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MAN-BITING SIMULIIDAE (DIPTERA) OF NORTHERN INDIA

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A B S T R A C T

Simulium Indicum **Becher, a man-biting species, is reviewed in detail. The female of this species is redescribed. The male of *Simulium nodosum* Puri is described for the first time and supplementary notes on the female, pupa and larva are presented.**

INTRODUCTION

Simulium indicum Becher has been reported from Chilas in Pakistan and Mount Inthanon in Thailand, and from many hilly areas in between. It exists evidently in eight countries, is a significant element in the world's blackfly fauna, and is one of the few known Oriental man-biting species, and a serious pest. The spread of agriculture may bring more people into contact with this insect, and it may possibly be a potential vector of onchocerciasis.

S. indicum was described in 1885 when Simuliidae were little known, and the relevant reference in the Zoological Record of the world literature is one of the only two about the family for that year. S. indicum was described before 97 per cent of the species listed in Crosskey's (1973) Oriental catalogue, but is one of the only two species which could not be placed in a subgenus, because no males or pupae were available. Apart from the important studies of Perti and Lopez (1962, 1964a,b) information on the biology of this species is confined to isolated reports; it is not even mentioned in some well known books on medical entomology, because it occurs largely in hitherto remote rural areas and, in the absence of human onchocerciasis, has not posed a major medical problem.

I made a short visit to India to learn more about the species and, in particular, to find out if records of this simuliid under its scientific and vernacular names refer to one species.

The abdominal dorsal cuticle of some females was examined with transmitted light after removal of the first seven terga from the body. Some areas were inspected with an oil immersion objective, a Wild Variomag adaptor and a x 6 eyepiece to give a 'useful magnification' of x 1,300, and were drawn at x 2,250 to allow for reduction in printing.

Most altitude records quoted below were originally in feet in round numbers and are here converted to metres exactly. The following abbreviations are used: BMNH British Museum (Natural History); CSTM, Calcutta School of Tropical Medicine; FRI, Forest Research Institute, Dehra Dun; ZSI, Zoological Survey of India, Calcutta.

Many records of *S. indicum* come from Arunachal Pradesh which was the North East Frontier Agency. It lies north of Assam and was formerly part of it (Elwin, 1959).

THE INDIAN SIMULIIDAE

Crosskey (1973) found that the Oriental Simuliidae belonged to the genus *Simulium*, and to the subgenera *Eusimulium, Gomphostilbia* (diagnosis by Crosskey, 1967a), *Odagmia, Simulium, Tetisimulium* and *Wilhelmia,* but (Crosskey, 1969, pp. 12, 115) that nearly all described forms were probably assignable to only three subgenera, *Eusimulium, Gomphostilbia* and *Simulium.* Lewis (1973) added the subgenus *Himalayum,* and a species of *Prosimulium* may occur in the Himalaya (Manim,1962).

There is no key to the Indian or the Oriental blackflies, but the keys of Crosskey (1967a, b; 1969) to other areas may be used in combination for recognising subgenera. On page 114 of his 1969 paper he discussed the misleading occurrence of hairs on the base of the radius in females of some Oriental species of the subgenus *Simulium,* and such hairs are found in the Diju and Doigroon species seen in the present survey. Crosskey (1973) listed 32 species from India,

some of which were studied by Puri (in a series of papers till 1933) whose collection is in the National Institute of Communicable Diseases at Delhi. Some Oriental species belong also to the fauna of the USSR which has been studied by Rubtsov (1959-64, 1962, 1969). Some Oriental species are known from adults only, and many are doubtless still unknown. In 1963 a few days of collecting in Pakistan increased the number of species known there from seven to 31, and the present short local survey yielded about a third of the known number of Indian species. In these circumstances it is not possible to identify all species collected, without further prolonged study of the fauna, and nine unnamed species found in the present work have been allotted vernacular names and deposited in the BMNH.

SIMULIUM INDICUM BECHER (Fig. 1-10)

Simulium indicum Becher, 1885: 199 [♀, type locality 'Assam']; 1885b: 162; Brunetti, 1911: 286 [♀ not ♂]; 1912: 193 [♀ not ♂]; 1920: 42; Edwards, 1927: 170; 1928: 59; Crosskey, 1972; Lewis, 1973, [♂ and early stages]. Type not located, possibly lost.

Simulium nigrogilvum Summers, 1911: 586 [♀, type locality Mount Inthanon slopes, Thailand; particulars in Crosskey, 1973. Holotype in BMNH [examined]. Syn. Edwards, 1928.

Simulium kashmiricum Edwards, 1927: 169 [♀, type locality, Chilas, Kashmir]. Holotype in BMNH [examined]. Syn. Lewis, 1973.

Existing descriptions of the female are old and were based partly on poor specimens. Its characters are as follows, apart from subgeneric features already described.

Female. Face grey with golden yellow scales and some black hairs. Frons similar but with denser scaling. Cibarium with long median process, sometimes detached during dissection, which extends into the pharynx and is shaped like a narrow spoon, with many teeth on the convex upper surface. Antenna with segments 1 and 2, and part of 3, pale brown, the rest dark. Mandible with about 35 inner teeth, and about 9 vestigial outer ones at some distance from the tip. Maxilla with 11 inner and 14 outer teeth; palp vesicle

one third length of segment 3. Scutum black, thickly covered with golden scales. Scutellum with golden scales and black hairs. Pleural membrane, katepisternum and postnotum bare. Wing length, from humeral cross vein, 2.95 mm (2.76 to 3.47, n = 4); subcosta with scattered hairs. Legs: each leg with cuticle pale on about basal half of femur, tibia and basitarsus, pale scales on each leg corresponding to pale cuticle; black scales on first basitarsus forming dorsal crest. Dorsum of abdomen by incident light: segments 1 and 2 usually pale, but cuticle is transparent and can appear dark if specimen is blood-fed or decayed; 3 usually mainly pale yellow but with variable amount of grey on hind margin; 4 and 5 black; 6 to 8 grey; segments 1 to 8 with golden scales. Dorsal cuticle of abdomen by transmitted light: segments 1 and 2 pale, tergite 2 with semi-linear pattern of microtrichia, which is visible at x 240 and, under high magnification, appears as discontinuous irregular ridges like sand ripples; 3 with broad tergite and grey field; 4 and 5 with brown tergite and dark grey field; 6 to 8 with tergites brown except at sides. Genital rod with dilated end, arms of furca with long narrow ends.

Male, pupa and larva. Described by Lewis (1973). Pupal gill stated by Perti and Lopez (1962) usually to have eight filaments.

Variation. During a discussion of Becher's (1885b) paper it was stated that *S. indicum* or a closely allied species probably extended all along the southern slopes of the Himalaya. It now appears that all the available specimens belong to one species and that the female varies somewhat in the extreme west, '*S. kashmiricum*' (discussed later) having regularly a rather large dark area on the hind femur. Three specimens from Chakrata, kindly lent by Dr. F. K. Sen Sarma, appear to be typical *S. indicum,* but more from this area could usefully be examined. The available specimens from Burma and Thailand also appear typical.

A false appearance of variation is given by shrinkage of flies pinned in the normal way (compared with spirit specimens), to fading of scales, and to darkening of the abdominal pale band by underlying tissues.

Three pupae from Diju, with one extracted male, appear to belong to this species and to indicate some variation in

the area. The thoracic dorsum of the pupa bears many tubercles, and the first branch of the gill is much more curved than the third, making the gill distinctly asymmetrical.

Specimens examined. All in BMNH except 3 from Chakrata; description of female based on some from Assam. BURMA: 60 ♀. INDIA. ASSAM: 28 ♀ (including 4 collected at Jaihing in 1905 by F.W. Collins and sent to London by Major E.A.W. Hall of the Indian Medical Service), 1 ♂, 3 pupae. UTTAR PRADESH: Chakrata, 3 ♀. WEST BENGAL: Kurseong, 4 ♀. PAKISTAN: 39 ♀, 3 ♂, 104 pupae, 45 larvae. THAILAND: 4 ♀.

Comments. Search was made in literature (Needham 1886; MacGregor, 1886; Woodthorpe, 1889, 1890) which might indicate the provenance of the type specimen. It is evident that several expeditions were carried out shortly before *S. indicum* was described, and that dimdam (see below) were known in the Aka Hills, as shown by Woodthorpe's remarks which are quoted under the heading of Arunachal Pradesh.

In Becher's Latin diagnosis the description of the femora and tibiae tallies with the figure, but the description of these parts in the English translation differs and is presumably wrong.

Brunetti's (1911, 1912) male 'new type' from Bombay Island proved to be another species (Puri, 1933b).

Edwards (1927) stated that *S. kashmiricum* differed from *S. indicum* chiefly in having less yellow at the base of the abdomen (*S. indicum* having segment 3 yellow), more black on the hind femur, and a rather broader front. The abdominal colouring varies in both forms and depends partly on the condition of specimens, the hind femur varies in *S. indicum,* and the character of the frons is difficult to verify and seems indefinite. The Kashmir form appears to be a local variant characterised by the constancy of the colour pattern of the hind femur, but its position may have to be reconsidered when the early stages are found in several areas.

Vernacular names. The pepsi or damdum encountered in 1883 by Woodthorpe (1889) in the Aka Hills, and dam-dim, the dangerous yellow-banded blister fly of Bor (1952) seem to have been *S. indicum.* The following are some local vernacular

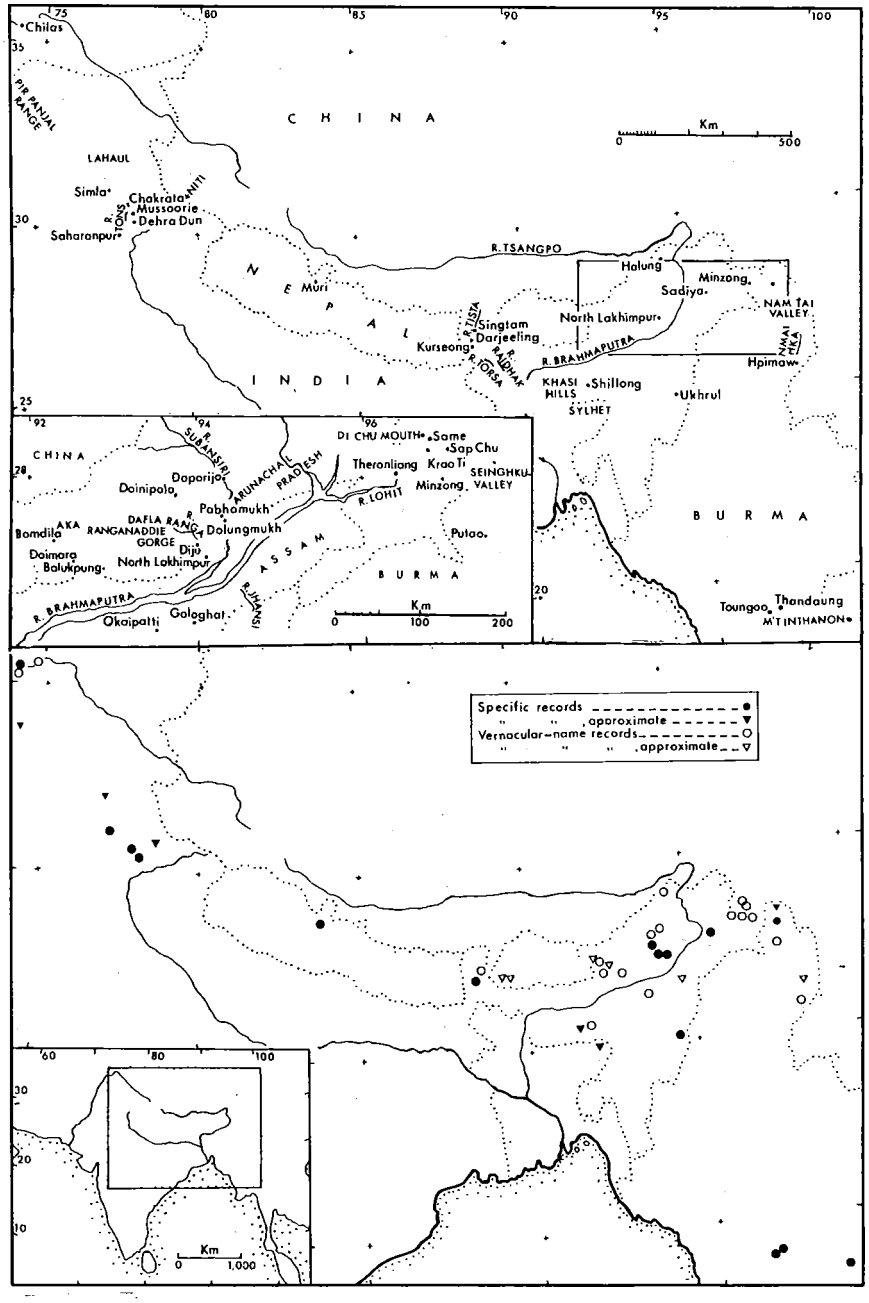
names reported for this species or, where indicated, simuliids in general. The names are useful for making preliminary enquiries about prevalence. BURMA: mawchi fly, near Toungoo (McDonagh, 1927). INDIA. WESTERN HIMALAYA: potu (Hindustani), phisnari (Pehari, or Pahari, a Himachal Pradesh-Nepal language), phisho (Balti), (De Nicéville, 1896). HIMALAYA: potu and pipsa, as simuliids (Maxwell-Lefroy, 1909). ARUNACHAL PRADESH: dam dim near North Lakhimpur (Hall, 1905); dimdam, as simuliids (Jacob, 1957); dimdams, commonly *S. indicum* (according to Perti, 1963); potu sometimes (enquiry near North Lakhimpur). PAKISTAN: moi near Chilas (Lewis, 1973). SIKKIM: pipsa (Cotes, 1894). THAILAND: kuns or sandflies in Inthanon area (Garrett and Kerr, 1925).

In India well-known names are potu in the west and dimdam in the east, and presumably may have some association with Mount Potu in Arunachal Pradesh and the town of Dam Dim in West Bengal. It is possible that the word dimdam may occasionly be used for *S. nodosum* Puri, for the midge *Forcipomyia stimulans* (Meijere) or for sweat-sucking insects.

REPORTS OF DISTRIBUTION AND PREVALENCE, IN INDIA AND OTHER COUNTRIES, OF *S. INDICUM*, DIMDAM, POTU AND OTHER FLIES WHICH MAY BE THIS SPECIES (MAP 1).

An asterisk (*) indicates specific records. The great majority of the vernacular-name records may refer to *S. indicum*, and give a useful preliminary assessment of distribution, because this rather large yellow-banded simuliid, appropriately named *nigrogilvum* by Summers, can often be recognised with the naked eye. Some of these records are taken from a selection of the extensive general literature. The old Bombay record is omitted as explained above.

BANGLADESH: Sylhet (district) (2.iii, 18.iv, 1905, Brunetti, 1912*). BHUTAN: area in general (dimdam common between 1,220 and 2,440 m from April to June, 1938, Ludlow, 1971). R. Raidhak and R. Torsa (and in the Indian terai belt from Nepal border to Burma border, including R. Tista, in summer till October, biting morning and afternoon in scrub jungle, Kapur, 1971). BURMA: Hpimaw (25° 58', 98° 40', vi, vii. 1914, yellow and black blood-blister flies, Ward, 1921). Nam Tai valley (27° 42', 97° 54', 914 m, R. Kaulback, BMNH*). Nmai Hka basin (a very poisonous variety of jungle fly, Young,



Map 1. -- Showing some places mentioned in the text, and the recorded distribution of *Simulium indicum*. Some closely adjacent places are omitted.

1907). Putao or Fort Hertz (17.IV.1926, F. Kingdon Ward; BMNH*). Seinghku valley (28° 05', 97° 35', 1,524 m. 20.V. 1926, F.K. Ward. BMNH*). Thandaung (XII.1932), F.J. Meggitt, BMNH*) (In 1961 R.B. Griffiths reported taking 173 simuliids on 3 people in 2.5 hours in January; the fly was said virtually to disappear in the May-September season when about 500 mm of rain falls, and to be most abundant in the October-May dry season; 11 females in BMNH*). Toungoo area (Mawchi, 1927, McDonagh, 1927*). CHINA: Same (51 km NNW of Minzong, IX.1950, blister flies bad, Ward, 1952).

INDIA. ARUNACHAL PRADESH (old records): area in general (1,220 to 2,440 m, commoner, especially in east, than in Bhutan, abundant in humid forest from April to June but dying out in dry country northward towards R. Tsangpo or Upper Brahmaputra, 1938, Ludlow, 1971) (dam-dims one of worst enemies, biting all exposed parts of the body and causing lymphangitis which prevented walking; protective clothing necessary; Bor, 1952) (1,524 to 2,122 m near streams, not necessarily near trees, Joseph, 1971) (457 to 914 m, in March and April in thick forest in moderate numbers, Sahani, 1971) (widespread from plains to 2,133 m, biting in open in 1959 and later, Palit, 1971) (250 to 2,750 m, Perti, 1963) (adult *Simulium* reported from November to September, not numerous in thick jungle or complete clearings; Perti and Lopez, 1962; some places mentioned are Balukpung, Bomdila, Dporijo, Dirang, Doimara, Doinipolo, Pandoli, Petapul, Tega valley, Tez, Tipi and Yazali). Aka country (Woodthorpe, 1889, p. 431, wrote of the Akas encountered on his 1883 expedition: 'Strings of many coloured beads adorn their necks and are worn as garters to keep up gaiters of loose pieces of cloth to protect their calves from the bite of a very pestilent little fly called the "pepsi" or "damdum" which abounds in these hills. Its bite raises a nasty little blister of coagulated blood, followed by swelling and intolerable itching, the victim's legs often presenting the appearance of elephantiasis. The very thinnest cloth serves as a protection against their attacks. We all suffered greatly from these insects.') (Dam-dims apalling, Bor, 1952). Bompu and Chaku (Jacob, 1957). R. Borelli (one tributary was a plague spot for dam-dims, Bor., 1952). Dafla area (infesting foothills near Diju from January to March and April, Hall, 1905*). Di Chu mouth (48 km NNW of Minzong, mid April 1950, dim dams in thousands, Ward, 1952). R. Digra (which passes Sijuli in the Diju area; local people near North Lakhimpur in April 1971 had many black spots and

said they had been badly bitten by dimdam). Halung or Lahlung (28° 42', 94° 12', many brought out by sunny days, making life almost unbearable, bit two hours after dawn on 1.V.1938, Ludlow, 1971). Krao Ti (39 km NNW of Minzong, III.1950, black and yellow dim-dam, blister flies or *Simulium* very bad, a plague in Lohit valley all way from Theronliang which is 60 km to WNW, Ward, 1952). Rochinalla area (Jacob, 1957). Rotung (?Brunetti, 1920). Ranganaddie gorge (26.XII.1909, H. Steven, ZSI*). Sap Chu (55 km N of Minzong, 1.IV.1950, blister flies very annoying but main season probably not begun, Ward, 1952). Saidyia (possibly Sadiya area, 1927 or before, from CSTM, BMNH*). Sisini (Jacob, 1957). ASSAM: Diju or Dejoo, 19 km NW of North Lakhimpur (upstream of tea garden, very bad in 1955 but less in recent years. Strang,1971; at 105 m near R.Ranga (=Ranganaddie) but not on tea garden, P.W.W. Castle in 1971). Dolungmukh (about 105 m, just above village, P.W.W. Castle in 1971). Jaihing, 4.8 km NE of Diju, (1.III.1905, had a very poisonous bite and interfered a good deal with the tea workers, Hall, 1905*). Okaipatti (rapid on R. Kaliani 28 km WSW of Gologhat, March and April, Clayton, 1971; might be *S. nodosum* which exists in the area). Pabhomukh (mouth of R. Pabho entering R. Subansiri 10 km NNW of Dolungmukh, not seen in II.1971; few on 17.IV.1971, D.J. Lewis*). Shillong (Perti and Lopez, 1962). HIMACHAL PRADESH: area in general (2,133 to 2.440 m, biting in afternoon near woodland and villages but not in heart of forest, Seth, 1971). Lahul area (Lahaul and Mani, 1962*). Simla (24.IV.1907, Brunetti,1911 *). KASHMIR: area in general (abundant above tree line in Himalaya, particularly in Pir Panjal Range, Mani, 1962*). MANIPUR: Ukhrul (Brunetti, 1912). MEGHALAYA (hills, formerly of Assam): Khasi Hills (Brunetti, 1911*). NAGALAND: R. Jansi (local report in Jorhat). SIKKIM: area in general (distribution much as in NW Himalaya but less abundant, Cotes, 1894). R. Tista in Singtam area (1,219 m, peepsa and midges, Hooker, 1891). UTTAR PRADESH: area in general (in NW Himalaya up to 3,048 m, Beeson, 1961*) (worst in the hot season of April to June, but not uncommon in lower valleys in February and March; being usually absent from early rains to spring, very common and sometimes very abundant and troublesome between 914 and 3,048 m, especially in chir and deodar forest, usually not far from streams; Cotes, 1894*) (from Chakrata and Mussoorie northward to Niti valley near snows, De Nicéville, 1896*) (in Mussoorie area, in forests and open land from 914 to 3,048 m; at 3,048 m one traveller had to rest for two days after

bites; De Nicéville, 1896) (in Mussoorie district, chir forests of Yamuna Forest Division, 1,067 to 1,676 m, on hot southern aspects, potu present from May to July, but not higher up among deodar or blue pines, Mathur, 1971). Banog Hill (10 km from Mussoorie, 2,250 m, 19.X.1909, L.B. Scott, ZSI*). Chakrata area (Sainji Khud or valley, 1,981 m. 27.V. 1922, S.N. Chatterjee, 10 females, FRI*). Chakrata-Sahranpur road (workers said to have died after bites, De Nicéville, 1896*). R. Tons valley (about 1,067 m, VII.1893, yellow and black fly resembling original description of *S.indicum*, habits and appearance like pipsa of Sikkim, Cotes, 1894*). Tons forest division (menacing forest workers in March and possibly whole year, present on main road about 1,524 m in late March and early April, Mathur, 1971). WEST BENGAL: Darjeeling, 12.VIII.1909, Brunetti, 1911*; not seen in 1968 by Das Gupta et al., 1969, or in 1970 by Datta, 1971). Kurseong (10 to 26.IX.1909, Brunetti, 1911*; IX.1922, P.J. Barraud, BMNH*; not seen in 1970, Datta, 1971). R. Tista (Kapur, 1971).

NEPAL: area in general (no simuliids seen in east by Sheals and Inglis, 1965; sandflies mainly in west, where chir pine is widespread, also seen among other trees in several areas, but much of country is deforested, Williams, 1971). Muri *(Lewis 1972). PAKISTAN: Chilas (bit man, Edwards, 1927*). Jaglot, Jakerkot, Jal, Jalipur, Raijot, Shang area (Lewis , 1973). THAILAND: Doi, or Mount, Inthanon (IX and X.1910, Summers, 1911*; 18.IX.1919, numerous, Garrett and Kerr, 1925*).

Field observations in 1971

I visited three areas, not in closed frontier districts, in search of *S. indicum* and any other man-biting species.

Mussoorie area, March 31 to April 6. No *S. indicum* were found around Mussoorie where much forest has been cut and few streams were flowing. Four pupae of the Kamti species were found in the Kamti falls. One pupa of the Diju species and five of the Subansiri species were found in the R.Sahastradara where simuliid pupae were surprisingly scarce.

North Lakhimpur area, April 16 to 25. The early rains of Assam had started by March and caused spates, and pupae could be found in only a few places, on trailing grasses. Search was made for crabs, prawns and mayfly nymphs because a considerable number of blackfly species are now known to be phoretic (Lewis, 1973). Mayfly nymphs were sought on stones but few were seen.

The R. Dikrang at Harmutti (27 km SW of Diju) had become sandy rather than gravelly since partial deforestation. No dimdam were reported, and no simuliids were seen, but crabs, *Parathephusa (Barytelphusa) lugubris* Wood-Mason (bearing temnocephalean symbionts) and prawns, *Macrobrachium* sp., were found in a small tributary. Simuliids are conspicuous by their absence from this genus in Africa.

At Diju much forest has been cleared in recent years and, following this and the 1950 earthquake, the R. Ranga below Diju has become sandy. Dimdam were said to occur above Diju, but not on the tea garden there, and had been known on the river for one km downstream 20 years before but not since. Pupae collected at Diju, in the broad shallow stony R. Ranga 5.6 km NNW of the tea garden, on April 19 were: Assam sp., 11; Diju sp., 283; *S. indicum*, 3; Lakhimpur sp., 11; Ranga sp., 22; Rengma sp., 6; Subansiri sp., 6.

At Jaihing dimdam were unknown on the tea garden. On the stony R. Jaihing, a tributary of the Ranga, they were said to bite some people from September to November. In it were found many crustacea of the species seen at Harmutti, and one crab, *Potamon (Acanthtelphus) feae* de Man.

The R. Subansiri was examined at Pabhomukh, roughly 135 m above sea level, on April 18. Very few *S. indicum* were seen, biting in such a hesitant manner that they were more easily caught in a net than in vials. Flooding had evidently ended the dimdam season, but a few simuliid pupae were found in a small tributary which had a small catchment area and had not been heavily flooded. They were: Pabho sp., 9; Subansiri sp., 5.

Murphulani, near Gologhat, April 28. This is 20 km SSW of Gologhat near the foot of the Rengma Hills. Dimdam were reported to be a pest on the R. Doigroon and proved to be *S. nodosum*. Also biting were many midges of a species indistinguishable in the female from *Forcipomyia (Lasiohelea) stimulans* (Meijere), which is the common Oriental man-biting *Lasiohelea* discussed by Edwards (1922).

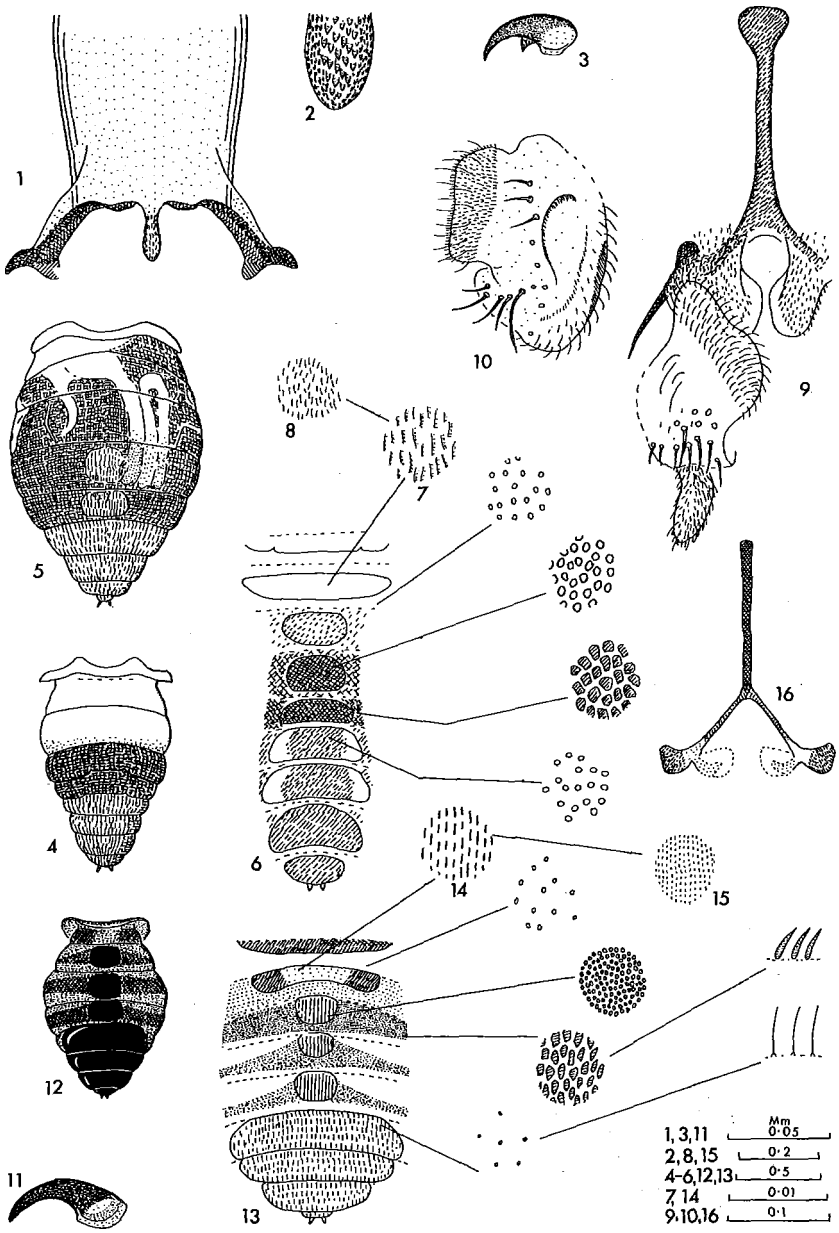
SIMULIUM NODOSUM PURI (Fig. 11-31)

Simulium nodosum Puri, 1933a: 813 [♀, pupa and larva; type locality, India, Coorg, Fraserpet]; 1933c: 12; Crosskey, 1973. Holotype in Puri's collection.

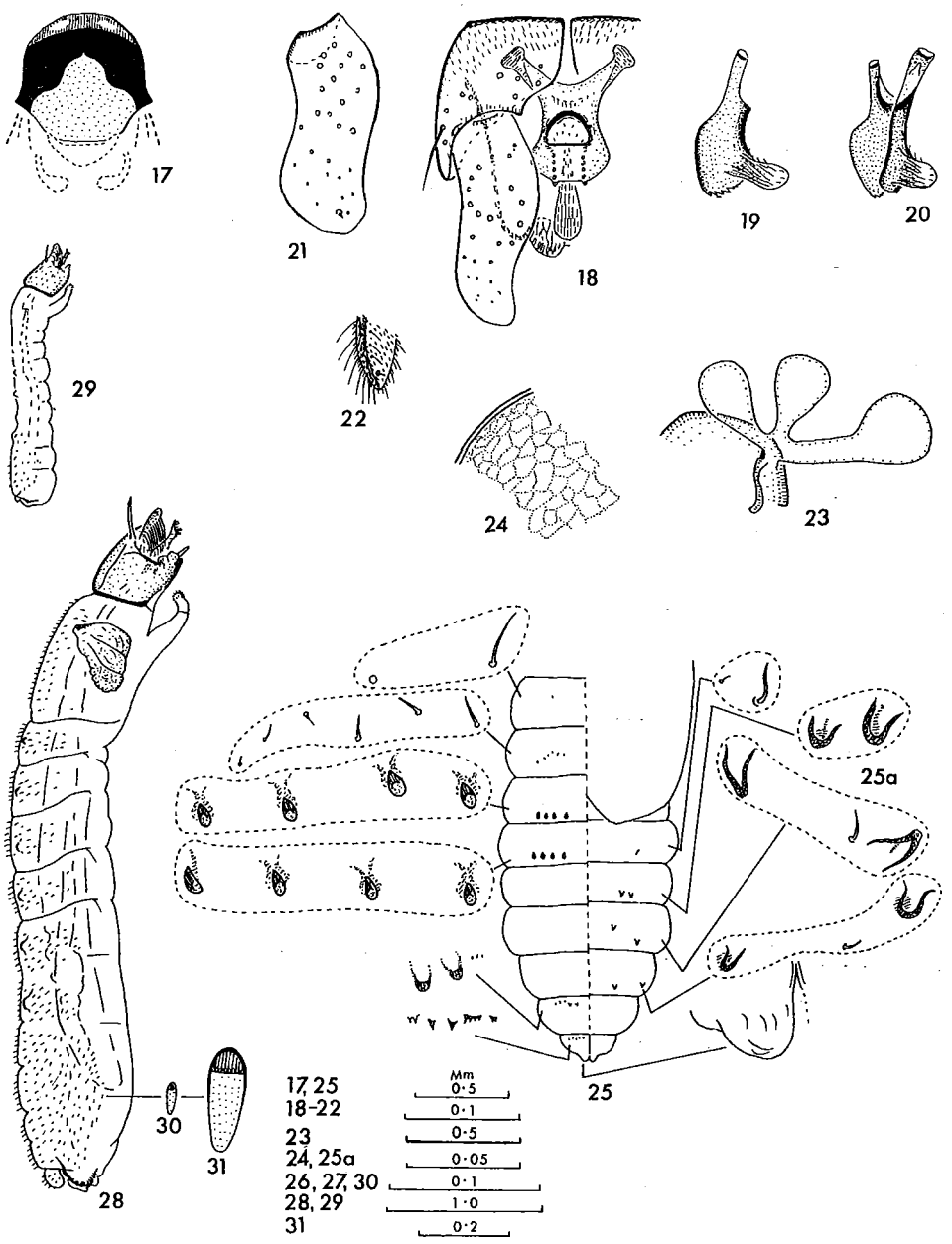
The male is described below for the first time, and supplementary notes are added for the female, pupa and larva.

Female. Mandible with 24 outer and 12 inner teeth. Maxilla with 10 inner and 12 outer teeth, palp vesicle 0.35 times length of segment 3. Dorsum of abdomen by incident light: segment 1 with flap, or so called scale, black, and cuticle behind it with pale sheen; 2 with pale sheen in middle of tergite and rest of segment black velvet; 3 to 5 with black velvet tergite and black matt field; 6 to 8 with black shining tergite. Abdominal dorsal cuticle by transmitted light: segment 1 pale except for flap; tergite 2 dark at sides, centre at x 240 appearing faintly dotted, at increasing magnifications showing dots, more or less in rows, and then parallel broken lines; field of 2 somewhat shagreened; 3 to 5 with dark brown velvety tergites, and field with rather narrow transverse bands which are densely shagreened and look blue except where the surface is seen at an angle and looks brown; 6 to 8 with tergites brown, except in pharate flies, and shining, with sparse pattern of very minute microtrichia. Furca delicate with median arm black and truncated, lateral arms with broad, partly dark, ends.

Male. Face grey and pruinose. Scutum with sparse covering of brown hairs; anterior margin pruinose with a silvery spot on each side, rest of anterior half black except for dome-shaped area which is continuous with silvery grey hind half. Pleural membrane, postnotum and katepisternum bare. Leg 1 with basitarsus 5.5 times as long as high, dark except for basal part of femur; leg 2 with coxa, femur and tibia largely dark, and tarsus pale except for tips of segments; leg 3 with coxa dark, femur broad, and pale except for tip, tibia broad and pale except at base and tip, and tarsus pale except at tips of segments; scale patterns approximating to cuticular patterns. Abdomen black with the usual pruinose areas. Ventral plate with about 6 distal teeth on each side and a large bulbous ventral lobe with pale tip. Paramere with numerous



Figs. 1-16. (1-10) *Simulium indicum* ♀ (1,2) Cibarium and tip of process. (3) Claw. (4) Dorsum of abdomen from Pabhomukh. (5) Same of gorged fly. (6-8) Dorsum of abdomen from Himalayan foothills, by transmitted light. (9,10) Terminalia. (11-16) *S. nodosum* ♀. (11) Claw. (12-15) Dorsum of abdomen by incident and transmitted light. (16) Furca.



Figs. 17-31. *Simulium nodosum*. (17) Scutum of ♂ (18-22) Terminalia, style and ventral plate of ♂. (23-37) Gill and onchotaxy of pupa (28-31) Larvae showing scales.

teeth. Style much longer than coxite, with subapical spinule in the form of a short hair with large socket, which is sometimes unapparent.

Pupa. Dorsal and ventral abdominal spines as figured.

Larva. Metathorax with a pair of dorso-lateral tubercles which are repeated on first 5 abdominal segments. Abdomen with dorsal scales, and a few ventro-lateral ones on hind segments. Lateral lobe of rectal gill with about 10 lobules.

Variation. It appears from Puri's description that the pupal onchotaxy of the type form is like that of *S. himalayense* Puri except for having four strong ventral hooks on segment 4. Puri's description of the larva of *S. nodosum* does not mention abdominal scales or tubercles. The Murphulani form evidently differs from the type form in the nature of the hooks on pupal abdominal segment 4, and may differ in some larval characters.

Specimens seen. INDIA: Assam, Murphulani, R. Doigroon, 28.IV.1971, D.J. Lewis, 5 ♀ biting, 5 ♀ and 7 ♂ reared or dissected from pupae, and many pupae, pelts and larvae.

Comments. The linear pattern on abdominal tergite 2 of the female corresponds with a pruinose area and bears some resemblance to the pattern on the iridescent structures in other insects, illustrated by Onslow (1921) and Hinton (1970). Unusual features in this species include the terminalia of the female and the scales and tubercles of the larva.

Habits. This small black species was biting people on the R. Doigroon, attacking quickly, unlike *S. indicum,* and causing intense irritation. The local rainfall is rather low, the river had not flooded, and many blackfly pupae were found. The river was mainly placid, and the pupae were on vegetation stranded or growing in a small rapid below a weir. They and pupal pelts represented: *S. nodosum,* 164; Diju sp., 491; Doigroon sp., 29; Rengma sp., 1. Pupae of *S. nodosum,* as in the type locality, were outnumbered by other species.

KEY TO PUPAE OF SPECIES FOUND

Pupae of species found in the present survey may be distinguished from each other by the following key. The subgenus or apparent subgenus of most is indicated.

1 Pupal gill with 3 bulbous lobes . . . . (*Simulium) nodosum*
Pupal gill filamentous 2
2 Gill with 6 points (tips of filaments) 3
Gill with 8 or more points 6
3 Gill branch 1 with strongly curved filaments 4
Gill branch 1 with nearly straight filaments 5
4 Filaments thick. Cocoon shoe-shaped. *(Himalayum) indicum*
Filaments thin. Cocoon slipper-shaped, with large gap behind collar (*Simulium?*) Assam sp.
5 Pupal thoracic dorsum with large platelets and many-branched trichomes (*Simulium*) Kamti sp.
Pupal thoracic dorsum with small platelets and simple trichomes (*Simulium*) Rengma sp.
6 Gill with 8 points 7
Gill with 10 points 10
7 Gill branching 6, 2; branch 1 bifurcating near base (*Gomphostilbia*) Lakhimpur sp.
Gill branching otherwise. . . . . .
8 Gill branching 3, 3, 2; filaments very slender (*Gomphostilbia*) Ranga sp.
Gill Branching 2, 2, 2, 2 9
9 Filaments uniformly thick. Cocoon slipper-shaped (*Simulium*) Subansiri sp.
Filaments of branch 4 thinner than the rest. Cocoon shoe-shaped (*Simulium)* Doigroon sp.
10 Gill branching 2, 3, 3, 2 . . . . . (*Simulium*) Diju sp.
Gill branching 4, 4, 2. Small species. Trichomes long and single. Spermatheca elongated . . . . Pabho sp.

D I S C U S S I O N

S. indicum

This species is one of the important man-biting Diptera which show great taxonomic differences from most members of their families. Other examples are *Phlebotomus papatasi* (Scopoli), *P. argentipes* Annandale and Brunetti, S.*nodosum*, *S. neavei* Roubaud and *S. damnosum* Theobald. *S. indicum*, like *S. griseicolle* Becker of the Nile and *S. quadrivitattum* Loew

of Central America, is one of the important but little known simuliids of the world. It is now possible to discuss some aspects of the biology of *S. indicum*, bearing in mind the need to confirm the identity in some reports.

Recorded distribution. It appears that, during this century, *S. indicum* has occupied a large part of the Himalaya and their south-eastern extensions. The unevenly distributed records suggest that there is a main area from east Bhutan eastwards, an area of limited numbers in part of Nepal, and an area of restricted distribution from western Nepal westwards.

Local distribution and ecology in the west probably differ from those elsewhere because the foothills begin at a higher altitude, the rainfall is less and begins later, winter is colder, and the chir pins *(Pinus roxburghii* Sargent) is an important element in the forest. Schweinfurth's (1957) map showed the general distribution of the tree, but was evidently not intended to give details, for it indicated extensive chir around Mussoorie where this tree is only patchy (Puri, 1960). *S. indicum*, which is associated with forest, as mentioned below, also has a sporadic distribution which doubtless accounts for the fact that some mountain travellers give vivid accounts of it and a few do not know it. Some writers refer to its occurrence all along the Himalayan foothills, without giving details, and several of these statements may have originated in the discussion mentioned above in the section on variation.

S. indicum is obviously a mountain species, being reported from high altitudes up to about 3,000 m. It evidently comes down to about 900 m in Uttar Pradesh, and possibly 700 m in Kashmir (Lewis, 1973). In the east, where hills descend near the plain and there is more forest, this insect has been reported as low as 105 m.

Changes in distribution. Records from several localities or areas, such as Darjeeling, Kurseong and Simla, are very old ones, and the lack of recent reports from there may well be due to decrease or disappearance of *S. indicum*. This seems very likely in view of failure to find this species during special searches at Diju, Jaihing and Mussoorie in 1971, and of reports of recent changes at Diju and Jaihing. Extensive deforestation has occurred, and has probably driven back this insect which is known to be associated with forest and susceptible to control by clearing.

If this is so, *S. indicum* is one of a number of insects which have retreated in the face of tree-cutting. South American forest phlebotomids have doubtless been driven from some areas, and certain mosquitoes (Surtees, 1971; Smith, 1972) and tsetse flies in Africa and Arabia (Buxton, 1955) have been affected in this way. Many species of wild life are disappearing as a result of growing human population but no one will regret the decrease in *S. indicum*.

Deforestation is only one of the human activities which are adversely affecting blackflies (Lewis, 1973; Rivosecchi, 1969).

Association of adults with woodland. Many independent reports indicate that *S. indicum* is often associated with trees, and Raghavan (1971) has often found it near jungle. It lives largely in wooded country and, in the west, in a particular type of woodland. Many of the distribution records refer to the presence of land leeches which are animals of tropical rain forest and emphasize the largely woodland distribution of this blackfly. The range of *S. indicum* evidently corresponds with the Himalayan subtropical life zone of Maxwell-Lefroy (1909). This begins at 152 m in the east and 610 m in the west, extended up to 1,524 or 1,830 m, and consisted largely of forest or dense jungle. It was determined largely by rainfall and had a higher humidity, longer rainy season and a more equable temperature than the 'tropical' zone.

Pande (1966) gave additional information about the association, in the west, of *S. indicum* with a particular tree, the chir pine. In the Tons Forest Division this blackfly occurs in the chir zone in winter and spring and in the deodar (*Cedrus deodara* Laws) zone in summer. The chir zone occupies nearly the whole area up to 1,800 m, or 2,100 m depending on aspect, and typical deodar forest occurs from 1,950 to 2,700 m, or 3,000 m on dry exposed slopes. In Pakistan, also, *S. indicum* evidently occurs at high altitudes in summer, possibly in wooded areas. (Lewis, 1973), and its western limit approximates to that of the chir pine.

The association of a simuliid with a particular tree in the western Himalaya is reminiscent of the relation between *Phlebotomus ariasi* Tonnoir and certain trees in southern France (Rioux and Golvan, 1969).

Larval and pupal habitat. Pupae collected by Jacob (1957) proved to belong to species other than *S. indicum,* and few pupae of this species were found in the present survey, but it presumably breeds in the common stony stream of the area.

Blood-sucking. Several reports mentioned above in the section on distribution provide information about blood-sucking. Evidently flies often appear during sunny weather (Jacob, 1957) and are active in sunshine and sunny places. Flies often bite unnoticed behind the knees or elbows. Bites are followed after some time by itching, and eventually black spots, and sometimes blisters and fever. Some people are unaffected and some become immune to effects. Additional records are as follows.

According to Cotes (1896), in the western Himalaya irritation usually ceased after a few days but newcomers might be badly affected; bites were sometimes followed by sores and ulcers, and leg-sores could make walking almost impossible. Pande (1966) recorded that the potu fly, *S. indicum,* was a great nuisance in the Tons Forest Division and might cause fever at times.

Ludlow (1971) reported that in Arunachal Pradesh simuliids had caused bad blisters which lasted for days, and that some people did not react to dimdam. In the same general area engineers reported that dimdam were a great nuisance and caused much discomfort to road-construction workers, according to Jacob (1957) who noted that only one in five people was bitten in January 1954, that dimdam bites were followed either by slight itching and development of a small dark spot which lasted some days, by temporary swelling, or by swelling, fever and pustulation, possibly due to secondary infection; boils occurred in a few cases. Perti and Lopez (1962) noted that in Arunachal Pradesh bites were on all exposed parts of the body and were often followed by considerable localised oedema, lymphangitis and swelling of the adjacent lymph glands, and sometimes by low fever or transient rhinitis. These, probably allergic, phenomena might last two or three days, and the bite might leave a small black mark for a few days or three weeks. McDonagh (1927) reported that *S. indicum* at Mawchi in Burma caused multiple boils which incapacitated one patient for several weeks if not months.

During the present survey several people reported that *S. indicum* (and *S. nodosum*) bit women more than men, who may perhaps be protected by hairy legs. Many people spoke of scarcely noticing the flies but seeing spots of blood and later feeling irritation.

S. indicum is obviously an important pest, but its sometimes hesitant biting and apparent choice of certain people suggest that man may be a secondary host. Cotes (1894) recorded that dogs were sometimes bitten on the nose by *S. indicum* and that it was especially common where sheep and buffaloes had been. De Nicéville (1896) reported that a tame deer (kakhur) had nearly died after bites of *S. indicum*.

Flight range. Perti and Lopez (1962) considered that simuliids in Arunachal Pradesh could fly four or even eight km. In the Diju area *S. indicum* seem to be restricted to the river, possibly because it is not numerous.

S. indicum seasons. Reports of prevalence in certain areas depend partly on times at which they were visited, but it is possible to make a general inference about the main outbreak seasons, which evidently vary somewhat from place to place according to local conditions. In much of the Himalayan area the species evidently disappears or decreases in the monsoon, when larvae and pupae are probably destroyed by torrents and silt, and decrease in winter. In Arunachal Pradesh the season appears to last from October to April, with a partial lull from December to February, and in Burma and Thailand the seasonal distribution may be somewhat similar.

In the western Himalaya, with a cold winter and low rainfall, the species evidently disappears in winter and occurs at relatively high altitudes in summer. In parts of Uttar Pradesh *S. indicum* seems to appear about October and is present from April to July. There is some evidence that it is common in February at low levels, about March at medium levels, and in summer at high levels. At its western extremity in Kashmir *S. indicum* seems to be common at low levels in September, October and April, and to be found at high levels in June and August (Lewis, 1973). At a low level in June 1963 adults were not generally noticeable, but a few were discovered by intensive searching and pupae were numerous. The off-season requires further study, for in Kashmir and at Diju (Assam) adults were rarely or not seen although pupae

were present, and at Pabhomukh (Assam) a few adults were seen in the absence of pupae.

Possible relation to human onchocerciasis. Perti (1963) regarded *S. indicum* as a potential vector of onchocerciasis. Some infected people from Africa or tropical America travel widely, but it seems doubtful whether enough are likely to reach areas of *S. indicum* to establish the disease. The likely role, if any, of this species and *S. nodosum* could be ascertained experimentally, and it is not unlikely that they could play some part, because many blackfly species in the world are now known to have some association with *Onchocerca volvulus*. The number of suspected vectors, namely species capable of harbouring worms resembling *O. volvulus*, is growing, and they belong to several subgenera and occur in both Old and New Worlds. Furthermore, it seems that transmission can be maintained by a poor vector (Barreto et al., 1970) or by a good vector in small numbers, as in the Abuja district of Nigeria (Davies, 1968) and the West Nile district of Uganda (McMahon, 1967).

Personal protection and control. Brauer (1895) recommended numerous remedies then known in Europe, including fomentations of luke-warm milk and warm poultices of linseed and water, which make one appreciate the value of modern simple methods. Ludlow (1971) in 1938 had to use gloves, smudge fires and repellents, Ward (1921) used protective clothing and pricked blisters to reduce irritation, and Perti and Lopez (1962) employed anti-histamine drugs, and (1964a) recommended protective clothing and described larval control by DDT, suggesting a control radius of five km. Clearing vegetation for 50 to 100 m was found to reduce numbers of adults (Perti and Lopez, 1964b).

Comparison with subgenus Lewisellum. *S. indicum* is comparable in several ways with the African subgenus *Lewisellum* which includes the onchocerciasis vector *S. neavei* Roubaud. Each has a flattened fore-tarsus and certain structural features which separate them from most other simuliids.

The reported range of distribution of each is extensive, some three and five thousand km respectively. Each occurs at both high and low altitudes and is associated with forest. In each case there is a high, relatively dry, area (in the west and east respectively) in which more or less isolated populations exist and some local speciation or variation has occurred.

Each taxon appears to have retreated in the face of deforestation in recent decades. This effect on *S. indicum* has been discussed. With regard to *Lewisellum*, *S. woodi* De Meillon used to be a pest in the Cholo area of Malawi but virtually disappeared after bush clearing for tea cultivation (Lewis, 1961). Williams et al. (1964) concluded that in the eastern highlands of Kenya *S. neavei* had become less widespread, partly owing to forest clearing for cultivation up to 2,134 m or more, and that in much of north-eastern Tanzania *Lewisellum* might have been accidentally and unwittingly eliminated by clearing. In the Mount Elgon onchocerciasis area of Uganda much deforestation had occurred and been followed by the growing of coffee and a little tea and by general agricultural development; in rivers away from the forest there has been a general decline in numbers of immature *S. neavei*, and onchocerciasis seems to have diminished (McCrae, 1971; Prentice, 1971).

S. indicum is an important man-biter and pest of forest workers, and *Lewisellum* includes several such species. In each case many years elapsed without the discovery of the aquatic stages, and control measures have included tree clearing.

S. nodosum

Previously this species was known only from Fraserpet (12° 28', 75° 57') in the hills of south India 2,400 km from Murphulani which is in the low-lying Brahmaputra plain. It may well prove to be a pest in several areas.

Other man-biting species

Several species are known to bite animals in India, one bit man at Pusa (Sen and Fletcher, 1962), and several have been found on man or animals in Pakistan (Lewis, 1973). Further study may show that more than two species attack man in northern India.

Some further basic knowledge required

The females of many species of blackflies are notoriously unreliable for identification, and larvae, pupae and males of *S. indicum* are needed from several areas to confirm existing records of distribution, and to show if it varies considerably. Juveniles are likely to be obtainable where

adults are numerous and when levels of streams are steady or falling. Aquatic vegetation, sticks and stones should be examined, and dark pupae can be used for emergence of females and males, or can be preserved so that enclosed adults can be dissected out. In some areas pupae of *S. indicum* are likely to be outnumbered by other species.

Observations in Nepal could show what effect deforestation has had on it.

If the biology of *S. indicum* is studied, the remarkable transparent first three abdominal terga of the female might serve as a window for inspecting some internal organs of living flies.

More knowledge of *S. nodosum,* any other man-biting species, and of phoretic forms would be instructive.

S U M M A R Y

Simulium indicum Becher had been reported to occur in eight countries, from the western Himalaya to Thailand, possibly as a single species.

The female is redescribed. The species appears to be a single one with little variation in the female and some in the pupa.

Available information on the species in India and other countries, based on records of it, and of biting flies which are probably the same, is shown in the form of an annotated distribution list with a map.

The male of *S. nodosum* Puri, and certain features of the female and larva, are described, and a key is provided for pupae of the 11 species found. Three areas in India, one western and two in Assam, were visited in 1971. At Mussoorie no biting blackflies were seen. Near North Lakhimpur a few *S. indicum* were found, and near Gologhat a troublesome simuliid proved to be *S. nodosum* which had not been known to bite man.

Present knowledge of *S. indicum* is discussed. Evidently it is a mountain species, ranging up to 3,000 m, but extending down to 900 m, possibly 700 m, in the west, and 100 m in the east.

The two known breeding sites are in stony rivers with some vegetation.

S. indicum has apparently retreated in some areas, probably owing to deforestation. Evidently it is largely a woodland species, and in the western Indian Himalaya associated with the chir pine, *Pinus roxburghii* Sargent.

In north-east India *S. indicum* appears to breed from the end of one monsoon to the start of the next, with a partial lull in winter. In the western Himalaya, with a very cold winter and low rainfall, the species evidently disappears in winter and occurs at relatively high altitudes in summer. In some places where flies are not noticeable it is possible to find pupae.

Many reports show that *S. indicum* is an important biting pest, and the possibility of it being a potential vector of human onchocerciasis is not ruled out. Control has been carried out in one area by Perti and Lopez.

S. indicum is comparable in many ways with the African subgenus *Lewisellum* which includes *S. neavei* Roubaud.

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