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Soil Nematode identification service and training in the new normal

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Abstract. Nematodes constitute one of the key components of soil ecosystems, and further studies are needed to explore the roles of each nematode taxon in soil ecosystems. Nematode communities can serve as bioindicator of soil health. However, the two points necessitate accurate identification of existing nematode taxa which in Indonesia is challenging due to the insufficient skill of workers and lack of identification service. The present study was aimed to explore the prospect of online nematode identification training and service as a solution to the above problem. A video conference with 38 participants was held during which still and video images of nematodes examined under a microscope were shared. The results showed that most participants reported clear images with minimum delay, although a smaller percentage had problems related to unstable internet connection. Therefore, the present study suggested the possibility of online nematode identification training and service. In this paper some procedures and setups are proposed for implementing such services, emphasizing on online activities during New Normal and beyond. Fully online or blended deliveries are proposed with increasing nematode handling skill development but also increasing need of access to laboratory facilities. The blended program is extensible to the post-pandemic state or new normal schemes of such activities have been proposed. The present paper also argues that Indonesia needs to build center(s) of nematode collection employing specialist taxonomists who can identify nematodes and are competent in providing identification services.

1. Introduction

Nematodes occur in almost every habitat and in such a high density that approximately 90% of all metazoans on earth are nematodes [1]. In terrestrial ecosystems, nematodes are also the most abundant metazoans with high species diversity, occupying all trophic levels of the terrestrial food web [1-3]. Soil nematode diversity has been shown to be indicative of general biodiversity in the soil [4]. Therefore, nematodes are thought to play crucial roles in soil processes, correlate with soil functional parameters and reflect soil functioning [5-7].

The relationship with environmental conditions serves as the basis for the using of nematode community structure as bioindicator of soil ecological condition. Nematode community structure has practical characteristics to serve as an efficient instrument for the biomonitoring system of soil quality, functioning, and condition [8-10].

Despite the high diversity estimates, perhaps only 10% of nematode species is known [11], and that constitutes mainly the temperate region of the world [12]. We have no definitive picture about nematode diversity in tropical regions because in most tropical countries, including Indonesia, the



study of nematodes is still in its infancy and there has been relatively few samplings of nematode communities [13]. That hinders the use of nematodes as bio-indicators of soil quality and biodiversity in most tropical countries.

Actually, it is not the taxonomist to identify specimens in routine works of ecology or plant protection, for example. It is the responsibility of the worker who wants the specimen identified. Unfortunately, regarding soil nematodes, even routine identification works are hindered by the shortage of competent workers [14]. Sadly, the number of active specialists of soil nematodes is even declining.

One way to overcome the unfortunate situation is identification training for the so-called routine workers. Because most of the time soil nematode identification for routine works in applied biology does not demand species level determination, the training can be carried out in a small to medium sized class with intensive hands-on morphological examination of specimens. However, due to the pandemic Covid-19 and the work-from-home policy of many institutions, the onsite identification training has been put aside. Then, a kind of remote training is needed.

For some group of organisms there are institutions that provide identification service to the public. Usually, the client has to send his or her specimens to the taxonomist for identification. Regrettably, there is no such institution in Indonesia which officially offers identification service of soil nematodes.

The present paper reports the development of a strategy for encouraging soil nematode biodiversity studies in Indonesia, despite the lack or insufficiency of needed resources. Special emphasis is given on the development of remote identification service and training for implementation during the pandemic COVID-19 and the corresponding new normal.

2. Materials and methods

Considering the intensive use of Zoom and Google Meet platforms of remote synchronous meeting during the Pandemic COVID-19, online demonstrations of microscopic examinations of living and preserved specimens of soil nematodes were arranged. Living specimens of nematodes were observed under a zoom stereomicroscope with continuous 7-45x magnification, and fixed specimens were examined under a compound microscope with up to 1000x magnification. For online sharing of microscopic examination, an adapter was placed on one eyepiece to attach a smartphone to the microscope.

A Zoom meeting was organized with 38 student participants. Droidcam application was used to play still and video images from smartphone camera to laptop for sharing with the audience. At the end of the meeting, a questioner was distributed to the participants. Quantitative responses were scored using 5-point Likert scale, while qualitative responses were grouped and listed.

3. Results and discussion

Responses of participant students are summarized in Table 1. Most participants reported clear voice of the instructor (56.8%) and the shared images (75.7%) during the meeting, with minimum delay. Those who had problems with the voice and images blamed the poor internet connection in their places and suggested that the online activity be accompanied by a recorded video and still pictures to allow those who could not properly join the activity to catch up. Most (76.3%) participants found the online activity interesting, despite some problems they may have encountered. Most (63.2% and 60.5%) students prefer synchronous demonstration of microscopic examination over recorded video for asynchronous activity as it allowed direct communication whenever they have question or comment. However, some reminded that demonstrations can never replace hands on experience. The set up did not allow the use of real or virtual pointer on the images shared during the video meeting. Every time the instructor intended to show or talk about a certain spot of a relayed image, he had to place the spot right on the center of the field of view. This has put some constraint on the communication and has been criticized by one participant.

Table 1. Summary of questionnaire results

| Response | SA | A | N (%) | D | SD |
|--|-------|------|-------------|------|---|
| Clear voice of instructor | - | 56.8 | 29.7 | 13.5 | - |
| Clear shared images | 13.5 | 62.2 | 18.9 | 5.4 | - |
| Observation of living nematodes with stereo microscope: | | | | | |
| • clear images | 10.8 | 21.6 | 46.0 | 21.6 | - |
| • can replace direct observation | 2.7 | 21.6 | 37.8 | 35.1 | 2.7 |
| Examination of fixed specimen under compound microscope: | | | | | |
| • clear images | 2.7 | 43.2 | 48.7 | 5.4 | - |
| • can replace direct observation | 2.7 | 27.0 | 40.5 | 29.7 | - |
| Synchronous or asynchronous | Synch | | Indifferent | | Asynch |
| • Living specimens | 63.2 | | 13.1 | | 23.7 |
| • Fixed specimens | 60.5 | | 7.9 | | 31.6 |
| Interesting activity | 34.2 | 42.1 | 21.1 | 2.6 | - |
| Suggestion | | | | | |
| | | | | | <ul style="list-style-type: none"> • Recorded video with voice for backup or later study • Pointer • Connection problems |

Abbreviations: SA= Strongly Agree; A= Agree; N= Neutral; D= Disagree; SD= Strongly Disagree

3.1. Identification training and internship

Results showed that Zoom Meeting can be reliably used in synchronous sharing of video images of nematodes examined under a microscope. The resolution of mobile phone cameras has significantly improved lately and overcome skepticism on the image quality in image sharing through a network [15]. This provides opportunity for online trainings on identification of nematodes with simple setup. It is also possible to address barriers to quantitative imaging [16].

In a fully online program, instructors prepare photos and videos of exercise specimens. Instructions can either be synchronous or asynchronous, but synchronous interaction usually allows more effective delivery. In a blended scheme, the trainees prepare slides by themselves to be used in the identification exercises synchronously guided by the trainer (Figure 1). This implementation might become a new standard in the future, not only during the new normal.

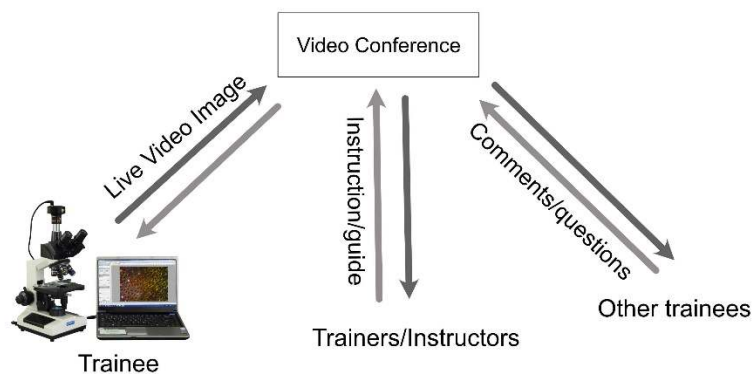


Figure 1. A scheme of online identification training that may be jointly given by several trainers

If the [potential] trainee does not have the nematode extraction and slide preparation skills, he may have to attend a training for that. A set of equipment, including a stereo and a compound microscope, must be handy. Instructions can be delivered online, either synchronously or asynchronously. The basic training should include simple methods of nematode extraction from soils, killing and fixing, transferring nematode to glycerol, and mounting nematode with paraffin method [17].

Expectedly, some trainees would be interested in more in-depth coaching as a step towards a specialization. This is presumably the primary source for the making or the regeneration of nematode taxonomists and specialists. However, this kind of intensive training then becomes an internship that can only be carried out on site under direct guidance from the senior taxonomist.

3.2. Identification service

Identification service will function as a support or backup whenever a worker finds difficulty in his or her identification, to avoid mislabeling that may lead to misleading results and inappropriate decisions. The speed of internet connection nowadays allows a video conference with minimum lag, allowing an identification service without the taxonomist himself to examine the specimen. The client does the specimen preparation and microscopic works, shares the video image during a video conference, and carries out the examination under the taxonomist(s) instruction (Figure 2). This approach can be implemented by using a simple setup on top of a light microscope as practiced in the present study, without an expensive remote microscope system. Telemicroscopy has been applied in telemedicine, in diagnosis of diseases [18-20]. It is noteworthy that this kind of service requires that the client also has the skill of microscope operation for nematode examination, besides the slide preparation. Otherwise, he or she has to attend the prerequisite training somewhere.

Video conference also permits collaboration of taxonomists from different institution in providing identification services, as is also depicted in Figure 2. Their different scope of specialization can be joined through a network of collaborative efforts, forming a wider extent of expertise. Online collaboration in identification service can be a solution to the limited expertise either during or beyond the new normal.

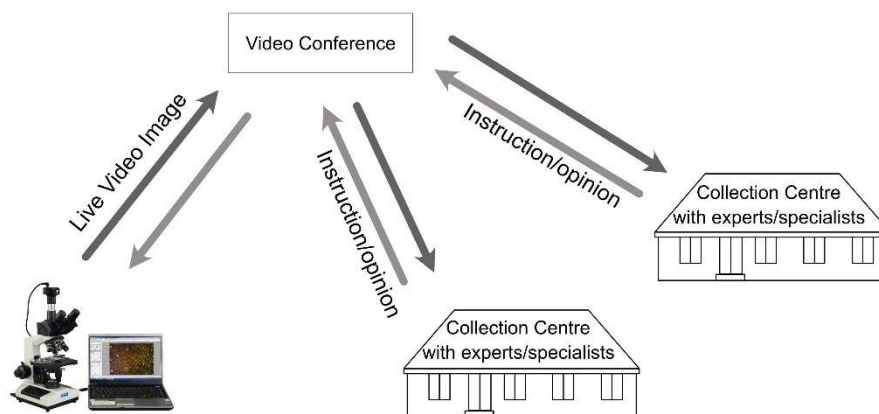


Figure 2. Online identification service given by a network of centers and taxonomists

3.3. Nematode collection centers

As a comparative science, biological classification is always based on comparisons of specimens. Therefore, comparative collection of specimens is indispensable for classification. Collection serves as documentation or reference tool, supplying a permanent record of biota. The record is particularly useful when the biota of the corresponding localities has been destroyed or the localities are inaccessible for any reason. Some material is of unique importance because it forms the basis of

publications of taxa. In addition to research in biological sciences, systematic collection also play important roles in educating society on biodiversity and conservation [21].

Systematic collections are painstakingly developed by specialists. It would take many years of efforts to include a sufficiently broad geographic coverage of collection, usually beyond the life span of a single collector. If every collector works individually collecting specimens and curating his own collection, sustainability of the collection is questionable with his or her death or retirement. Besides, taxonomic collections should be housed, just like libraries, in air-conditioned, low humidity rooms or buildings, far beyond the financial resource of voluntary works of most collectors. A collection center, employing several specialist curators, would allow consolidation of resources and better management of collection. Further, sustainability of curatorship of collection is better in a collection center.

As a large and biodiversity-rich country, Indonesia should have at least one nematode collection center. Unfortunately, despite the established zoology museums in some places, no nematode collection could be found in the country. Preserved specimens of human/animal or plant parasitic nematode are deposited in university laboratories, but they are not soil nematodes or are mainly for exercise purposes.

There are two options for nematode collection center: centralized and decentralized. Centralized collection houses specimens from throughout the country. However, because of the large and fragmented area of Indonesia, the tasks of collecting and processing specimens from all over the country may be too complex. Therefore, there should be several collection centers, at least one in each big island. Each regional center is responsible for services in its corresponding area. Laboratories in universities and research centers must have useful basic resources for the establishment of the nematode collection centers. Human resources can be developed through trainings and internships discussed above.

A network of collection centers will enhance their capacity to provide better services, despite their individual weaknesses due to limited resources. The advancement of information technology opens opportunities for online collaboration in delivering identification service as depicted in Figure 2.

4. Conclusion

In view of the potential use of nematodes as bioindicator of soil conditions, there is a need for soil nematode biodiversity studies in Indonesia. That requires expertise in soil nematode identification which, in most cases, is not available. Therefore, there is an urgent need for soil nematode identification service and trainings, organized by nematode collection center(s) who is also responsible for collection and preservation of reference specimens. The large and fragmented area of the country necessitates establishment of several centers each focusing on their surrounding areas. The quality of internet connection nowadays allows online identification service and training and networking among centers.

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