effects of competition may be less serious but root damage could continue and uncontrolled weeds could harbour other types of pest including rats. The parasitic mistletoes (Loranthaceae) can occur in both citrus and deciduous fruit but rarely cause serious damage except under conditions of drought stress. They are often the symptom rather than the cause of poor tree growth.

The main weeds

A wider range of weeds occurs in orchards than is found in annual cropping systems. This is because many annuals and perennials that are too slow to become

established in annual crops have time to develop in orchards. Even so, the most important weeds are those which also occur in annual crops, including:

<i>Digitaria ciliaris</i>	tampula (Dzo.); chittrey (Nep.)
<i>Persicaria runcinata</i> (P)	chuchum (Dzo.); ratnaulo (Nep.); gangchuma (Sha.)
<i>Persicaria nepalensis</i>	helepsi (Dzo.); ratnaulo (Nep.); metoshim (Sha.)
<i>Galinsoga parviflora</i>	jagyouma (Dzo.); udasoy (Nep.); yurungpa (Sha.)
<i>Amaranthus</i> species	moth (Dzo.); ludey jhar (Nep.); lasomo (Sha.)
<i>Chenopodium</i> species	hethu (Dzo.); bethe, bathu (Nep.); bethu (Sha.)
<i>Cynodon dactylon</i> (P)	rampa (Dzo.); dubo (Nep.); saram (Sha.)
<i>Cyperus rotundus</i> (P)	guchen (Dzo.); mothey (Nep.)
<i>Bidens pilosa</i>	kuro (Nep.)

(P) indicates perennial species.

At high altitudes there may be additional perennials such as:

<i>Rumex nepalensis</i>	haleley (Nep.); sheylempo (Sha.)
<i>Pennisetum flaccidum</i>	jillijum (Dzo.)

while at lower altitudes in citrus these perennials may be replaced by:

<i>Paspalum conjugatum</i>	
<i>Axonopus compressus</i>	
<i>Spermacoce latifolia</i>	alujhar (Nep.)
<i>Mikania micrantha</i>	titay laharo (Nep.)

Weed control methods in orchards

Land preparation can be critical for the successful establishment of fruit trees. While it is not desirable to clear-cultivate the whole orchard area, especially where there is an erosion risk, it is important to hand-dig planting circles 1 to 2 m in diameter. This is done to eliminate perennial weeds, **before** planting, so as to avoid the damaging deep digging and disturbance of tree roots that will otherwise be necessary later.

Manual weeding of the 1 to 2 m weeding circle around each tree is desirable at least 3 or 4 times per year, depending on the local climate. Where perennials have been eliminated this can be achieved by very shallow hoeing, or hand-pulling. Circles should be cleaned before fertilizer application, at the end of the rainy season (to minimise competition for moisture during the dry season), and occasionally during the wet season, to prevent weeds getting too tall and rank. Slashing may sometimes be all that is needed, thereby reducing erosion risks, but regular slashing will tend to

favour the more competitive perennial grasses. Occasional slashing should be all that is required **between** the weeding circles, and cut material can be used for mulching.

Inter-cropping with legume ground cover is widely used elsewhere and may be suitable for citrus in the wetter districts of S. Bhutan, but further work may be needed to establish the optimum species and management systems. In young orchards, other crops such as wheat can profitably be grown in the alleys between apple trees.

Chemical weeding has not yet been well evaluated in Bhutan, but it is likely that the translocated herbicide, glyphosate ('Round-up') will shortly be available and this should prove valuable for control of most of the perennial weed species. It should be applied when the perennial weed foliage is well-developed, so that the maximum dose can be absorbed and translocated to the underground parts. Glyphosate is **not** a selective herbicide and fruit trees will be badly damaged if the tree foliage is wetted, either directly or by spray drift. Care is therefore needed to use only suitable low-pressure, large-droplet sprayers (not power sprayers) and to avoid wetting the lower branches of the trees. Glyphosate has no residual effect in the soil so, after use for perennials, there will be copious germination of annual weeds which will need to be controlled manually.

Integrated control of weeds in orchards

- i) Clear planting circles of perennial weeds before planting trees
- ii) Maintain a 1-2 m weeding circle by regular shallow hoeing
- iii) Use glyphosate when available for perennial weeds, but combine with manual methods for annual weeds

The identification and collection of weeds

From the comments in the previous sections on the biology and on the importance of the control of weeds, it should be clear how valuable and essential the correct scientific identification of weed species can be. Not only can it affect the successful application of local weed control methods, but it is also of immense value in exploiting the great body of knowledge available in the published literature on the biology and control of weeds elsewhere in the world. The important weed *Potamogeton distinctus* ('shochum') is now known to be the same species as that which occurs in South Korea where its biology has been studied in detail. The results of these studies are already being applied in Bhutanese research. Furthermore, even quite closely related species can differ in their response to herbicides. Thus any wider exploitation of herbicides in Bhutan is going to require sound weed identification skills from all involved in their development.

It is hoped that this book will enable researchers and extension personnel to identify their main weed species simply by reference to the pictures without the need for any specialised botanical knowledge. No keys are provided because they would prove difficult to use and would almost certainly be misleading. However, additional information is given on those characteristics which should help to confirm or throw doubt on any identifications. Characteristics of each family are also given which should help the reader to get to know the families gradually and so reduce the amount of random searching required. Important features to look for are the number and arrangement of the petals and other parts of the flower, and their arrangement in the inflorescence; the arrangement of the leaves, (opposite or alternate); the pattern of veins and the way they are divided.

Inevitably there are going to be weeds which do not match the illustrations, either because they are not included — at least a further 100 species are likely to occur as weeds occasionally — or because they (or the illustrations) are not quite typical. Those with some knowledge of botanical terms and classification are recommended to refer to the volumes of the *Flora of Bhutan* already published and available from the Forestry Research Division at Thapa, or to other sources listed on p. 224. In any case it is important that a specimen is collected and preserved in such a way that it can be referred on to others for identification or confirmation.

Collection

Whenever possible collect several complete plants, including at least some roots or other underground parts, and fruits as well as flowers. Make notes in the field, recording as much as possible of the following:

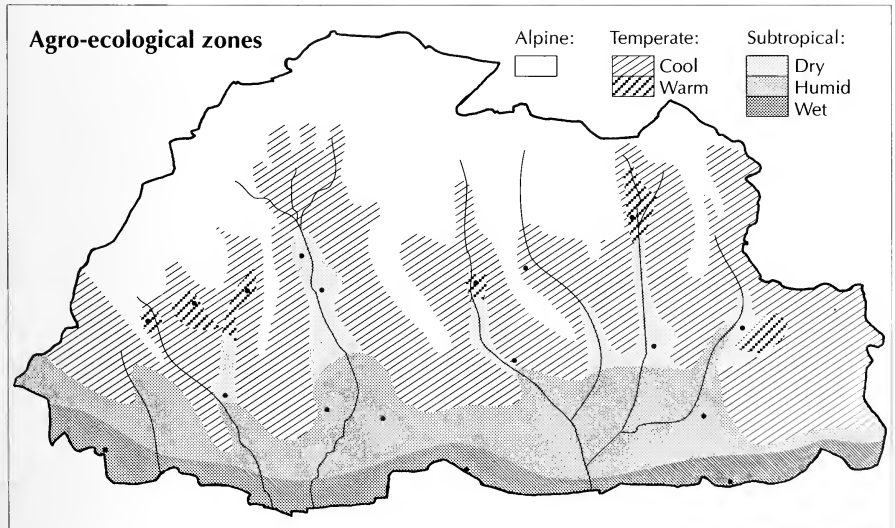
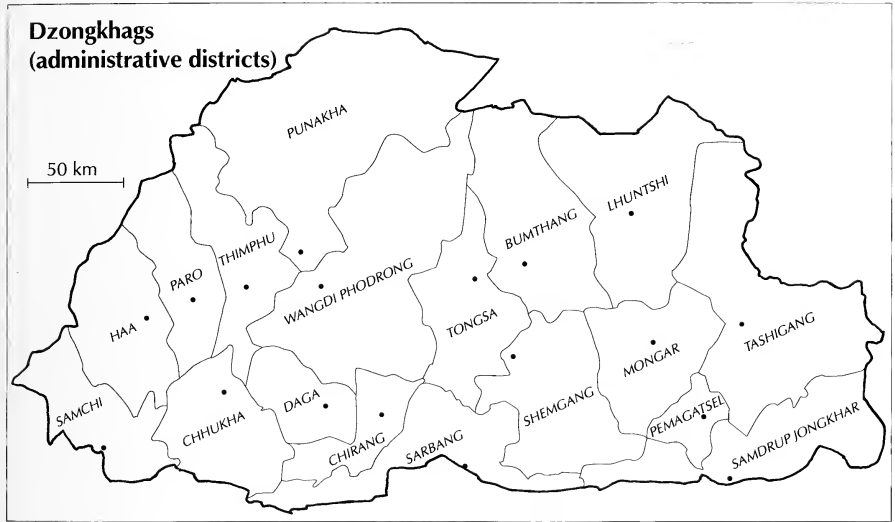
Date; village; gewog; dzongkhag; altitude; any local name; range of height of the weed and whether erect or prostrate; annual or perennial; make notes on underground parts if not collected; colour of foliage (pale or dark); size and colour of flowers (these may not preserve well); any fragrance before or after crushing; crop; frequency and seriousness as a weed; soil type; any other relevant information.

Put the plants collected in a plastic bag to prevent them wilting. As soon as possible, place individual plants (or parts, if large) in the fold of a single layer of newspaper, arranging leaves and flowers to show their shape as clearly as possible. Make sure each specimen is numbered or labelled so the correct notes can be attached later. Each of these folds of newspaper (about 30 x 40 cm when folded), with their contents, should be stacked alternately with one or two layers of absorbent drying paper or multiple layer of newspaper and placed in a herbarium press or under a stack of large books. Each day, the layers of drying paper should be replaced with fresh, dry paper but leaving the specimen undisturbed in its fold. Grasses should be dry enough after 3 or 4 days, others may take 5 to 7 days.

To make a permanent herbarium collection, the specimens should be mounted on stiff paper or card, preferably about 40 x 25 cm in size, using a polyvinyl wood glue. One such glue available locally is 'Fevicol'. A copy of the collecting notes should be attached to each sheet.

Even professional botanists have difficulty identifying plants that are not yet flowering, so it may be necessary to wait for weeds to mature before collecting. At the very early seedling stage, however, it is sometimes possible to get a useful idea of a weed's identity by gently uprooting it and finding the seed still attached to the roots. It can then be compared with the seeds on herbarium specimens or on mature plants nearby.

Maps of Bhutan



AMARANTHACEAE

A dicot family with alternate leaves, usually entire, without stipules; flowers small, in tightly congested inflorescences; often unisexual (but monoecious — both sexes on the same plant), subtended by dry narrow bracts; 3-5 sepals, no petals. Fruit a capsule, more-or-less round.

Alternanthera pungens Kunth

Local names:

Characteristics: Prostrate perennial, growing flat on the ground, with opposite leaves. Inflorescences compact about 1 cm across in the axils of the leaves, white or greenish turning brownish, sharply spiny from pointed bracts, painful to bare feet.

Distribution/importance: Introduced from tropical America. In Bhutan usually below 1500 m and present in most districts. Mainly a roadside weed but occasionally in the edge of cultivated fields and in perennial crops. Readily controlled by hoeing.

Alternanthera sessilis (L.) DC.

Local names:

Characteristics: Annual or short-lived perennial with long trailing stems and opposite leaves, turning up to form erect shoots to 30 cm high. Leaves usually quite shiny and often pinkish. Stems round with two lines of very short hairs down opposite sides. Inflorescences dense and round, about 1 cm across in the axils of the leaves, white or pink, not spiny.

Distribution/importance: A plant of wet places, mainly below 2000 m, probably in all districts. A weed of flooded rice, sometimes quite important. Susceptible to butachlor, and hand-weeding effective in early stages.



Alternanthera pungens flowering (top)

A. sessilis seedling (left)

A. sessilis flowering (right)



***Amaranthus hybridus* L.**

Local names: pigweed (Eng.); ludey jhar (Nep.); lasomo (Sha.)

Characteristics: Annual. Mainly erect, 30-100 cm high but branched, with dark green alternate leaves. Seedling leaves often reddish and with indented tips but later leaf tips rounded or pointed. Whole taproot pinkish. Inflorescences mainly terminal but with some in the axils of leaves below. Flowers green, up to 5 mm long with distinctly sharp-pointed bracts which feel prickly on sensitive skin, such as the back of the fingers or hand.

Distribution/importance: A common and often important weed of dryland crops and irrigated vegetables at higher altitudes, mainly above 1200 m. Bumthang, Lhuntshi, Paro, Tashigang, Thimphu, Wangdi. Usually associated with high soil fertility when it can be very luxuriant, competing seriously for light and water. Not difficult to hoe or hand-pull, and susceptible to most standard herbicides in dryland crops.

A subspecies of *A. hybridus*, also known as *A. hypochondriachus* L., with bright red inflorescences, is grown as a crop for its seed.

***Amaranthus lividus* L.**

Local names: ludey jhar (Nep.)

Characteristics: Annual. Usually prostrate, but sometimes erect, with alternate dark green leaves, often with a distinct blotch in the centre and differing from other species of *Amaranthus* in Bhutan in having a pronounced indentation of the leaf tip. Taproot pink. Inflorescence greenish, similar to that of *A. spinosus*, not at all spiny to the touch but with small axillary inflorescences commoner down the stem.

Distribution/importance: A minor dryland weed, relatively uncommon. Mainly above 1200 m. Bumthang, Punakha, Tashigang and Wangdi. Readily controlled by hoeing.



Amaranthus hybridus seedling (left)

A. hybridus flowering (right)

A. lividus flowering (bottom)



***Amaranthus spinosus* L.**

Local names: naumoth (Dzo.); ludey jhar kadey (Nep.)

Characteristics: Annual. Mainly erect and generally similar to *A. hybridus* but with spines at least 1 cm long in the axils of the lower leaves. Inflorescences also terminal and in axils but the individual flowers a little smaller and not feeling prickly to the touch.

Distribution/importance: A common, widespread dryland weed but rarely abundant. Mainly below 1500 m. Chhukha, Lhuntshi, Mongar, Punakha, Tashigang. Readily hoed or uprooted and susceptible to many herbicides.

***Amaranthus viridis* L.**

Local names: moth (Dzo.); ludey jhar (Nep.)

Characteristics: Annual. Mainly erect to about 50 cm. Leaves less dark green than in *A. hybridus*, thinner and smoother in texture, and often reddish. Leaf tips usually more-or-less pointed, rarely indented at the tip. Taproot pink only in uppermost 1-2 cm. Seedlings often tinged purple. Terminal reddish inflorescence of very small flowers, each only about 1 mm long.

Distribution/importance: A common dryland weed mainly at lower altitudes below 2000 m. Chhukha, Mongar, Punakha, Sarbang, Tashigang, Tongsa, Wangdi. Rarely dominant, and controlled readily by hoeing or uprooting. Susceptible to many herbicides.



Amaranthus spinosus flowering (top); *A. viridis* flowering (bottom)

ARACEAE

A monocot family which includes the *Arum* lilies, with leaves and stem emerging from a deep tuber or rhizome and having an unusual, characteristic inflorescence, comprising an elongated spadix, encircled by a large bract, the spathe. The spadix carries many very small flowers, hardly visible individually, developing into a cluster of fleshy berries.

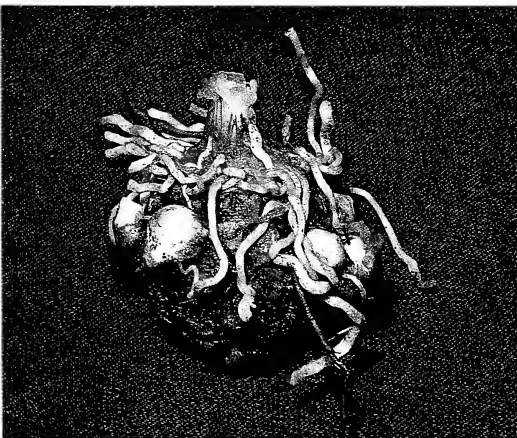
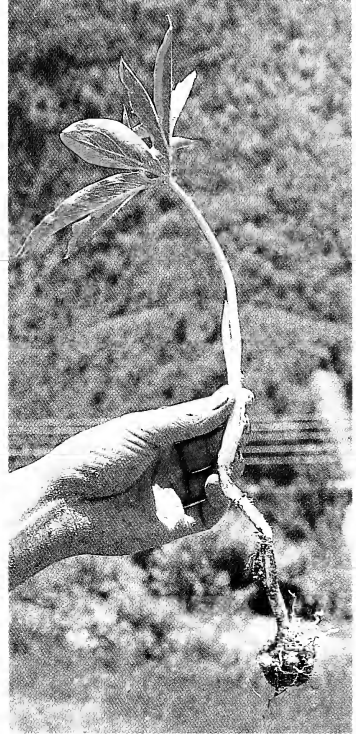
***Arisaema flavum* (Forsk.) Schott**

Local names: dho (Dzo.); boda sop, gurbo, birbanke, sarpa ko makai (Nep.); buchila-to (Sha.)

Characteristics: Perennial, growing from a round corm, at 20-30 cm deep in the soil. The corm develops daughter corms around its circumference which break off and so spread the weed. The corm produces one or two large leaves, up to 75 cm high, each deeply divided into 9 to 11 lobes. The inflorescence, produced in June, develops laterally about halfway up the stem/petiole and consists of a spathe up to 10 cm long, yellow-green outside, reddish inside, and a central spadix about 5 cm long. Later the peduncle curls over as it develops a mass of red berries each about 5 mm in diameter.

Distribution/importance: This is regarded as a major weed of potato and other crops locally at high altitudes, about 2500 m, in Chhukha and Haa districts. It also occurs in Lhunthshi, Punakha and Thimphu between 2200 and 2800 m. Control is extremely difficult without deep digging to remove the corm, otherwise it requires repeated hand-pulling. It is unlikely to be controlled by standard herbicides and may therefore become worse with repeated herbicide use.

Many other species of *Arisaema* occur in Bhutan and some at least probably occur as weeds. They vary in the colour and size of the spathe and in the division of the leaves. All are believed to be poisonous to some extent, perhaps all have poisonous underground parts, though the leaves of certain species are sometimes eaten.



Arisaema flavum showing leafshape (top left)

A. flavum whole plant, with corm (right)

A. flavum fruiting (middle left)

A. flavum corm (bottom left)

BORAGINACEAE

A dicot family, including the 'forget-me-nots', having simple alternate leaves, characteristically bristly and rough. Flowers with 5-lobed calyx and generally blue 5-lobed corolla in inflorescences which are dichotomously branched and may curl under towards the tip. The fruits are 4-lobed, often with hooked spines or bristles.

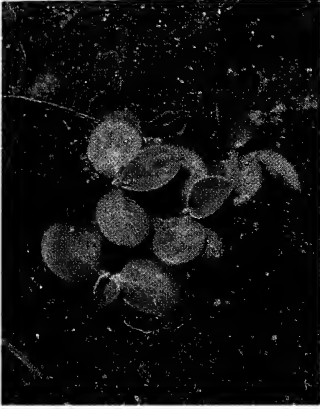
Cynoglossum furcatum Wall.

Local names: cimba (Dzo.); khirpatey (Nep.)

Characteristics: Annual or short-lived perennial up to 60 cm high. Leaves lanceolate, rough with short bristly hairs. Flowers bright blue, about 6 mm across. Fruits have hooked spines causing them to stick to clothing when ripe.

Distribution/importance: A common dryland weed mainly of roadsides and fallow areas but occasionally occurring in both winter and summer crops. Mainly above 1000 m, in most districts. Readily controlled by hand-pulling or hoeing when young but tough when allowed to mature.

The closely related *Cynoglossum amabile* Stapf and Drummond is very similar but with larger deep blue flowers, 8-10 mm across. It occurs occasionally in Paro, Punakha, Thimphu and Tongsa districts.



Cynoglossum furcatum seedlings
(left)

C. furcatum flowering (top right)
C. furcatum fruiting (bottom right)



***Cynoglossum lanceolatum* Forsskhal**

Local names: khirpatey (Nep.)

Characteristics: Annual or short-lived perennial up to 50 cm high, similar to *C. amabile* but with narrower leaves and the flowers smaller, 2-3 mm across and very pale blue. Fruits are smaller but also stick to clothes.

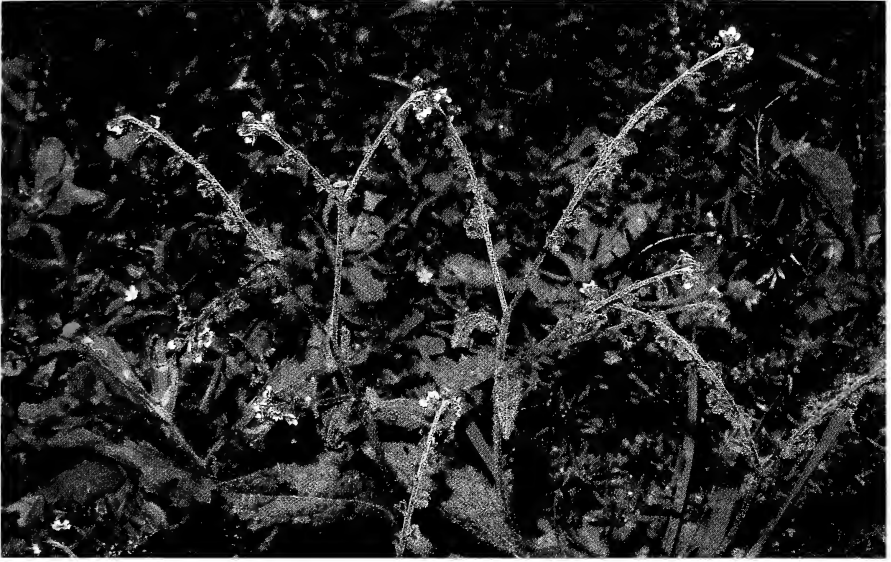
Distribution/importance: A minor dryland weed of waste places and fallows, occasionally in winter crops. Mainly above 1000 m. Mongar, Paro, Punakha, Sarbang and Tongsa. Readily controlled by hand-pulling or hoeing.

***Bothriospermum tenellum* (Hornem.) Fischer & C.A. Meyer**

Local names:

Characteristics: Annual. Erect up to 25 cm or sometimes spreading. Leaves small, 2-3 cm long, slightly rough with short hairs. Flowers white or very pale blue, 3-4 mm across.

Distribution/importance: A minor weed of winter cereal and vegetable crops between 1000 and 2500 m. Punakha, Tashigang, Thimphu and Wangdi. Easily hand-weeded.



Cynoglossum lanceolatum flowering (top); *Bothriospermum tenellum* flowering (bottom)

CANNABACEAE

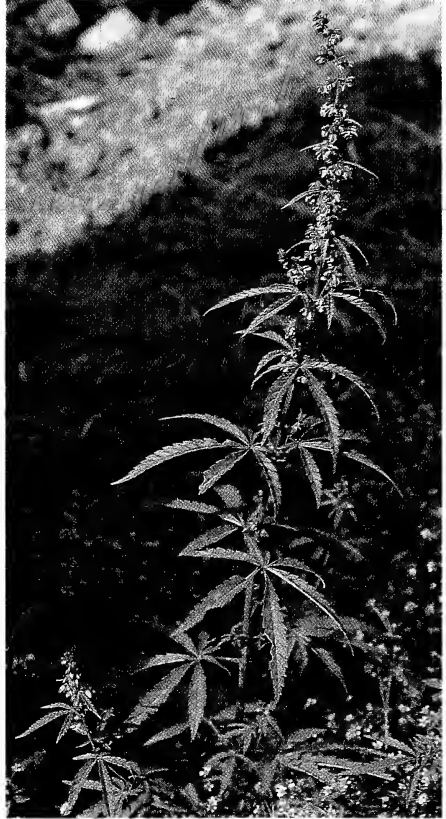
A very small dicot family also known as Cannabinaceae, with palmately divided leaves and male and female flowers on separate plants — dioecious. Individual flowers have 5 perianth segments.

Cannabis sativa L.

Local names: hemp (Eng.); keyria (Dzo.); gunza (Nep.); phagpa nam (Sha.)

Characteristics: Annual, up to 2 m high. Leaves characteristically palmate, deeply divided, up to 20 cm long with 3-11 elongated sharply toothed lobes. Distinctive smell when crushed. Male and female flowers on separate plants. Male flowers up to 3 mm long in greenish inflorescences up to 10 cm long in the axils of the upper leaves. Female flowers less conspicuous, in very small clusters in the leaf axils.

Distribution/importance: Common as a dryland roadside plant but also an occasional weed in cereal, oilseed and vegetable crops. Occurs widely at altitudes up to 3000 m, probably in all districts. Can be used as a source of fibre and also of an intoxicating resin. Readily controlled by hand-pulling or hoeing.



Cannabis sativa seedling (top left)

C. sativa mature (right)

C. sativa flowers (bottom left), female (left) and male (right)

CARYOPHYLLACEAE

A dicot family which includes the pinks and carnations. Leaves are opposite and usually entire, without stipules. Flowers are solitary or in small clusters, actinomorphic with 4 or 5 sepals and an equal number of petals, often notched at the apex (or occasionally none). Up to 10 stamens. Fruit usually a dry capsule opening by apical tooth-like valves.

Cerastium glomeratum Thuill.

Local names: mouse-ear chickweed (Eng.)

Characteristics: Annual, erect or spreading, with dull green, hairy leaves, flowers white with five petals, notched at the apex, about the same length as the sepals. Capsule is curved, about 10 mm long.

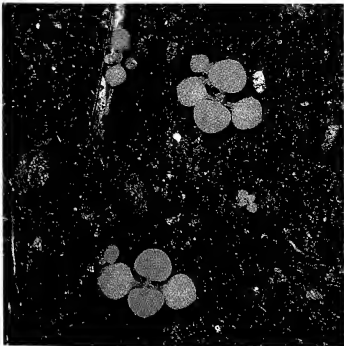
Distribution/importance: A minor dryland weed of high altitudes, over 1500 m. Bumthang, Punakha, Tashigang, Thimphu, Tongsa. A weed of winter crops but readily controlled by hand or hoe.

Drymaria cordata (L.) Roemer & Schultes

Local names: ovizalo (Nep.)

Characteristics: A weakly straggling annual, with glaucous (bluish) opposite leaves and small white flowers, the five petals 2-3 mm, about equal to the sepals.

Distribution/importance: A common weed of wet shady conditions especially at lower altitudes but occurring up to 2600 m. Bumthang, Chhukha, Mongar, Punakha, Sarbang, Tashigang. Sometimes becoming dominant in perennial crops. Readily controlled by hand-pulling or hoeing, but may regenerate from fragments under wet conditions.



Cerastium glomeratum flowering (photocopy x 2/5); *Drymaria cordata* flowering (top right);
D. cordata seedlings (bottom left); *D. cordata* close-up of flowers (bottom right)

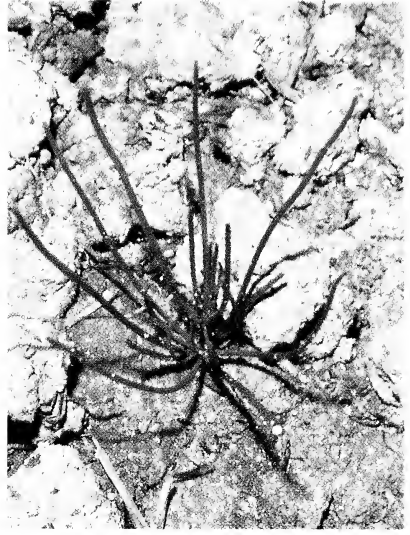
***Spergula arvensis* L.**

Local names: spurrey (Eng.)

Characteristics: Annual, erect or spreading, up to 30 cm high with whorls of narrow, dark-green leaves, often feeling sticky to the touch. Flowers about 8 mm across with 5 white petals, equal to sepals, open only after mid-day. Capsules about 4 mm long, almost round.

Distribution/importance: A common dryland weed of winter crops, usually associated with acid soil conditions. Mainly above 1000 m. Bumthang, Haa, Punakha, Tashigang, Thimphu, Wangdi. Sometimes semi-dominant but probably not seriously competitive. Readily removed by hand or hoe.

Spergula arvensis seedling (right)
S. arvensis flowering (bottom)



***Stellaria media* (L.) Villars**

Local names: chickweed (Eng.)

Characteristics: Annual, usually straggling, up to about 20 cm high. Stems with a single line of short hairs down one side. Leaves opposite, bright green. Flowers white, about 8 mm across, the petals a little shorter than the sepals and deeply divided.

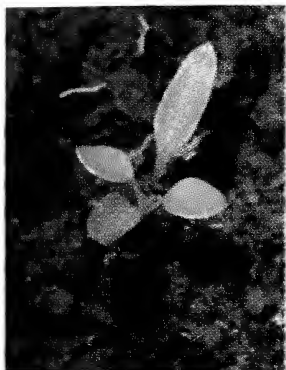
Distribution/importance: A widespread temperate dryland weed of winter cereals and other crops, probably introduced from Europe. Mainly at high altitudes but also down to 600 m. Chhukha, Mongar, Punakha, Samchi, Tashigang, Thimphu, Wangdi. Can become semi-dominant and sometimes seriously competitive. Readily removed by hand or hoe.

***Stellaria vestita* Kurz**

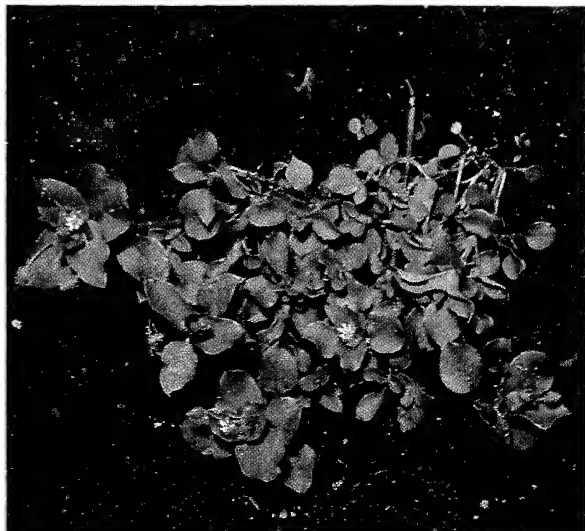
Local names:

Characteristics: A straggling annual weed like *S. media*, but with distinctly grey foliage, resulting from dense, white, star-shaped hairs.

Distribution/importance: A minor dryland weed of roadsides and waste places but sometimes in potato and cereal crops. Mainly above 1500 m. Bumthang, Chhukha, Haa, Punakha, Tongsa. Readily controlled by hand or hoe.



Stellaria media seedling (left)
S. media flowering (right)
S. vestita flowering (bottom)



CHENOPODIACEAE

A dicot family with alternate leaves often covered in whitish wax or in glands causing a strong aromatic smell when crushed. Flowers very small, greenish, with 3-5 perianth segments, in dense masses forming axillary and terminal inflorescences.

Chenopodium album L.

Local names: fat hen, lambsquarters (Eng.); hethu (Dzo.); bathu, bethe (Nep.); bethu (Sha.)

Characteristics: Annual, erect up to 1 m, with mealy grey-green foliage, without aromatic smell when crushed. Flowers small, 1 mm, in pale grey/green inflorescences, mainly terminal. Leaves broader than *C. ficifolium* and with a more-or-less triangular terminal lobe. Seedling markedly mealy grey but also often tinged reddish.

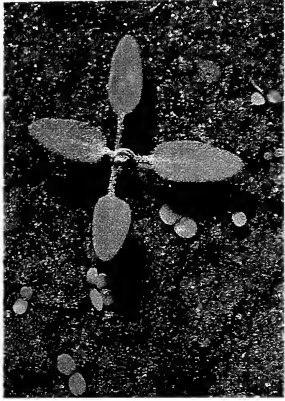
Distribution/importance: A common dryland weed at higher altitudes, mainly above 1000 m, probably in all districts. Apparently does not germinate as early as *C. ficifolium* in winter crops and commonest in spring-sown crops. Readily controlled by hand or hoe and by most herbicides.

Chenopodium ficifolium Smith

Local names: hethu (Dzo.); bathu (Nep.); bethu (Sha.)

Characteristics: Erect annual, very similar to *C. album* but usually less robust. Leaves narrower and most with 2 distinct lobes near the base, the rest of the blade almost parallel sided and blunt-tipped rather than triangular. Germinates in the winter, earlier than *C. album*.

Distribution/importance: A common and widespread weed in most dryland crops and irrigated winter vegetables, mainly above 1000 m, probably in all districts. Can sometimes be dominant but readily controlled by hand or hoe and by most herbicides.



Chenopodium album seedling (top left);
 Seedlings (top right), *C. ficifolium* (left) and *C. album* (right);
C. album flowering (bottom left); *C. ficifolium* flowering (bottom right)

***Chenopodium ambrosioides* L.**

Local names: rato latte (Sha.)

Characteristics: Annual, usually erect, up to 1 m high, with bright green shallowly toothed leaves, strong-smelling when crushed. Inflorescence of very small greenish flowers on axillary branches.

Distribution/importance: A minor weed of roadsides and occasionally in crops at lower altitudes below 1500 m. Chhukha, Punakha, Sarbang, Tashigang, Wangdi. Readily controlled by hand or by hoeing.

***Chenopodium botrys* L.**

Local names:

Characteristics: An erect annual to 30 cm high with stem densely covered in short glandular hairs. Pale green leaves much divided (pinnatifid) with some scattered glandular hairs. Glands responsible for strong aromatic smell when touched or crushed, but not as penetrating and unpleasant as *C. nepalense*. Flowers very small, about 1 mm, in diffuse axillary and terminal panicles.

Distribution/importance: A localised plant of higher altitudes 1500-2500 m. Chhukha, Haa, Paro, Thimphu. Occasional weed in potatoes, etc, rarely dense and readily controlled by hand or hoe.

***Chenopodium nepalense* Colla**

Local names:

Characteristics: Annual, erect to about 40 cm, not always distinguishable from *C. botrys*, but the leaves are less finely divided and more densely covered with sticky glands, extremely strong-smelling and unpleasant when crushed. Flowers greenish and small in mainly terminal inflorescences.

Distribution/importance: A minor weed of dryland vegetable crops at high altitude, over 2000 m. Bumthang, Chhukha, Thimphu, Wangdi. Rarely abundant and offering no special difficulty in control.



Chenopodium ambrosioides flowering (top left)
C. botrys seedling (top right)
C. botrys flowering (bottom right)
C. nepalense flowering (bottom left)

COMMELINACEAE

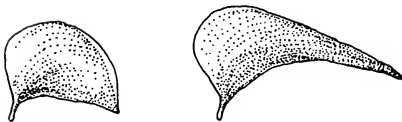
A monocot family with prostrate stems, rooting at the nodes. Leaves simple, alternate, fleshy, with basal sheaths surrounding the stem. Flowers in clusters in a roughly triangular spathe. Individual flowers have 3 spreading petals, usually blue, and conspicuous stamens, often of 2 or 3 different types.

Commelina benghalensis L.

Local names: kaney jhar (Nep.); humbatenang (Sha.)

Characteristics: A spreading annual or short-lived perennial with fleshy stems, rooting at the nodes. Leaves broadly elliptic (1.5 to 2 times as long as broad) distinctly petioled and with sheaths bearing characteristically brown-tipped hairs. Flowers about 1 cm across, consisting of three petals, all blue, open in the morning and fading by noon. Flowers emerge one at a time from a shortly triangular spathe with two sides closed, only one side open. Also producing short underground stolons, bearing cleistogamous (non-opening) flowers and setting viable seeds of a different shape and size to those from aerial flowers.

Distribution/importance: A common weed of lowland areas but extending up to 2300 m. Lhuntshi, Mongar, Punakha, Tashigang, Thimphu, Tongsa. Prefers high rainfall but not usually in flooded rice. Difficult to control owing to its resistance to desiccation and ability to re-establish from stem fragments. It needs to be carried out of the field or heaped to prevent regrowth. Also not readily controlled by most herbicides.



Spathes of *Commelina benghalensis* (left) and *C. hasskarlii* (right)



Commelina benghalensis seedling (top left); *C. benghalensis* stolons (top right);
C. benghalensis flowering (bottom)

***Commelina hasskarlii* C.B.Cl. and *Commelina diffusa* Burm. f.**

Local names: korum (Dzo.); kaney jhar (Nep.); humbatenang (Sha.)

Characteristics: Spreading annual or short-lived perennials, similar to *C. benghalensis*, rooting at the nodes but with leaves narrower, 3-4 times as long as broad. Also without brown hairs on the leaf sheath and without underground stolons. Flowers very similar, blue but the spathe an elongated triangular shape, open on two sides, closed only along its base (see p. 50). These two species are closely related and can only be distinguished by the seeds which are smooth in *C. hasskarlii* while those of *C. diffusa* are rough.

Distribution/importance: Common and widespread plants in both dryland and wet situations. The relative importance of the two species is uncertain as most records are from immature plants but they occur mainly at lower altitudes, below 2000 m, probably in all districts. Common and occasionally dominant weeds in dryland crops and in rice. Difficult to control once well established and need to be carried out or heaped to avoid re-establishment, but can be pulled or hoed when young.



Commelina hasskarlii flowering mat



Commelina hasskarlii
seedling (top)

C. hasskarlii flowering
(bottom)



***Commelina maculata* Edgeworth**

Local names: pishamphi (Sha.)

Characteristics: Perennial, growing from a tuberous root up to 15 cm long, often forked. Leaves elliptical 2-3 times as long as broad, less fleshy than in other common *Commelina* species and sometimes purplish, especially in young plants. Flowers July to October but the flowers are very rarely seen. They are known to be like other *Commelina* species, blue and emerging from a shortly triangular spathe, closed along two sides as in *C. benghalensis*.

Distribution/importance: A common plant of crops and occasionally in field borders, especially at higher altitudes, up to 3000 m but also occurring down to 300 m. Mainly in Mongar and Tashigang but also Bumthang, Punakha and Thimphu. Locally a serious weed in dryland crops, especially maize and potatoes. Difficult to control as hoeing and hand-pulling often leave the tubers to re-grow, or they regenerate on the soil surface. Requires digging to remove tuberous roots and heaping or removal from the field.





Commelina maculata tuberous roots (top left)
C. maculata young plant (top right)
C. maculata close-up of spathe (middle right)
C. maculata mature plant (bottom)

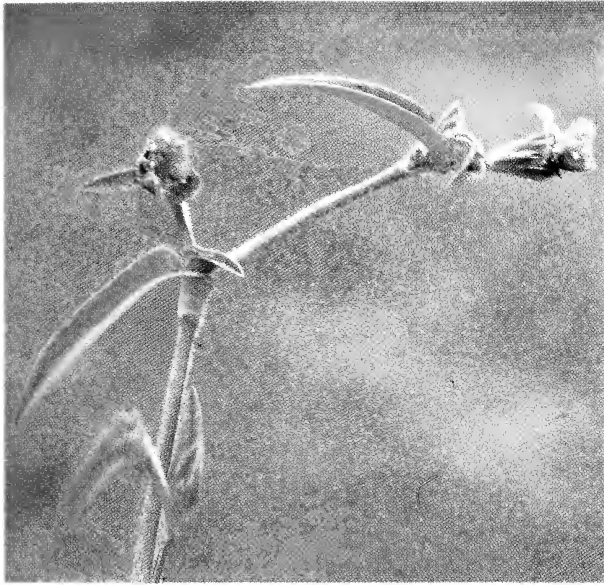
Opposite page
C. maculata whole plant with roots



Cyanotis vaga* (Lour.) Schultes*Local names:**

Characteristics: Perennial, growing from a bulb and first producing two very long narrow leaves, up to 40 cm long, but then fleshy shoots with shorter elliptic leaves about 5 cm long. Flowers about 1 cm across, deep blue, densely packed in spathes of elongated triangular shape.

Distribution/importance: A minor weed of dryland crops at high altitude, mainly over 2000 m. Bumthang, Chhukha, Mongar, Punakha, Tashigang, Thimphu, Tongsa and Wangdi. Not often dominant but sometimes locally serious in potato etc., and requiring quite deep digging to remove. Probably resistant to standard pre-emergence herbicides.



Cyanotis vaga flowering
(top)

C. vaga whole plant
excavated (bottom)



COMPOSITAE

Also known as Asteraceae — the sunflower family, a very large and important dicot family, with a distinctive, densely packed 'composite' inflorescence, usually having small actinomorphic (radially symmetrical) flowers (disc-florets), surrounded by asymmetrical ray-florets each with a single petal pointing outwards. The florets are attached to a disc-shaped receptacle, often domed, and surrounded by an involucre of overlapping bracts. Fruits often with a pappus for wind dispersal.

Acanthospermum hispidum DC.

Local names: starbur (Eng.)

Characteristics: Annual, erect to 40 cm. Leaves opposite, pale green, softly hairy. Flowers star-shaped, greenish, developing into spiny fruits 1-2 cm across.

Distribution/importance: A plant of dryland areas, introduced from Mexico and occurring locally, up to 1500 m. Mongar, Punakha, Tashigang, Wangdi. An occasional weed in dryland crops, especially on light soils. Readily controlled by hand or hoe.

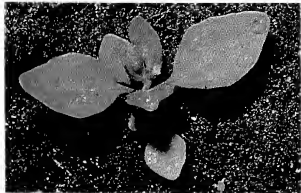
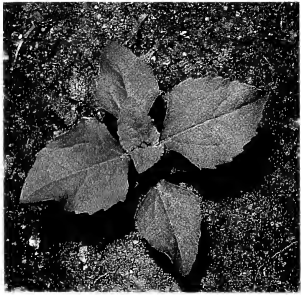
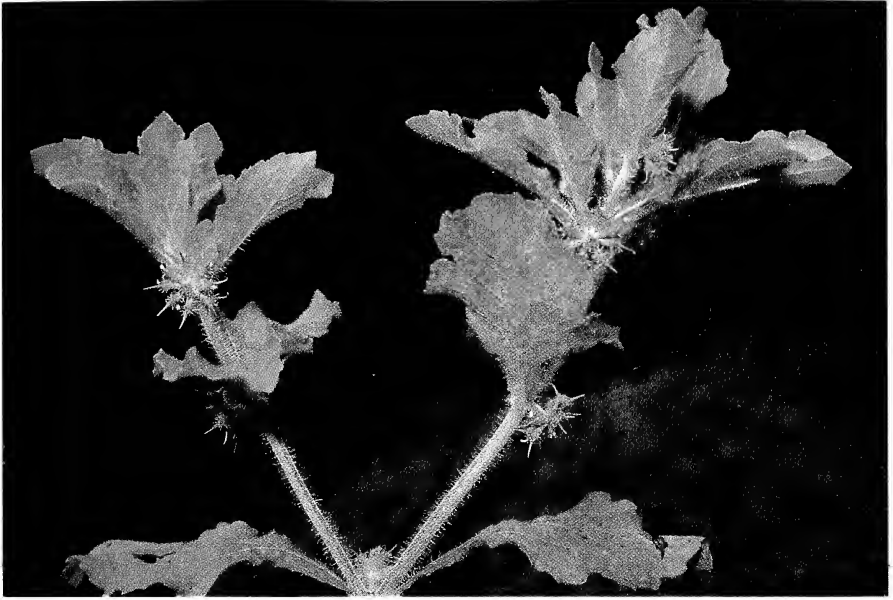
Acmella uliginosa (Schwartz) Cassini

Synonym: *Spilanthes iabadicensis* A.H. Moore

Local names: heydonam (Dzo.)

Characteristics: Annual, up to 30 cm high with bright green opposite leaves and composite heads with a varying number of yellow ray-florets around a distinctly conical disc, especially in fruit.

Distribution/importance: A common plant of wet places over a range of altitudes up to 2500 m. Chhukha, Mongar, Punakha, Samchi, Samdrup Jongkhar, Tashigang, Thimphu, Tongsa. Often a weed of rice paddies and sometimes abundant in poorly flooded terraces. Prevented by good flooding, otherwise readily controlled by hand or hoe.



Acanthospermum hispidum flowering (top); *Acanthospermum hispidum* seedling (middle left);
Acnella uliginosa seedling (bottom left); *Acnella uliginosa* flowering (bottom right)

***Ageratum conyzoides* L.**

Local names: elamey (Nep.); rogpu-ngon (Sha.)

Characteristics: Annual or short-lived perennial, erect to 70 cm. Leaves softly hairy, ovate, with wedge-shaped base, not heart-shaped. Flower-heads blue, consisting of up to 75 densely-packed disc-florets, about 5 mm long (no ray-florets) surrounded by an involucre of oblong, abruptly acuminate bracts which are glabrous or only shortly hairy. Styles exerted from florets only about 1 mm.

Distribution/importance: A common dryland weed, mainly at lower altitudes but extending up to 2000 m, probably in all districts. Not usually troublesome in annual crops, perhaps because of relatively slow establishment, but often serious in perennial crops. Readily controlled by hand or hoe when not allowed to get too big.

***Ageratum houstonianum* Miller**

Local names: elamey (Nep.)

Characteristics: Annual, very similar to the above, but differing in leaves having a more square or heart-shaped base and the flower-heads being larger, with more (about 100) florets about 6 mm long and a much more distinctly hairy involucre of linear-lanceolate bracts. The flowers also have conspicuous blue styles exerted 2-3 mm.

Distribution/importance: The relative distribution and importance of the two species is not quite certain, but this species appears to be much less widespread. It is perhaps more restricted to lower altitudes. Known from about 1000 m in Mongar, Sarbang and Wangdi districts, but probably elsewhere too. Biology and control similar to that for *A. conyzoides*.



Ageratum conyzoides seedlings (top left); *A. conyzoides* flowering (top right);
 Flowers (middle left), *A. conyzoides* (left) and *A. houstonianum* (right);
 Leaves (bottom left), *A. conyzoides* (left) and *A. houstonianum* (right);
A. houstonianum flowering (bottom right)

***Artemisia myriantha* Besser**

Local names: kempa (Dzo.); titepathi (Nep.); mayreng-ma (Sha.)

Characteristics: Perennial up to 2 m high. Foliage grey below and strongly aromatic. Flowers only late in the summer, with inconspicuous small grey flowers in elongated terminal panicles.

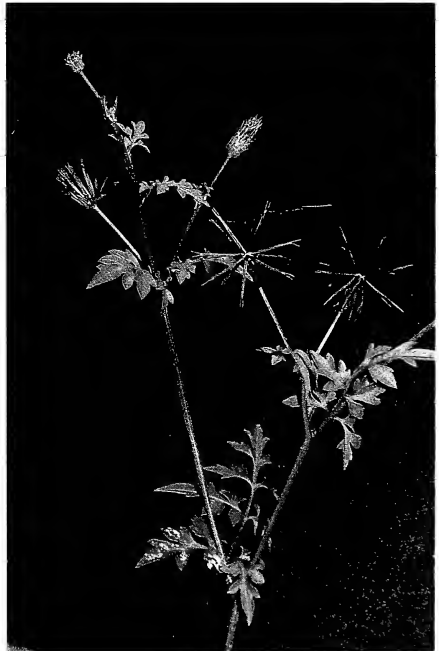
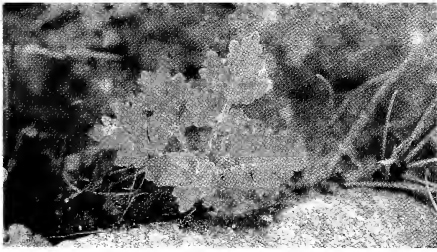
Distribution/importance: Mainly a weed of roadsides. Extremely widespread and well-known, probably occurring in all districts at least above 1000 m but recorded as a weed in Haa, Mongar, Punakha, Thimphu, Wangdi. Much used for mulching in chilli plots and to deter insects. Only occasionally occurring as a weed in crops and readily controlled by hand or hoe when young.

***Bidens bipinnata* L.**

Local names:

Characteristics: Annual, erect to 50 cm, with dark green, deeply divided leaves. Flowers yellow, without ray-florets. Fruit 1 cm long, with barbs which attach to clothing.

Distribution/importance: A localised plant of middle altitudes, 1200-2500 m. Lhuntshi, Paro, Tashigang. A minor weed of crops, rarely abundant. Readily controlled by hand or hoe.



Artemisia myriantha flowering (top)
A. myriantha seedling (middle left)
Bidens bipinnata seedling (bottom left)
B. bipinnata flowering (bottom right)

***Bidens pilosa* L.**

Local names: blackjack (Eng.); kuro (Nep.)

Characteristics: Annual up to 60 cm. Foliage quite dark green, usually divided into 3, sometimes 5 toothed lobes. Flowers with yellow disc-florets and white ray-florets up to 5 mm long. Fruits about 1 cm long with barbs which stick in clothing.

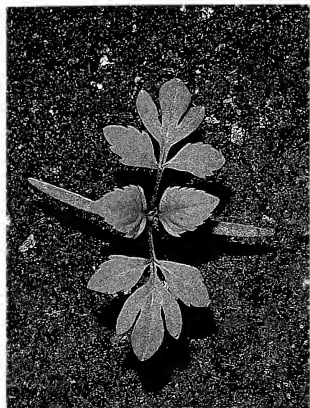
Distribution/importance: A common dryland weed, mainly of lower altitudes, but extending up to 2400 m, probably in all districts. Widespread in many crops and sometimes dominant, especially in perennial fruit crops. Readily controlled by hand or hoe.

***Bidens tripartita* L.**

Local names: yedum (Dzo.)

Characteristics: Annual up to 60 cm. Leaves bright green, simple in young seedlings, gradually becoming three-lobed, in some individuals much earlier than in others. Flowers late in the summer with a compact inflorescence of brownish-yellow disc-florets, about 2 cm across, without ray-florets.

Distribution/importance: A common plant of wet places, mainly above 2000 m. Chhukha, Paro, Thimphu, Wangdi. Sometimes abundant and of significance in rice paddies. Readily controlled by hand or hoe and susceptible to butachlor. May not germinate under flooded conditions but biology not well known and requires more observation.



Bidens pilosa seedling (top left)

B. pilosa flowering (top right)

B. tripartita seedling (bottom left)

B. tripartita flowering (bottom right)



Conyza bonariensis* (L.) Cronq.*Local names:**

Characteristics: Annual or biennial up to 60 cm high. Foliage dull grey-green, leaves narrow and slightly wavy-edged. Inflorescence of greyish-green heads 4-5 mm in diameter with cream-coloured disc-florets and no visible ray-florets. Pappus white or pinkish, 4-5 mm long (see pp. 68 and 69). Seedlings form a rosette.

Distribution/importance: A common dryland weed of fallows and perennial crops at a wide range of altitudes. Noted in crops in Mongar and Thimphu but probably present in most districts. Sometimes troublesome in perennial crops. Spreading freely by wind-blown seeds. Readily controlled when young but tough when older.

Conyza canadensis* (L.) Cronq.*Local names:**

Characteristics: Annual or biennial, similar to *C. bonariensis*, and often growing in mixture with it, but usually larger, up to 1 m high with larger much-branched inflorescences. Leaves distinctly brighter green, often yellowish, broader, often over 1 cm wide with some shallow teeth, flat, not wavy and with long hairs along the leaf edge, especially toward the base (see p. 68). Flower heads only about 2 mm in diameter with distinct white ray-florets about 0.5 mm long. Pappus off-white, shorter than in *C. bonariensis*, 3 mm long.

Distribution/importance: This is a widespread species with similar ecology and habitat to *C. bonariensis* but restricted to higher altitudes, mainly above 2000 m, in Chhukha, Paro, Tashigang, Thimphu, Wangdi. Control measures as for *C. bonariensis*.



Conyza bonariensis
 flowering (left)
C. canadensis
 vegetative (top right)
C. canadensis
 flowering (bottom)



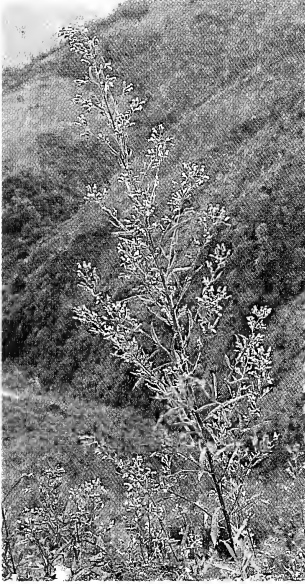
Conyza floribunda* H.B.K.*Local names:**

Characteristics: Annual or biennial, very similar to *C. canadensis*, variable in size but can be vigorous, with diffuse much-branched inflorescence at least 1 m high. Leaves similar in shape and colour to those of *C. canadensis*, but lacking all but a few marginal hairs. Flower heads greenish-brown and intermediate in size between the previous two species, 3-4 mm diameter, narrowing abruptly to 2 mm and without ray-florets. Pappus similar in size to that of *C. bonariensis*, but brownish rather than white.

Distribution/importance: A widespread plant of fallows and roadsides, mainly at lower altitudes, below 2000 m and especially in E. Bhutan. Chhukha, Lhuntshi, Mongar, Punakha, Sarbang, Tashigang, Wangdi. Ecology and control measures as for the previous two species.



Leaves, *Conyza canadensis* (left), *C. floribunda* (middle) and *C. bonariensis* (right)



Conyza floribunda flowering (top left)
 Flowers (top right), *C. floribunda* (left) and *C. bonariensis* (right)
 Fruits (bottom), *C. floribunda* (left) and *C. bonariensis* (right)



***Cosmos bipinnatus* Cav.**

Local names: cosmos (Eng.)

Characteristics: Annual up to 1.5 m. Foliage bright green, very finely divided. Flowers appear only in late summer, about 5 cm across, attractive, mainly pink, sometimes white.

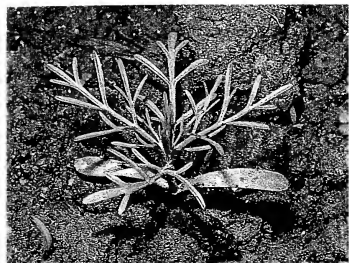
Distribution/importance: A common and conspicuous dryland roadside plant, introduced from Mexico. Mainly above 2000 m. Bumthang, Paro, Tashigang, Thimphu. Occasionally occurring in annual or perennial crops. Readily controlled by hand or hoe.

***Crassocephalum crepidoides* (Benth.) S. Moore**

Local names: dhadung phuley (Nep.)

Characteristics: Annual. Erect to 1 m, foliage usually dark green, flowers of reddish orange disc-florets, no ray-florets, nodding in bud, erect in fruit. Fruit a pappus carried by the wind.

Distribution/importance: A common dryland plant of waste places, mainly at lower, wetter altitudes up to 2000 m. Chhukha, Lhuntshi, Mongar, Punakha, Tashigang and Tongsa. Often a weed in perennial crops, occasional in annual crops. Readily controlled by hand or hoe.



Cosmos bipinnatus seedling (top left)
Cosmos bipinnatus flowering (top right)



Crassocephalum crepidoides
 seedling (bottom left)
Crassocephalum crepidoides
 flowering (bottom right)



Dichrocephala integrifolia* (L.f.) O. Ktze.*Local names:**

Characteristics: An annual or short-lived perennial, erect or semi-prostrate. Leaves very dark green, deeply divided (pinnatifid). Inflorescences axillary and terminal with flowers almost spherical, 5 mm across, yellow disc-florets in the centre, surrounded by silvery bracts. No ray-florets.

Distribution/importance: A widespread plant of dryland at a range of altitudes from 200-2500 m, in most districts. Mainly a weed of roadsides and field borders but quite commonly seen in maize and potato and especially in orchards. Not thought to be difficult to control.

***Eclipta alba* (L.) Hassk.**

Synonyms: *E. prostrata* (L.); *E. erecta* L.

Local names:

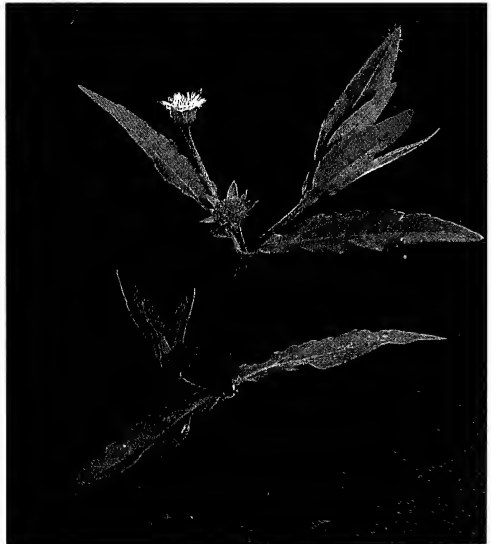
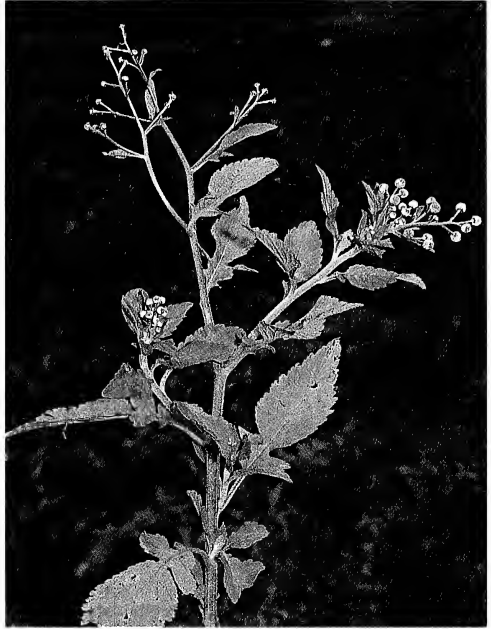
Characteristics: Annual up to 40 cm. Leaves rough, dull green, entire. Flowers about 1 cm across with yellow disc-florets and white ray-florets.

Distribution/importance: A common weed of wetland, especially at lower altitudes but extending up to 1800 m. Chhukha, Punakha, Samchi, Samdrup Jongkhar, Tashigang, Tongsa, Wangdi. Frequent in rice paddies, mostly around the edges but occasionally numerous in the crop. Readily controlled by hand or hoe but possibly somewhat resistant to butachlor.

Dichrocephala integrifolia flowering
(top)

Eclipta alba seedling (left)

E. alba flowering (bottom right)



***Eupatorium adenophorum* Spreng.**

Synonym: *Eupatorium glandulosum* H.B.K.

Local names: black weed (Eng.); namseeling (Dzo.); kaley jhar (Nep.)

Characteristics: Perennial, erect to 2 m. Leaves opposite, dark green. Stem dark, almost black. Flowers white, 4-5 mm across in clusters 5-10 cm diameter. Flowering early, March to June.

Distribution/importance: An introduced plant of lower altitudes up to 1750 m. Probably in all southern districts and in valleys of N. Bhutan. A weed of roadsides, often abundant and replacing more useful native vegetation. Believed by farmers to be responsible for poisoning horses but this is not confirmed. May also occur in plantations and grazing land. Stems sometimes swollen by galls caused by the fly, *Procecidochares utilis* Stone, which was introduced to India for biological control but is only partially successful. Requires repeated slashing or hoeing.

***Eupatorium odoratum* L.**

Synonym: *Chromolaena odorata* (L.) R.M.King & M.Robinson

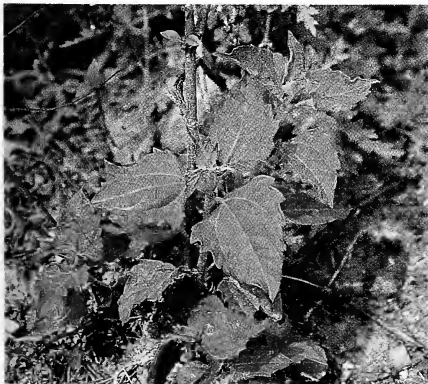
Local names: achame (Nep.); nayra-ngon (Sha.)

Characteristics: Perennial, growing rankly up to 2 m. Leaves opposite, dark green, strong-smelling when crushed. Flowers about 5 mm across with white to pale pink disc-florets (no ray-florets) in heads up to 10 cm across. Flowering late in the season, October to December.

Distribution/importance: A common weed of low altitudes, introduced from S. America, mainly below 1000 m, probably in all lowland districts. Often dominant on roadsides and can be troublesome in forestry and perennial crops. Difficult to pull or hoe when well established. May need slashing.



Eupatorium adenophorum flowering (top)
E. odoratum young plant (bottom left)
E. odoratum flowering (bottom right)



***Galinsoga parviflora* Cav.**

Synonym: *G. ciliata* (Raf.) Blake

Local names: jagyouma, jagasuju (Dzo.); udasoy (Nep.); yurungpa (Sha.)

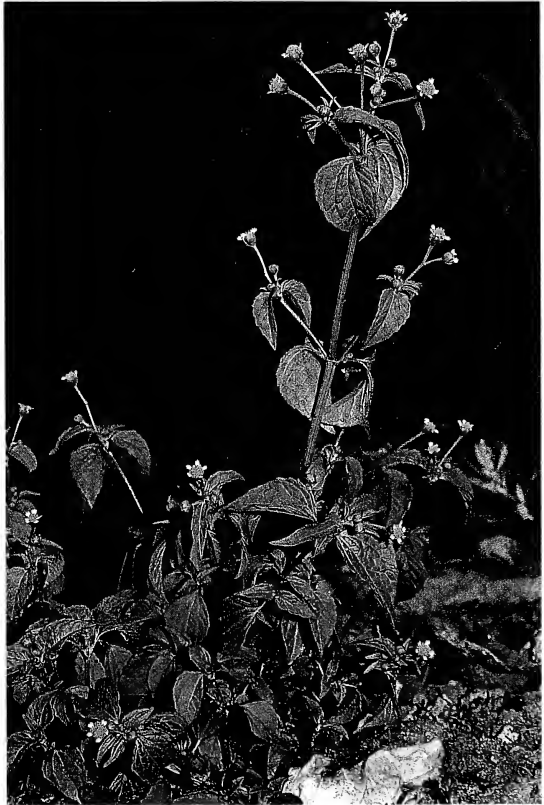
Characteristics: Annual, erect up to 40 cm. Foliage typically pale, yellowish green, softly hairy. Flowers about 1 cm across with yellow disc-florets and white ray-florets.

Distribution/importance: A plant introduced from C. America but now an abundant weed at a wide range of altitudes over 1000 m and sometimes below. All districts. One of the commonest of all dryland weeds in both summer and winter crops and very often dominant, though not usually causing severe competition. Readily controlled by hand or hoe and susceptible to most pre-emergence herbicides.



Galinsoga parviflora dominant in maize

Galinsoga parviflora seedlings
(top)
G. parviflora flowering (bottom)



***Gnaphalium affine* D. Don**

Local names: bokre phool, hooki phul (Nep.)

Characteristics: Annual or biennial, erect to 30 cm. Foliage almost white with dense fine hairs. Flowers about 2 mm across with vivid yellow disc-florets and no ray-florets but involucre also yellow, papery.

Distribution/importance: A common dryland plant of roadsides and fallows, mainly above 1000 m, probably in all districts. Occasionally a weed in both summer and winter crops and in perennial plantations. Readily controlled by hand or hoe.

***Gnaphalium pensylvanicum* DC.**

Local names:

Characteristics: Annual, erect to 40 cm. Foliage almost white with dense fine hairs. Flowers about 2 mm across with silvery brown disc-florets, and no ray-florets.

Distribution/importance: An introduced plant from N. America but now a common dryland plant, mainly between 1000 and 2000 m but sometimes lower. Chhukha, Lhuntshi, Mongar, Punakha, Samchi, Sarbang, Tashigang, Tongsa, Wangdi. A weed especially of winter crops, though rarely dominant. Readily controlled by hand or hoe.



Gnaphalium affine seedling (top left)

G. affine flowering (top right)

G. pennsylvanicum flowering (bottom left)



***Ligularia amplexicaulis* DC.**

Local names: dola (Sha.); shelempha (Dzo.)

Characteristics: A robust perennial up to 1.5 m high with broad leaves up to 50 cm long, the upper ones clasping the stem, the lower ones with the base of the petiole red below ground. Flowers in a head which is initially round, but expands to a flat-topped mass. Individual flowers 1 cm across with many yellow ray-florets. Involucral bracts green below, but tipped with black.

Distribution/importance: A plant of high altitudes, above 3000 m, occurring in yak grazing lands in the Sakten-Merak (Tashigang) district and identified there as a probable source of pyrrolizidine alkaloid poisoning, contributing to yak deaths when other forage is short. Also known from Bumthang, Punakha, Thimphu, Tongsa and Wangdi but not thought to be causing any toxic problem in those areas. Control only feasible by chopping out.

***Ligularia mertonii* (Clarke) Hand.- Mazz.**

Local names: bong dok pu (Sha.); dangbeb, dongrep (Dzo.)

Characteristics: A tall erect perennial, up to 3 m high with large palmately divided leaves over 50 cm long. Inflorescence a terminal, flat-topped mass of clusters, consisting of individual yellow flowers without ray-florets.

Distribution/importance: A widespread plant of high altitudes, over 2100 m. Identified in the Sakten-Merak (Tashigang) district as a major source of pyrrolizidine alkaloids, causing yak deaths. Also known from Haa, Punakha, Thimphu, Tongsa and Wangdi districts but not thought to be causing any toxicity in those localities. Presumably livestock avoid it when other forage is available. Control possible only by chopping out.



Ligularia amplexicaulis flowering (top left)
L. amplexicaulis close-up of flower (top right)
L. mortonii about to flower (bottom right)



***Mikania micrantha* H.B.K.**

Local names: mile-a-minute (Eng.); titay laharo (Nep.)

Characteristics: Annual or short-lived perennial climber, twining over shrubs and trees to several metres height. Foliage bright green. Flowers about 5 mm long with white disc-florets, in heads about 5 cm across. Flowers in the winter, December to February.

Distribution/importance: A common plant of lower altitudes, below 1000 m. Chhukha, Mongar, Samchi and Sarbang. Mainly on roadsides and in fallows but it can be troublesome in poorly managed perennial crops. It is best removed by hand but this can be difficult if it is allowed to grow dense, as the crop is then likely also to be damaged in the process.

***Parthenium hysterophorus* L.**

Local names: congress grass (Eng.)

Characteristics: Annual or biennial, erect to 1 m. Foliage dull grey-green, rather like *Artemisia* in the seedling stage but not aromatic. Flowers are many in diffuse panicles, about 2 mm across with white disc-florets (no ray-florets).

Distribution/importance: This is a dryland weed at lower altitudes, mainly below 1200 m, but occasionally to 1700 m. Mongar, Tashigang, Tongsa, Wangdi. Introduced from Central America, via India, this is mainly a weed of roadsides and waste places, but can occur in perennial crops. A noxious weed in parts of India where it causes severe allergic illness in adult males, including those whose only contact is with the pollen. It has been shown to be allelopathic and appears in places to be replacing *Artemisia* on roadsides. It may be pulled or hoed, but contact with skin should be minimised. Biological control methods are being introduced in some parts of the world.



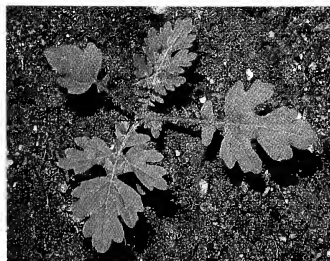
Mikania micrantha twining shoots
(top left)



M. micrantha flowering (top right)

Parthenium hysterophorus
seedling (bottom left)

P. hysterophorus flowering
(bottom right)



***Siegesbeckia orientalis* L.**

Local names: boumara, gobrey (Nep.)

Characteristics: Annual, erect, robust to 1.5 m. Foliage roughly hairy and with characteristic wings down the petiole. Flowers about 1.5 cm across, with yellow disc-florets, without ray-florets but surrounded by a few long very glandular, sticky spoon-shaped bracts.

Distribution/importance: A common plant of dryland at a wide range of altitudes from 500 up to 2700 m, probably in all districts. Occurring as a weed sporadically in annual and perennial crops, presumably competitive for light where it occurs, but fortunately rarely dominant. Readily removed when young, but tough once established.

***Soliva anthelmifolia* (Juss.) R.Br.**

Local names:

Characteristics: Annual, forming a flat rosette on the ground never more than a few cm high. Foliage much divided radiating out, dark green. Inflorescence a cluster of 1-3 sessile, circular heads in the centre of the rosette, with many greenish florets, a few yellow.

Distribution/importance: A minor dryland weed, occurring locally at about 1300-2100 m in Punakha and Wangdi districts. A weed of winter crops, occasionally dominant. Presumably easily hoed but difficult to grip for hand-pulling.

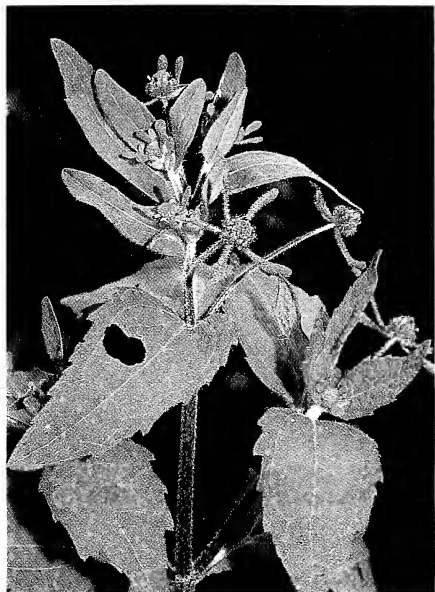
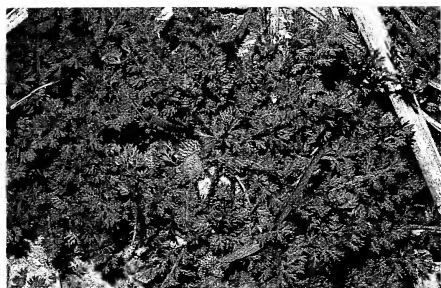
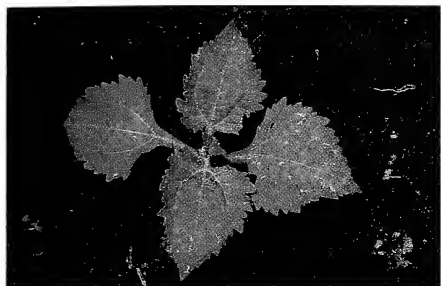
Illustrations (opposite page)

Siegesbeckia orientalis seedling (top left)

Siegesbeckia orientalis flowering (top right)

Soliva anthelmifolia flowering (middle left)

Soliva anthelmifolia fruiting (bottom)



***Sonchus asper* L.**

Local names: sowthistle (Eng.)

Characteristics: Annual, erect to 70 cm with milky sap when broken. Leaves with crispy, softly spiny edge. Auricle also spiny but rounded in outline, instead of pointed as in *S. oleraceus*. Flowers with spreading pale yellow ray-florets, open only in the morning, and fruits windblown.

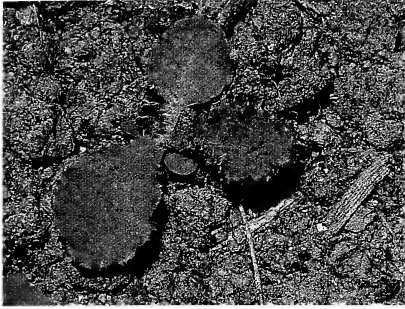
Distribution/importance: A common plant of dryland, mainly above 1500 m, probably in all districts. A weed of winter and summer crops, rather less common than *S. oleraceus* but often occurring with it. Readily controlled by hand or hoe.

***Sonchus oleraceus* L.**

Local names: sowthistle (Eng.)

Characteristics: Annual, erect to 70 cm with milky sap when broken. Foliage soft, grey-green, toothed irregularly, not finely as *S. asper* and auricles with one long acute lobe, not rounded. Flowers with spreading pale yellow ray-florets, open only in the morning. Fruits wind-blown.

Distribution/importance: A common plant of dryland, mainly above 1000 m, probably in all districts. A weed in both winter and summer crops. Readily controlled by hand or hoe.



Sonchus asper seedling (left)
S. asper flowering (right)
S. oleraceus flowering (bottom)



***Tagetes minuta* L.**

Local names: mexican marigold (Eng.); saypatri (Nep.)

Characteristics: Annual, erect to 1.5 m. Foliage bright green, finely, pinnately divided, toothed and strongly aromatic when crushed. Flowers individually 2 mm across with brownish disc-florets, in compact flat-topped heads.

Distribution/importance: A common plant of dryland, mainly above 1000 m, introduced from Central America. Probably in all districts. An important weed of annual and perennial crops, occasionally dominant. Readily controlled by hand or hoe

***Xanthium indicum* Roxb.**

Synonym: also known as *X. strumarium* L., but incorrectly

Local names: cocklebur (Eng.)

Characteristics: Annual, erect, robust to 1 m. Foliage generally dull green. Male flowers in small spherical heads 5 mm across and above female flowers which soon develop into oval fruits, 1-2 cm long, with hooked spines.

Distribution/importance: A plant of dryland, at a wide range of altitudes, 800 to 2400 m, occurring sporadically in Chhukha, Lhuntsi, Mongar, Tashigang, Thimphu, Tongsa and Wangdi districts. A weed especially of high soil fertility, forming very rank, competitive growth, occasionally dominant. Readily controlled when young, by hand or hoe. Tough to remove when well established.



Tagetes minuta seedling (top left)

T. minuta flowering (top right)

Xanthium indicum seedling (bottom left)

X. indicum flowering (bottom right)



CONVOLVULACEAE

Including Cuscutaceae — a dicot family consisting mainly of free-living herbs and shrubs, many of them having a climbing, twining habit (bindweeds). Flowers typically have petals fused into a bell-shape. The parasitic 'dodders', usually included in Convolvulaceae, but sometimes in the separate family Cuscutaceae, have no leaves and almost no chlorophyll but consist mainly of yellow twining stems which are parasitic on the shoots of other plants. Fruit a capsule, usually round.

Calystegia hederacea Wall.

Local names:

Characteristics: Perennial, producing shoots from a spreading root or rhizome system. Shoots prostrate or twining up crop plants. Leaves characteristically 5-lobed. Flowers white with pink streaks below, 3 cm across. Two broad bracts almost enclose the calyx.

Distribution/importance: Only known from near Lingmethang, Mongar district, at about 1000 m, occurring in and around rice paddy terraces. Potentially a difficult weed due to its deep root system unlikely to be readily controlled without deep digging.

Convolvulus arvensis L.

Local names: bindweed (Eng.); sagarkhandey (Nep.)

Characteristics: Perennial, producing shoots from the spreading root system, even from depths of 0.5 m. Shoots prostrate or twining up crop plants and often dragging them down. Leaves 2-3 cm long, cordate or hastate. Flowers bell-shaped, white or pink, smaller than those of *C. hederacea*, about 2 cm across. Very small bracts on the flower stalk, at least 1 cm below the calyx.

Distribution/importance: A very localised weed, recorded only at about 800 m at Lingmethang in the Mongar district, a few km from the site of *C. hederacea*. Troublesome in other parts of the world, in both annual and perennial crops and extremely difficult to eradicate once established, due to regeneration from deep roots. Susceptible to repeated applications of 2,4-D or glyphosate.

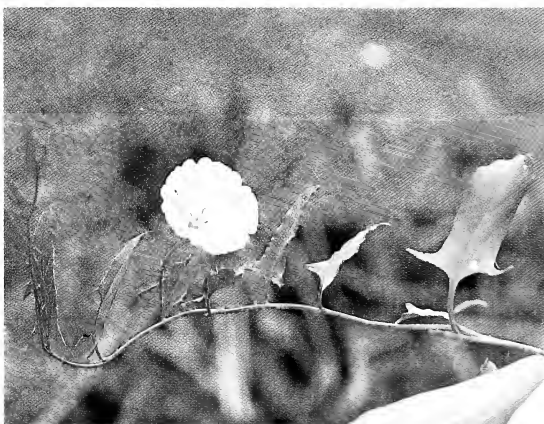


Calystegia hederacea flowering (top left)

Calystegia hederacea close-up of flower showing bract (top right)

Convolvulus arvensis plant growing from deep roots (bottom left)

Convolvulus arvensis flowering (bottom right)



***Cuscuta campestris* Yuncker**

Local names: dodder (Eng.)

Characteristics: A parasitic plant, almost without chlorophyll. Stems orange-yellow, 1-2 mm diameter twining tightly round host stems and leaves. White flowers 3 mm across in clusters 1.5 cm across. Fruit spherical. Styles with knobs on.

Distribution/importance: A plant mainly of roadsides, occurring sporadically over many altitudes and districts, including Lhuntshi, Samdrup Jongkhar, Tashigang and Thimphu. It is usually parasitic on *Artemisia* and other roadside plants but can occur on many vegetable and forage crops causing extremely severe damage to its hosts, sometimes complete crop failure. There is no ready means of control other than manual removal which may itself damage the host. It is often a problem due to the sowing of contaminated seed, so wherever any crop is attacked the source of the seed should be checked, and care taken in the harvesting of crop from the area.

***Cuscuta reflexa* Roxb.**

Local names: dodder (Eng.); roba-je (Dzo.); swarnlata, amar lata (Nep.)

Characteristics: A parasitic plant with very little chlorophyll, consisting of branching yellowish/reddish stems 2-3 mm in diameter spreading over host plants and twining tightly round leaves and stems. Flowers about 3 mm across and 8 mm long, white or reddish, in loose clusters formed late in the season, September onwards.

Distribution/importance: A plant of roadsides, quite widespread at higher altitudes, over 600 m, probably in all districts. It frequently attacks *Artemisia* and other vegetation on roadsides, but may also attack citrus in S. Bhutan and can then be very damaging. There is no easy means of control other than manual removal, not only from the crop but also from surrounding vegetation to stop it spreading into the crop.



Cuscuta campestris
 twining on *Artemisia* (top left)
C. campestris flowering
 (top right)
C. reflexa flowering
 (middle left)
C. reflexa vegetative
 (bottom right)



***Ipomoea purpurea* (L.) Roth**

Synonym: *Pharbitis purpurea* (L.) Voigt

Local names:

Characteristics: An annual, prostrate or climbing to 1 m or more by twining around other plants. Leaves alternate, heart shaped on petioles up to 10 cm long. Flowers in the axils of the leaves, up to 8 cm across, white but with distinct pink markings. The commoner, cultivated form of this species has deep purple-blue flowers. The seedlings have cotyledons with characteristically indented tips.

Distribution/importance: A localised weed seen only at 1500 to 1800 m at Tangmachu in Lhuntshi district occurring in both dryland crops and rice. Not abundant but likely to cause problems by spreading rapidly and causing lodging of crops at harvest. Needs to be hoed or pulled early, otherwise difficult to remove without causing damage to the crop.



Ipomoea purpurea seedling
(left)

I. purpurea flowering (right)



CORIARIACEAE

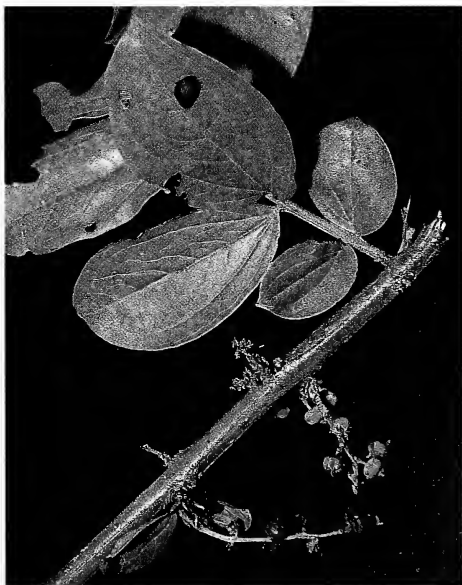
A very small dicot family of shrubs with opposite entire leaves. Flowers in racemes, actinomorphic, with 5 sepals and 5 slightly shorter petals.

Coriaria napalensis Wall.

Local names: limphu shi, nimbo (Dzo.)

Characteristics: A woody shrub growing up to 2 m high with glossy opposite leaves with distinct veins. Flowers with 5 very small petals in small racemes up to 10 cm long, leading to black fleshy fruits about 5 mm in diameter.

Distribution/importance: A plant of roadsides and forest borders at higher altitudes, above 1000m. Bumthang, Chhukha, Haa, Mongar, Paro, Tashigang, Thimphu, Tongsa. The fruits are temptingly sweet and are eaten occasionally by children and by cattle, leading to sickness, though this is not normally serious.



Coriaria napalensis leaves and fruits

CRUCIFERAE

A dicot family of mainly annual herbs, including mustard and related *Brassica* species. Characterised by alternate leaves without stipules, flowers with four free petals and a pod divided longitudinally into two cells separated by a thin membrane.

***Barbarea intermedia* Boreau**

Local names:

Characteristics: Annual, erect to 50 cm. Foliage dark green. Flowers small, yellow, the petals just exceeding the sepals. Pods only 1-2 mm wide, 2-3 cm long,

Distribution/importance: A plant of damp places at higher altitudes, above 1000 m. Lhuntshi, Mongar, Punakha, Tashigang, Thimphu. A minor weed of dryland and irrigated crops, especially in winter but also in early-sown summer crops. Readily controlled by hand or hoe.

***Capsella bursa-pastoris* (L.) Medik.**

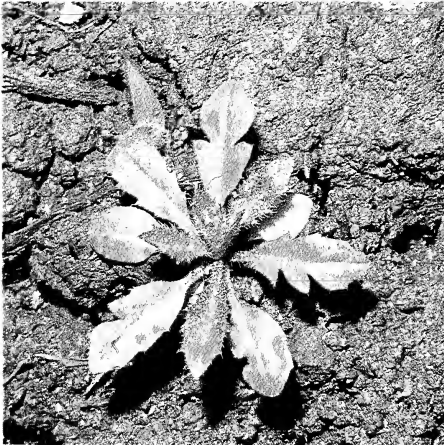
Local names: shepherd's purse (Eng.); tori ghans (Nep.)

Characteristics: Annual or biennial, starting as a rosette of flat greyish green simple leaves, gradually producing more divided, pinnatifid leaves and finally an erect stem to 30 cm with small white flowers and characteristically heart-shaped pods.

Distribution/importance: A common dryland plant, mainly above 1200 m in all districts. A weed of winter crops, occasionally numerous but rarely troublesome. Readily controlled by hand or hoe.



Barbarea intermedia flowering (top)
Capsella bursa-pastoris seedling (bottom left)
C. bursa-pastoris flowering (bottom right)



Lepidium virginicum* L.*Local names:**

Characteristics: An annual, erect to 40 cm with dark green leaves, the lower coarsely toothed, the upper narrow and entire. Flowers 1-2 mm across with 4 very small white petals equal to sepals. Pods flat, almost round, 3 mm across.

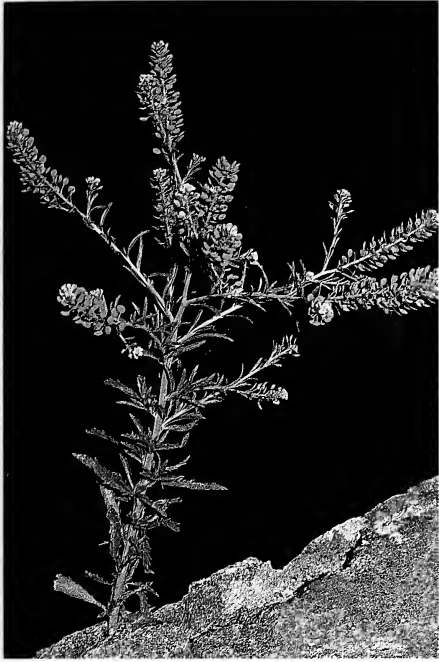
Distribution/importance: A localised plant of dryland at high altitudes, over 2000 m. Paro, Tashigang, Thimphu. Most often seen along roadsides but occasionally in dryland crops, especially in Tashigang district. Control should not be difficult by hoeing or hand-pulling.

***Nasturtium officinale* Brown**

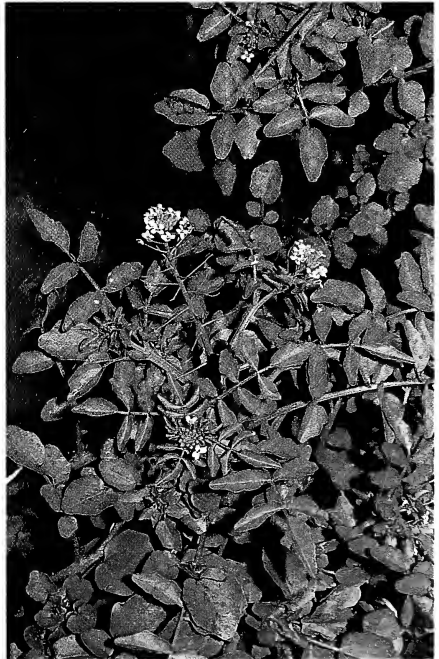
Local names: water cress (Eng.); sim rayo, pani saag (Nep.)

Characteristics: Aquatic annual or short-lived perennial forming spreading mats up to 20 cm high in water or on wet mud. Leaves pinnate, dark green. Flowers about 8 mm across with 4 white petals in clusters about 5 cm across.

Distribution/importance: A plant of wet places, mainly above 1500 m. Chhukha, Paro, Thimphu. This is presumably introduced from Europe where it is eaten as a salad. In Bhutan it is rarely utilised but occurs along streams and in wet places, occasionally encroaching on rice paddies. Readily pulled by hand.



Lepidium virginicum flowering (top)
Nasturtium officinale flowering (bottom)



Rorippa palustris* (L.) Besser*Local names:**

Characteristics: Annual or perennial, with erect shoots and dark green pinnatifid leaves, sometimes spreading by a root system producing adventitious shoots, so forming mats. Otherwise behaving as an erect annual with strong tap-root. Flowers 3-4 mm across with 4 small yellow petals, later forming slightly curved pods about 6 mm long.

Distribution/importance: A localised weed mainly above 1500 m in Chhukha, Paro, Punakha and Thimphu districts. It occurs in both rice and dryland situations and has the potential to become troublesome. Easily pulled or hoed in the early stages but difficult once the root system is well developed.

***Thlaspi arvense* L.**

Local names: pennycress (Eng.)

Characteristics: Annual, erect up to 30 cm. Leaves oblong or oblanceolate, shallowly toothed, very dark green. Flowers about 3 mm across with four white petals, developing into distinctively winged pods, flat and almost round, about 1 cm across, with a notch at the apex.

Distribution/importance: A common winter weed, mainly above 1800 m. Bumthang, Chhukha, Mongar, Punakha, Tashigang, Thimphu. A weed of dryland crops, especially in cereals. Occasionally dominant but probably not too seriously competitive. Readily controlled by hand or hoe.



Rorippa palustris flowering (top)
Thlaspi arvense flowering (bottom)



CYPERACEAE

The sedge family — a large and important monocot family with narrow, linear leaves like the grasses, with a sheathing base but usually no ligule. Stems mostly triangular in section and unjointed. Inflorescence of spikelets somewhat like grasses in which very reduced flowers are enclosed by single bracts arranged spirally or distichously.

Cyperus cyperoides (Retzius) O. Kuntze

Synonym: *Mariscus sieberianus* Nees ex Steudel

Local names: mothey (Nep.)

Characteristics: Perennial tufted sedge up to 50 cm with bright, yellowish-green foliage and inflorescences of radiating bracts up to 15 cm long and cylindrical spikes up to 4 cm long by 1 cm diameter, also yellowish-green, the individual spikelets about 5 mm long.

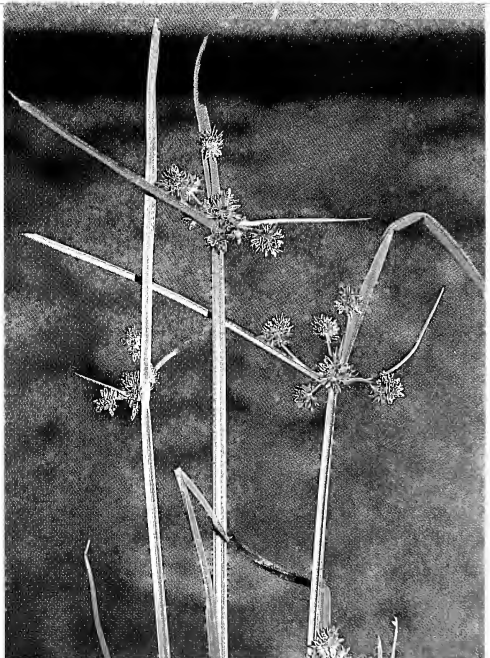
Distribution/importance: A minor weed occurring at all altitudes up to 2700 m. Chhukha, Haa, Mongar, Sarbang, Thimphu, Tongsa. Mainly on roadsides, field borders and paddy banks but sometimes also occurring in both annual and perennial crops. Not readily pulled out and requires hoeing to remove established plants.

Cyperus difformis L.

Local names: guchen, ochumani, chow (Dzo.); mothey (Nep.)

Characteristics: Annual sedge, erect to 40 cm. Leaves pale green. Inflorescence of very small spikelets, compact, brownish, almost spherical, 1-2 cm diameter. Seedlings not sweet smelling when crushed.

Distribution/importance: An abundant weed of wet places, from 500 up to 2500 m, probably in all districts. A major weed of flooded rice, able to germinate and establish even in well-flooded crops. Sometimes dominant. Readily controlled by normal manual weeding and by butachlor.



Cyperus cyperoides flowering (top)
C. difformis seedling (middle left)
C. difformis flowering (right)

Cyperus distans* L.f.*Local names:**

Characteristics: Perennial tufted sedge, up to 1 m high. Inflorescence very wide spreading with very fine narrow spikelets about 10 mm long, only 1 mm wide.

Distribution/importance: A weed of uncultivated areas at low altitude, mainly below 1500 m. Chhukha, Sarbang, Mongar, Samdrup Jongkhar. Mainly a weed of roadsides and field edges but occasionally found in perennial crops. Requires hoeing.



Cyperus distans flowering (photocopy x 1/2)

Cyperus iria L.

Local names: guchen, ochumani, chow (Dzo.); mothey (Nep.)

Characteristics: Annual sedge, very like *C. difformis* in the early stages but distinguished by sweet smell when crushed. Later it may be larger than *C. difformis* and the inflorescences are quite different with elongated spikes of flattened golden yellow or golden brown spikelets.

Distribution/importance: A common plant of wet places, from 500 up to 2500 m, probably in all districts. Common in rice paddies, but less truly aquatic than *C. difformis* and mainly occurring where they are not so well flooded. It may also occur in dryland crops but is rarely dominant. Can be prevented in rice by good flooding. Otherwise readily controlled by hand, hoe or butachlor.



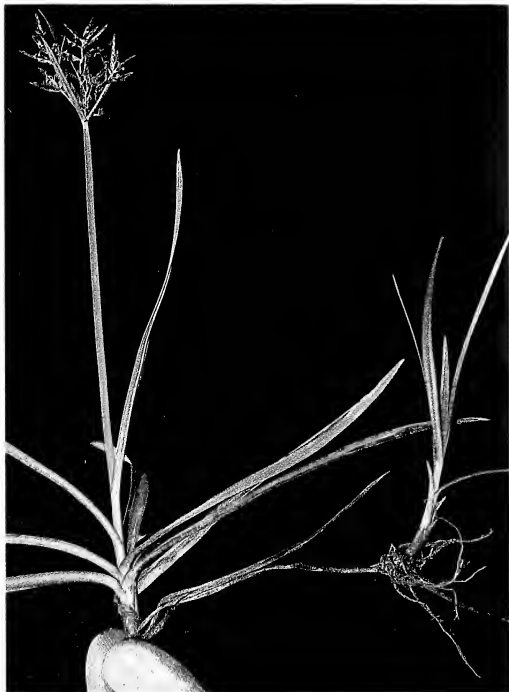
Cyperus iria flowering

Cyperus rotundus L.

Local names: nutsedge, nutgrass (Eng.); guchen (Dzo.); mothey (Nep.)

Characteristics: Perennial sedge with rhizomes and tubers down to 20 cm in the soil forming spreading patches of shoots up to 30 cm high. Leaves dark green, abruptly tapered to a point at the tip. Inflorescence varying from pale to dark brown. Individual spikelets about 10 mm by 2 mm.

Distribution/importance: An important weed at all altitudes from 500 to 2300 m in all districts. Often referred to as the world's worst weed because of the extreme difficulty of control. Not widely serious in Bhutan but locally a problem at lower altitudes, especially in perennial crops. Control is difficult but is possible by repeated deep cultivation during the dry season. Crops which smother and the herbicide glyphosate are both useful.



Cyperus rotundus plant with rhizome, flowering (left)

C. rotundus dormant tuber (right)

Cyperus tenuispica* Steudel*Local names:**

Characteristics: An annual sedge, tufted, up to 30 cm. The spikelets are small and very narrow on widely radiating inflorescences with long bracts. Leaves are generally shorter than the inflorescence.

Distribution/importance: A localised plant of flooded conditions, mainly at lower altitudes, below 1000 m. Mongar and probably some southern districts. A minor weed of rice, rarely abundant. Readily controlled by hand or hoe and presumably by butachlor.



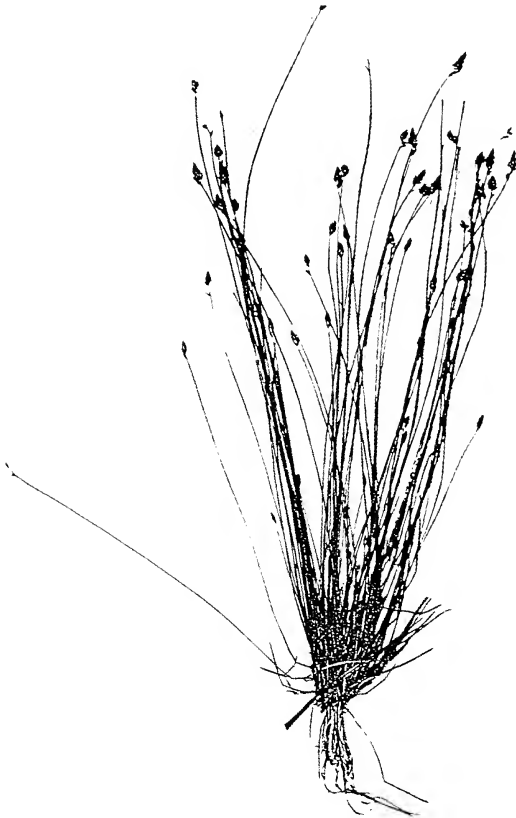
Cyperus tenuispica flowering

***Eleocharis atropurpurea* (Retz.) Presl**

Local names:

Characteristics: An annual, tufted sedge only up to 15 cm, with fine, leafless cylindrical stems ending in brown spikes up to 5 mm long.

Distribution/importance: A localised plant of flooded conditions at higher altitudes, over 2000 m. Thimphu district. A minor weed of rice, only occasionally seen. Readily controlled by hand or by butachlor.

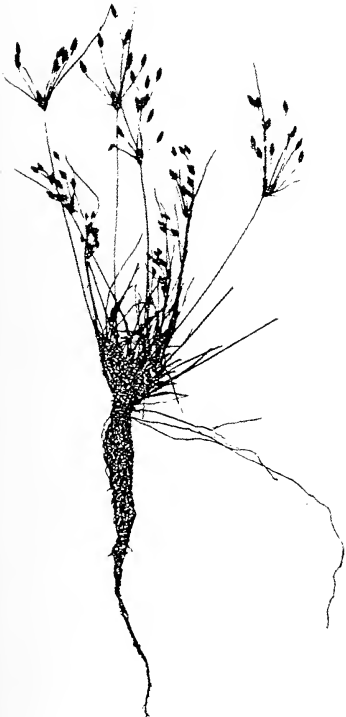


***Eleocharis atropurpurea* flowering**
(photocopy x 7/10)

Fimbristylis aestivalis* (Retzius) Vahl*Local names:**

Characteristics: An annual sedge, erect to 15 cm. with short fine leaves only half the height of the inflorescence which has spikelets only 2-3 mm long.

Distribution/importance: A plant of flooded conditions known from Thimphu district, over 2000 m. Very likely overlooked elsewhere. A minor weed of flooded rice. Readily controlled by hand and by butachlor.



Fimbristylis aestivalis flowering
(photocopy x 7/10)

***Fimbristylis littoralis* Gaudichaud**

Synonym: *F. miliacea* Vahl

Local names:

Characteristics: Annual sedge up to 50 cm high, tufted with extremely flattened stem and leaf bases. Inflorescence of very small, almost round spikelets, 2-3 mm long, produced relatively late in the season, September onwards.

Distribution/importance: A localised weed of wet places, up to 1400 m in Punakha and Wangdi districts and probably elsewhere. An important weed of flooded rice where it occurs but readily controlled by hand and apparently by butachlor.

The closely related ***Fimbristylis miliacea* (L.) Vahl** has a very similar inflorescence but spikelets are a little longer, 3-5 mm long, and stem bases are not flattened. This can also occur in rice but is probably rather less important.

***Kyllinga squamulata* Tonn. ex Vahl**

Local names:

Characteristics: Annual sedge, small, up to 15 cm, with bright green leaves, giving a pleasantly sweet smell when crushed. Inflorescence a single oval head on a stalk only about 5 cm high.

Distribution/importance: A weed of dryland crops at high altitudes, over 2000 m. Bumthang, Thimphu, Tongsa. Readily controlled by hand or hoe.



Fimbristylis littoralis seedlings (top left)
F. littoralis flowering (right)
Kyllinga squamulata flowering (bottom)



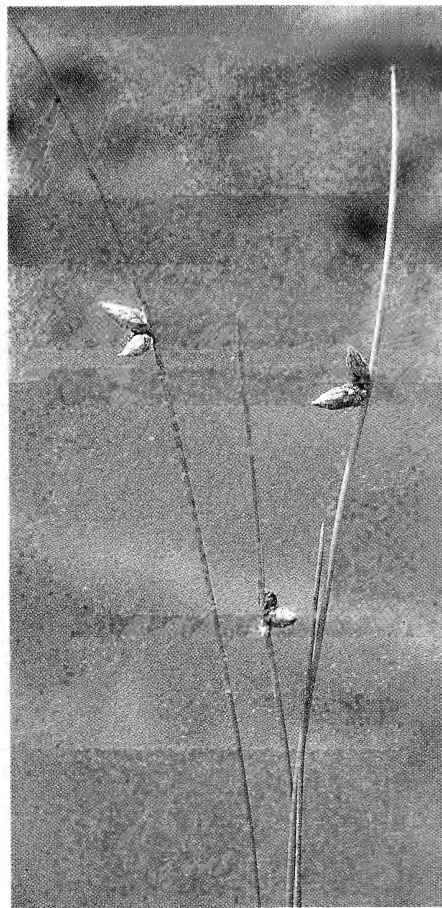
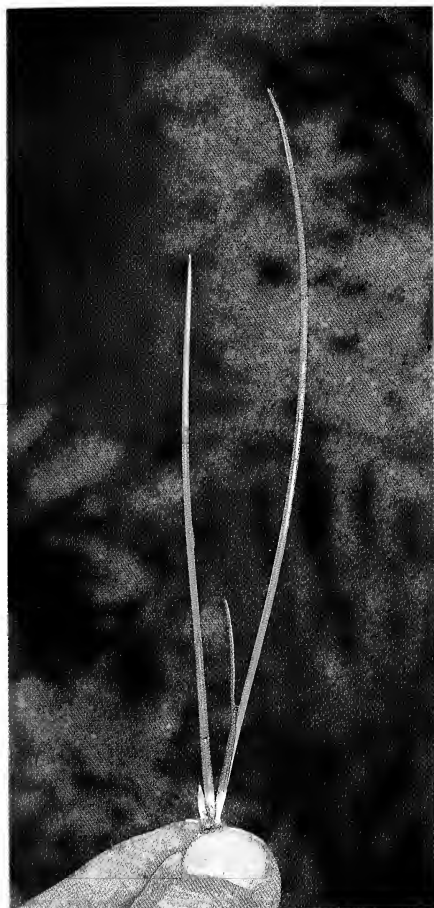
***Schoenoplectus juncooides* (Roxb.) Palla**

Synonym: *Scirpus juncooides* Roxb.

Local names: inchodum, chocksen, shesem, manitsau (Dzo.); swirey (Nep.)

Characteristics: Annual or short-lived perennial, tufted sedge up to 50 cm high. Stems cylindrical with a cluster of 2-3 spikelets each 1-2 cm long, to one side 10-15 cm below the tip.

Distribution/importance: An abundant plant of wet places, from 500 up to 2500 m in all districts. A major weed of flooded rice, present almost everywhere and often a dominant component of the weed flora. Readily removed by hand when small, and susceptible to butachlor.



Schoenoplectus juncooides seedling (left)
S. juncooides flowering (right)

EQUISETACEAE

The horsetail family, a non-flowering, spore-bearing family related to the ferns. Mostly perennials with a deep rhizome system from which the shoots emerge. The fertile shoot usually emerges first, consisting of a jointed, unbranched yellowish stem without chlorophyll with a terminal spore-bearing organ. The later vegetative shoots are also jointed, green, thinner, more elongated and with whorls of jointed branches at each node. The branches sometimes show secondary branching.

Equisetum diffusum D. Don

Local names: horsetail (Eng.); salley (Nep.)

Characteristics: Perennial producing finely branched, jointed shoots up to 30 cm high from a very deep rhizome system, often down to 30 cm or more. The angles on the branches are blunt. The spore-bearing heads are produced at the end of the green vegetative shoots.

Distribution/importance: A common plant of dryland, mainly at higher altitudes, above 1000 m in most districts. A weed of field borders but also in dryland crops and poorly flooded rice paddies, but probably not seriously competitive. Extremely difficult to control because of its deep underground system. Can only be repeatedly hand pulled or hoed.

Related species include *E. arvense* L. which is somewhat less common than *E. diffusum* and is not readily distinguished from it. This has a slightly coarser and more regularly branched shoot than *E. diffusum* with the ribs on the stem sharply angled. The fertile shoots produced early in the season are specialised, distinctly different from the vegetative shoots, having no green colour or development of branches. The third species, *E. ramosissimum* Desf., differs in having very robust shoots up to 2-4 mm thick, longer and relatively little branched. Ecology and control as for *E. diffusum*.



Equisetum diffusum fertile shoot (photocopy
x 1/2)

E. diffusum vegetative shoot (top right)

E. arvense fertile and young vegetative shoots
(bottom right)

ERICACEAE

A family of woody perennials, including the heathers and *Rhododendron* species. Leaves alternate or sometimes in apparent whorls, usually simple and entire, without stipules. Calyx and corolla usually 5-lobed in racemes or clusters. Fruit a berry or capsule.

Pieris formosa (Wall.) D.Don

Local names: khapshing (Dzo.); balu (Nep.)

Characteristics: A woody shrub, growing up to 2 m high with elliptic, glabrous, shiny leaves, finely toothed. Young flushes of growth characteristically bright red. Flowers about 5 mm long, white, in small panicles, leading to dry capsular fruits about 5 mm in diameter.

Distribution/importance: A plant of roadsides and forest edges at higher altitudes, mainly above 2000 m. Haa, Paro, Tashigang, Thimphu. Both young and old foliage are occasionally eaten by cattle, especially when other forage is scarce, or when livestock are previously unfamiliar with it. Quite serious illness can result, occasionally fatal.

Rhododendron barbatum G.Don

Local names: takshing (Dzo.); lal chimal (Nep.)

Characteristics: A large shrub up to 5 m high with reddish bark. Leaves lanceolate about 15 cm long, glabrous above but with characteristic brown bristles up to 1 cm long on the petioles. Flowers typical *Rhododendron* type, deep red, in an inflorescence up to 15 cm across.

Distribution/importance: In common with many other *Rhododendron* species, and the *Pieris* above, the foliage of this species is normally avoided by livestock, but is occasionally consumed by inexperienced livestock or when other feed is short, with serious and occasionally fatal results.



Pieris formosa new shoot (top left)
P. formosa flowering (top right)
P. formosa fruiting (middle right)
Rhododendron barbatum vegetative
 shoot (bottom)



EUPHORBIACEAE

A dicot family known as the 'spurge' family, usually with milky sap. Leaves mainly alternate or in whorls. Flowers unisexual, but male and female flowers usually in clusters together on the same plant (monoecious), occasionally dioecious. Sepals and petals very variable and often obscure or absent and effectively replaced by bracts. Fruit a capsule splitting into 3 segments.

Euphorbia heterophylla L.

Synonym: *E. geniculata* Ortega

Local names:

Characteristics: Annual, erect to 50 cm with horizontally spreading, bright green leaves and a rosette of leaflike bracts surrounding a cluster of greenish-yellow flowers.

Distribution/importance: A localised weed of dryland, introduced from tropical America and so far only known from a few localities in Mongar, Tashigang and Wangdi districts, between 700 and 1700 m. Not yet appearing in crops but a dominant problem in other parts of the world and could pose problems locally. Readily controlled by hand or hoe but resistant to some herbicides.

Euphorbia himalayensis (Klotzsch) Boissier

Local names: omthongdu (Dzo.)

Characteristics: Perennial up to 50 cm high growing from a rhizome about 1 cm thick, all parts leaking milky sap when broken. Leaves up to 4 cm long, dark green above and greyish below. Flowers in umbels about 10 cm across, mainly green, but fruits turning deep purple as they mature.

Distribution/importance: A plant of high altitude pastures, mainly above 3000 m. Haa, Paro, Thimphu districts. Not usually eaten by livestock but causing sickness if taken at times of shortage of forage, and by cattle not familiar with it. The milky sap can also be dangerous to the eyes of livestock and humans.



Euphorbia heterophylla seedling
(left)



E. heterophylla flowering (top
right)

E. himalayensis flowering
(bottom right)



Euphorbia hirta* L.*Local names:**

Characteristics: Annual or short-lived perennial, with mainly prostrate hairy stems and often reddish leaves. Flowers greenish in dense axillary clusters about 1 cm across.

Distribution/importance: A weed of dryland, especially at low altitudes up to 1500 m, probably in all districts. A weed mainly in perennial crops but rarely numerous or dominant. Readily controlled by hand or hoe. Resistant to some herbicides including paraquat.



Euphorbia hirta flowering

Euphorbia indica* Lamk.*Synonym:** *E. hypericifolia* L.**Local names:****Characteristics:** Annual with glabrous stems, prostrate or semi-erect to 30 cm.

Leaves glaucous (bluish), especially below, neatly rounded, opposite. Heads of greenish flowers in the axils 1-1.5 cm diameter. Somewhat like *E. hirta*, but leaves smoother, paler and inflorescence not reddish.

Distribution/importance: A minor dryland weed, mainly of low altitudes up to 1800 m. Punakha, Samdrup Jongkhar, Sarbang, Tongsa, Wangdi.

Occasionally a weed of dryland crops but not common. Readily removed by hand or hoe.

*Euphorbia indica* flowering

FUMARIACEAE

The fumitory family — a dicot family deriving its name from the characteristic smokey-grey colour of the foliage. Flowers zygomorphic with 2 sepals and 4 petals in two dissimilar pairs, outer pair large, often spurred and inner pair often joined. Fruit a capsule or one-seeded nutlet.

Fumaria indica (Haussknecht) Pugsley

Local names: fumitory (Eng.)

Characteristics: Annual with very divided grey foliage and flowers purple, 6-7 mm long in racemes about 4 cm long.

Distribution/importance: A minor weed of dryland, mainly 1000-2000 m. Mongar, Tashigang, Tongsa. An occasional weed especially in winter crops, occasionally abundant. Readily controlled by hand or hoe.



Fumaria indica flowering

GERANIACEAE

A dicot family with mainly palmately-lobed or -veined leaves and radially symmetrical flowers with 5 free petals. The fruit is 5-chambered and distinctive with the styles fused into an elongated beak (hence the English names of cranesbill or storksbill).

Geranium nepalense Sweet

Local names:

Characteristics: Annual weak herb, spreading or erect to about 40 cm. Leaves much divided, softly hairy. Flowers up to 15 mm across, white or pale mauve.

Distribution/importance: A minor weed of dryland situations, mainly above 1500 m, probably in all districts. A weed of roadsides and occasionally in dryland perennial crops. Readily controlled by hand or hoe.



Geranium nepalense seedling (left)
G. nepalense flowering (right)



GRAMINEAE

The monocot, grass family — one of the largest and most important of all plant families including all the main cereal crops and also many of the most serious weed species. Grass species survive grazing by having meristems at the leaf base, allowing regrowth after defoliation. Inflorescences are made up from spikelets, each with one or two glumes and one or more florets, each with lemma and palea (see glossary).

Alopecurus aequalis Sobol.

Local names: orange foxtail (Eng.)

Characteristics: Annual grass spreading by extensive runners, rooting at the nodes, but without underground rhizomes. Inflorescence cylindrical and with bright orange anthers.

Distribution/importance: A common plant of wet places above 1000 m in most districts. Grows mainly in the winter and common in rice paddies after harvest, but can also occur as a weed in cereals and in rice. Occasionally dominant. Readily controlled when young but difficult to remove completely when well established.

Arthraxon quartinianus (A.Rich.) Nash

Local names:

Characteristics: Annual or perennial prostrate spreading grass rooting at the nodes. Leaves short, broad and pointed, often fringed with long hairs. Inflorescence of 3-8 racemes, spikelets about 3 mm long with a short awn.

Distribution/importance: A widespread plant of lower altitudes, up to 2000 m, mainly in E. Bhutan. Mongar, Tashigang. A weed of field borders but frequently encroaching on both dryland and irrigated crops. Needs thorough hoeing and removal to prevent regeneration from the runners.

A number of other *Arthraxon* species may also occur.



Alopecurus aequalis flowering (top)
Arthraxon quartianus flowering (bottom)



***Avena fatua* L.**

Local names: wild oat (Eng.); jangali jar (Nep.)

Characteristics: Annual grass up to 1 m high with inflorescence resembling the crop oats (*A. sativa*) but spikelets with brown hairs at the base and long awns, breaking up into single seeds which drop, leaving empty glumes. Young plants distinguished from wheat and barley by the lack of auricles at the leaf-base.

Distribution/importance: A common and potentially serious weed of cereals at higher altitudes, over 1000 m. Bumthang, Chhukha, Haa, Mongar, Punakha, Tashigang, Thimphu, Wangdi. It is one of the few species which farmers bother to weed from wheat. Must be hand-pulled to prevent build-up. It is liable to be spread in contaminated crop seed.



Avena fatua flowering in a wheat crop

***Axonopus compressus* (Swartz) P. Beauv.**

Local names:

Characteristics: Perennial grass, prostrate, spreading and rooting at the nodes.

Leaves broad and flat, from very flattened leaf sheaths. Inflorescence of 3-4 very fine racemes, like *Digitaria*, prostrate or erect up to 30 cm high.

Distribution/importance: A grass mainly of low altitudes, below 1000 m. Chhukha, Mongar, Punakha Sarbang. A weed of roadsides and field edges, but sometimes an important component of vegetation in orchards. Not readily pulled by hand. Requires hoeing or use of the herbicide glyphosate.



Axonopus compressus flowering

Brachiaria ramosa* (L.) Stapf*Local names:** pashipang (Nep.)**Characteristics:** A mainly prostrate or spreading annual grass, rooting at the nodes, with broad, bright green, hairy leaves. Inflorescence a panicle of racemes up to 5 cm long, with spikelets about 3 mm long.**Distribution/importance:** A plant of dryland at low altitudes, below 1500 m, mainly in E. Bhutan. Mongar, Tashigang. An aggressive weed, sometimes dominant in maize, etc. Needs hoeing early and heaping or removal to prevent re-rooting at the nodes.*Brachiaria ramosa* flowering (photocopy x 1/2)*B. ramosa* seedling

***Cynodon dactylon* (L.) Pers.**

Local names: bermuda grass (Eng.); rampa (Dzo.); dubo (Nep.); saram (Sha.)

Characteristics: Perennial grass with strong, extensive rhizome system down to 20 cm in the soil. Shoots distinguished from all other common grasses by having at least 2-3 leaves at each node. Inflorescence a whorl of 3-6 racemes, like *Digitaria* species, but finer and shorter, up to 4 cm long.

Distribution/importance: This is a major weed, mainly at lower altitudes, below 2500 m, in all districts. Serious in both annual and perennial crops and in less well-flooded rice. Difficult to remove by hand or hoe. Needs to be dug deeply and rhizomes removed. May be controlled by herbicides such as glyphosate.



Shoots (right), *Cynodon dactylon* (left) and *Paspalum distichum* (right)
C. dactylon flowering (bottom)



Cynodon dactylon flowering
 (photocopy, x 1/2)

***Digitaria ciliaris* (Retz.) Koel.**

Synonym: *D. adscendens* (H.B.K.) Henr.

Local names: crabgrass (Eng.); tampula (Dzo.); chittrey banso (Nep.)

Characteristics: Annual grass often spreading and rooting at the nodes. Leaves broad, softly hairy. Inflorescences up to 40 cm high, with 3-10 radiating racemes, 2 mm thick, very variable in length from 4 to 10 cm long. Spikelets in pairs, one sessile and the other shortly stalked, about 3 mm long with wide spaces each side of the mid-nerve of the lower lemma. Lower glume minute; upper glume at least half, usually three-quarters the length of the spikelet (see illustration p. 133). Border of the lower lemma sometimes with long hairs, sometimes almost glabrous.

Distribution/importance: This is one of the commonest and most important of all weeds in Bhutan, mainly at altitudes above 1000 m but occasionally lower. All districts. A major weed of dryland crops, annual and perennial. Often dominant and likely to cause significant competition when not removed promptly. Readily controlled by hand or hoe when young, but older plants more difficult. Susceptible to most herbicides for dryland crops.



Digitaria ciliaris dominant in maize, partially weeded

Digitaria ciliaris seedling (top)
D. ciliaris flowering (bottom)



Other *Digitaria* species

Other *Digitaria* species occurring as weeds in Bhutan are all annuals, superficially similar to *D. ciliaris* and are only distinguished by studying the spikelets with a close-up lens or microscope. They have not always been distinguished in the course of the survey and their relative importance is not certain. Most have been recorded as weeds only locally but *D. timorensis* is widespread at lower altitudes. Ecology and control methods are not thought to differ significantly from those for *D. ciliaris*.

***Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.** has small spikelets, about 2 mm long, grouped in threes, with nerves on the lower lemma very evenly spaced and the upper glume extending the full length of the spikelet.

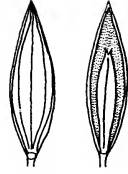
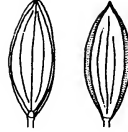
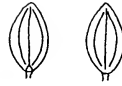
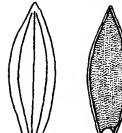
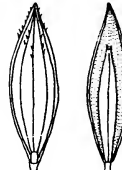
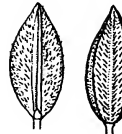
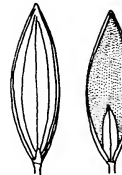
***Digitaria longiflora* (Retz.) Pers.** has very delicate racemes with minute spikelets only about 1 mm long, densely hairy and nerves evenly spaced. Upper glume extending the full length of the spikelet.

***Digitaria microbachne* (Presl) Henr.** has spikelets 2-2.5 mm long, the lower lemma similar to that of *D. ciliaris* with a wide space each side of the central nerve, but the upper glume minute, leaving the brown, shiny upper lemma almost completely exposed.

***Digitaria sanguinalis* (L.) Scop.** is almost indistinguishable from *D. ciliaris*, differing merely in the presence of minute spines on the nerves of the lower lemma, only visible under the microscope. It has been confirmed from only a few districts including Chukkha.

***Digitaria ternata* (A.Rich.) Stapf** has spikelets grouped in threes, 2 mm long with 2 nerves on the lower lemma very close to the central nerve and with dense whitish hairs outside these nerves. Upper glume extends the full length of the spikelet but narrow, not completely concealing the dark brown, shining upper lemma.

***Digitaria timorensis* (Kunth) Bal.** is very like *D. ciliaris* but racemes are often rather longer and the upper glume is less than half the length of spikelet. It tends to replace *D. ciliaris* at lower altitudes, below 1000 m, and is often a major weed of annual and perennial crops.

*D. ciliaris**D. ischaemum**D. longiflora**D. microbachne**D. sanguinalis**D. ternata**D. timorensis*

***Echinochloa colona* (L.) Link**

Local names: barnyard grass (Eng.); jam, jama (Dzo.); sama, molera (Nep.)

Characteristics: Annual grass, sometimes prostrate at first but later erect to 1 m. Base of stem flattened and often purplish. Leaves broad with no ligule at all. Inflorescence of small spikelets, 2.5 mm long.

Distribution/importance: A common grass weed mainly of lower altitudes up to 2000 m, but sometimes higher. All districts. Occurring in both dryland crops and rice. Commonest in the latter but usually when flooding has not been complete. Readily controlled by hand or hoe and by butachlor in rice.

***Echinochloa crus-galli* (L.) P. Beauv.**

Local names: barnyard grass (Eng.); jam, jama (Dzo.); sama, molera (Nep.)

Characteristics: Annual grass, more robust than *E. colona*, up to 1.5 m high. Stem base flattened and lacks any ligule as above, but inflorescence and spikelets larger, 3-4 mm long and sometimes with a long awn.

Distribution/importance: A common weed of a wide range of altitudes and in all districts. A major weed of flooded rice and also in many dryland crops. It is often mistaken for rice in the nursery and so is transplanted with the crop in which it grows rapidly and competes strongly. Some forms are able to germinate under water but good flooding should reduce it. Otherwise readily controlled by hand or hoe in young stages, and susceptible to butachlor.

***Echinochloa glabrescens* Munro**

Local names: As for *E. crus-galli*.

Characteristics: Very similar to *E. crus-galli* in size and vigour and spikelets similarly variable in size and colour but the lower lemma shiny, yellowish. Importance relative to *E. crus-galli* is not certain but it is believed to be quite common and important. Control measures are the same.



Echinochloa colona seedling (left)
E. colona flowering (top right)
E. crus-galli flowering (middle)
E. glabrescens flowering (bottom)



***Eleusine indica* (L.) Gaertn.**

Local names: goosegrass (Eng.); cholep (Dzo.); dadey, kode jhar (Nep.)

Characteristics: Annual grass, tufted, up to 30 cm high with flattened stem bases, usually silvery rather than reddish at the base. Leaves bright green. Inflorescence of radiating racemes about 5 mm thick. Spikelets about 3 mm long, densely packed to one side of each raceme.

Distribution/importance: A common weed of all altitudes and all districts. Frequent in dryland crops, occasionally dominant and certainly causing significant competition when not controlled promptly. Readily controlled by hand or hoe when young but develops strong root system making uprooting difficult. Susceptible to most herbicides.

***Imperata cylindrica* (L.) Raeuschel**

Local names: thatch (Eng.); becho (Dzo.); khar, sirru (Nep.)

Characteristics: A perennial rhizomatous grass with a system of rhizomes down to 20 cm forming extensive dominant swards. Leaves spear-shaped very erect, sharp on the edges. Inflorescence a fluffy head about 10 cm long, 1 cm wide.

Distribution/importance: A common species of lower altitudes but also occurring up to 2500 m. All districts. A plant mainly of field borders and terrace banks where it is often dominant and fulfills a valuable role in consolidating the soil. It is also a useful grass for thatching but it can prove aggressive and become a weed in both annual and perennial crops. Difficult to control without deep cultivation, preferably under dry conditions for desiccating the rhizomes. Susceptible to glyphosate.



Eleusine indica seedling (top left)

E. indica flowering (right)

Imperata cylindrica flowering (bottom left)

***Paspalum conjugatum* Berg.**

Local names: signal grass (Eng.)

Characteristics: Perennial grass, mostly prostrate and spreading, rooting at the nodes, with broad, dark green leaves and with inflorescence stalks up to 40 cm, bearing two strictly horizontal, narrow racemes about 10 cm long.

Distribution/importance: A very common weed of low altitudes, below 1000 m in all low-altitude districts. Often dominant in perennial plantations and encroaching also in fallows and annual crop areas. Difficult to remove by hand, requires hoeing or glyphosate.



***Paspalum conjugatum* flowering**

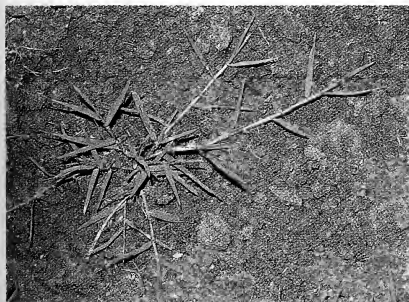
***Paspalum distichum* L.**

Synonym: *Paspalum paspaloides* (Michx.) Scribn.

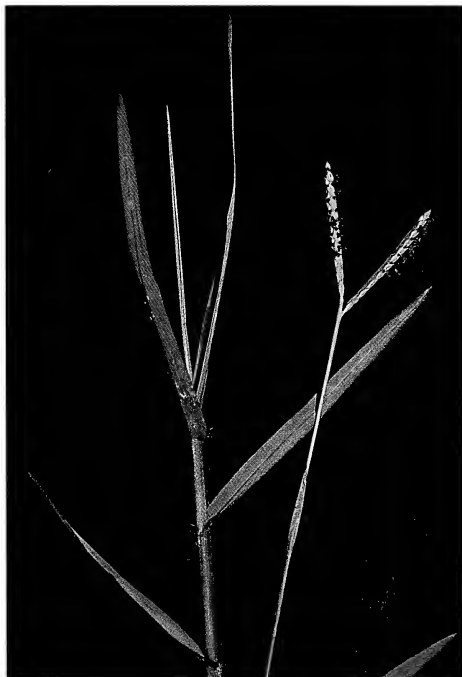
Local names: jagarampa (Dzo.); chittrey (Nep.)

Characteristics: Perennial grass with an extensive but quite shallow rhizome system, forming prostrate mats. Flower heads, on stems up to 20 cm, consist of a pair of racemes each 2-3 cm long. Spikelets about 3 mm long. Lower glume unusually variable, from 0 to 1 mm long.

Distribution/importance: A common weed of wet places at lower altitudes and up to 2500 m in all districts. Most commonly seen around the edges of rice paddies and in drainage channels but sometimes troublesome in rice paddies and in dryland crops. Difficult to pull when well established. Needs to be carefully dug out when soil is dry. Could be killed by glyphosate.



Paspalum distichum vegetative (left)
P. distichum flowering (right)



***Pennisetum clandestinum* Hochst.**

Local names: kikuyu grass (Eng.)

Characteristics: Perennial grass with a shallow but tough rhizome system and aggressive runners with bright green leaves. Inflorescence hidden in the leaf sheath and only visible by exerted styles or stamens.

Distribution/importance: A weed of high altitudes, mostly over 1000 m, in all districts. Like *Imperata cylindrica* this grass serves a useful function of binding paddy banks and furthermore provides good forage for cattle. But it can encroach on terraces and become a weed in annual crops and be even more troublesome in orchards. Needs thorough digging out, or glyphosate.

***Pennisetum flaccidum* Griseb.**

Local names: jillijum (Dzo.)

Characteristics: A perennial grass with an extensive, deep rhizome system, down to 20 cm in the soil, forming extensive infestations. Leaves broad with a pale mid-rib. Inflorescence cylindrical, about 1 cm wide, on stalks up to 2 m high.

Distribution/importance: A localised weed of higher altitudes, over 1000 m. Bumthang, Chhukha, Thimphu. A patchy weed of dryland crops including cereals and other crops near Bumthang and in apple orchards near Thimphu. Requires deep digging to expose and dry out the rhizomes. Response to glyphosate is not known but is probably effective.



Pennisetum clandestinum (top left), flowering (left) and vegetative (right)

P. flaccidum dominant in orchard (middle left)

P. flaccidum flowering (right)

P. flaccidum rhizomes in the soil (bottom left), cane marks the soil surface

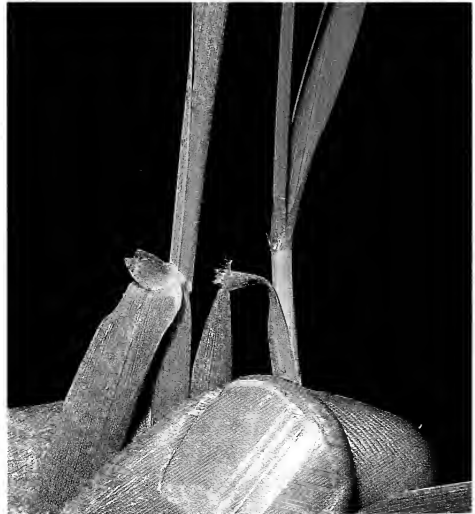


***Phalaris minor* Retz.**

Local names: yup (Dzo.); ghongey banso, ragate jhar (Nep.)

Characteristics: Annual grass up to 1 m high with broad leaves and long membranous ligule. Inflorescence cylindrical, 5-8 cm long by 1 cm diameter.

Distribution/importance: A localised weed, possibly introduced, mainly between 1000 and 2000 m. Punakha, Tashigang. A weed of higher fertility soils and perhaps increasing, through spread in contaminated wheat seed and through increased fertilizer use. A major problem in N. India and has the potential to become serious in Bhutan. Readily pulled by hand and this should be standard practice in cereals wherever it occurs.



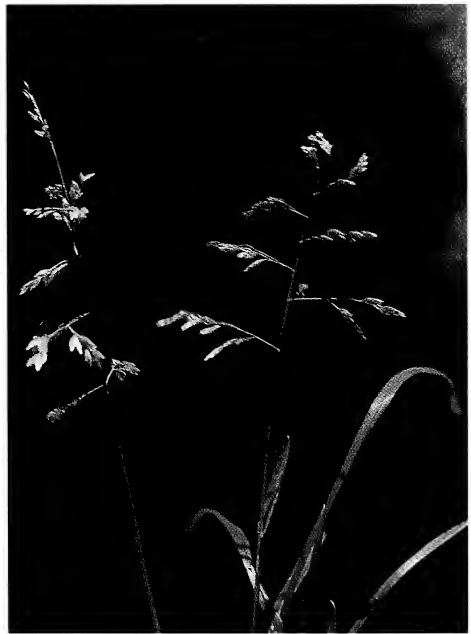
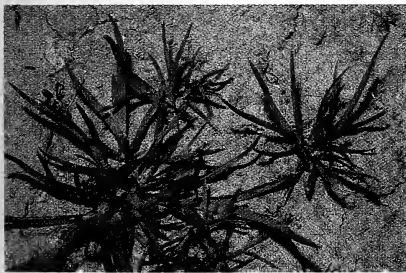
Phalaris minor flowering in a wheat crop (left)
Leaf-base and ligule (right), ***P. minor*** (left) and
wheat (right)

***Poa annua* L.**

Local names: annual meadowgrass (Eng.); cha (Dzo.)

Characteristics: Annual grass, small up to 20 cm. Leaves bright green with boat-shaped tips. Inflorescence a branched panicle.

Distribution/importance: A common winter weed, mainly above 2000 m, probably in all districts. A weed of dryland winter crops, including wheat and vegetables but rarely dominant. Difficult to pull by hand but readily hoed.



Poa annua seedlings (left)

P. annua flowering (right)

Polypogon fugax* Nees*Local names:**

Characteristics: Annual or short-lived perennial grass, tufted or loosely spreading. Leaves bright green, with a long membranous ligule. Inflorescence a branched dense panicle of small spikelets with fine awns.

Distribution/importance: A weed of field edges at a range of altitudes from 1000 m upwards in all districts. This weed is usually restricted to roadsides, field edges and fallows, especially after rice, when it can create a problem in land preparation. Readily controlled by hand or hoe when young but mature mats require heavy tillage.



***Polypogon fugax* flowering**

***Setaria pumila* Roemer & Schultes**

Synonym: *Setaria pallide-fusca* (Schumach.) Stapf & Hubbard

Local names: foxtail grass (Eng.)

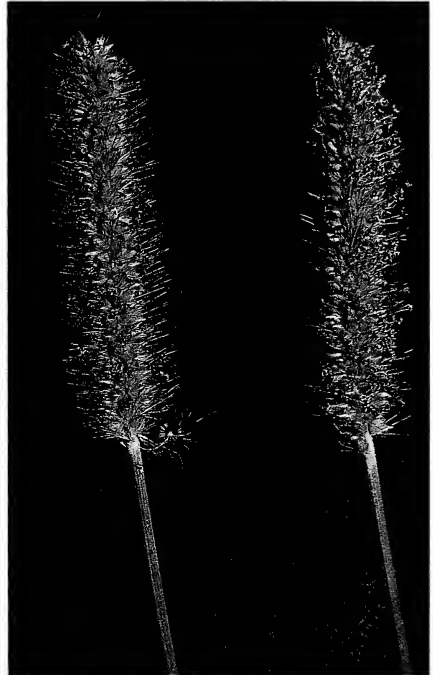
Characteristics: Annual grass up to 50 cm high with flattened stem bases and leaf sheaths often reddish. Usually a few scattered long hairs near the base of the leaves in seedlings. Young seedlings can also be identified by uprooting and finding the very distinctive seed with a wrinkled face. Foliage normally green, not red as in the plate below. Inflorescence cylindrical, 5-6 mm wide with conspicuous bristles, sometimes yellow.

Distribution/importance: A common weed of almost all altitudes in all districts. Very widespread in dryland crops and sometimes in poorly-flooded rice but rarely dominant. Readily controlled by hand or hoe.



Setaria pumila flowering (abnormally purple), (left)

S. pumila close-up of flower-heads (right)



***Yushania microphylla* (Gamble) Stapleton**

Local names: bamboo (Eng.)

Characteristics: Perennial bamboo grass with extremely tough rhizome down to 20 cm and mainly erect shoots up to 2 m, bearing tufts of short leaves about every 15 cm.

Distribution/importance: A weed of roadsides, fallows and grazing land above 2500 m, and sometimes dominant over large areas. Although eaten by yaks, it is not generally regarded as good grazing, and is very difficult to replace by improved pasture species. It is likewise troublesome when land is first cleared for cultivation and persistent digging is required over several seasons.



***Yushania microphylla* mature, with rhizomes**

JUNCACEAE

A monocot family known as the rush family, close to Cyperaceae, with dense inflorescences of very small flowers, but these are actinomorphic with 3 or 6 perianth segments. Fruit a capsule.

Juncus prismatocarpus R.Br.

Synonym: *J. leschenaultii* Gay

Local names: rush (Eng.)

Characteristics: Annual rush, erect to 30 cm. Stems round. Inflorescence widely branching. Spikelets yellowish-green or slightly reddish when mature.

Distribution/importance: A widespread plant of wet and flooded conditions at higher altitudes, above 1000 m. Paro, Punakha and probably most other districts. A minor weed of rice mainly where flooding has not been continuous. Control requires better water control. Otherwise readily controlled by hand and apparently by butachlor.



*Juncus
prismatocarpus*
flowering

LABIATAE

A dicot family containing the mints. Typically with square stems and opposite, toothed leaves, without stipules, often highly aromatic when crushed. The flowers, in axillary and terminal racemes, have a united calyx with 5 usually acute lobes and a corolla of united petals forming a tube, opening into 4 main lobes. Fruit a cluster of 4 nutlets.

Lamium amplexicaule L.

Local names: henbit deadnettle (Eng.)

Characteristics: Annual, weakly erect or sprawling and sometimes rooting at the nodes. Flowers purple about 2 cm long in axils of sessile leaves of characteristic shape.

Distribution/importance: A common weed of winter and high altitudes, mainly above 2000 m. Bumthang, Haa, Thimphu and Tongsa. Generally a minor weed of dryland crops especially in winter but also in summer crops and sometimes quite abundant. Readily controlled by hand or hoe.

Clinopodium umbrosum (Bieb.) Koch

Local names:

Characteristics: perennial, mostly prostrate and rooting at the nodes. Leaves opposite, rounded, dull green, giving minty smell when crushed. Flowering shoots up to 30 cm high, with round clusters of mauve flowers in the leaf axils.

Distribution/importance: A plant of roadsides and fallow areas at both low and higher altitudes. Bumthang, Chhukha, Haa, Punakha, Samchi, Thimphu and Tongsa. An occasional weed in apple orchards and in poorly cultivated buckwheat crops. Controlled by hand-pulling and hoeing.



Lamium amplexicaule flowering (top)
Clinopodium umbrosum flowering
(bottom)



LEGUMINOSAE

A large and extremely important dicot super-family, often referred to as the pea family and comprising three sub-families all of which include weedy members in Bhutan. Leaves are often compound (especially pinnate), alternate and often with stipules and/or tendrils. The Caesalpinoideae have relatively large flowers, with 5 almost equal petals (e.g. *Cassia tora*). The Mimosoidae have relatively simple flowers with very reduced corolla but showy styles and anthers (e.g. *Mimosa pudica*). The Papilionoideae (also known as Papilionaceae or Fabaceae) have the more typical pea flower with large standard petal, two smaller wings and a narrow keel of two united petals below. Both families have variations on the typical pod of the pea, splitting lengthwise and containing a number of relatively large seeds. The family is important for carrying *Rhizobium* bacteria in nodules on the roots, which fix atmospheric nitrogen and enable them both to flourish on and enrich soils low in nitrogen.

Cassia tora L.

Local names: methi jhar, serisay, tapre (Nep.)

Characteristics: Annual plant, erect to 80 cm with hairless bright green pinnate leaves, strong smelling when crushed, with dark glands in the axils of the lower pairs of leaflets. Flowers yellow, 1.5 cm across. Pods long, narrow and curling downwards.

Distribution/importance: A weed of low altitudes, up to 1000 m. Chhukha, Sarbang. An abundant weed of roadsides and orchards in S. Bhutan and occasionally serious in annual crops. Readily controlled by hand or hoe.

Lathyrus aphaca L.

Local names: jangali khesari, materay (Nep.)

Characteristics: Annual, weakly erect to 50 cm with bluish green foliage and bright yellow pea-like flowers.

Distribution/importance: A dryland weed of winter crops at middle altitudes, 1000 to 2000 m. Chhukha, Thimphu, Wangdi. An occasional weed, rarely serious and readily controlled by hand or hoe.



Cassia tora seedling (top left)
C. tora flowering (top right)
C. tora leaf plus glands (middle right)
Lathyrus aphaca flowering (bottom left)

***Mimosa pudica* L.**

Local names: sensitive plant (Eng.); buhari jhar (Nep.)

Characteristics: Annual or short-lived perennial, mainly prostrate, spreading, with spiny stem and finely pinnate leaves which quickly fold down when touched. Flower head pink, 1.5 cm in diameter.

Distribution/importance: A common weed of low altitudes, below 1000 m. Chhukha, Sarbang. A weed of roadsides and perennial crops, often extremely troublesome due to its sharp spines. Spines make hand-pulling unpleasant but it can be hoed.

***Vicia hirsuta* (L.) S.F.Gray**

Local names: vetch (Eng.); kutuki kosa (Nep.)

Characteristics: Annual, weakly erect to 30 cm. Leaves finely pinnate with a terminal tendril. Flowers small, less than 1 cm, pale mauve. Pods about 1 cm long with 2-5 seeds.

Distribution/importance: A common dryland weed of higher altitudes, above 1000 m. Bumthang, Punakha, Tashigang, Thimphu, Wangdi. A weed of winter crops, sometimes quite abundant in cereals. Readily controlled by hand or hoe.

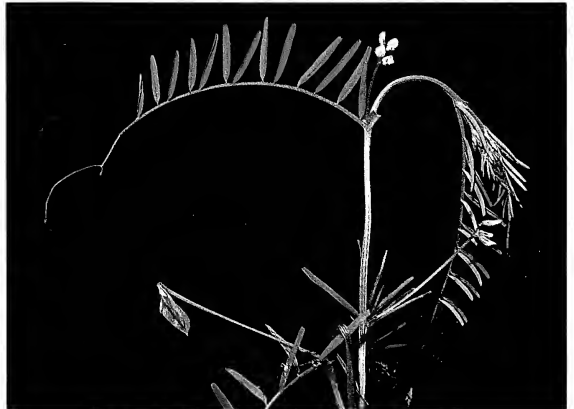
Two other species of vetch can occur in Bhutan:

***Vicia sativa* L.** often occurs together with *V. hirsuta* and differs only in having slightly broader leaflets, a larger bright purple flower, 1.5 cm long and longer pods, 3-5 cm long with 5-10 seeds.

***Vicia villosa* Roth** is a much larger plant, introduced as a forage species, which grows to 50 cm and has a striking raceme, up to 10 cm long, of deep purple flowers. This can occasionally occur as a weed in crops where it has persisted or spread from deliberate plantings.



Mimosa pudica flowering (top)
Vicia hirsuta seedling (left)
V. hirsuta flowering (right)



LORANTHACEAE

The largest of the dicot families of mistletoes, parasitic on the shoots of trees and shrubs. See also Viscaceae, which is sometimes included within Loranthaceae but is separated in this volume. Leaves are undivided and flowers of Loranthaceae are usually tubular up to 3 cm long, often colourful and conspicuous. The fruits are berries with extremely sticky flesh. Birds eat the berries and then excrete or wipe off the seeds from their bills onto the branches of neighbouring trees, so spreading the problem.

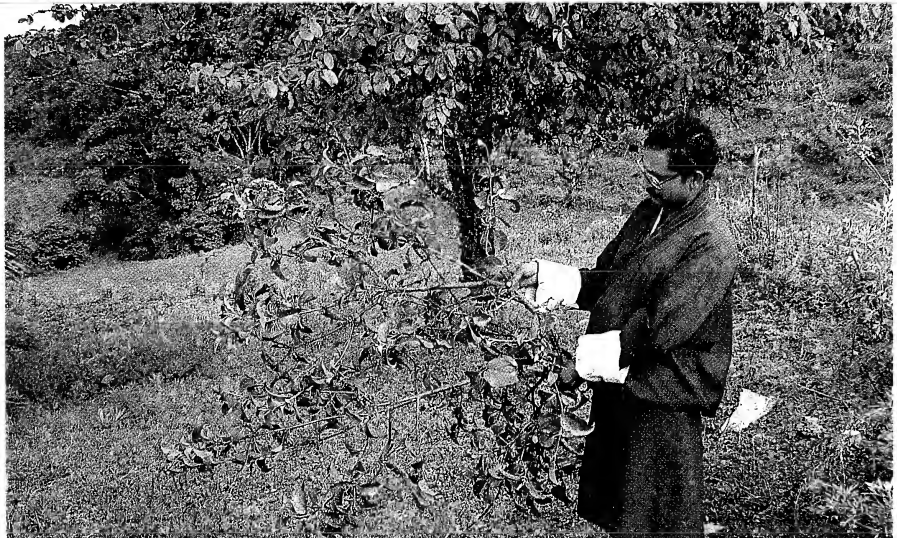
The seeds germinate and sink a parasitic haustorium into the tree branch, so establishing a source of water and minerals from the host xylem. This initial haustorium may remain the only connection with the tree but many species develop secondary haustoria from other parts of the parasite stem where it is in contact with the host. Some species are restricted to few hosts; others attack a wide range of both angiosperm and conifer species. Damage is not always serious but can be so under drought stress conditions when dieback of branches and occasionally of the whole tree may occur. Most mistletoes are extremely brittle as they do not require structural strength to support an upright stem.

Scurrula elata (Edgeworth) Danser

Local names: aijeru (Nep.); khaining shing, khaining shabu, rungrung (Sha.)

Characteristics: A parasite with multiple attachments to the host branch, forming a mass 1 to 2 m across with a generally purplish appearance from a distance. Young leaves brownish but becoming glossy, glabrous and dark green as they mature and tending to fold up on each side of the down-curved midrib. Flowers in axillary clusters, opening in May to July, tubular, curved, 3 cm long, red at the base, green above, with 4 small down-turned lobes. Fruits pear-shaped up to 1 cm long, red when ripe.

Distribution/importance: A high-altitude plant, abundant and conspicuous from about 2200 m upwards in most districts. A frequent parasite, sometimes abundant in deciduous forest species and in fruit trees including apple, pear and peach. Not in conifers. Control is not generally feasible other than by pruning back branches of the fruit tree on which it occurs and also destroying infestations so far as possible in neighbouring wild trees to reduce the risk of spread into the crop.



Scurrula elata flowering (top); *S. elata* whole plant from apple tree (bottom)

***Scurrula parasitica* L.**

Local names: aijeru (Nep.); khaining shing, khaining shabu (Sha.)

Characteristics: Similar in growth habit and multiple haustorial attachments, to *S. elata* but general appearance silvery grey, due to the whitish down on the undersides of the leaves. Plants not usually much over 1 m across. Flowers later in July/August. Berries 6-7 mm long.

Distribution/importance: A plant of lower altitudes than *S. elata* down to 1200 m or less. Mongar, Punakha, Thimphu, Tongsa. A parasite of both conifers such as chir pine (*Pinus roxburghii* Sargent) and deciduous species, including both tropical citrus (mandarin orange) and temperate apple. Control, as for *S. elata*, requires pruning of the host branch and of surrounding trees, to reduce risk of spread into the crop.

***Taxillus kaempferi* (DC.) Danser**

Local names: lam deka (Dzo.)

Characteristics: A much smaller-leaved plant than the the *Scurrula* species, and forming smaller masses not generally greater than 50 cm across. Leaves very thick and dark green. Flowers developing in axillary clusters in June to August bright red, 3 cm long with 4 small lobes.

Distribution/importance: A widely distributed parasite, mainly at high altitudes, above 2000 m, probably in all districts. Attacks only conifers but can be seriously damaging to hemlock (*Tsuga*), pine (*Pinus*) and spruce (*Picea*). No practical control measures are feasible in forestry other than the felling of old heavily infested trees before re-planting.

Other species occurring occasionally in citrus below 1500 m. include ***Macrosolen psilanthus* (Hook.f.) Danser** and ***Helixanthera parasitica* Loureiro**. Both have glossy, glabrous, ovate leaves, somewhat like *S. elata* but *H. parasitica* has axillary racemes of many small (5 mm) bright red flowers with 5 petals in July/August, while *M. psilanthus* has axillary clusters of large red flowers 4-5 cm long in October to December.



Scurrula parasitica vegetative (left)
Taxillus kaempferi damaging hemlock tree
(right)
T. kaempferi flowering (bottom)



LYTHRACEAE

A dicot family including both herbs and trees, with leaves opposite or whorled, simple, and the flowers usually small, in leaf axils or forming a terminal raceme. Fruit a capsule, often quite round with many seeds.

Rotala densiflora (Roth. ex R. & S.) Koehne

Local names: locatham (Dzo.)

Characteristics: Annual, erect to 20 cm with fleshy square stem. Leaves opposite, broadest very near the base and tapering to an acute tip. Flowers very small, pink, with five petals, in axils of the leaves, subtended by bracts which are longer than the calyx. Fruit spherical, 2-3 mm diameter, not exceeding the calyx lobes.

Distribution/importance: A common weed of flooded conditions at high altitudes, above 2000 m. Paro, Thimphu. A weed of rice, occasionally dominant in the localities where it occurs. Readily controlled by hand or by butachlor.



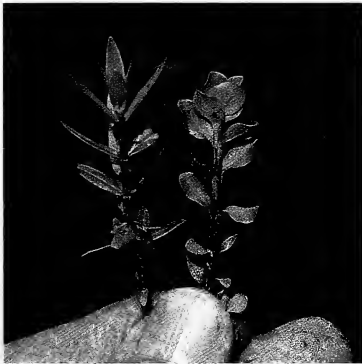
Rotala densiflora seedlings (left)
R. densiflora flowering (right)



Other *Rotala* species

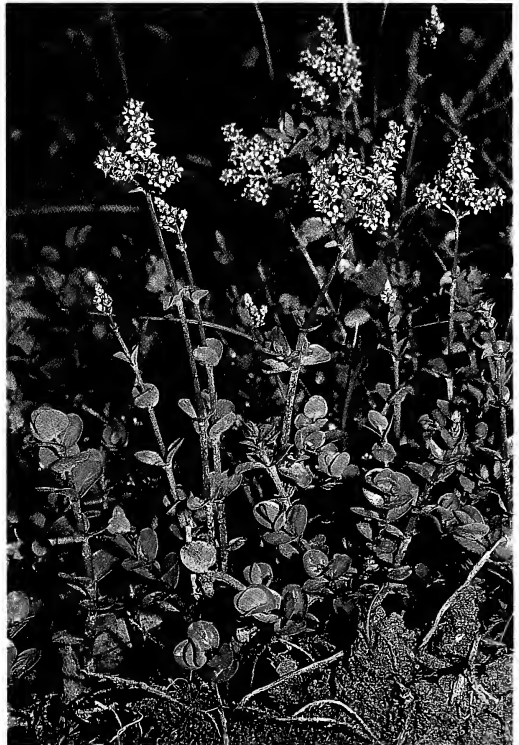
***Rotala rosea* (Poiret) Cook** is closely similar to *R. densiflora* and not readily distinguished, even at the flowering stage, but has a somewhat different leaf shape with less acute apex. Also, the bracts are about the same length as the calyx, and the fruit exceeds the calyx. The status of this species is uncertain, owing to confusion with the above but it is thought to be quite common also in the same localities. Not known to differ in biology or response to butachlor.

***Rotala rotundifolia* (Roxb.) Koehne** is a perennial with creeping rhizomes and erect shoots to 25 cm high. Leaves opposite, almost round. Inflorescence a panicle of densely packed small pink flowers. This occurs in and around rice paddies at 1700 m in the Lhuntshi district and possibly elsewhere.



Vegetative shoots (left), *Rotala rosea* (left) and *Bacopa monieri* (right) (see p. 200)

R. rotundifolia flowering (right)



MALVACEAE

A dicot family which includes trees and herbs, the most important of which is the crop cotton (*Gossypium* spp.). Stems are often tough and fibrous as in the crop kenaf (*Hibiscus cannabinus* L.). Leaves are alternate, usually palmately lobed and often with stellate hairs. Calyx and corolla both 5-parted. Fruit a circular arrangement of wedge-shaped segments.

Malva parviflora L.

Local names: mallow (Eng.)

Characteristics: An annual with prostrate to erect shoots up to 40 cm. Leaves almost round with very shallow lobes, up to 5 cm diameter on distinct petioles up to 10 cm long. Flowers axillary, white or pale pink and only about 5 mm across, the petals only just exceeding the sepals. Fruit of 8-10 segments.

Distribution/importance: A localised plant at altitudes from 700 to 3000 m. Haa, Mongar, Thimphu. A minor weed of dryland crops, rarely serious. Readily controlled by hoeing.



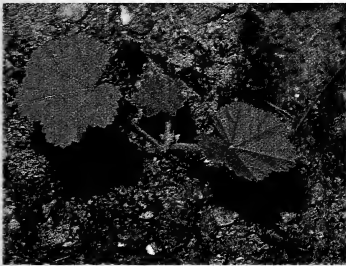
Malva parviflora
flowering

***Malva verticillata* L.**

Local names: mallow (Eng.); niga (Dzo.)

Characteristics: Annual, spreading, or erect to 1 m. Leaves large, more-or-less round but shallowly lobed, often over 10 cm. diameter. Flowers about 1 cm across, mauve, almost hidden in the axils of the leaves. Fruit consists of 10-12 segments almost enclosed in the calyx.

Distribution/importance: A common plant of dryland at higher altitudes, generally over 2000 m. Bumthang, Chhukha, Haa, Paro, Thimphu, Wangdi. A common weed of dryland crops, including potato. Very robust under fertile conditions and then certainly competitive if not removed early. Readily controlled by hand or hoe when young.



Malva verticillata seedling (left)
M. verticillata flowering (right)



***Sida acuta* Burm.f.**

Local names: balu jhar, cannaino, jaharu, khareto (Nep.)

Characteristics: Annual or short-lived perennial, woody, erect to 50 cm with bright green, almost glabrous leaves with acute apex and stipules distinctly unequal. Flowers yellow about 1.5 cm across on pedicels less than 1 cm long. Fruits with 5-10 segments.

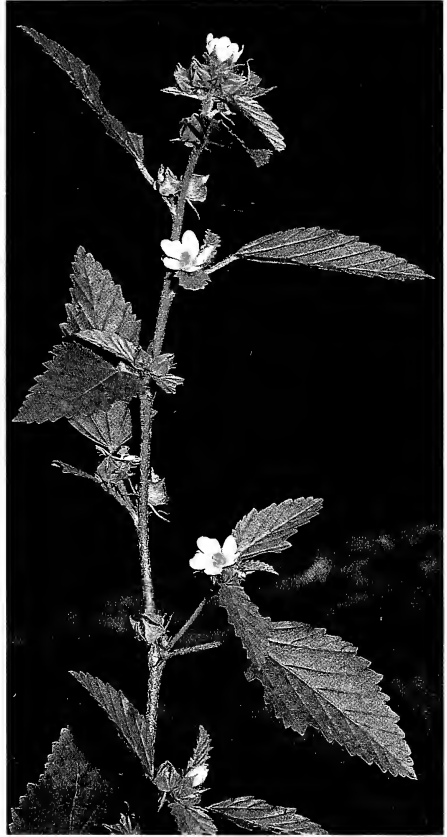
Distribution/importance: A plant of dryland at lower altitudes, mainly below 1500 m. Chhukha, Sarbang, Tashigang. Usually a weed of roadsides and fallows, but also developing in long duration annual crops, and orchards. Tough to remove once established and not readily hand-pulled. Requires hoeing.

***Sida rhombifolia* L.**

Local names: as for *S. acuta*

Characteristics: Annual or perennial up to 80 cm with dark green leaves, much broader than in *S. acuta*, shortly furry below and with equal stipules 1-1.5 cm long. Flowers yellow, 1.5 cm across on pedicels 1-2 cm long. Stems very tough, and whole plant used for making brooms. Fruits with pedicels 1-2 cm long.

Distribution/importance: A plant of dryland at low altitudes, mainly below 1500 m. Chhukha, Mongar, Punakha, Sarbang, Tashigang. Mainly a weed of roadsides and fallows, but sometimes numerous as seedlings in annual crops. Once established the tough root system needs chopping out by spade.



Sida acuta seedling (top left)

S. acuta flowering (right)

S. rhombifolia flowering (bottom left)

MARSILEACEAE and POLYPODIACEAE

Two families of ferns in the Pteridophyta, brought together here for convenience. The ferns, like Equisetaceae, have no flowers but bear spores. In the Marsileaceae which are all water ferns, the spores are produced in special sporocarps at the base of the leaves (usually referred to as fronds). In the Polypodiaceae, which includes all the common terrestrial ferns, the spores are produced on the underside of the leaves/fronds. Most ferns are perennial, and often have a system of rhizomes.

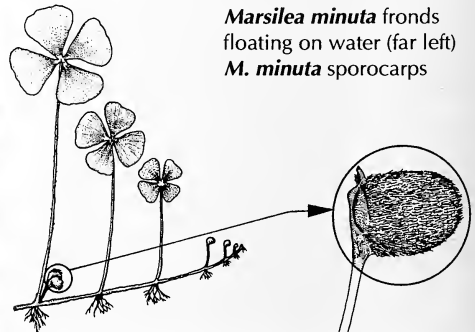
Marsilea minuta L.

MARSILEACEAE

Local names:

Characteristics: A perennial aquatic with a creeping rhizome system buried shallowly in the mud, producing clover-like leaves with four leaflets which float on the water surface. Pairs of sporocarps, 2-3 mm in diameter develop at the base of the petiole.

Distribution/importance: A common plant of flooded areas at lower altitudes, below 1500 m. Noted in Punakha and probably in most southern districts. A weed of rice but does not establish as rapidly as *Potamogeton distinctum* and seen mainly in fallows. Control not easy due to the rhizomes but these are shallow and thorough hand pulling is usually effective.



Marsilea minuta fronds floating on water (far left)
M. minuta sporocarps

Pteridium aquilinum (L.) Kuhn

POLYPODIACEAE

Local names: bracken fern (Eng.); unew (Nep.)

Characteristics: Perennial fern spreading by tough rhizomes down to 20 cm, with fronds up to 1.5 m high, bearing brown spores on the underside.

Distribution/importance: An abundant plant of higher altitudes, above 1000 m, in all districts. Mainly a plant of uncultivated land and a serious weed in grazing land but also occasionally persisting in crops where cultivations have not been sufficiently thorough. Requires deep and thorough digging to remove the rhizomes. Occasionally eaten in place of the more favoured wild ferns (*Diplazium* species), but known from other parts of the world to be a potential carcinogen, so not to be recommended as human food. All ferns should in any case be boiled repeatedly and the water discarded, to minimise risks of toxicity.



Pteridium aquilinum developing frond (left)

P. aquilinum close-up of spore-bearing frond (right)

NAIADACEAE

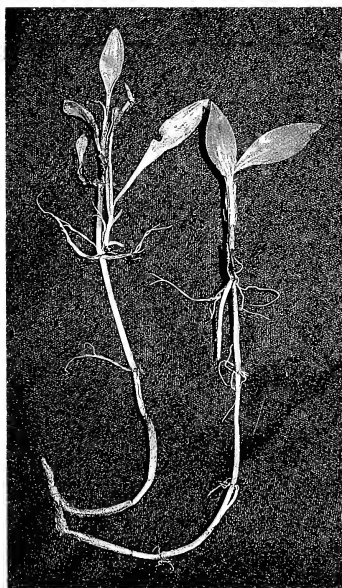
A monocot family of aquatic plants which here includes *Potamogeton* species, although these are sometimes placed in a separate family — Potamogetonaceae.

Potamogeton distinctus A. Bennett

Local names: shochum, shoum (Dzo.); pani jhar (Nep.)

Characteristics: A perennial, floating-leaved aquatic plant with rhizomes down to 20 cm which form resting organs (rhizome tips, or turions) at the end of the season, which emerge as soon as the paddies are flooded next season. Flowers on cylindrical spikes which bend down into the water when in fruit. Fruit 1-4 lobed and presumably producing viable seeds, but the importance of reproduction from seeds is uncertain.

Distribution/importance: An abundant weed of flooded conditions at middle altitudes of 1200 to 2500 m. Chhukha, Lhuntshi, Paro, Punakha, Thimphu. A dominant weed of rice in several important rice-growing districts and the most difficult of all weeds for the farmers to control. The resting rhizome tips produce emerged shoots within 7-10 days of flooding and are established almost before the crop has recovered from transplanting. New rhizomes are initiated within 2 weeks and grow downwards to a depth from which they cannot be fully removed. A long narrow implement is sometimes used to uproot as much as possible but this itself must inevitably cause damage to the crop root system. It is not controlled by butachlor and probably increases as a result of the removal of other competing weeds. Some new herbicides may be effective, but other methods are needed.



Potamogeton distinctus flowering (top)
P. distinctus young shoots, 12 days old (left)
P. distinctus dormant rhizome tips in the soil (bottom right)

OROBANCHACEAE

A dicot family of total root parasites, lacking chlorophyll and totally dependant on the host for all carbohydrate and most of their water and minerals too. The seeds are only 0.25 mm long and the seedling must attach to a host root within a few days of germination to continue developing. Germination normally occurs in response to a stimulant substance exuded by the host root. A nodule develops on the host root which eventually produces a fast-growing, branched or unbranched, fleshy shoot with racemes of zygomorphic flowers with a 5-lobed calyx.

Orobanche aegyptiaca Pers.

Local names: broomrape (Eng.)

Characteristics: An annual with branching fleshy stems up to 30 cm high, yellowish or purplish with no green colour, bearing small scales but no leaves. Flowers 20-25 mm long in a terminal raceme, pale to deep blue, with a white patch on the inside. The anthers are distinctly hairy. A capsule develops up to 1 cm long with many hundreds of minute seeds each 0.25 mm long.

Distribution/importance: Not yet known to occur in Bhutan but a serious pest in Nepal and it is important that it be recognised as soon as it occurs. Many crops are attacked, including mustard, tomato, eggplant, potato and cucurbits. Crop yields can be seriously reduced, especially under conditions of drought stress. Control is extremely difficult and seed may remain dormant in the soil for 5-10 years. Any plants that are seen should be uprooted, removed from the field and destroyed by burning.

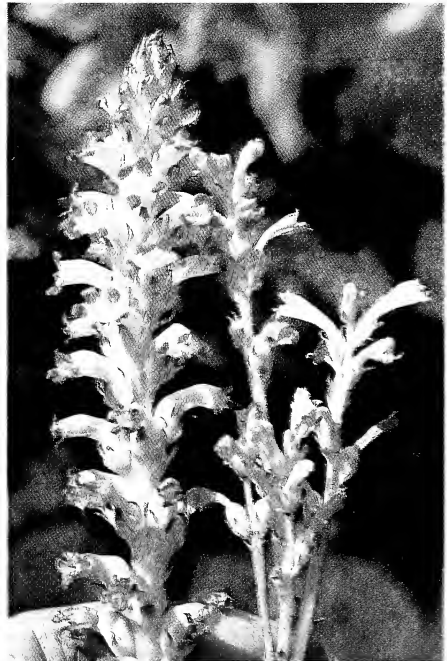
Two other species which could occur include *Orobanche ramosa* L., very similar to *O. aegyptiaca*, also branched, but smaller with flowers only 15-20 mm long and the anthers glabrous or with only a few scattered hairs. This attacks the same range of crops, other than cucurbits; and *Orobanche cernua* Loefl. which differs in having simple, unbranched, thicker stems up to 1 cm thick and flowers mainly pale except for deep blue or purple lips. This species attacks tobacco in Nepal but can also occur on tomato and other Solanaceae or on sunflower.



Orobanche aegyptiaca
flowering on tomato
(top)

O. ramosa flowering
on mustard (bottom
left)

Flowers (bottom right),
O. cernua (left) and
O. ramosa (right)



OXALIDACEAE

A small dicot family in which most of the main weedy species have trifoliolate leaves. Growth form is very variable from creeping seed-producing annuals like *Oxalis corniculata* to perennials with rhizomes, tubers or bulbs. Flowers have 5-part calyx and corolla and 10 stamens. *Oxalis* species are the original source of oxalic acid and the sour taste resulting from the high concentrations of this substance give rise to the English name of 'sorrel'.

Oxalis corniculata L.

Local names: sorrel (Eng.); amilo jhar, cheri amilo (Nep.)

Characteristics: Annual, prostrate or weakly erect to 15 cm. Leaves trifoliolate. Flowers yellow, about 1 cm across. Pods green, erect and releasing seed explosively when ripe.

Distribution/importance: An extremely widespread plant of dryland at all altitudes and in all districts. A common weed of dryland crops, annual and perennial, but rarely dominant or troublesome. Readily controlled by hand or hoe.

Oxalis latifolia Kunth

Local names:

Characteristics: Perennial growing from bulbs down to 15 cm in the soil and spreading by stolons and daughter bulbs. Leaves on petioles up to 20 cm high, arising directly from the bulb, trifoliolate, each leaflet being distinctly heart-shaped. Flower stalk also up to 20 cm with a cluster of pink flowers up to 1.5 cm across. Forms no seed.

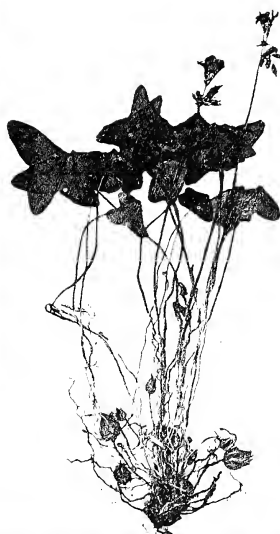
Distribution/importance: An introduced plant occurring only locally so far, at altitudes from 900 to 2700 m. Paro, Tashigang, Thimphu, Wangdi. Liable to be spread in soil on roots of tree seedlings and transplants and precautions are needed to limit further spread. Not seriously competitive but once introduced extremely difficult to eradicate. Needs to be smothered by dense cover crop.



Oxalis corniculata flowering (top left)

O. latifolia whole plant showing stolons and bulbs
(photocopy x 3/10)

O. latifolia flowering (bottom)



PAPAVERACEAE

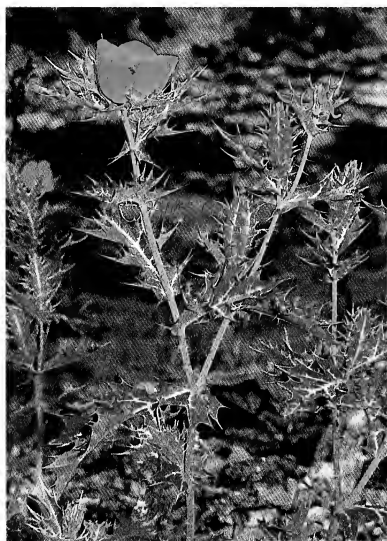
The poppy family; a dicot family usually with erect stems and milky sap. Flowers large and showy, most often with 4 petals and 2 or 3 sepals. Fruit an upright capsule splitting open by pores or valves.

Argemone mexicana L.

Local names: mexican poppy (Eng.); satya nasi (Nep.)

Characteristics: Annual or short-lived perennial, erect to 1 m with prickly grey-green leaves with pale veins. Flowers showy, yellow up to 6 cm across.

Distribution/importance: A marginal weed of roadsides and waste places at low altitude, below 1000 m. Only seen near Mongar and Tashigang so far, but known to be a troublesome weed in other parts of the world and has potential to encroach on dryland crops. Difficult to pull by hand but susceptible to hoeing.



Argemone mexicana flowering

PLANTAGINACEAE

The plantain family; a small dicot family typically with a rosette of leaves and a number of leafless flower-stalks bearing densely packed small greenish or brownish flowers. Fruit a dry capsule.

Plantago erosa Wall.

Local names: plantain (Eng.)

Characteristics: Annual or short-lived perennial, forming a rosette of leaves up to 10 cm long and a number of flower stalks up to 20 cm with cylindrical inflorescences of small greenish flowers.

Distribution/importance: A very common and widespread plant of dryland at altitudes above 1000 m. Probably all districts. A common weed of roadsides, fallows and dryland crops, occasionally abundant in winter cereals. Not readily uprooted by hand once established and then requires hoeing.



Plantago erosa
flowering

POLYGONACEAE

A large dicot family, very well represented in Bhutan and including some of the most important of all dryland weed species. Various annual or perennial, erect or creeping, leaves are usually simple (but divided in *Persicaria runcinata*) and characterised by sheaths at their base (ochreae). Inflorescence most often a round or elongated raceme of small pink or white flowers. Styles either 2 or 3, associated with biconvex or triangular-shaped seeds respectively.

Fagopyrum dibotrys (D. Don) Hara

Local names: titi phapar (Nep.); khala, themnang (Sha.)

Characteristics: Perennial, developing a strong rhizome system down to at least 20 cm. Shoots spreading or erect to 2 m high with large triangular leaves and flat-topped clusters (up to 10 cm across) of small white flowers.

Distribution/importance: A widespread weed of dryland at higher altitudes, generally above 1000 m. Bumthang, Chhukha, Mongar, Tashigang, Thimphu. Mainly in roadsides and waste places but can be dominant in cultivated land, especially maize and potatoes unless worked very intensively. Requires repeated hoeing and digging to remove the rhizomes. Controlled after 2-3 years of sufficient effort.



Fagopyrum dibotrys young plant (left)

Opposite page

F. dibotrys flowering (top)

F. dibotrys rhizome system (bottom)



***Fagopyrum gracilipes* (Hemsley) Dammer**

Local names: jangali titi phapar (Nep.)

Characteristics: Annual, sprawling or erect to 40 cm. Leaves soft, triangular. Flowers small, 1-2 mm across, white or pale pink in erect axillary racemes. May be confused with the crop sweet buckwheat (*Fagopyrum esculentum* Moench) but in the latter, the flowers are larger, 3 mm across, and the leaves have a more elongated, acuminate tip.

Distribution/importance: A dryland weed of higher altitudes, generally over 1800 m. Bumthang, Chhukha, Haa, Lhuntshi, Mongar, Paro, Tashigang, Thimphu. A minor weed of dryland crops, common locally, and occasionally troublesome in orchards. Readily removed by hand or hoe.



Fagopyrum gracilipes seedling (top)
F. gracilipes flowering (bottom)

***Fallopia convolvulus* (L.) Holub**

Synonyms: *Polygonum convolvulus* L.

Local names: black bindweed (Eng.)

Characteristics: A prostrate or climbing annual with twining stems up to 1 m long. Leaves alternate, heart-shaped, up to 8 cm across on long petioles. Flowers in terminal and axillary clusters, 3 mm long, pink or greenish with calyx segments expanding to 5 mm to enclose fruit as they mature.

Distribution/importance: A localised plant of higher altitudes, above 1000 m. Chhukha, Paro, Tashigang, Thimphu. An occasional weed of potato and other dryland crops. Rarely abundant but can be troublesome due to climbing habit interfering with harvest. Readily controlled when young but crop may be damaged when it is removed at a later stage.



Fallopia convolvulus flowering

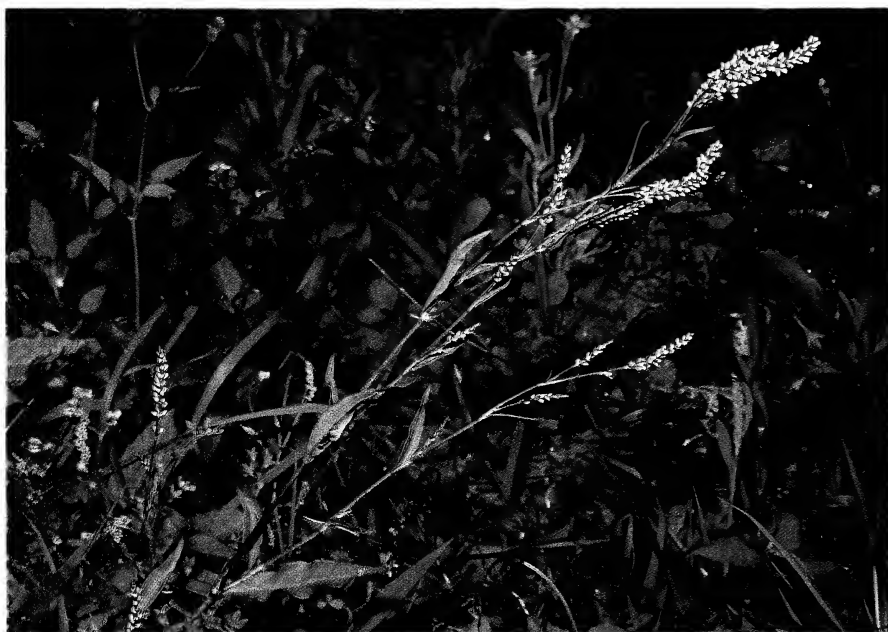
***Persicaria dolichopoda* (Ohki) Sasaki**

Synonym: *Polygonum persicaria* L.

Local names: willow-weed (Eng.); pirat (Dzo.)

Characteristics: Annual, erect to 70 cm, with lanceolate leaves up to 10 cm long. Leaves not peppery to taste. Ochreae with a fringe of bristles about 5 mm long (see p. 184). Inflorescence a dense terminal spike of small pink flowers. Similar to *P. tenella* but generally larger in all parts, and seeds three-angled instead of biconvex.

Distribution/importance: A widespread plant of moist places, mainly between 1000 and 2000 m. Mongar, Punakha, Tashigang, Thimphu. A common weed of both wet places and dryland crops but rarely dominant. Readily controlled by hand or hoe.



Persicaria dolichopoda flowering

Persicaria hydropiper* (L.) Spach.*Synonym:** *Polygonum hydropiper* L.**Local names:** water pepper (Eng.); pipre jhar (Nep.)**Characteristics:** Annual, erect to 60 cm with foliage very pale green, ochreae with a short fringe of hairs up to 4 mm (see p. 184). Leaves taste peppery. Inflorescence of small pink flowers like *P. dolichopoda* but narrower and less compact. The ovary has two styles leading to biconvex, rather than three-angled seeds.**Distribution/importance:** A plant of very wet places, apparently requiring saturated soil for establishment. Mainly at higher altitudes, above 1000 m, probably in all districts. A common weed around edges of rice paddies and often occurring as a weed in rice, and in other heavily irrigated crops, though rarely dominant. Used to poison fish. Readily controlled by hand or hoe and susceptible to butachlor.

Persicaria hydropiper seedlings (left)
P. hydropiper flowering (right)



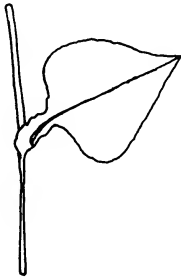
***Persicaria nepalensis* (Meisner) H.Gross**

Synonym: *Polygonum nepalense* Meisner

Local names: helepsi, shido (Dzo.); berkhey ratnaulo (Nep.); metoshim, gangchuma (Sha.)

Characteristics: Annual, sprawling or erect to 30 cm. Leaves with characteristic decurrent wing down petiole, but not divided. Often with a black blotch. Flowers in compact heads about 1 cm across, varying from pure white to deep pink.

Distribution/importance: An extremely common plant of higher altitudes above 1000 m. in all districts. A major weed of dryland crops, often dominant. Farmers not usually concerned as it is fed to cattle and pigs, and is easier to control manually than the perennial *P. runcinata*, but almost certainly competitive when not removed early. Readily controlled by hand or hoe.

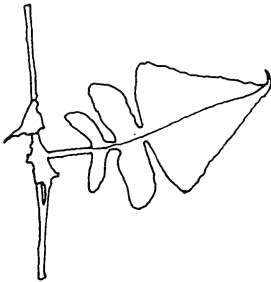


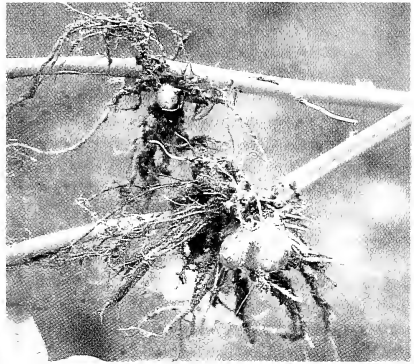
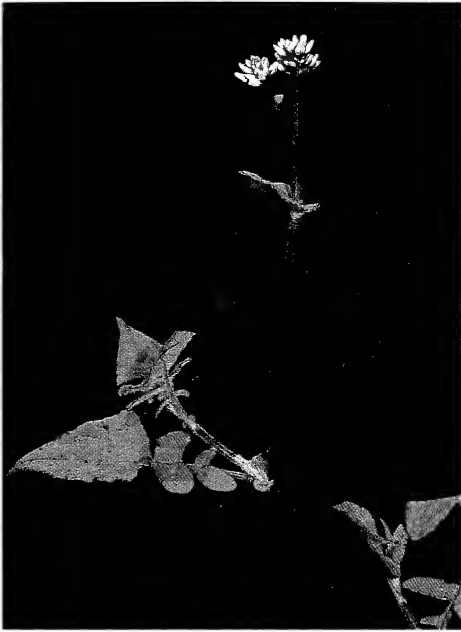
Persicaria nepalensis outline of leaf (x 1/2)



Persicaria nepalensis
seedling (left)
P. nepalensis flowering
(bottom)



Persicaria runcinata* (D.Don) H.Gross*Synonym:** *Polygonum runcinatum* D.Don**Local names:** chuchum, helepsi, shido (Dzo.); dherai salay, ratnaulo (Nep.); gangchuma, gangchimi (Sha.)**Characteristics:** Perennial, spreading by runners with regularly alternate leaves, characteristically divided into 2-3 pairs of lobes at the base. Tubers develop at the nodes from late June onwards. These remain dormant until the next season and can produce shoots from 15-20 cm deep after ploughing under. Tubers may be white or deep reddish when cut open. Flowers pale to bright pink in a larger (1.5 cm diameter), more compact head on a longer flowering stalk than in *P. nepalensis*.**Distribution/importance:** An abundant plant of higher altitudes, mainly over 1500 m. in all districts. Probably the most troublesome weed of main season dryland crops at higher altitudes in Bhutan. Often dominant especially in maize and potato but also in winter cereals and apple orchards, causing farmers great difficulty due to the problem of preventing regrowth from the runners and/or the tubers. Requires very thorough pulling and digging to remove all the tubers. Often heaped in the field but it tends to grow out and re-establish. Preferably cleared from the field before planting to avoid burial of tubers. Fortunately it appears to be susceptible to the herbicide metribuzin in potatoes.*Persicaria runcinata* outline of leaf (x 1/2)



Persicaria runcinata flowering (left)
P. runcinata young tubers (right)
P. runcinata old tubers (bottom)



***Persicaria tenella* (Blume) Hara**

Synonym: *Polygonum minus* sensu F.B.I. non Hudson

Local names:

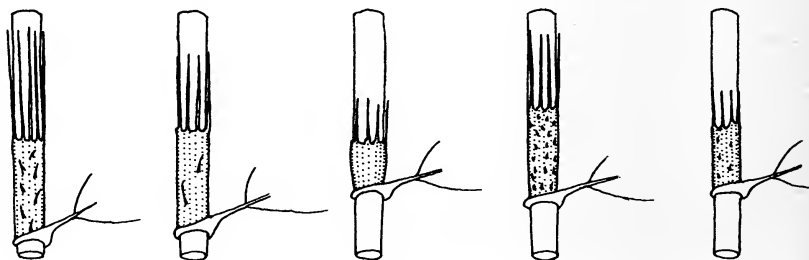
Characteristics: Annual, erect to 30 cm. Generally less robust than other species. Leaves small and often with a distinct black mark, not peppery to taste. Inflorescence compact, a little smaller than *P. dolichopoda*, white or pink and seeds biconvex rather than 3-angled. Under the microscope round yellow-green scales are visible under the leaves.

Distribution/importance: A common plant of wet places at lower altitudes up to 2000 m. Chhukha, Mongar, Punakha, Sarbang, Tongsa, Wangdi. Frequently a weed of rice when not sufficiently well flooded and of dryland crops under moist soil conditions. Readily controlled by hand and apparently by butachlor.

Among a number of other *Persicaria* species which commonly occur in Bhutan:

***Persicaria barbata* (L.) Hara** is closely related to *P. dolichopoda* but differs in having much longer bristles on the ochreae, up to 15 mm. It occurs around field edges and is less common in crops.

***Persicaria pubescens* (Blume) Hara** is related to *P. hydropiper* and is also a plant of wet places, with a lax inflorescence. However, it has a rougher leaf with short hairs and lacks the peppery taste. The ochreae are also hairy and have longer bristles. It occurs less often in crops and is mainly a plant of ditch-banks.

Persicaria* species ochreae (x 1)**P. barbata******P. dolichopoda******P. hydropiper******P. pubescens******P. tenella***



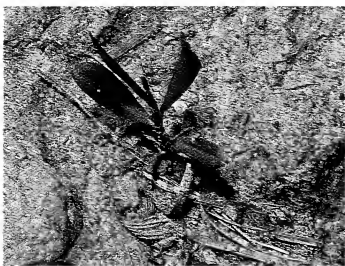
Persicaria tenella flowering, (top); *P. pubescens* flowering, (bottom)

***Polygonum aviculare* L.**

Local names: knotgrass (Eng.)

Characteristics: Annual, prostrate or erect to about 30 cm, with lanceolate leaves 2-3 cm long, widest about the middle. Flowers pink about 4 mm long.

Distribution/importance: A common plant during winter months at higher altitudes, above 1000 m. Paro, Thimphu, Wangdi. Frequently a weed of wheat and other winter crops, deep rooted and very competitive for nutrients. Possibly allelopathic. Not often dominant but probably damaging where it does occur. Readily uprooted when young but older plants need hoeing.



Polygonum aviculare seedling (left)
P. aviculare flowering (right)



Polygonum plebeium* R. Brown*Local names:**

Characteristics: Annual, prostrate, rarely erect to 10 cm. Leaves smaller than those of *P. aviculare*, 1-2 cm long and oblanceolate (broadest beyond the middle). Flowers also pink but smaller about 2 mm long.

Distribution/importance: A common winter annual, at middle altitudes, between 1000 and 2000 m. Chhukha, Mongar, Punakha, Sarbang, Tashigang and Thimphu. Occurrence perhaps a little more widespread than *P. aviculare* and frequently seen in vegetables. Competitiveness and control measures as for *P. aviculare*.



Polygonum plebeium seedlings (left)
P. plebeium flowering (bottom)



***Rumex acetosella* L.**

Local names: sheep's sorrel (Eng.); halhaley (Nep.)

Characteristics: Perennial, with a spreading root system from which adventitious shoots can develop, leading to spreading patches. Shoots erect to 20 cm with hastate leaves and panicles of very small reddish flowers. Male and female flowers on separate plants (dioecious).

Distribution/importance: A localised plant of dryland at high altitudes, above 2000 m. Probably introduced. Bumthang, Thimphu. A minor weed as seen so far but it has the potential to be very troublesome because of its creeping root system. Requires thorough digging out and/or smothering by a dense leafy crop.



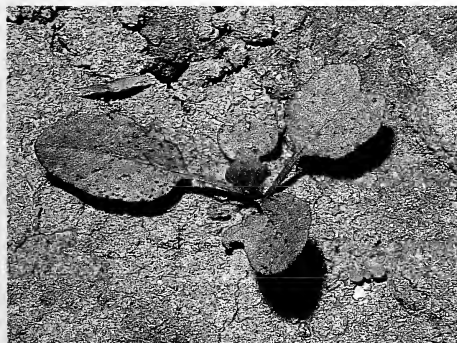
Rumex acetosella flowering

***Rumex nepalensis* Sprengel**

Local names: dock (Eng.); haleley (Nep.); sheylempo (Sha.)

Characteristics: Biennial or perennial, with a tough, deep tap-root, and rosette of broad leaves initially, then an erect stem to 1 m, with spike of reddish flowers and fruits. Seedlings often have a characteristic blotchy colouration.

Distribution/importance: A very widespread plant of higher altitudes, mainly above 1000 m. in all districts. A major weed of pastures, often becoming dominant and swamping more desirable pasture species. Also serious in dryland crops, often regenerating from tap-roots in the seed-bed when land preparation has not been sufficiently thorough. Also establishes quickly as seedlings in annual crops as well as in orchards. Often regarded by farmers as their most difficult weed. Not difficult to pull in early stages, but tough tap root soon becomes difficult to remove, and is not readily killed by tillage. Thorough digging out needed.



Rumex nepalensis seedling (left)
R. nepalensis flowering (right)



PONTEDERIACEAE

A monocot family of aquatic plants, rooted or floating. Leaves alternate. Flowers in a cluster subtended by a spathe-like leaf-sheath, with 6 petaloid perianth segments, often quite showy, leading to a capsule with many small seeds. The family includes the notorious aquatic weed, water hyacinth (*Eichhornia crassipes* (Mart.) Solms).

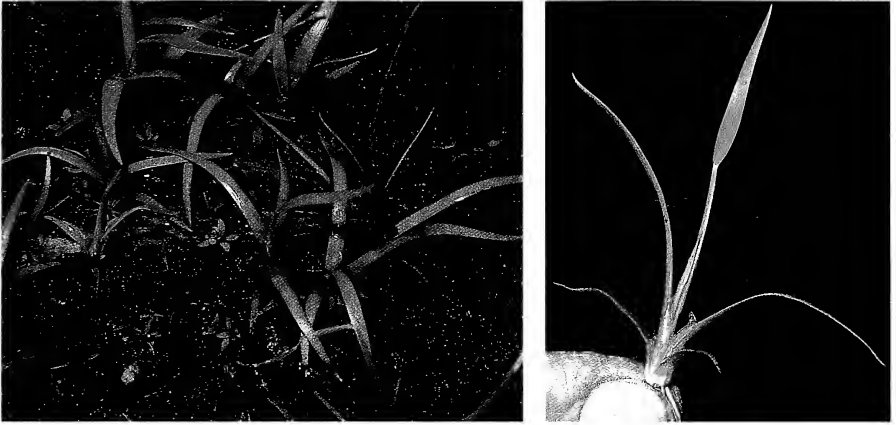
Monochoria vaginalis Presl

Local names: damperu, olasam (Dzo.); piralay (Nep.)

Characteristics: Annual aquatic plant forming rosettes and spreading by short stolons. Shoots up to 30 cm. Leaves narrow, lanceolate initially but gradually developing a broad cordate to hastate base. Flowers blue/purple about 2 cm across with 6 petals.

Distribution/importance: A common plant of flooded conditions at a wide range of altitudes from 100 to 2400 m, probably in all districts. A major weed of flooded rice, often the most abundant and dominant species and regarded as one of the most important by farmers. Not difficult to remove by hand but needs persistence to remove prolonged flushes of germination. Usually controlled by butachlor but requires a full dose of the herbicide.

The related *Eichhornia crassipes* (water hyacinth) already occurs in Chhukha district and is common in neighbouring parts of India and could quite easily spread further. It is quite similar to *M. vaginalis* but more robust, up to 1 m high at times, and flowers are larger and more numerous on a separate stalk rather than appearing laterally on the leaves. It grows as a free-floating aquatic plant on lakes and ponds and spreads rapidly once introduced.



Monochoria vaginalis young seedlings (top left); *M. vaginalis* older seedling (top right);
M. vaginalis flowering (bottom)

PORTULACACEAE

A small dicot family of succulent annual plants. Leaves are simple in outline, thick and fleshy with small dry stipules. Flowers have 2 sepals and 5 petals. The fruit is a capsule which splits around the top to release the seeds.

Portulaca oleracea L.

Local names: purslane (Eng.); phagpa jakpo (Sha.)

Characteristics: Annual, prostrate, with very thick fleshy leaves and yellow flowers, very variable in size from 0.5 to 1.5 cm across in axillary clusters of 5-10, but usually only one open at any time.

Distribution/importance: A sporadically distributed plant mainly of lower altitudes up to 1500 m. Chhukha, Punakha, Tongsa, Wangdi. An occasional weed of summer dryland crops especially vegetables. Rarely abundant but can be very troublesome where it occurs, due to great resistance to desiccation and tendency to regrow after uprooting, even under quite dry conditions. Not difficult to uproot or hoe, but needs to be removed from the field to prevent regeneration.



Portulaca oleracea flowering

PRIMULACEAE

A dicot family including the primroses. Leaves in basal rosettes or opposite on leafy stems, without stipules. Flowers have regular 5-part calyx and corolla. Fruit a capsule splitting by teeth at the tip.

Anagallis arvensis L.

Local names: pimpernel (Eng.)

Characteristics: Annual, sprawling or erect to 15 cm. Leaves neat, opposite, elliptical, bright green. Flowers on stalks in leaf axils, deep blue about 1 cm across. Fruit an almost spherical capsule.

Distribution/importance: A localised plant of winter crops, between 1000 and 2000 m. Punakha. An occasional weed of dryland winter crops but rarely dominant and probably not seriously competitive. Readily controlled by hand or hoe.



Anagallis arvensis flowering (photocopy x 3/10)

A. arvensis flowering (abnormally small plant), (right)

RANUNCULACEAE

The buttercup family — a dicot family with wide variation of leaf and flower form. Flowers can be actinomorphic or zygomorphic and have varying numbers of petals and sepals, but almost always quite showy. An important characteristic is the large and indefinite number of stamens.

***Aconitum bisma* (Hamilton) Rapaics**

Local names: aconite (Eng.); shodu (Dzo.)

Characteristics: Perennial growing from a thick tuberous rootstock, erect to about 1 m high. Leaves alternate, deeply palmately divided. Flowers deep purple with characteristic hood-shaped upper petal. A characteristic of all *Aconitum* species is their powerful toxicity, especially the tuberous root, which is used as a source of poison for arrow-tips in hunting wild animals.

Distribution/importance: A plant of pastures and forest borders at high altitude, over 2700 m. Haa, Paro, Punakha, Tongsa, Wangdi. Important as a cause of accidental poisoning and occasional death of livestock.

The related ***Aconitum ferox* Seringe** known as 'chendu' in Dzongkha has similar flowers to *A. bisma* but is shorter, up to 50 cm, and its leaves are evenly more deeply divided. It occurs at somewhat higher altitude and is regarded as being even more dangerous than the above.

***Ranunculus chinensis* Bunge**

Local names: buttercup (Eng.)

Characteristics: Annual or biennial, erect to 40 cm. Foliage bright green. Stems hairy below. Flowers yellow, about 1.5 cm across, with conical centre.

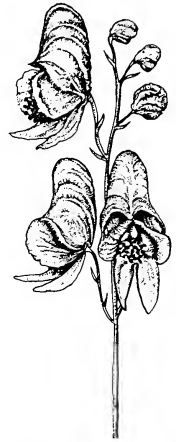
Distribution/importance: A plant of wet places at higher altitudes, above 1000 m. Thimphu, Wangdi. Mainly a weed around field borders. Occasionally in rice, but rarely numerous. Readily controlled by hand.



A. bisma



A. ferox



Aconitum species leaves (x 1/4); typical flower

Aconitum bisma vegetative (left)
Ranunculus chinensis flowering (right)



RUBIACEAE

A dicot family, somewhat like Labiatae, with leaves simple and entire, opposite or in whorls, the whorls sometimes consisting partly of leaf-like stipules (distinguished from true leaves by the lack of axillary buds). Flowers with a simple four-lobed corolla, usually in axillary clusters.

Galium aparine L. var. *echinospermum* (Wallr.) Cufodontis

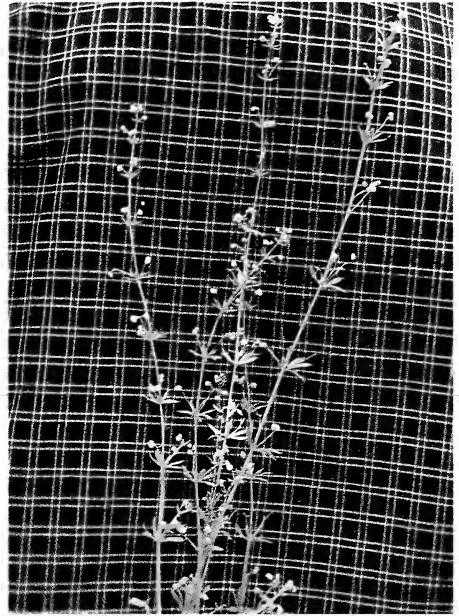
Local names: cleavers (Eng.)

Characteristics: Annual with weak stems sprawling or climbing to 60 cm. Leaves about 2 cm long in whorls. Hooked hairs on stem and seeds make them cling to other plants and to clothing. Flowers very small, white.

Distribution/importance: A plant of dryland at high altitudes, above 2000 m. Bumthang, Chhukha, Haa, Thimphu, Wangdi. A common weed of dryland crops, especially wheat and potato, occasionally dominant and can interfere with harvesting by forming dense sticky mat. Readily pulled by hand but dense mats may be more difficult.



Galium aparine flowering



G. aparine plant sticking to clothes

***Spermacoce latifolia* Aubl.**

Synonym: *Borreria latifolia* Schumann

Local names: alujhar (Nep.)

Characteristics: Perennial square-stemmed prostrate spreading plant, rooting at the nodes. Opposite leaves slightly yellow-green, especially when dried, with small clusters of pale mauve flowers 2-3 mm across in leaf axils.

Distribution/importance: An introduced plant of low altitudes, below 1000 m. Chhukha, Sarbang. A common and often dominant weed of dryland crops especially perennial orchards. Requires hoeing and removal to prevent re-rooting. Thorough land-preparation is needed before annual cropping.



Spermacoce latifolia flowering

***Spermacoce mauritiana* Gideon**

Synonyms: *Spermacoce ocymoides* Burm., *Borreria ocymoides* s.l.

Local names:

Characteristics: Annual prostrate weed, rooting at the nodes, with small pale green opposite leaves and clusters of very small white flowers in leaf axils.

Distribution/importance: A widespread plant of low altitudes, below 1000 m. Chhukha, Sarbang. A common weed of both annual and perennial crops in S. Bhutan, occasionally dominant. Readily controlled by hoe and hand-pulling provided it is not given the opportunity to re-root.



Spermacoce mauritiana
flowering

SCROPHULARIACEAE

A dicot family, somewhat like Labiatae, but leaves are mainly alternate. Flowers axillary or in terminal racemes, with 5 united petals, regular or zygomorphic. Fruit usually a capsule with many small seeds. Many members of the family are semi-parasitic, having apparently normal green foliage, but making haustorial attachments to the roots of neighbouring plants and relying to varying degrees on the host for water, minerals and sugars. Some (including *Striga* species) have such minute seeds that they cannot establish independently and are obligate parasites. Others, including the very widespread *Pedicularis* species in Bhutan are facultative parasites, i.e. they have normal-sized seeds and can grow independently but usually supplement their nutrition from adjacent hosts.

Bacopa monieri (L.) Pennell

Local names:

Characteristics: Annual, erect to 20 cm. Leaves opposite, obovate with rounded tips, fleshy, shiny, dark green. Flowers solitary in the axils of the leaves, pink, on a pedicel about 3 cm long. Fruit a capsule.

Distribution/importance: A plant of flooded conditions at low altitudes, below 1000 m. Chhukha. A minor weed of flooded rice, rarely dense. Readily removed by hand and presumably by butachlor.



Bacopa monieri flowering

Dopatrium junceum* Hamilt.*Local names:**

Characteristics: Annual aquatic plant, with spongy square stem and opposite leaves, identifiable even at the young seedling stage by parallel veins and lack of mid-rib. Shoots up to 15 cm high with leaves only on the lower one third. Upper part tapering and rather bare, with widely spaced pink flowers about 5 mm across.

Distribution/importance: A plant of flooded conditions at higher altitudes above 1000 m. Chhukha, Punakha, Thimphu, Tongsa, Wangdi. A common weed of flooded rice, often very numerous and occasionally dominant but probably too small to be causing significant damage. Readily controlled by hand and by butachlor.



Dopatrium junceum seedlings (left)

D. junceum flowering (right)



Lindernia antipoda* (L.) Alston*Local names:**

Characteristics: Annual, much branched to 20 cm high. Leaves opposite, entire at first, with regular shallow notches later. Flowers mauve/blue about 1 cm across, developing into narrow capsules about 1 cm long.

Distribution/importance: A plant of wet places at a wide range of altitudes up to 2500 m. Chhukha, Thimphu, Tongsa, Wangdi. A weed of field borders and paddy banks, and occasionally in rice but rarely numerous. Readily controlled by hand and probably by butachlor.



Lindernia antipoda
flowering

Lindernia procumbens Philcox

Local names:

Characteristics: Annual, erect to 15 cm, with opposite leaves and square stem. Leaf axils and stem usually purple-tinged even in the early seedling stage. Flowers pink, on short pedicels in the leaf axils, developing into oval capsules about 4 mm long.

Distribution/importance: An aquatic plant of higher altitudes, above 1000 m. Paro, Punakha, Thimphu, Tongsa, Wangdi. A weed of flooded rice, often abundant but probably not seriously competitive. Readily controlled by hand and by butachlor.



Lindernia procumbens seedlings (left)

L. procumbens flowering (right)



Mazus delavayi* Bonati*Local names:**

Characteristics: Annual or short-lived perennial, prostrate and creeping or erect to 15 cm. Flowers white and purple about 1 cm across.

Distribution/importance: A widespread plant of low and higher altitudes above 500 m. Probably in all districts. A weed of roadsides and field edges and occasionally in annual and perennial dryland crops but rarely abundant. Readily controlled by hand or hoe.



Mazus delavayi flowering

Scoparia dulcis L.**Local names:**

Characteristics: Annual or short-lived perennial, erect to 70 cm. Stem tough, wiry. Leaves greyish-green, distinctly toothed. Flowers white, 2-3 mm across in small clusters in the leaf axils. Fruit almost round, 3 mm in diameter.

Distribution/importance: A plant of dryland introduced from tropical America, occurring at low altitudes, below 1500 m. Chhukha, Mongar, Samchi, Sarbang, Thimphu, Tongsa. A weed of field margins and in perennial crops. Readily hand-pulled when young but becomes very tough and wiry.



Scoparia dulcis flowering

***Striga asiatica* (L.) O. Kuntze**

Local names: witchweed (Eng.)

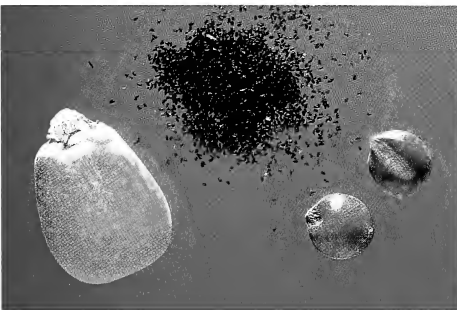
Characteristics: A small erect annual up to 30 cm with narrow dark green leaves, and white flowers 5-8 mm across in terminal and axillary racemes. Elongated capsules mature within 2-3 weeks to release enormous numbers of very fine seeds only 0.25 mm long. These seeds are too small to establish seedlings unaided and they normally germinate only within a few mm of the root of a potential host such as maize or millet and then make a parasitic attachment to the root. They then not only draw most of their nutrition from the host but also cause severe physiological disturbance, wilting and scorch, often leading to total crop failure.

Distribution/importance: Not known to occur in Bhutan but conditions are suitable in many maize growing areas especially at low altitude and where rainfall is less than usual. Effects on maize or millet can be quite devastating and it is important that this pest is recognised as soon as it occurs. Control of low infestations is by hand-pulling all flowering plants regularly every two weeks through harvest, and disposal of the pulled plants in a shallow pit prior to burning when dry.

Related *Striga* species include ***S. densiflora* Benth.** with only 5 ribs to the calyx and flowers which tend to dry blue. Otherwise very similar to *S. asiatica* and ***S. angustifolia* (D. Don) Saldanha**, differing mainly in having a larger calyx with 15 ribs. Both species have a similar biology to *S. asiatica*, are similarly dangerous and require the same vigilance and control methods.



Striga species flowering (left), *S. asiatica* (left) and *S. densiflora* (right); Damage from *S. asiatica* in sorghum crop (right)



Seeds (bottom left) of *Striga* compared with maize and sorghum (x 6)

***Veronica anagallis-aquatica* L.**

Local names: water speedwell (Eng.)

Characteristics: Annual, semi-aquatic plant with soft stem, erect to 40 cm. Leaves bright green. Flowers small, blue, in axillary and terminal racemes.

Distribution/importance: A plant of wet places, mainly above 2000 m. Paro, Thimphu. A weed of ditches and rice paddy borders but occasionally numerous in rice paddies. Readily controlled by hand.

***Veronica javanica* Blume**

Local names:

Characteristics: Annual or short-lived perennial, prostrate and rooting at the nodes but also with erect flowering shoots to 25 cm. Leaves rough, dull green. Flowers small, blue in clusters surrounded by bracts at the tips of axillary branches.

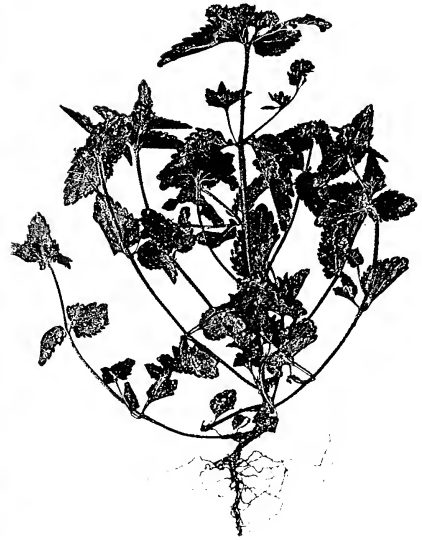
Distribution/importance: A widespread plant of dryland situations at higher altitudes above 800 m. Probably in all districts. A weed of roadsides, field borders and occasionally in annual and perennial crops. Readily controlled by hand or hoe.

***Veronica persica* Poir.**

Local names: speedwell (Eng.)

Characteristics: Annual, weak stemmed, straggling or up to 15 cm. Leaves hairy. Flowers blue and white about 1 cm across. Capsule heart-shaped.

Distribution/importance: A localised, introduced plant of higher altitudes, above 2000 m. Haa, Tashigang. A minor weed of dryland crops, mainly in winter. Sometimes abundant but probably not causing significant harm. Readily controlled by hand or hoe.



Veronica anagallis-aquatica flowering (left)
V. javanica flowering (photocopy x 2/5)
V. persica flowering (bottom)



SOLANACEAE

A dicot family which includes tomato and potato, often containing poisonous alkaloids and smelling strongly when crushed. Leaves alternate, without stipules. Flowers usually actinomorphic with 5-part calyx and corolla. Fruit a capsule or berry.

Datura stramonium L.

Local names: thornapple (Eng.); dhaturu (Nep.); nyangmo-throkchang (Sha.)

Characteristics: An annual, coarse plant to 1 m high, with dark green leaves up to 30 cm long, unpleasant smelling when crushed. Flowers white, trumpet shaped, up to 10 cm long, 6 cm across. Fruit spiny, 3 cm long. Cotyledons long, narrow, pointed.

Distribution/importance: A widespread plant, mainly above 1000 m. Probably in all districts. A common and very vigorous and aggressive weed of dryland crops especially on fertile soil, very competitive for light if not removed early. Readily pulled when young but established plants need hoeing.



Datura stramonium
seedling (left)
D. stramonium flowering
(right)



Nicandra physalodes* (L.) Gaertn.*Local names:**

Characteristics: Annual, erect to 2 m high with bright, slightly yellowish-green leaves up to 20 cm long. Flowers nodding or erect, pale blue about 2 cm across. Fruits inflated like chinese lantern.

Distribution/importance: An introduced plant mainly of higher altitudes above 1000 m. Chhukha, Lhuntshi, Punakha, Tashigang, Thimphu, Wangdi. A weed of dryland crops, not very common in Bhutan but often dominant in other parts of the world and a potentially significant weed, very tall-growing and vigorous especially on fertile soils. Readily controlled by hand or hoe but must be removed early.



Nicandra physalodes seedling



N. physalodes flowering

Physalis divaricata D.Don

Synonym: Previously known, incorrectly, as *Physalis minima* L.

Local names: cape gooseberry (Eng.); rus berry (Nep.)

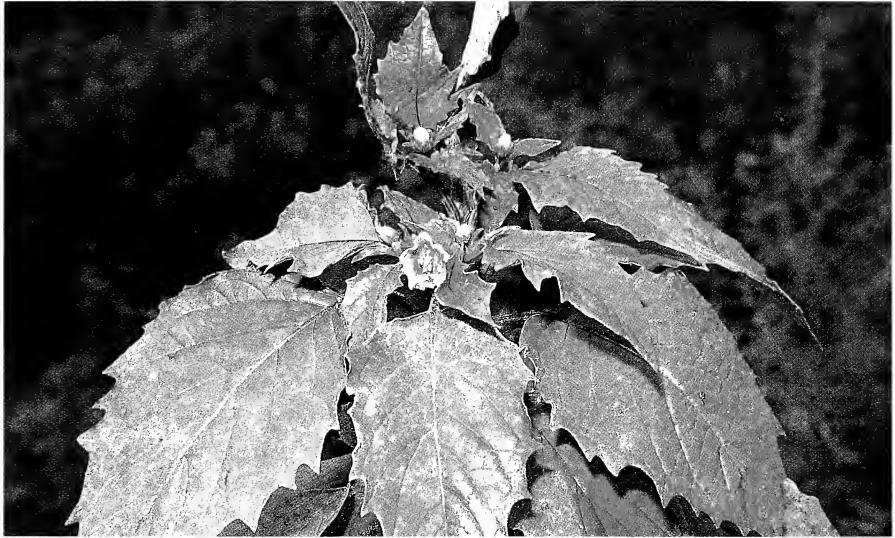
Characteristics: Annual, erect to 50 cm. Leaves bright green up to 8 cm long. Varying greatly from glabrous to softly hairy. Flowers pale yellow 1.5 cm across. Fruits inflated as chinese lantern.

Distribution/importance: A localised plant of middle altitudes, 1000 to 2000 m. Lhuntshi, Mongar, Wangdi. A minor weed of dryland crops, not often seen but with the potential to be competitive. Readily controlled by hand or hoe.

Some closely related species may also occur, including *P. pubescens* L. and/or *P. peruviana* L. These may have more softly hairy leaves and flowers with a distinctly dark centre. Their relative importance is not yet certain.



Physalis divaricata flowering



Other forms of *Physalis*, not precisely identified

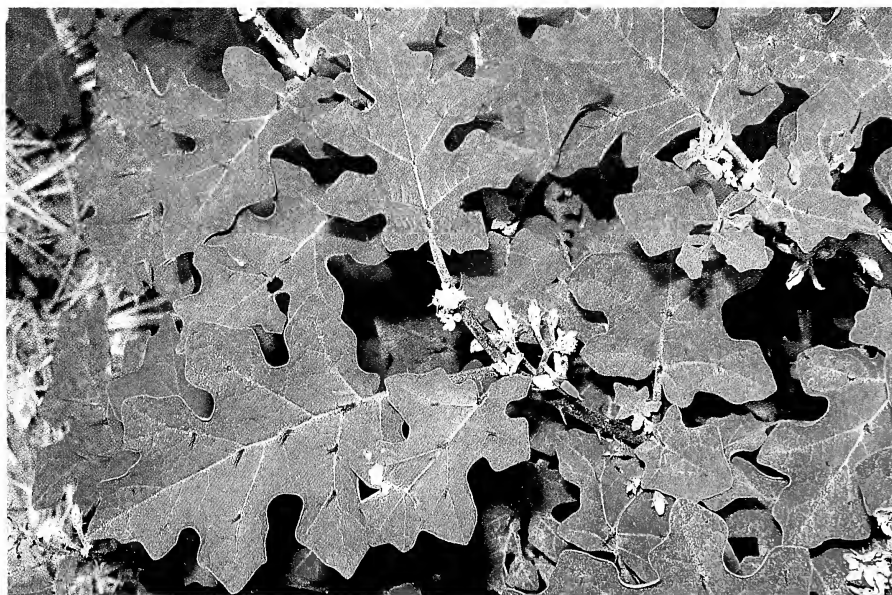
Solanum khasianum* Clarke*Synonym:** *Solanum myriacanthum* Dunal**Local names:****Characteristics:** An erect annual or short-lived perennial up to 70 cm high, with generally pale green foliage and with spines up to 1 cm long, almost straight, scattered on the upper surface of leaves, below, on the mid-rib, and along the stems. Flowers 2 cm across with 5 white petals facing downwards under the leaves. Fruits pale green with network of darker green marks, oval up to 3 cm long, maturing yellow.**Distribution/importance:** A widespread plant of dryland, mainly at lower altitudes, below 2000 m. Lhuntshi, Mongar, Punakha, Wangdi. A common weed of roadsides and field borders but also quite often in both annual and perennial crops, causing competition and also inconvenience due to its spines. Requires hoeing early.

The closely related ***Solanum anguivi* Lam.** (= *S. indicum* L.) is also seen along roadsides but is more rarely seen in crops. It has duller, almost bluish-green foliage, spines rather more curved and the more conspicuous purple flowers develop into smaller, uniformly green and later yellow fruits only 2 cm long.



Solanum khasianum
young plant (left)

Opposite page
Solanum khasianum
flowering (top)
S. anguivi flowering
(bottom)



***Solanum nigrum* L.**

Local names: black nightshade (Eng.); khorsaney (Nep.)

Characteristics: Annual, much branched but usually erect to 50 cm. Leaves dark green. Flowers white with yellow centre variable in size from 0.5 to 1 cm across. Fruit a berry, green at first and later dull orange or black.

Distribution/importance: A widespread plant of all altitudes and probably all districts. A common weed of dryland crops, occasionally dominant, especially in vegetables. The fruits are mildly poisonous. Readily controlled by hand or hoe.



Solanum nigrum seedlings (left)
S. nigrum flowering (bottom)



TILIACEAE

A dicot family of plants with widely varying form from small herbs to large trees, related to Malvaceae and including the important fibre plant jute (*Corchorus* species). Leaves alternate in two ranks, with stipules and often with stellate hairs. Flowers mainly in leaf axils, actinomorphic, with 4 or 5 petals. Fruit usually a capsule.

Triumfetta rhomboidea Jacquin

Local names:

Characteristics: Annual or short-lived perennial, erect to 1 m, often woody at the base and with a very strong fibrous stem. Leaves softly hairy with star-shaped hairs especially on the veins, broad, almost round in overall outline but with shallow pointed lobes. Flowers yellow, about 1 cm across in the leaf axils.

Distribution/importance: A widespread plant of dryland, mainly at low altitudes, below 1000 m. Chhukha, Lhuntsi, Mongar, Punakha, Samchi, Sarbang, Tashigang. A common plant of roadsides and field edges, sometimes quite abundant as seedlings in annual crops. Readily controlled when young but rapidly develops a very tough stem.



Triumfetta rhomboidea

seedling (left)

T. rhomboidea flowering (right)



URTICACEAE

A dicot family which includes the stinging nettles, with simple leaves, usually opposite, with stipules and sometimes with stinging hairs. Flowers minute in terminal and/or axillary clusters.

Pouzolzia hirta (Bl.) Hassk.

Local names:

Characteristics: Annual or short-lived perennial, semi-prostrate, with leaves all opposite, 5-8 cm long, distinctly three-veined. Flowers minute in reddish axillary clusters 1 to 1.5 cm diameter.

Distribution/importance: A plant of roadsides, field edges and orchards at middle altitudes above 1000 m, probably in all districts. Frequently a weed in orchards. Not difficult to remove by hand or hoe.



Pouzolzia hirta
vegetative (far left);
P. hirta flowering

VERBENACEAE

A dicot family which includes many woody species. Stems often square and leaves generally opposite, without stipules. Flowers in a terminal raceme, with 5-part calyx and corolla.

Verbena officinalis L.

Local names: vervain (Eng.)

Characteristics: Annual or short-lived perennial, erect to 80 cm. Leaves dark green. Flowers small, blue, in terminal and axillary racemes.

Distribution/importance: A widespread plant of dryland above 1000 m, probably in all districts. A weed of field edges but occasional in both annual and perennial crops. Readily uprooted when young but may be tough and require hoeing when established.



Verbena officinalis flowering

VISCACEAE

A dicot family of mistletoes differing from Loranthaceae in having relatively small, inconspicuous flowers, usually the male and female flowers separate on the same or different plants. While most genera, including *Viscum*, have a structure and biology very like Loranthaceae and depend on the host only for water and minerals, the genus *Arceuthobium* (dwarf mistletoes) have a very different structure developing an 'endophyte' almost entirely within the tree and only very small shoots externally, many of which erupt extensively over the branches and twigs. *Arceuthobium* species also differ in being far more dependant on the host for carbohydrate and being correspondingly more damaging.

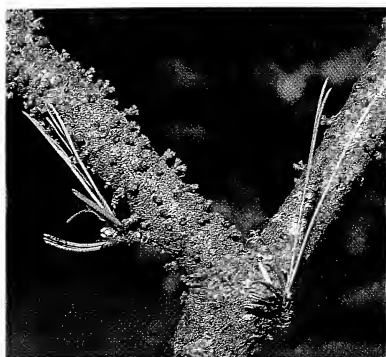
Arceuthobium minutissimum Hook.f.

Local names: dwarf mistletoe (Eng.); aijeru (Nep.)

Characteristics: The only growth visible is a mass of tiny shoots up to 3 mm long emerging from the bark of the host, with 2-3 scales and a terminal flower, developing an elongated fruit about 3 mm long in August/September. Seeds of other *Arceuthobium* species are known to be spread 10-15 m by an explosive mechanism but this has not been observed for *A. minutissimum*.

Distribution/importance: Known to occur between 2000 and 3000 m in the valleys around Thimphu and Paro and perhaps elsewhere. It occurs almost exclusively in blue pine (*Pinus wallichiana* A.B. Jackson) and causes severe swelling of branches, witches broom growths and gross distortion of the whole tree. There is severe inhibition of growth and dieback occurs especially during dry spells. Control is not possible once trees are infected but risks of new infection can be reduced by clear-felling infected trees.

A related species *Arceuthobium pini* Hawksworth and Weins var. *Sichuanense* H.S. Kiv occurs more locally, mainly on spruce (*Picea spinulosa* (Griff.) Henry) in Paro district (Chele La), causing similar types of witches broom and deformity of the trees.

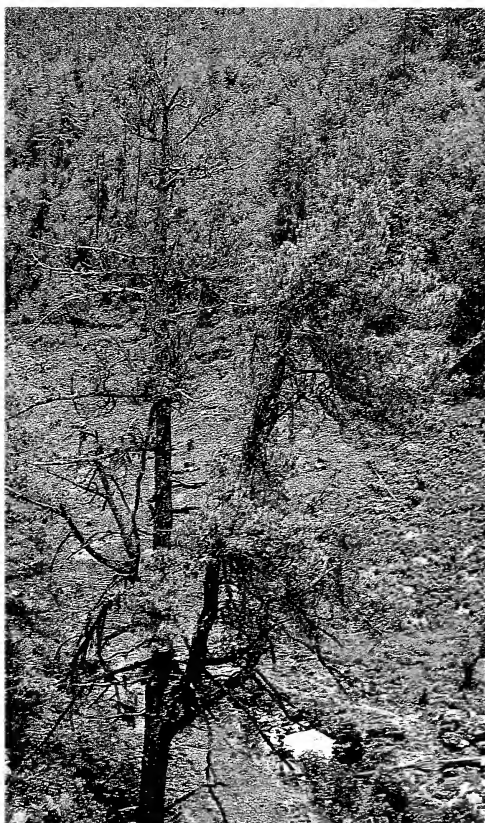
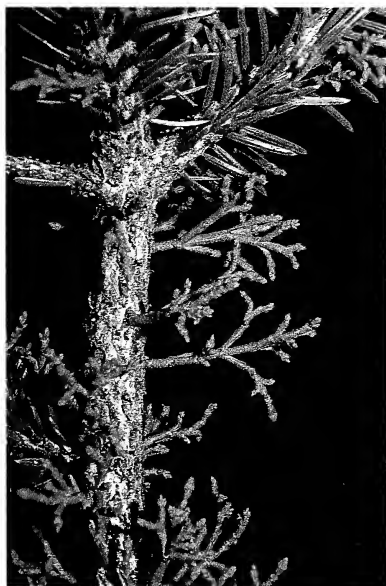


Arceuthobium minutissimum vegetative shoots on blue pine (top left)

A. minutissimum fruiting (top right)

A. minutissimum damage on blue pine (bottom right)

A. pini vegetative shoots on Himalayan spruce (bottom left)



Most important weeds of Bhutan by crop and zone

Most important weeds of rice in relation to agro-ecological zones

Species	WS/HS	DS	WT
<i>Acmella uliginosa</i>	**	*	*
<i>Bidens tripartita</i>		**	**
<i>Cyperus difformis</i>	**	**	**
<i>Dopatrium junceum</i>		**	**
<i>Echinochloa crus-galli</i>	*	**	**
<i>Fimbristylis littoralis</i>		**	
<i>Monochoria vaginalis</i>	**	**	
<i>Persicaria tenella</i>	**	*	
<i>Potamogeton distinctus</i>		**	**
<i>Rotala densiflora</i>			**
<i>Schoenoplectus juncooides</i>		**	**

** recorded as a major weed at this altitude

* occurring but not seen to be important

WS wet sub-tropical zone (below 600 m)

HS humid sub-tropical zone (600-1200 m)

DS dry sub-tropical zone (1200-1800 m)

WT warm temperate zone (1800-2400 m)

CT cool temperate zone (above 2400 m)

N.B. weeds of rice at lower altitudes not adequately surveyed

CORRECTION SHEET for pages 222 and 223

MOST IMPORTANT WEEDS OF BHUTAN BY CROP AND ZONE

 MOST IMPORTANT WEEDS OF RICE
 IN RELATION TO AGRO-ECOLOGICAL ZONES

Species	WS/HS	DS	WT
<i>Acmella uliginosa</i>	**	*	*
<i>Bidens tripartita</i>		**	**
<i>Cyperus difformis</i>	*	**	**
<i>Dopatrium junceum</i>		**	**
<i>Echinochloa crus-galli</i>	*	**	**
<i>Fimbristylis littoralis</i>		**	
<i>Monochoria vaginalis</i>		**	**
<i>Persicaria tenella</i>	*	**	*
<i>Potamogeton distinctus</i>		**	**
<i>Rotala densiflora</i>			**
<i>Schoenoplectus juncooides</i>		**	**

** recorded as a major weed at this altitude

* occurring but not seen to be important

WS wet sub-tropical zone (below 600 m)

HS humid sub-tropical zone (600-1200 m)

DS dry sub-tropical zone (1200-1800 m)

WT warm temperate zone (1800-2400 m)

CT cool temperate zone (above 2400 m)

N.B. weeds of rice at lower altitudes not adequately surveyed

 MOST IMPORTANT WEEDS OF MAIZE AND POTATO
 IN RELATION TO AGRO-ECOLOGICAL ZONES

Species	----- MAIZE -----			----- POTATO -----		
	WS/HS	DS	WT	DS	WT	CT
<i>Ageratum conyzoides</i>	**	*				
<i>Amaranthus hybridus</i>		**	*			**
<i>Arisaema flavum</i>		*	*		**	**
<i>Bidens pilosa</i>	**	**	*	*	*	
<i>Brachiaria ramosa</i>	*					
<i>Chenopodium album</i>	*	*	**	**	**	**
<i>Commelina benghalensis</i>	*	**	*			
<i>Commelina diffusa/hask</i>	**	**	*			
<i>Commelina maculata</i>		*	**		**	
<i>Cynodon dactylon</i>	**	**	*	*	*	**
<i>Cynoglossum furcatum</i>	*	*	**			
<i>Cyperus rotundus</i>	**	**		*		
<i>Digitaria ciliaris</i>	**	**	**		**	**
<i>Digitaria timorensis</i>	**					
<i>Echinochloa crus-galli</i>			*			**
<i>Equisetum species</i>	*	*			**	
<i>Fagopyrum dibotrys</i>		**	**		**	*
<i>Galinsoga parviflora</i>	**	**	**		**	**
<i>Galium aparine</i>					*	**
<i>Oxalis latifolia</i>						**
<i>Pennisetum clandestinum</i>		**				
<i>Persicaria nepalensis</i>		**	**		*	**
<i>Persicaria runcinata</i>		**	**		**	**
<i>Pteridium aquilinum</i>			*			**
<i>Rumex nepalensis</i>		*	*		*	**
<i>Setaria pumila</i>	*	**	**		*	*
<i>Siegesbeckia orientalis</i>		**	*		*	
<i>Spergula arvensis</i>		*				**
<i>Xanthium indicum</i>	**	**		*		

Footnotes as p. 222

Most important weeds of maize and potato in relation to agro-ecological zones

Species	Maize				Potato		
	WS	HS	DS	WT	DS	WT	CT
<i>Ageratum conyzoides</i>	**	*					
<i>Amaranthus hybridus</i>		**	*			**	
<i>Arisaema flavum</i>			*	*		**	**
<i>Bidens pilosa</i>	**	**	*		*		
<i>Brachiaria ramosa</i>		*	*				
<i>Chenopodium album</i>		*	*	**	**	**	**
<i>Commelina benghalensis</i>		*	**	*			
<i>Commelina hasskarlii</i>		**	**	*			
<i>Commelina maculata</i>		*	**	**			
<i>Cynodon dactylon</i>		**	**	*	*	*	**
<i>Cynoglossum furcatum</i>		*	*	**			
<i>Cyperus rotundus</i>		**	**		*		
<i>Digitaria ciliaris</i>	**	**	**		**	**	
<i>Digitaria timorensis</i>	**						
<i>Echinochloa crus-galli</i>				*			**
<i>Equisetum species</i>		*	*		**		
<i>Fagopyrum dibotrys</i>		**	**		*	**	
<i>Galinsoga parviflora</i>	**	**	**		**	**	
<i>Galium aparine</i>				*	**		
<i>Oxalis latifolia</i>					**		
<i>Pennisetum clandestinum</i>			**				
<i>Persicaria nepalensis</i>		**	**		**	**	
<i>Persicaria runcinata</i>		**	**		**	**	
<i>Pteridium aquilinum</i>			*			**	
<i>Rumex nepalensis</i>			*	*		*	**
<i>Setaria pumila</i>	*		**	**		*	*
<i>Siegesbeckia orientalis</i>			**	*		*	
<i>Spergula arvensis</i>		*				**	
<i>Xanthium indicum</i>		**		**		*	

List of floras and other useful books

Flora of Bhutan by A.J.C. Grierson and D.G. Long.

Volume 1 Part 1 (1983)

Volume 1 Part 2 (1984)

Volume 1 Part 3 (1987)

Volume 2 Part 1 (1991)

Royal Botanic Garden, Edinburgh.

Flowers of Bhutan by S. Nakao and K. Nishioka (1984)

Asahi Shimbun Publication Co., Tokyo.

Flowers of the Himalaya by O. Polunin and A. Stainton (1988)

Oxford University Press, Delhi.

Flowers of the Himalaya; a supplement by A. Stainton (1988)

Oxford University Press, Delhi.

Concise Flowers of the Himalaya by O. Polunin and A. Stainton (1987)

Oxford University Press, Delhi.

The grasses of Burma, Ceylon, India and Pakistan by N.L. Bor (1979)

International Book Distributors, Dehradun.

Useful wild plants of Nepal by N.P. Manandhar (1989)

Nepal Research Centre Publication No. 14

Franz Steiner Verlag, Stuttgart, Germany.

An Enumeration of the Flowering Plants of Nepal

Volume 1 by H. Hara, W.T. Stearn and L.H.J. Williams (1978)

Volume 2 by H. Hara and L.H.J. Williams (1979)

Volume 3 by H. Hara, A.O. Chater and L.H.J. Williams (1982)

Trustees of the British Museum (Natural History), London.

Farmland Weeds of China (1990)

Agricultural Publishing House, Beijing

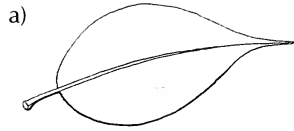
Thomson Publications, P.O. Box 9335, Fresno, Ca 93791, U.S.A.

Crop Weeds and their control in Nepal by J.D. Ranjit and A.N. Bhattarai (1988)

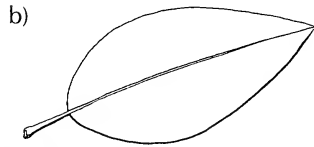
Ministry of Agriculture, Kathmandu, Nepal.

Glossary

acuminate coming to a fine elongated point (a)

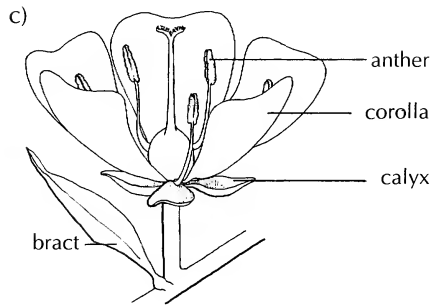


acute sharply pointed (b)



annual completing its life-cycle in one year

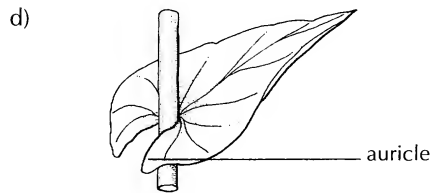
anther the top part of the stamen containing the pollen (c)



auricle ear-like lobe at the base of leaf-blade (d)

awn a stiff bristle-like projection

axil the junction of leaf and stem (e)



biennial completing its life-cycle in 1 to 2 years

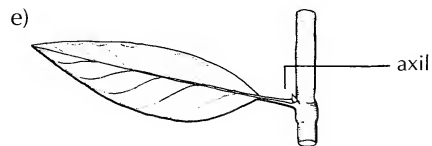
bract modified leaf subtending flower or inflorescence (c)

calyx the sepals collectively (c)

cordate heart-shaped

corolla the petals, collectively, free or joined together (c)

cotyledon seed-leaf, usually different from later leaves



decurrent with the base of the leaf-blade forming wing down stem

dicotyledon or 'dicot', member of Dicotyledonae, with two cotyledons

digitate with several finger-like branches or leaflets

dioecious male and female flowers on separate plants

disc-florets in Compositae, the central 5-lobed florets

dissected divided into many segments

distichous arranged in two opposite rows

Dzo. Dzongkha language

elliptic oval in outline and narrowed to rounded ends (a)

Eng. English language

entire without lobes or teeth

filament the stalk of the stamen, bearing the anther (b)

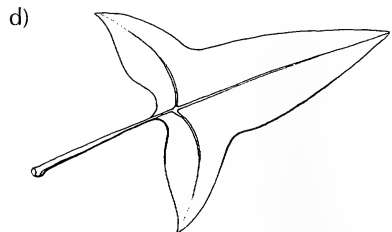
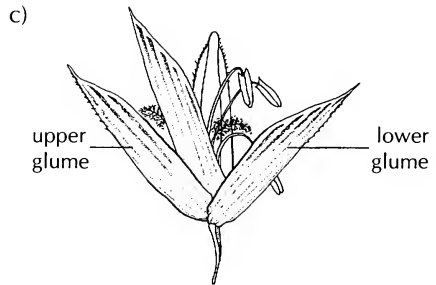
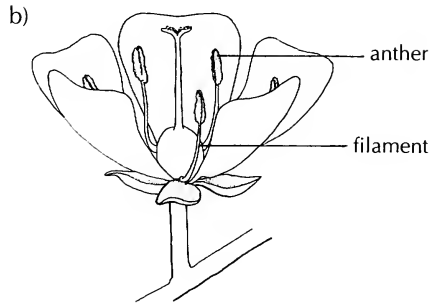
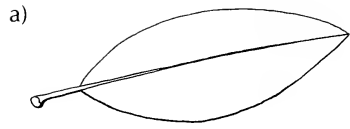
floret a small flower, one in a cluster or head

gland organ (e.g. hair) or area of secretion

glaucous with a waxy bloom, looking bluish or grey

glume chaff-like bract, part of flower in grass and sedge (c)

hastate shaped like a spear (d)



inflorescence flowering branch,
collection of flowers

internode part of stem between nodes

introduced not native to the country

involucre collection of bracts around a
flower head

keel a sharp central ridge

lanceolate spear-shaped with widest part
near the base (a)

lateral on or at the side

lax loose, not dense

leaflet part of compound leaf (b)

lemma the lower of the fertile bracts in
flower of Gramineae (c)

ligule small flap of tissue at the base of
leaf blade of Gramineae (d)

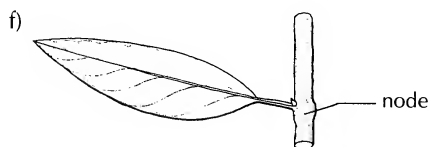
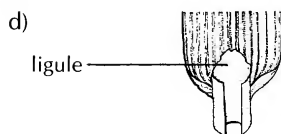
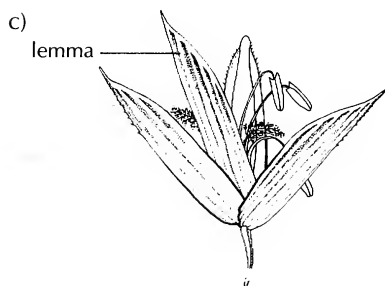
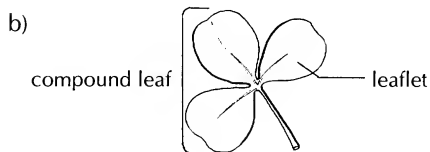
linear long and narrow with
parallel-sides (e)

monocotyledon or 'monocot', member
of Monocotyledonae, with one
cotyledon (e.g. Gramineae, Cyperaceae)

Nep. Nepali language

node point on the stem from which
leaves arise (f)

oblanceolate as lanceolate, but widest
part nearest the tip (g)



oblong longer than broad and sides mainly parallel (a)

obtuse blunt or rounded, not sharp

ochrea a sheath at base of petiole in Polygonaceae (b)

ovary female part of flower containing ovules/seeds (c)

ovate egg-shaped, with widest part towards the base (d)

ovule immature seed

palea the upper of the fertile bracts in flower of Gramineae (e)

palmate hand-like, lobed with 3 or more radiating leaflets (f)

panicle much-branched inflorescence

pappus feathery appendages on fruit of Compositae

parasite plant living and feeding on another

pedicel stalk of an individual flower (c)

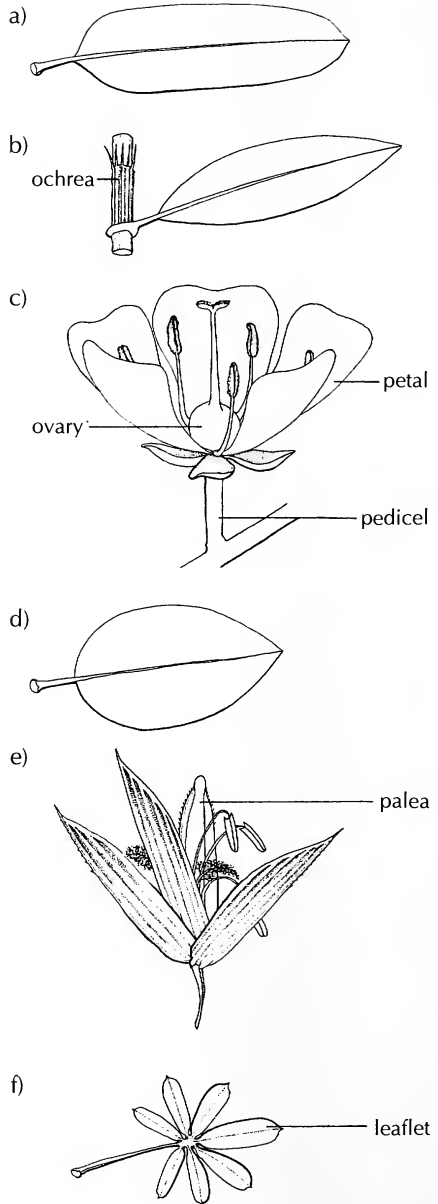
peduncle stalk of an inflorescence

perennial living for more than 2 years

perianth the corolla and calyx together

perianth-segment component of perianth when sepals, petals not differentiated

petal component of the corolla, usually coloured (c)



petiole the stalk of the leaf (a)

pinnate arranged in two rows on each side of central stalk (b)

pinnatifid as pinnate but not completely divided into leaflets

pistil the female organ of the flower (style, stigma and ovary) (c)

procumbent prostrate, trailing over the ground, not erect

raceme simple unbranched inflorescence with stalked flowers

rachis central stalk of pinnate leaf or grass inflorescence (b)

ray-floret outer flower in Compositae with strap-shaped petal

receptacle thickened tip of flowering stem in Compositae

rhizome perennial underground stem with nodes, scale leaves and buds

runner stem spreading above ground, often rooting at nodes

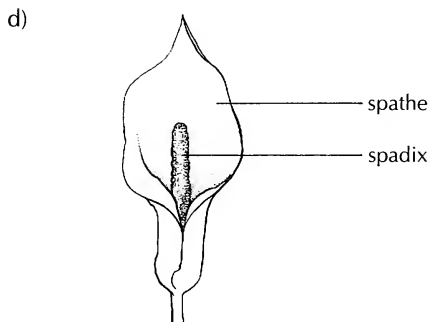
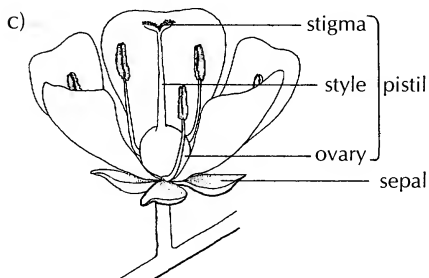
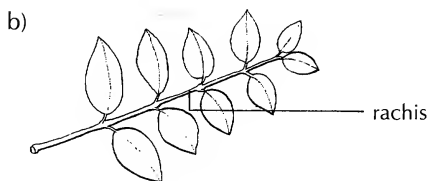
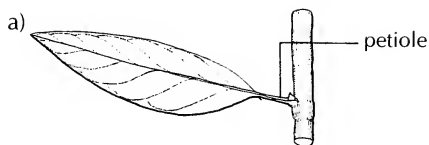
sepal outer perianth segment, usually green (c)

sessile without a stalk

Sha. Shachop language

simple not divided

spadix fleshy inflorescence in Araceae, surrounded by spathe (d)



spathe large bract surrounding spadix in Araceae, see p. 229 (d)

spike simple unbranched inflorescence with flowers sessile

spikelet the flower unit in Gramineae (a)

stamen the male part of the flower (filament and anther) (b)

stigma the part of the pistil which receives the pollen (b)

stipule scale, sometimes leafy, at the base of the petiole (c)

stolon as rhizome but short-lived

style the stalk of the pistil, supporting the stigma (b)

succulent fleshy, thick, swollen

terminal at the tip

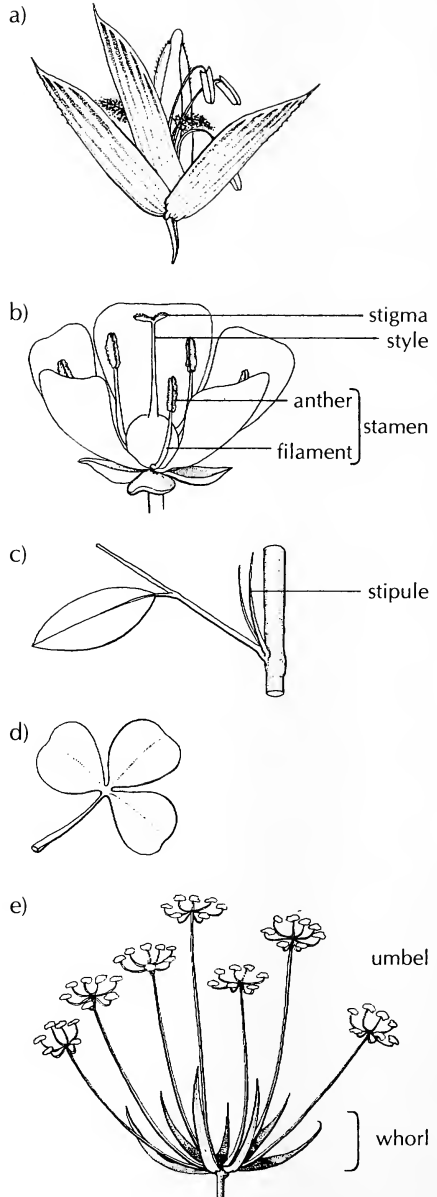
trifoliate with 3 separate leaflets (d)

tuber swollen underground stem or root

umbel inflorescence arranged like umbrella (e)

whorl three or more leaves or bracts from the same node (e)

zygomorphic with one half the mirror image of the other



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