REVIEW OF LITERATURE

The nematodes are one of the most successful group of animals which were known for more than 3,000 years. Nematodes which is commonly known as “roundworms” and “threadworms” find definite references in Greek writings; from the time of Hippocrates (circa 400 B.C.) and Aristotle (circa 350 B.C.). The taxonomists such as Dujardin (1845), Diesing (1850), Bastian (1865) and Schneider (1866) laid the foundations for modern classification of the nematodes. Since then a number of authors such as Yorke and Maplestone (1926), Chitwood, B.G. and M.G. (1950), Hyman (1984), Skrjabin (1984), Yamaguti (1985), Moravec (1987), Anderson et al., (1974 and 1983), etc. have contributed to a remarkable progress in the systematics of this group of animals. In the present study, the nematodes which are infecting the cold-blooded vertebrates comes under six orders of the Class Nematoda of the Phylum Nemathelminthes. The six orders are- Strongylida, Oxyurida, Spirurida, Ascaridida, Enoplida and Rhabditida.

Chabaud (1974) divided the order Strongylida into five superfamilies viz., Diaphanocephaloidea, Ancylostomatoidea, Strongyloidea, Trichostrongyloidea and Metastrongyloidea. More than 50 species of Diaphanocephaloidea (Travassos, 1920) have been described. Only one family Diaphanocephalidae was proposed by Travassos, 1920 on the basis of stouter worms with bivalvular and well developed buccal capsule. The genus
Kalicephalus comes under the family Diaphanocephalidae. The genus Kalicephalus was erected by Molin, 1861 with *K. mucronatus* as its type species. It is mainly a parasite in alimentary tract of snakes and lizards. Several species of *Kalicephalus* were described by many workers viz., *K. subulatus* Molin, 1861 in *Lachensis rhombeata, Boa constrictor* from Brazil and Venezuela; *K. minutus* (Baylis et Daubney, 1922) syn. *K. nainae* Maplestone, 1931 in *Naja tripudians, N. melanoleuca, Bungarus fasciatus* in India and Africa; *K. indicus* Ortlepp, 1923 syn. *K.bengalensis* Maplestone, 1929; *K. elongatus* Maplestone, 1931 in *Zamenis mucosus, N. tripudians* from Calcutta. Schad (1962) arranged 22 of 23 species and numerous subspecies of *Kalicephalus* into “six” groups. The 23rd species (*K. willeyi*) and species described since 1962 can also be placed in Schad’s six groups.

The superfamily Trichostrongyloidea consists of monoxenous parasites with reduced buccal capsules, which inhabit the stomach or small intestine of all classes of terrestrial vertebrates. The genus *Oswaldocruzia* comes under the family Molineidae (Skrjabin and Schulz, 1937) Durette-Desset and Chabaud, 1977 of this superfamily. The genus *Oswaldocruzia* was erected by Travassos, 1917 with *O. subauricularis* (Rudolphi, 1819) as its type species. Subsequently, many species have been assigned to the genus – *O. filiformis* (Goeze, 1782) in *Anguis fragilis, Lacerta viridis, L. muralis* from Europe and Asia; *O. denudate* (Rudolphi, 1819) in
Tropidonotus tesselatus from Europe; O. dispar (Dujardin, 1845) in A. fragilis, Vipera berus from Europe; O. goezi Baylis and Daubney, 1923 in Bufo melanostictus in Andaman & Nicobar Island; O. pipiens Walton, 1929; O. braziliensis Lant et Freitas, 1935 in Drymobius bifossatus from Brazil; O. skrjabin Travassos, 1937 in Lacerta vivipara from Germany. Lal in 1944 recorded a new species O. indica from B. melanostictus and Rana cyanophlyctis from Uttar Pradesh, India. Further, Skrjabin and Schulz (1952) also recovered O. goezi from Bufo bufo and other amphibian hosts.

The genus Globocephaloides Yorke & Maplestone, 1926 comes under the family Herpetostrongylidae (Skrjabin & Schulz, 1937) Durette-Desset & Chabaud, 1981. The genus is characterized by buccal capsule not subdivided, approximately as wide as long, presence of single dorsal and two small subventral teeth and absence of gubernaculum. The genus Globocephaloides now include 5 valid species: G.wallabiae Jonston et Mawson, 1939; G. trifidospicularis Kung, 1948; G. macropodis Yorke et Maplestone, 1926; G. affinis Jonston et Mawson, 1939 and the fifth species as G. mabuyensis sp.nov. Gambhir et al., 2013 recovered from the rectum and intestine of a reptilian host Mabuya multifasciata from Chingmeirong, Manipur, India and is reported in the present study.
The genus *Cosmoxyenemoides* was erected by Travassos, 1949 with *C. aguirrei* as its type species. The genus is considered to be of doubtful status as the males are unknown and are excluded from the key given by Chabaud (1974). As such, the present author has adopted the classification of Yamaguti (1961) which placed the genus under the subfamily Cosmocercinae of the family Oxyuridae. Sood (1972) added *C. nandusii* from *Nandus nandus*, Lucknow. Gupta and Naqvi (1984) recognised another species *C. indica* from *Callichrous pabda*, Lucknow. In 2006, Gambhir *et al.* added a new species *C. colisi* from the intestine of fresh water fish *Colisa labiosus* from Manipur, India.

The genus *Anterogoniporus* was erected by Gambhir *et al.*, 2009 with *A. filicaudatus* as its type species from the intestine of wall lizard, *Hemidactylus flaviviridis* from Manipur, India. The genus *Ataronema* and *Thelandros* comes under the family Pharyngodonidae Travassos, 1919 under the superfamily Oxyuridae of the order Oxyurida. The genus *Ataronema* was erected by Hasegawa, 2005 with *A. sekii* as its type species reported from the large intestine of *Rhacophorus viridis* from Japan.

The genus *Thelandros* was erected by Weinland, 1861 with *T. alatus* as its type species. Several species of the genus have been subsequently reported from various reptilian hosts viz., *T. sahariensis* Baylis, 1930 in *Uromastix acanthinurus* from Sahara; *T. sexlabiatus* Ortlepp, 1933 in
*Testudo verreauxi* from South Africa; *T. maplestonei* Chatterji, 1933 in *Hemidactylus flaviviridis* from Calcutta, India; *T. taylori* Chatterji, 1935 in *Uromastix hardwicki* from India. Patwardhan (1935) recovered *T. hemidactylus* from *H. flaviviridis* which was later synonymised with *T. maplestonei* by Karve (1938) on the basis of having unpaired post-anal papillae.

Chabaud, A.G. (1974) accommodated two sub-orders under the order Spirurida, the Camallanina and the Spirurina, divided into two and ten superfamilies respectively. The family Camallanidae Railliet et Henry (1915) comes under superfamily Camallanoidea. Yeh, L.S. (1960) has divided the family Camallanidae into two sub families, Procamallaninae with the genera *Procamallanus* Baylis (1923) and *Spirocamallanus* Olsen (1952) and Camallaninae with the genera *Camallanus* Railliet et Henry (1915), *Camallanides* Baylis and Daubney (1932), *Paracamallanus* Yorke and Maplestone (1926), *Zeylanema* Yeh (1960), *Piscillania* Yeh (1960) and *Serpinema* Yeh (1960). Chakravarty and Majumdar (1960) considered tridents as an important character in the taxonomy of the Camallanids. Sahay (1966) and Sinha (1966) also were in support of this view.

The genus *Camallanus*, based on the presence of tridents was erected by Railliet and Henry (1915) with type species *Echinorhynchus lacustris* Zoega (1776). Chabaud (1975) upheld the original genus stressing the
variability of the distinguishing character of the longitudinal bands in cephalic valves. However, Chabaud has not included the genus *Zeylanema* in his recent classification of the group. But keeping in view the importance of tridents, the present author also have adopted the different genera of *Camallanus* and *Zeylanema* as upheld by Yeh (1960), Kalyankar (1971), Sahay and Narayan (1967), Myers and Kuntz (1969), Zaidi and Khan (1975), Agrawal (1976) and Gupta and Duggal (1981). Sahay and Narayan (1967) mentions that “in case the teeth has a origin from longitudinal thickening it belongs to the genus *Zeylanema*”.

Olsen (1952) on the basis of presence or absence of spiral thickenings in buccal capsule split the genus *Procamallanus* into two as - *Procamallanus* for those forms lacking thickenings and *Spirocamallanus* for those showing their presence. *Spirocamallanus* was given the rank of subgenus by Sahay (1966) and Kalyankar (1971). Ali (1960) and Yamaguti (1961) also considered *Spirocamallanus* to be a subgenus. It was given the status of genus by Yeh (1960), Sinha and Sahay (1966), Sahay (1967), Khan and Yaseen (1969), Freitas and Ibanes (1970), Ivashkin *et al.*, (1971), Mazumdar and Datta (1972), Bashirullah (1973), Basirullah and Hafizuddin (1974), Zaidi and Khan (1975), Chabaud (1975), Kalyankar and Palladwar (1977) and currently upheld by Petter (1979). Dhar and Fotedar (1980),
Arya (1980) and Bashirullah and Williams (1980) too accepted the genus *Spirocamallanus*.

The genus *Camallanides* Baylis et Daubney, 1922 with *C. prashadi* as its type species from *Bungarus fasciatus, Naja hannah* (*N.bungarus*), *Ptyas (Zamensis) mucosus, Rana tigrina* from Burma, Ceylon and India, Karve (1930) and Walton (1950). Some other species of this genus viz., *C. piscatori* Khera, 1956 was reported from *Natrix piscator*, Lucknow and *C. ptyas* Khera, 1956 in *Ptyas (Zamensis) mucosus*, Lucknow. Khera (1956) suggested that *Camallanides* should be divided into two sub-genera, *Camallanides* and *Procamallanides*.

The genus *Pseudabbreviata* has been placed under the order Spirurida and superfamily Physalopteroidea (Chabaud, A.G. 1974). The genus *Pseudabbreviata* was erected by Lichtenfels and Quigley, 1968 with *P. nudamphida* as its type species reported from the intestine of a lizard from Ghana, Africa. It comes under the family Physalopteridae (Railliet, 1893) Leiper, 1908 and the subfamily Physalopterinae Railliet, 1893 on the basis of caudal alae of male united on ventral surface of body and caudal bursa ornamented. *Pseudabbreviata* are parasites of reptiles. *P. yambareansis* (Hasegawa and Otsura, 1894) was described from the tree lizard, *Japarula polygonata*, in Japan and *P. markovi* (Annaev, 1972) was reported from Black-necked Agama, *Acanthocercus atricollis* from the
Democratic Republic of Congo. Bursey et al., 2009 also reported *P. novaeguinaensis* from the stomach of *Hypsilurus modestus*, Papua New Guinea.

The genus *Rhabdocona* was erected by Railliet in 1916 and comes under the family Rhabdochonidae (Travassos, Artigas & Pereira, 1928) Skrjabin, 1946 as adopted by Chabaud (1959, 1965) where there is the division of superfamily Thelazioidea into three families viz., Thelaziidae, Rhabdochonidae and Pseumospiruridae. Saydov (1954) divided the genus *Rhabdocona* into two subgenera viz., *Rhabdocona* (Type: Denudata) and *Filichona* (Type: Sulaki). Sahay et al. (1969) was also in agreement with this separation which was based on the presence or absence of polar filaments on the eggs. About 37 species of the genus *Rhabdocona* have been described of which nearly 13 species are known in India viz., *R. sarana* Karve et Naik, 1951; *R. mazeedi* Prasad et Sahay, 1965 *R. garuai* Agarwal, 1959; *R. dasi* Sahay et Prasad, 1965; *R. bosei* Sahay, 1966; *R. ghaggari* Sood, 1967; *R. hospeti* Thapar, 1950 ; *R. kashmirensis* Thapar, 1950 ; *R. barbi* Karve et Naik, 1951 ; *R. glyptothoracis* Karve et Naik, 1951 ; *R. singhi* Ali, 1956, *R. smythi* Agarwal, 1959 and *R. baylisi* Rai, 1969.

Only two families are recognised by Chabaud A.G. (1974) for the superfamily Filarioidea of the order Spirurida i.e., the Filariidae (Weinland, 1858) Cobbold, 1879 and the Onchocercidae (Leiper, 1911). The genus
*Ochoterenella* was erected by Caballero in 1944 with the type species *O. digiticauda*. Formerly, this genus was placed in the Onchocercinae (Chabaud & Anderson, 1959) but recently the genus is accommodated under the subfamily Waltonellinae proposed by Bain & Prod’hon (1974). The species of genus *Ochoterenella* are parasites of Ranidae, Bufonidae and Racophoridae.

The order Ascaridida has been divided into three superfamilies by Chabaud, A.G. (1974) viz., Cosmocercoidea, Seuratoidea and Heterakoidea. Under the superfamily Cosmocercoidea, two genera are reported in the present study viz., *Cosmocerca* Diesing (1861) and *Oxysomatium* Railliet & Henry (1916) which are accommodated under the same family Cosmocercidae Travassos, 1925 and subfamily Cosmocercinae Railliet, 1916. The genus *Cosmocerca* was established by Diesing, 1861 with *C. ornata* as its type species. The genus *Cosmocerca* is characterized by having certain caudal papillae on plectanes. Several species of the genus *Cosmocerca* have been reported from various parts of the world viz., *C. commutata* Diesing (1851) from *Bufo viridis* at Europe; *C. longicauda* (Linstow, 1885) from *Tridon alpestris*; *C. trispinosa* (Railliet et Henry, 1916) from *Rana temporaria* at Europe; *C. parva* (Travassos, 1925) from *Helosia nasus* at Brazil; *C. brasiensis* (Travassos, 1925) from *B. crucifer* from Brazil; *C. minuscula* (Travassos, 1931) from *R. temporaria* at Brazil;
C. japonica (Yamaguti, 1938) from Rana sp. at Japan; C. australiensis (Jonston et Simpson, 1943) from Limnodynastes dorsalis at Adelaide; C. uruguayensis (Lent et Frietas, 1948) from Ceratophrys americana at Uruguay, Venezuela; C. timofejevoi Skarbilovitsch 1950 from Bufo and Rana sp. at South Kirgizia; C. banyulensis Chabaud et Ca-Rouget, 1955 in Rana ridibunda at Banyuls, etc. So far from the Indian sub-continent C. indica (Nama and Khichi, 1973) has been recorded from Rana cyanophlyctis from Rajasthan.

The genus Oxysomatium was erected by Railliet & Henry in 1916 (synonyms: Oxysoma Schneider, 1866) for its type species O. brevicaudatum. Chabaud (1974) placed Oxysomatium Railliet & Henry, 1916 under the subfamily Cosmocercinae Railliet, 1916. The genus is characterized by cuticle without somatic papillae and absence of lateral alae. Railliet and Henry described O. longispiculum. Walton (1941) pointed out four species of Oxysomatium-O.americanum, O. longicaudatum, O. macintoshii and O. ranae and showed that they were congeneric. A few species of Oxysomatium have been reported from different parts of India: O. macintoshii (Stewart, 1924) Karve, 1927; O. srinagarensis Fotedar, 1960; O. annurae Biswas and Chakravarty, 1963; O. stomatici Biswas and Chakravarty, 1963; O.manipurensis Gambhir and Tarnita, 2005; O. hylae Gambhir and Tarnita, 2005 and O.striatus Tarnita et al., 2012. A new
species of the genus Oxysomatium viz., O. teraensis sp.nov. Sonia et al., 2011 has also been reported from the rectum of Hyla annectens from Manipur, India by the present author.

The genus Paraquimperia has erected by Baylis, 1934 with P. tenerrima (Linstow, W. 1878) as its type species. The genus Paraquimperia is placed under the superfamily Seuratoidea and family Quimperiidae (Gendre, 1928) Baylis, 1930 for possessing characteristics like distinct oblique muscle bands in preanal region of male, oral opening surrounded by three small lips, esophagus with distinct pharyngeal portion and teeth protruding into buccal cavity. Karve (1941) added another species P.anguilla in Anguilla bengalensis from India and recently Shomorendra and Jha (2003) added a new species P. manipurensis from the intestine of freshwater fish Anabas testudineus from Loktak lake, Manipur, India.

The superfamily Heterakoidea was revised comprehensively by Inglis (1967) and divided it into three families viz., Heterakidae, Aspidoderidae and Ascaridiidae. The genus Meteterakis erected by Karve, 1930 comes under the family Heterakidae Rilliet and Henry, 1912 and subfamily Meteterakinae Inglis, 1967 and was erected for its type species M. goavindi Karve, 1930 which was recovered from Bufo melanostictus. Yamaguti (1935) described Spinicauda bufonis from B. melanostictus but Inglis (1958) synonymised it with M. goavindi. Cometeterakis Cruz & Ching, 1975 is also
treated as a synonym of *Meteterakis* as it is distinguished only by the marked difference in the length of its spicules.

The present work also includes another genus *Strongyluris* Mueller, 1894 under the family Heterakidae Railliet et Henry, 1912. The genus *Strongyluris* was erected by Mueller (1894) with *S. brevicauda* as its type species from *Agama colonorum*, from Africa. It comes under the subfamily Spinicaudinae Travassos, 1920 for having characteristics like male tail without long terminal spike and anterior cuticular flange forming major part of lip. Several species of this genus have been described viz., *S. bengalensis* Chakravarty (1936), *S. karawirensis* Karve (1938), *S. similes* Caballero (1938), *S. acudata* Caballero (1941) and recently a new species *S. manipurensis* was added by Lakshmipyari, W. *et al.*, 2011 recovered from the intestine and rectum of *Calotes versicolor* from Manipur, India.

Chabaud (1974) accommodated three superfamilies under the order Enoplida viz., Dictyophymatoidea, Trichuroidea and Muspiceoidea. The Capillariids comes under the family Trichuridae Ransom, 1911 within the superfamily Trichuroidea. Anderson and Bain (1982) considered *Capillaria* Zeder, 1800 as the only valid genus of the subfamily Capillariinae Railliet, 1915 within the family Trichuridae, and used Trichinelloidea Hall, 1916 as the superfamily. Moravec (1994) used Trichuroidea as the superfamily name and this is followed by the present author according to the proposed new

The order Rhabdiasidea was established by Railliet, 1916 for those parasitic nematodes not differentiated into males or females but hermaphroditic or parthenogenetic. Anderson and Bain (1983) adopted order Rhabditida in their classification under which there is only one superfamily- Rhabditoidea. The family Rhabdiasidae proposed by Railliet, 1915 comes under the superfamily Rhabditoidea on the basis of stout parasitic form with inflated cuticle, short esophagus and clavate, vulva near middle of body. The family Rhabdiasidae includes about 70 nominal species and possessing the alternation of two generations (heterogony) in their life histories (Saad *et al.*, 2009).
Stiles and Hassall (1905) established the genus *Rhabdias* and included the type species *Rhabdias bufonis* (Schrank, 1788) from American *Bufo* sp. Fifty-nine *Rhabdias* species have been described in recent years; thirteen of them were distributed on Ethiopian, Nearctic, Neotropical, Oriental and Paleartic realms (Martinez – Salazar, 2008) and few studies dealing with parasites of amphibians and reptiles in Egypt (Moravec et al., 1987, Mohammed, A. 1996). From the Indian sub-continent *Rhabdias* species have been reported from amphibian hosts viz., *R. bufonis* from Kashmir, India (Fotedar, 1965), *R. ranae* from Bangladesh (Gupta, 1960) and *R. bulbicauda* from West Bengal, India (Sarkar, M. and Manna, B. 2004). Only one *Rhabdias* species has been reported so far from reptilian host, garden lizard *Calotes versicolor* from Indian sub-continent viz., *R. pulmonus* (Gambhir et al., 2011) from Manipur, India. *R. kongmongthaensis* (Kuzmin et al., 2005) first was reported from Thailand has been recovered in *Bufo melanostictus* from Manipur in the present study.