INTRODUCTION

The Longidoridae (Thorne, 1935) Meyl, 1961 is one of the two families of the Order Dorylaimida Pearse, 1942 which includes phytoparasitic nematodes, the other being Trichodoridae (Thorne, 1935) Clark, 1961. The longidorid nematodes belong to three genera viz., Longidorus (Micoletzky, 1922) Filipjev, 1934, Xiphinema Cobb, 1913 and Paralongidorus Siddiqi et al., 1963, and are cosmopolitan attacking a variety of plants. Besides causing direct damage to their hosts, some species of Xiphinema and Longidorus are also known to act as vectors of soil-borne plant viruses. Although all the three genera occur in India but it is the genus Xiphinema which is quite prevalent and has been selected for the present investigations.

The members of the nematode genus Xiphinema Cobb, 1913 are commonly known as dagger nematodes. Since their first description in 1913 they were suspected to be phytoparasitic, but it was only in 1955 that White definitely proved their pathogenicity when he demonstrated that X. americanum Cobb, 1913 can cause injury to the roots of pine resulting into swelling, stubby branches, necrosis of different degrees etc. The same species also causes necrosis and swelling of roots and general decline in maple, Acer saccharum (Disanzo & Rhode, 1969), stunting in nursery stocks of ornamental source (Griffin & Epstein, 1964),
black roots of strawberry (Perry, 1958), severe decline of periwinkle (Epstein & Baker, 1966) and general weakening and premature decline of various plant species used in shelterbelts in U.S.A. (Malek, 1968). The species *X. diversicaudatum* (Micoletzky, 1927) Thorne, 1939 was associated with severe galling on the roots of rose, fig, peanut and strawberry (Schindler, 1957; Schindler & Braun, 1957) in U.S.A. In U.K., this species causes galling on a wide variety of woody and herbaceous plants and weeds (Harrison & Winslow, 1961; Taylor et al., 1966; Taylor & Thomas, 1968; Thomas, 1970). Similarly, species like *X. index* Thorne & Allen, 1950; *X. chambersi* Thorne, 1939; *X. brevicolle* Lordello & Da Costa, 1952 are known to be pathogenic to their host plants. The subsequent necrosis of the entire root system parasitised by dagger nematodes may occur due to the invasion by micro-organisms, such as fungi and bacteria etc., after initial damage is done by the nematode. Considerable attention was focused on the species of *Xiphinema* when it was discovered by Hewitt et al. (1958) that *X. index* is responsible for transmitting fanleaf grapevine virus. The other species of *Xiphinema* which are known to transmit viral infections to their host plants are, *X. americanum*, *X. basiri* Siddiqi, 1959, *X. brevicolle*, *X. coxi* Tarjan, 1964, *X. diversicaudatum*, *X. mediteraneum* Martelli & Lamberti, 1967 and *X. vuittenezi* Luc et al., 1964. Of these *X. americanum*, *X. basiri*, *X. brevicolle*, and *X. index* occur in India.

At present 83 species of this genus have been reported
from the world. The species are predominantly tropical and subtropical but a few species are also found in temperate countries of the world (cf. Southey, 1973a). In spite of their large size, the *Xiphinema* species were not recorded in India until Siddiqi (1959) recorded them for the first time. The present work deals with 12 known and 3 new species from this country. These nematodes mainly attack our fruit trees and it is quite likely that they may cause extensive damage. Some species have also been suspected to transmit viruses (cf. Dhingra & Niazi, 1972). So far our knowledge of this group in this country has more or less been confined to taxonomic aspects (Siddiqi, 1959-64; Jairajpuri & A.H. Siddiqi, 1963; E. Khan, 1964; S.H. Khan & Ahmad, 1975).

The thesis has been divided in 3 parts for the sake of convenience. Part I provides an account of the morphology and systematics of *Xiphinema* species. The validity of subgenera and groups proposed by John & Sher (1972), Roy & Gupta (1974) and Southey (1973a) has been discussed. The descriptions of all the species of this genus so far recorded from India including 2 new records and 3 new species based on type material and/or fresh material collected from different parts of this country during the last several years has been provided and their distribution given. Part II deals with the study of intraspecific variations of *X. basiri* and *X. insigne* Loos, 1949 the two most widely distributed species in this country. The morphometric
and allometric variations of adults and juveniles of a single population of *X. basiri* have been studied and the relationships of these variations among various juvenile stages and adults has been worked out. The variability between 23 populations of *X. insigne* collected from different parts of this country is also provided. The life history studies of *X. basiri* and *X. insigne* have been dealt with in part III. These studies include observations on gametogenesis, embryogenesis and the juvenile stages. The population fluctuations of adults and juveniles of the two species have also been given.
MATERIALS AND METHODS

**Sampling:**

The soil samples were collected from around the roots of a variety of plants from several localities in Uttar Pradesh, Himachal Pradesh, Rajasthan, Jammu and Kashmir, etc. The soil was collected from a depth of 10-30 cm near the root zone of the plants.

**Processing of soil:**

About 250 gm of soil was mixed thoroughly with water in a bucket and was left undisturbed for about 10 seconds. This allows the heavy particles in the soil to settle down, while the lighter soil particles along with the nematodes remain suspended in water. The soil suspension was first passed through a coarse mesh to free it from undesirable substances like dead leaves, stones, debris etc. The homogeneous suspension was then stirred gently with hand for a minute or so and was allowed to stand for 2 minutes before passing it through a sieve of mesh No. 300 (pore size = 53 μm). The finer sieve was used so as to be able to catch both the adults and the juveniles. The nematodes along with the larger soil particles remain on the sieves whereas water and small particles pass through it. The residue thus collected on the sieve was transferred to a beaker.

The residue collected as above was passed through the tissue paper placed on a coarse nylon mesh. The latter was then
placed on a large conical funnel filled with water touching the bottom of the nylon mesh. A rubber tube was attached at the bottom of the funnel with a stopper for collecting the nematodes. This was left undisturbed for about 24 hours. During this period the nematodes on account of their activity pass through the tissue paper and the coarse sieve into the clean water of the funnel. After 24 hours, a small amount of water was collected through the bottom of the funnel into a test-tube.

**Killing and fixing:**

The nematodes were killed and fixed with hot 4% formaldehyde solution. This solution kills the nematodes in their natural posture and is a good fixative as well. The nematodes killed as above can remain in the solution for many years without showing any sign of deterioration.

**Mounting and sealing:**

The nematodes were transferred to glycerine by slow method (developed by Cobb, 1917 and improved by Thorne, 1935). In this method, the nematodes were transferred to a cavity block in glycerine-alcohol (5 parts glycerine and 95 parts 30% alcohol) and then placed in a desiccator. Within 2-3 weeks, the alcohol evaporates slowly leaving the specimens in pure glycerine.

The nematodes were mounted on an aluminium double coverslip slide. For this purpose, the nematodes were transferred
to a small drop of dehydrated glycerine on a 22 mm square coverslip fitted on a metallic slide. Pieces of glasswool of suitable thickness were placed at the corners of the drop of glycerine, making an angle of 120° with each other. It was then covered with a round coverslip of 18 mm. The mounts were ringed with 'Glyceel' or 'Cutex' nail-polish (hardening lacquer).

Life history studies:

For the study of life histories of *Xiphinema basiri* and *X. insigne*, the former species was collected from soil around the roots of *Citrus limnoia* from Jawahar Park, Lal Diggi, and the latter species from *Aegle marmelos* from the garden in front of Victoria Gate, Aligarh Muslim University. Soil samples were taken from around the roots of 4 trees at intervals of about 3 weeks. Each sample consisted of 10 subsamples which were taken at an equal distance from each other and at about 15 cm from the base of the host plants. These samples were taken at a depth of 15-30 cm where these nematodes occur in largest numbers. Subsequent samples were taken at a distance of at least 20 cm from the previous collection spot. When processed the samples were first mixed thoroughly. A modified Baermann's funnel technique was employed for the extraction of these nematode species.

The lengths of the ovaries and the genital branches of 20 females from each sample were measured. For this purpose the nematodes were killed in hot 4% formalin and mounted in anhydrous
glycerine. The number of eggs that were present in the anterior and posterior sexual branches were also recorded separately in the two species.

The structure of female gonads and oogenesis was studied by making an incision near the vulva of gravid females having developing oocytes in the hinder part of the ovary (this part appears brownish when the oocytes are present in this region) or the oviduct or the uterus having egg(s). The worm was placed on a glass slide coated with albumen. The body turgor pressure forces out the entire genital tract. The genital tract get adhered to the slide upon gentle heating for 4-5 minutes. These slides were first dipped in 5:1 alcohol-acetic acid solution (fixative) for 15-20 minutes and then in 2% acetic orcein (stain) for 5-10 minutes. If required, the gonads were destained with 40% acetic acid. It was mounted in acetic orcein and a coverslip was placed over it. The edges of the coverslip were sealed with 'Glyceel' or nail-polish. The females in the breeding as well as in the non-breeding seasons were studied similarly in order to compare the behaviour of the oocytes in the two seasons.

The spermatogenesis was studied similarly as the oogenesis by teasing out the entire male sexual branch. The incision was made near the cloaca.
The embryonic development was studied in gravid females having fully developed eggs near the vulva. These females were left in distilled water for several days to see if they lay their eggs in water or not. If they failed to deposit their eggs the same were teased out of their bodies carefully. The eggs were then transferred to a drop of distilled water placed over a 22 mm square coverslip. In case of females showing some embryonic development within the body, the entire animal was placed in a drop of water on a coverslip. The coverslip was then placed inverted over the cavity slide so that the water drop containing the eggs hangs in the cavity. The drop of water was changed a fresh at intervals of about 24 hours. The edges of the coverslip were sealed with petroleum jelly to minimize evaporation. Observations were made at intervals of one hour. When not under observation, the slides were placed on a moist filter paper in a petri-dish which was then kept in dark.

The juveniles were also fixed in hot 4% formalin and mounted in anhydrous glycerine as described above for the adults.

**Measurements and drawings:**

The nematodes were examined and measured in glycerine. An ocular micrometer was used for taking the measurements. de Man's formula (1884) was used for denoting the various dimensions of the body. The majority of the drawings were made with the help of camera lucida, a few microphotographs were also taken. In the text um stands for μm.
LIST OF ABBREVIATIONS

L = Total body length
a = Total body length / maximum body width
b = Total body length / oesophageal length
c = Total body length / tail length

V = Position of vulva from the anterior end x 100 / total body length

G1 = Anterior gonad length x 100 / total body length
G2 = Posterior gonad length x 100 / total body length
c' = Tail length / anal body-width

DO = Position of dorsal oesophageal gland orifice from the anterior end of the oesophageal bulb x 100 / length of the oesophageal bulb

DN = Position of dorsal oesophageal gland nucleus from the anterior end of the oesophageal bulb x 100 / length of the oesophageal bulb

RS1N = Position of first right subventral oesophageal gland nucleus from the anterior end of the oesophageal bulb x 100 / length of the oesophageal bulb

LS1N = Position of first left subventral oesophageal gland nucleus from the anterior end of the oesophageal bulb x 100 / length of the oesophageal bulb

S2O = Position of orifices of second subventral oesophageal glands from the anterior end of the oesophageal bulb x 100 / length of the oesophageal bulb
$L_1 =$ First stage juvenile
$L_2 =$ Second stage juvenile
$L_3 =$ Third stage juvenile
$L_4 =$ Fourth stage juvenile
$\bar{x} =$ Arithmatic mean
$\pm S.D. =$ Standard deviation
$C.V. =$ Coefficient of variation
$\mu m =$ Micron