

TRISETACUS PINI (NALEPA, 1889) IN SOME BALTIC COUNTRIES AND IN RUSSIA (TAXONOMY, MORPHOLOGY, BIOLOGY, DISTRIBUTION)

TRISETACUS PINI (NALEPA, 1889) В НЕКОТОРЫХ СТРАНАХ ПРИБАЛТИКИ И РОССИИ (ТАКСОНОМИЯ, МОРФОЛОГИЯ, БИОЛОГИЯ, РАСПРОСТРАНЕНИЕ).

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КЛЮЧЕВЫЕ СЛОВА: *Trisetacus pini*, морфология, таксономия, биология, степень поражения растений.

ABSTRACT

Trisetacus pini (Nalepa) is the only species of Tetrápodili inducing bark galls (= twig knots or swellings) on the twigs of the gymnospermous plant, *Pinus sylvestris* L. A more exact name for these abnormalities is «nodal or internodal tuberculoid cauloblastomes» [Slepyan, 1973]. The biology of this mite species is uncommon. The mites can live inside the same gall for about ten years. There are two types of females in *T.pini*. It still remains to be elucidated whether or not they are real proto- and deutogyne females. Males average 3.4% only. The development is very slow and presumably this species has one or two generations in a year.

Adult females are the principal overwintering and migrating stage. The vernal migration begins in the second half of May and lasts approximately up to one month. The mites can leave only galls of 3 and more years, which have cracks in their walls. *T.pini* induce galls in the plants of various ages, but new cauloblastomes appear only in the most favorable years or periods. Badly infested shoots die and appear to be dry. Nearly 45% of infested plants had only old galls. *T.pini* has a limited distribution. This species occupies certain habitats along Baltic Sea Shore.

РЕЗЮМЕ

Trisetacus pini (Nalepa) - единственный вид Tetrapodili, вызывающий коровые галлы (= веточковые узелки или утолщения) на веточках голосеменного растения - *Pinus sylvestris* L. Подходящее название для этих новообразований - «нодальные или интернодальные каулобластомы» [Слепьян, 1973]. Необычна биология исследованного вида. Клещи могут жить внутри одного и того же галла около 10 лет. У *T.pini* имеется два типа самок, но являются ли они протоили дейтогинными особями, еще предстоит установить. Самцы составляют всего 3.4%. Развитие вида идет очень медленно, и предполагается, что за год у него развивается лишь одно-два поколения. Самки - главная перезимовывающая и мигрирующая стадия. Весенняя миграция начинается во второй половине мая и длится до месяца. Клещи способны покидать только галлы трех и более лет, имеющие в стенках трещины. *T.pini* вызывает галлы на растениях разного возраста, но новые каулобластомы появляются только в наиболее подходящие годы или периоды. Сильно пораженные побеги погибают и засыхают. Около 45% растений имело только старые галлы. *T.pini* имеет ограниченное распространение. Этот вид занимает некоторые местообитания вдоль побережья Балтийского моря.

INTRODUCTION

Trisetacus pini (Nalepa) is not a common species among the four-legged mites. It was used by A. Nalepa [1887] as a model species for study of the tetrapodilid anatomy. Investigation of these mites gave most important data about the main morphological peculiarities of all Tetrapodili, which was very useful for the classification of the four-legged mites in general. This species is unique because of the specificity of its galls. They are not real galls in the exact meaning of this word, and everyday names for them are «knots» or «swellings». This is the reason to discuss the question about the scientific name for such new formations. This species is therefore a very interesting object for study. This led us to generalize the major data available on *T. pini*. The present study is based, nevertheless, chiefly on the authors' own observations. We shall consider some morphological peculiarities of *T. pini* females, some taxonomic problems, the biology and distribution of these mites. One of the tasks of this study is to produce a distribution map for this species in many points of Russia and some Baltic countries.

STUDY AREA, MATERIAL, AND METHODS

We began the investigation of *Trisetacus pini* at the Laboratory of Plant Acarology in 1965. This work was primarily connected with sampling faunistic materials, and since 1973 with the study of distribution of the mites on the territory of north-west Russia as well as on the territories of Estonia, Latvia, Lithuania, and Byelorussia. The mites used in this study for the investigation of their morphology were collected at the Ezerkraste farmstead in the vicinity of Riga in 1965, and near Jurmala in 1981-1985.

The major biological data were obtained in the two above-mentioned sites near Riga (Latvia). The material was sampled during May and June of 1984, in August of 1965, and in September of 1983. So we have information covering almost the

entire vegetative period.

Our study of the mite spatial distribution was conducted in the former USSR. We examined many locations from the Urals to the city of Brest (Byelorussia) and from the islands of White Sea to the city of Tula (Fig. 1). Some additional data were obtained in other regions (Middle Asia, Caucasus).

As a rule not less than 100 specimens of the host plant were observed in each site. To determine the degree of plant infestation we took into consideration the quantity of galls on the 5-7 major branches situated in the lower part of the crown. Where possible, the galls of different ages were considered separately. To establish the degree of mite infestation in the host plants the density of the mite colonies was estimated visually. The entire material consists of nearly 20000 samples obtained during all years. For the visual estimation we used the next scale of marks:

- 0 - no galls,
- 1 - very small quantity of the galls on some branches,
- 2 - noticeable number of the galls on some branches,
- 3 - moderate number of galls on many branches,
- 4 - large number of galls on most branches,
- 5 - the largest number of the galls on nearly all branches.

We calculated three main indexes: percentage of the plants invaded by the mites; the degree of damage (ID, mean number of galls on one invaded plant); index of mite gall abundance (IA, mean number of injuries in one observed plant).

$$ID = \frac{\text{Sum of points}}{n_{\text{invaded plants}}}$$

$$IA = \frac{\text{Sum of points}}{n_{\text{estimated plants}}}$$

The materials from Finland were sampled by V.G. Shevchenko and Veikko Rinne (August, 1990) in three sites: the Island of Seili (near Turku), in Rovaniemi, and in the vicinity of the Kevo Subarctic Research Institute.

The taxonomy and morphology of *Trisetacus pini*

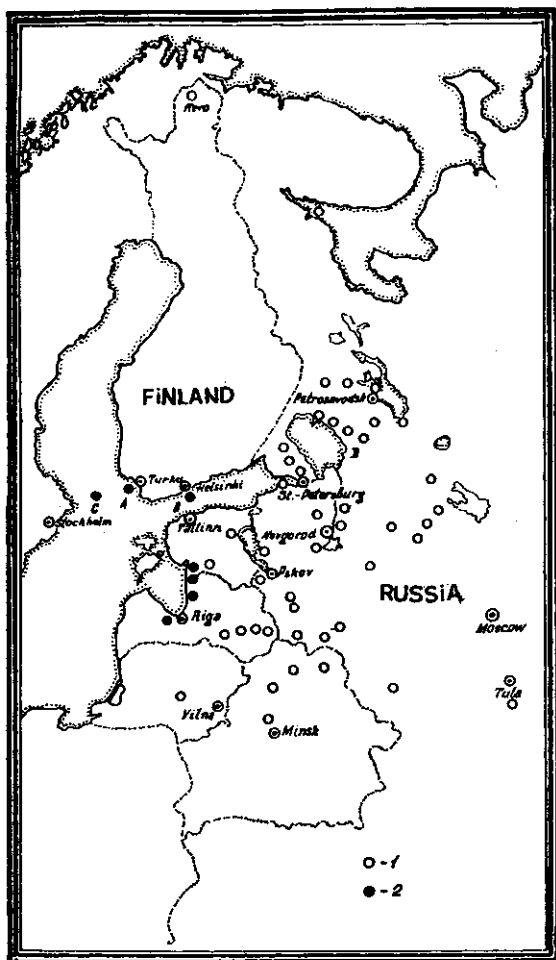


Fig. 1. The study sites in the Northeast Europe. 1- localities inhabited by *Trisetacus pini*, 2- localities free of mites. A-D- sites from which *T. pini* was reported by Liro and Roivainen [1951], A - Varsinas Suomi, B - Uusimaa, C - Ahvenanmaa, D - Aunuksen Karjala.

Рис. 1. Места обследований в Северо-Восточной Европе. 1- пункты с клещами *Trisetacus pini*, 2- пункты без клещей. А-Д- места, о нахождении в которых *T. pini* сообщили Лиро и Ройвайнен [1951], А - Varsinas Suomi, В - Uusimaa, С - Ahvenanmaa, D - Aunuksen Karjala.

TAXONOMY

The species *Phytoptus pini* was described by A. Nalepa in 1889 as the species inducing twig galls on *Pinus sylvestris* L. in south Tirol (Austria). Later on, a number of new species inducing quite different galls on some plants of the fam. Pinaceae were described. Once they were considered as the subspecies of *T.pini*. All of them were the members of one and the same «Formen-Kreis», according to Nalepa's opinion [Nalepa, 1917]. Some of these forms were attributed to the genus *Phytoptus*, then to the genus *Eriophyes*, and since 1952 to the genus *Trisetacus*. The last generic name was proposed by H.H. Keifer. The species «*pini* typicus» became the type species of the genus. Nalepa did not give the full description of *T.pini*. That was why Keifer [1952] decided to provide a new and more complete description of it. He used for this purpose the mites sampled from *Pinus torreyana* Parry in San Francisco, and also individuals collected from *P.radiata* Don. and *P.sabiniana* Dougl. But it was not a happy choice. Within the limits of *T.pini* Keifer described the mites living inside the sheaths of the youngest needles. It was *Trisetacus ehmanni* Keifer, 1963.

Smith [1984] published the review of species of *Trisetacus* from North America. This author believes that the morphology of specimens of *T.pini* was not characterized adequately until it was studied by Keifer [1963] and no comprehensive description of members of this species has yet been published. This is why we consider it necessary to give a new and fuller description of *T.pini* from *Pinus sylvestris* from Europe.

TO THE MORPHOLOGY OF *TRISSETACUS PINI*

In the galls of *T.pini* we have met different females: large and small. Taking into consideration that some of four-legged mites

* *Trisetacus kirghisorum* Shev., for instance [Shevchenko, 1962].

The taxonomy and morphology of *Trisetacus pini*

connected with coniferous plants have two forms of females* (proto- and deutogyne), it is necessary to check if *T.pini* also has two forms of females or not. The investigation of nearly 50 characters in the females demonstrated that some morphological differences between large and small females do exist. But these data fail to provide the evidence of the presence of two forms of females in *T.pini*. We shall use for them the names «small» and «large» females in this paper. They are represented in Fig. 2.

The present study addresses two problems. The first is the problem of size (length) of the mite body, and the second, of the number of dorsal semirings in *T.pini* females.

In the bark galls there occurred females having the body length (in general) from 130 to 350 μ . The smallest specimens were the youngest individuals (immediately after moulting from nymphs), and the longest were females laying eggs. The statistical comparison of small (130-260) and large (260-350 μ) females showed that they are different in this character. The main exponents are shown in Table 1. Data on migrating females are placed in this table as well.

Table 1. Length of the body in different females of *Trisetacus pini*

Type of females	n	Body length		S.D.	coefficient of variation
		Range	Mean		
Migrating females	73	156-280	202.5	28.6	4.2
Small females	67	133-260	210.7	28.4	13.6
Large females	27	260-348	290.1	27.0	9.3
All females from the galls (small and large)	94	133-348	233.5	46.7	19.9

The body length of migrating females does not differ from that of the small females sampled in the galls ($t_d > t_{01}$), but does differ from that of the large females ($t_d < t_{01}$) inhabiting the galls. Keeping in mind that proto- and deutogyne females in

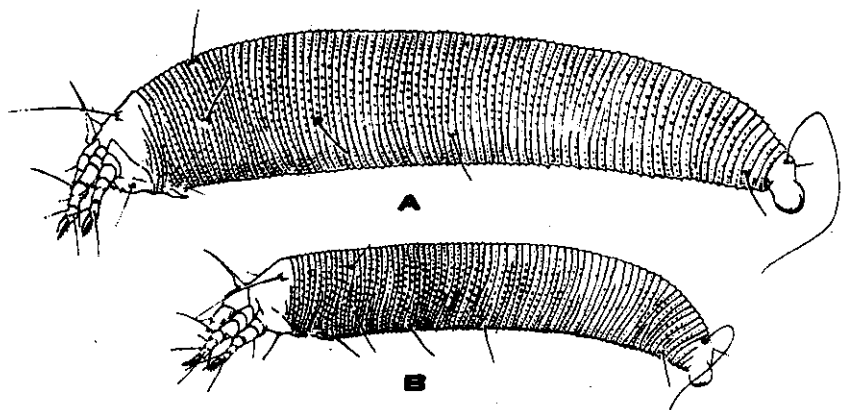


Fig. 2. Large (A) and small (B) females of *Trisetacus pini*
 Рис. 2. Крупные (A) и мелкие (B) самки *Trisetacus pini*

T.kirghisorum have different number of dorsal semirings, we compared all females for this character (Table 2).

Table 2. The number of dorsal semirings in different females of *Trisetacus pini*.

Type of females	n	Number of dorsal semirings			coefficient of variation
		Range	Mean	S.D.	
Migrating females	73	67-86	74.6	4.3	5.7
Small females	67	67-83	74.2	3.7	5.0
Large females	27	71-85	78.1	3.8	4.8
All females from the galls	94	67-88	75.4	4.1	5.4

The mean number of dorsal semirings in females of *T.pini* is limited within narrow bounds. Small females do not differ from migrating specimens. They have the same number of dorsal semirings as the migrants. But the large females differ in number

The taxonomy and morphology of *Trisetacus pini*

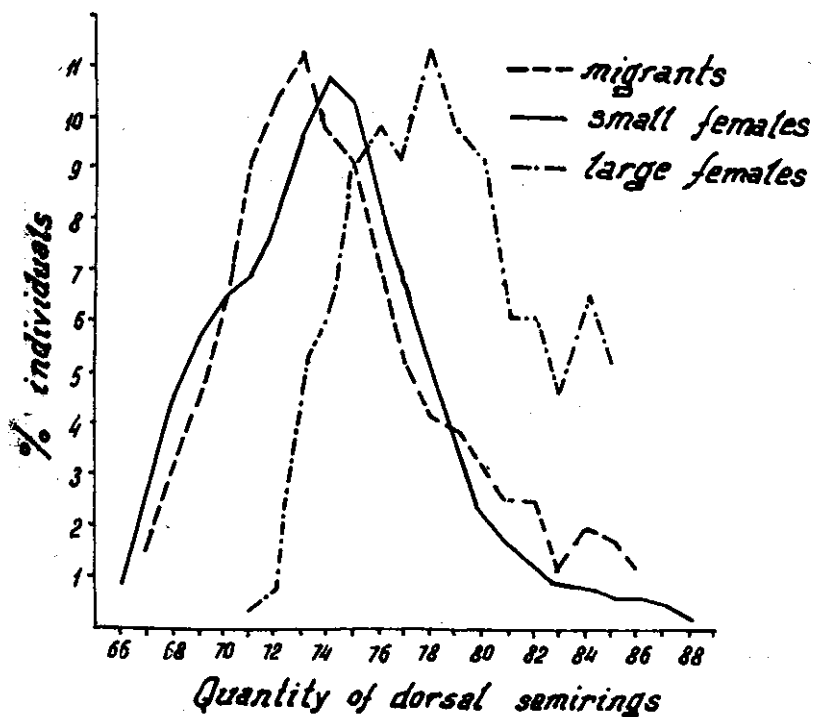
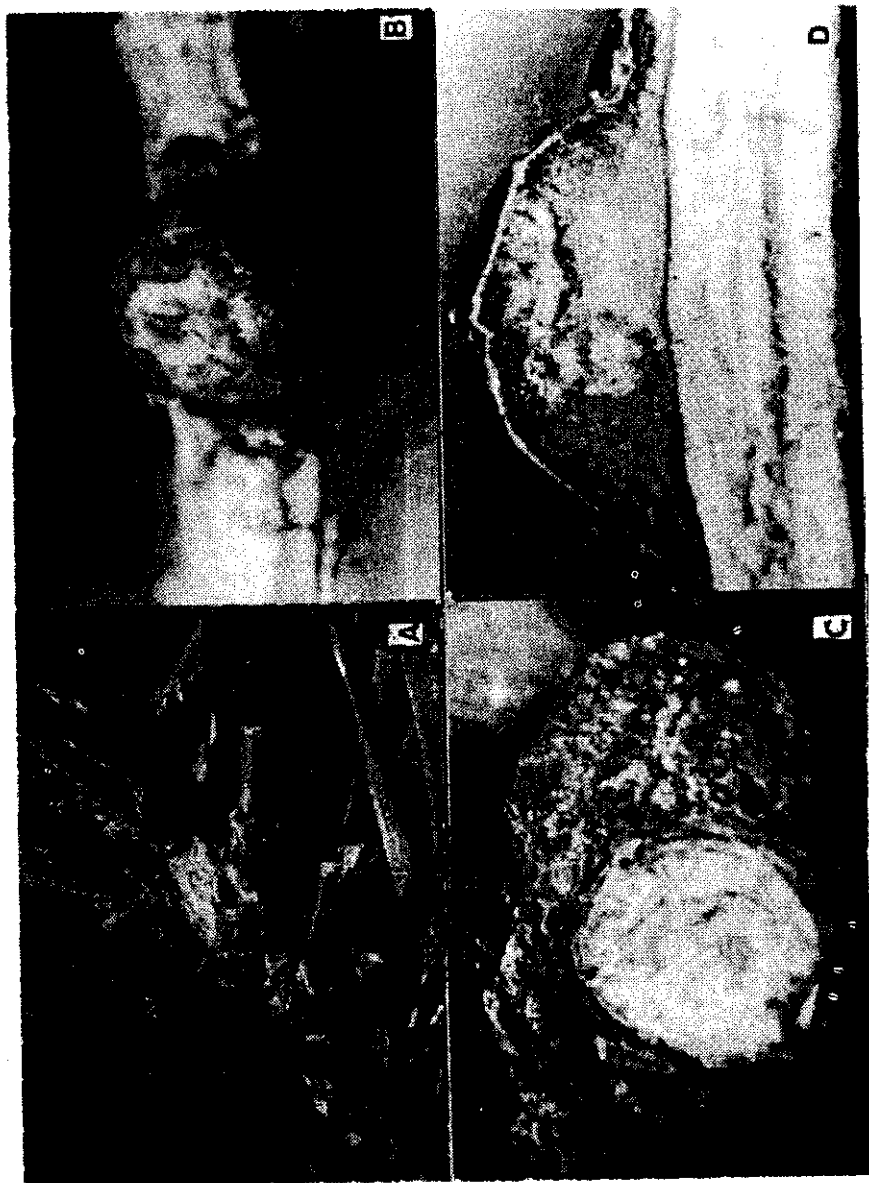


Fig. 3. Percentage of the migrating, small, and large females with different number of dorsal semirings in *Trisetacus pini*.

Рис. 3. Процент мигрирующих, мелких и крупных самок с различным числом дорсальных полуколец у *Trisetacus pini*.

of dorsal semirings from the migrants and from the small females (it was stated on the basis of Student's criterion).

As shown in Fig. 3, the larger are females, the more dorsal semirings they have. The calculations demonstrated that correlation coefficient between the quantity of semirings and the body length in the females that inhabited galls was very high ($r=+0.923$). But such dependence was not characteristic of migrating females and small females from the galls.



The taxonomy and morphology of *Trisetacus pini*

Fig. 4. Twig swelling (A,C,D) and twig knot (B) of *Trisetacus pini* on the shoot of *Pinus sylvestris*. A - young swelling on the two year shoot, B - typical twig knot not surrounding the twig, C - twig swelling surrounding the twig (cut off), D - longitudinal section of the plate-forming twig swelling with chambers or locules.

Рис. 4. Утолщения веточек (A,C,D) и веточковый узелок (B) *Trisetacus pini* на побегах *Pinus sylvestris* L. А - молодое утолщение на двухлетнем побеге, В - типичный веточковый узелок, не окружающий побег, С - веточковое утолщение, окружающее побег (срезан), D - продольный срез бляшковидного утолщения веточки с камерами и доулами.

BIOLOGY

The small females are the main form of hibernating females. They were found in large quantities inside the twig knots (Fig. 4). The vernal migration in Latvia began in 1984 in the middle of May. Females were leaving the old galls during long time and continued migrating up to the middle of June, when the shoots reached 15-20 cm. Migrating females crawl out through cracks where such cracks appear in the walls of relatively old twig galls. The young and small galls are covered with smooth bark (without cracks) and the mites remain unable to leave such twig knots for 1-2 years. They begin to migrate, as a rule, from the three year galls. But occasionally we encountered four year twig swellings without cracks and without migrants. The migrating individuals crawl for some time along the external surface of the gall. They take the position which it is possible to call «the take-off position». Mites attach themselves to the substrate by the anal sucker, rocking themselves from one side to another.

The migrants do not crawl a long distance over the young twigs. Reaching the surface of the shoot, they penetrate at first into the primary bark, and then affect the bast parenchyma. The latter begins to spread out and loosen. This results in the formation of small swellings (Fig. 4A). Most of the small swellings are situated in the basal part of the innovative shoot or in the lower third of it. The main part of the galls are induced by the early migrating females. It is possible to see the galls on all parts of innovative shoots (including their top).

The twig knots vary in shape. Some of them surround the twigs like complete rings, other have the form of plates. All types of twig swellings can retain their vitality for nearly 10 years. New parenchymatous cells appear from one year to another and new chambers are forming inside the galls as a result. The mites continue their development in the new crevices, migrating here from the old refuges. This is the «inner migration». The tissues of the walls of old chambers die off and become brownish. The cells under the twig knots form the cork tissue and some galls fall away. This process may appear in young (three year old) twig swellings, but sometimes 8-10 year galls can hold firmly on the twigs. So, *T.pini* has the life cycle duration of many years, remaining on one and the same place (Fig. 5).

After hibernation, the large females composed only about 5% of the general number of females. Then their quantity began to grow and could reach 34% in August. In the autumn the number of the large females decreased (10% in September). The females of this type lay eggs. It is possible to see some individuals with the nymphs inside their bodies. This means that *T.pini* is at any rate oviviviparous.

Large females begin to lay eggs in the second half of May, and first nymphs appear in the first half of June. Subsequently, the number of nymphs increases and reaches 40% of total population in September. All these data indicate that the rate of the development is low. One or maybe two generations occur during the vegetative period of the host plant.

In September the ratio of different stages in the galls becomes similar to that in May. The main difference is the presence of nymphs I and II (about 10%). Females predominate (84.7%). More than 90% of them are the small females: as a rule the mites do not lay eggs in the first year. Some eggs (2.4%) were present, however. The number of the nymphs II was larger than that of nymphs I (5.7%). This leads us to assume that the life cycle of *T.pini* is over in October.

The taxonomy and morphology of *Trisetacus pini*



Fig. 5. General scheme of the *Trisetacus pini* life cycle. 1 - small females, 2 - large females, 3 - eggs, 4 - nymphs, 5 - dying off of the large females, 6 - dying off of the small females. A - invasion of a pine shoot by a migrating female, B - first migration from the old chamber, C - twig without cauloblastome.

Рис. 5. Принципиальная схема жизненного цикла *Trisetacus pini*. 1 - мелкие самки, 2 - крупные самки, 3 - яйца, 4 - нимфы, 5 - отмирание крупных самок, 6 - отмирание мелких самок. А - заселение соснового побега мигрирующей самкой, В - первая миграция из старой камеры, С - веточка без каулобластомы.

The number of males was small during all cycle (3.2% in May, 1.2% in June, 4.1% in August, 4.7% in September). If we compare the abundance of males with that of large females only, it turns out that in August there were 52.2% females and 47.8% males (i.e. the proportion was close to 1:1).

The development of mites depends on the age of the chambers in which the mites are living. Sometimes the quantity of mites is small in the old crevices, and large in young ones (in one and the same time).

TERRITORIAL DISTRIBUTION OF *T.PINI*

This question has been studied for 20 years. The material was sampled in 50 localities (some of them were surveyed many times in different years). The principal ones are represented in Fig. 1. One can see that the mites were sampled only in some sites situated near the shore of the Baltic Sea. It is a very interesting fact, because the host plant of *T.pini*, *Pinus sylvestris*, has a very broad distribution area. It must be remembered that the species *Trisetacus sequoiae* K. from *Sequoja sempervirens* also has a coastal distribution, but this is determined by the distribution of their host plants and does not depend on the mites themselves. This kind of distribution is also characteristic of *Aceria sheldoni* invading lemon trees. According to Keifer [Jeppson et al., 1975], *A.sheldoni* in California only attacks citrus plants along the immediate coast and does not occur even in citrus orchards that

The taxonomy and morphology of *Trisetacus pini*

are behind the first high ranges of hills. Keifer believes that the distribution of this mite is limited by the level of humidity; presumably this is also true for of *T.pini*.

According to J. Liro and H. Roivainen [1951], *T.pini* can be encountered in Finland (Ahvenanmaa, Varsinas Suomi, and Uusimaa). Moreover, Dr. Roivainen collected some samples in Karelia in 1943 (not far from the town of Olonetz). He was sure that he was dealing with *T.pini*. This statement was the reason for sampling materials first of all near the border of Finland. But our investigation showed that *T.pini* does not exist in the territory noted by Roivainen (Aunuksen Karjala). V. Shevchenko wrote to Dr. Roivainen and he answered that he had sampled some mites of the genus *Trisetacus* on the surface of leafage of *Betula* sp. and added that he had never seen any twig knots in Aunuksen Karjala. Dr. Roivainen had discovered, evidently, some migrating specimens, brought occasionally to the birch from *Picea* and *Pinus*. No *T.pini* were sampled in the Middle Asia (town of Termez in Uzbekistan, Alai in Kyrghyzstan), in Caucasus, and in Urals (the Upper Pechora). Thus, we are absolutely sure that *T.pini* has a very limited distribution.

DEGREE OF INFESTATION

The infested plants occasionally form more or less clear-cut nidus. But not infrequently it was possible to find separate infested specimens. As a rule, the quantity of infested plants and twig knots was small (Table 3).

The locality with the exceptionally great quantity of twig knots was the Archipelago Research Institute in Finland. We encountered there two host plants with a number of twig swellings present on each branch (ID=5.0). Most of the galls were old and dry. Many infested twigs were dry as well.

Table 3. The degree of infestation of *Pinus sylvestris* with twig knots induced by *Trisetacus pini* in different localities.

No	Locality	Year	Number of plants investigated	Percentage of infested plants	Intensive-ness of infestation
1	Pärnu (Estonia)	1984	100	1.0±0.99	1.00
2	200 km from Tallinn to Riga	1984	132	4.5±1.80	1.17
3	Dzveniekziems (Latvia)	1984	100	1.0±0.99	1.00
4	Carnikava (Latvia)	1984	170	5.3±1.72	1.33
5	Ezerkraste (Latvia)	1983	300	3.3±1.03	1.10
6	Kemeri (Latvia)	1984	500	8.0±1.21	1.33
7	Archipelago Research Institute (Finland)	1990	20	23.3±7.70	2.57

The age of infested plants in all observed localities varies in wide range. There were quite young individuals among them (10 year old, 100-120 cm) and majestic big trees (about 70-80 years). On the Island of Seili two quite mature trees were infested heavily.

89 infested trees of *P. sylvestris* in different sites in Latvia were investigated in 1984. It turned out that 45% of the trees had the old bark galls only, 27% had only young galls, and 28% both types of the twig knots. In some places there were no young galls at all. The average infestation rate was 2.18 points for the old galls, and 1.85 for the young, the average IA in the first case was 0.08, versus 0.02 in the second. The young twig knots of *T. pini* occur in the forests four times less frequently than the old ones.

DISCUSSION

More than 50 species belong to the genus *Trisetacus* [Davis et al., 1982; Smith, 1984]. All of them are connected with the different pinaceous plants of the genera *Abies*, *Pinus*, *Picea*, *Juniperus*, *Cupressus*, *Chamaecyparis*, *Thuja*, *Larix*, *Pseudotsuga*, and *Sequoja*. Most species live on the surface of their hosts, or inside the needle sheaths. They do not induce abnormalities, as a rule, and only 8 species can induce stunting and needle deformation, bud proliferation, witches broom, rosetting, bud, «flower», or cone necrosis. *T.pini* is the only species that causes twig swelling, producing gall-like structures. Besides *P.sylvestris*, the twig knots have been registered on *Larix europaea*, *L.leptolepis*, *P.jeffrei*, *P.ponderosa*, *P.radiata*, *P.sabiniana*, and *P.torreyana* [Davis et al., 1982]. It still remains to be found out if we really deal with the same species on all these plants. We can say that bark galls induced by *T.pini* and twig swellings on other plants can be scientifically called «nodal or internodal tuberculoid cauloblastomes». This name was suggested by Slepyan [1973], the author of the special classification of various new-formations in plants.

According to our data, breeding of the mites within one and the same twig swelling may last about 10 years. Krueel [1963] described a similar picture. Keifer [Jeppson et al., 1976], resting on Krueel's data, wrote: «The twig swellings, or knots, are supposed to persist several years and turn out successive broods of mites». Thus, one of the main peculiarities of *T.pini* is its ability to breed and accumulate a number of migrants in the same place. It is the type of life cycle which can be called «life cycle with inward agglomeration».

The biological significance of such agglomeration is clear. Migrants can perish from year to year in unfavorable periods (dry periods). But a swarm of migrants may perish without visible harm to the population. The matter is that the agglomerated

individuals some time or another shall induce young twig knots (in years with favorable weather conditions). The species thus has the insurance reserve of migrants. This behavior shows that we deal with some assemblies representing equal-aged groups, separated by varying intervals.

The species *Trisetacus kirghisorum* also has something like this type of inward agglomeration [Shevchenko, De-Millo, 1968]. These mites inhabit juniper seeds. The deutogyne or small females of this species migrate from old seeds every spring and penetrate inside young «flowers». Here the mites yield the first generation which includes the summer (protogyne) females, males, and the new deutogynes. The next generation develops from the eggs of the summer (or large) females. It consists chiefly of new deutogyne females and males. They are hibernating within the seeds and in the next spring leave old seeds again. If their hosts have no young seed-buds, all migrants may perish, and population can then disappear. Repeated propagation has a great significance in such cases. And we probably deal with such propagation (in old juniper berries) in reality. But juniper seeds mature normally during the second year and fall away with the mites inside them. However, juniper berries occasionally remain on the plants for three years, and the migrants can penetrate into new seeds. In this way they save the population from total perishment. *T.pini* has two types of migrations (inward and outward). *T.kirghisorum* has only the outward migration. We do not know what kind of *T.pini* females (small or large ones) migrate within the galls. In addition, we do not know if the small females lay eggs after hibernation and inward migration or not.

Peculiar bark galls on the bases of buds of *Prunus domestica* L. are induced by *Acalitus phloeocoptes* (Nalepa). Its galls are polylocular, having on the average 6 locules which are completely separated from each other by the parenchymatous tissues. According to Keifer [Jeppson et al., 1976] these mites may have the structurally expressed dimorphism of females. This species

The taxonomy and morphology of *Trisetacus pini*

develops without inward agglomeration. All females of *A.phloeocoptes* migrate after hibernation.

The simplest and the most primitive is the life cycle of *T.pini* (with permanent inward agglomeration and without clear female dimorphism). Next comes the somewhat more specialized life cycle of *T.kirghisorum* (with the sporadic and limited inward agglomeration and a pronounced female dimorphism). The last step of this evolutionary series is the cycle of *A.phloeocoptes* (without inward agglomeration, but evidently with heteromorphic females).

We know that *T.pini* was a common species in South Tirol in Nalepa's time [Nalepa, 1887]. These animals lived in northern Italy [Nalepa, 1898] and in Germany, near Luneberg and Follingsbostel [Keifer, 1963]. Gusjev and Rimsky-Korsakov [1940] reported *T.pini* among the species sampled in Russia. Similar data were published by Volgin [1955]. But we have never seen any twig knots in the European part of Russia or in Byelorussia.

Vassiljeva et al. [1982] placed *T.pini* in the key of the species of Tetrapodili from Crimea. In the footnote the authors wrote that this species was not sampled in Crimea, but must be placed in the key, as it is a well-known mite in the European part of Russia.

The oldest Russian eriophyidologist Rossinsky [1911] wrote that *T.pini* had been found neither in Crimea and Caucasus, nor in Russia. We think that he was right. The distribution of the pine twig knot mite is not yet understood, but hopefully our data can help in the solution of this complex and interesting question. It is very important to study the distribution of this species in the Middle and South Europe, Canada, and USA, and in the future in all the distribution area of the genus *Pinus*. Such data together with the materials on biology of *T.pini* will provide a new possibility to judge on the evolution of the mites and their hosts.

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The taxonomy and morphology of *Trisetacus pini*

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